FIRST NATIONAL COMMUNICATION OF THE REPUBLIC OF MALDIVES TO THE UNITED NATIONS FRAMEWORK CONVENTION ON CLIMATE CHANGE

Published 2001 by Ministry of Home Affairs, Housing and Environment
Huravee Building
Malé 20-05
Republic of Maldives

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ACRONYMS AND ABBREVIATIONS

AOSIS	Alliance of Small Island States
ARI	Acute Respiratory Infection
C4	Centre for Clouds, Chemistry and Climate
CH_4	Methane
CHW	Community Health Worker
CO_2	Carbon Dioxide
CZMS	Coastal Zone Management Subgroup
DER	Department of External Resources
DGPS	Differential Global Positioning System
DHIRAAGU	Dhivehi Raajjeyge Gulhun Pvt. Ltd.
DoM	Department of Meteorology
DTM	Digital Terrain Model
ED	Enumeration Districts
EEZ	Exclusive Economic Zone
ERC	Environment Research Centre
ESCAP	Economic and Social Commission for Asia and the Pacific
FHW	Family Health Worker
GCRMN	Global Coral Reef Monitoring Network
GDP	Gross Domestic Product
GEF	Global Environment Facility
GHG	Greenhouse Gas
GIS	Geographic Information System
GNP	Gross National Product
IAB	International Advisory Board
ICAO	International Civil Aviation Organisation
ICRI	International Coral Reef Initiative
IMO	International Maritime Organisation
IMR	Infant Mortality Rate
INDOEX	Indian Ocean Experiment
IPCC	Intergovernmental Panel of Climate Change
IRRM	Integrated Reef Resources Management
JICA	Japan International Cooperation Agency
LPG	Liquid Petroleum Gas
MAGICC	Model for the Assessment of Greenhouse Gas Induced Climate Change
MATI	Maldives Association of Tourism Industry
MCPW	Ministry of Construction and Public Works
MCST	Ministry of Communication, Science and Technology

MHAHE	Ministry of Home Affairs, Housing and Environment
MHREL	Ministry of Human Resources, Employment and Labour
MHUDB	Maldives Housing and Urban Development Board
MMA	Maldives Monetary Authority
MMR	Maternal Mortality Rate
MOAA	Ministry of Atolls Administration
MOE	Ministry of Education
MOFAMR	Ministry of Fisheries, Agriculture and Marine Resources
MOFT	Ministry of Finance and Treasury
MOH	Ministry of Health
MOT	Ministry of Tourism
MOTCA	Ministry of Transport and Civil Aviation
MOTI	Ministry of Trade and Industries
MPND	Ministry of Planning and National Development
MRC	Marine Research Centre
MWSA	Maldives Water and Sanitation Authority
MWSC	Male' Water and Sewerage Company
N_2O	Nitrous Oxide
NDP	National Development Plan
NEAP (II)	Second National Environment Action Plan
NGO	Non-Governmental Organization
NSS	National Security Service
Rf	Rufiyaa
SAARC	South Asian Association for Regional Co-operation
SACEP	South Asia Co-operative Environment Programme
SBR	Still Birth Rate
SCENGEN	Scenario Generator
STELCO	State Electric Company Limited
TBA	Traditional Birth Attendant
UN	United Nations
UNDP	United Nations Development Programme
UNFCCC	United Nations Framework Convention on Climate Change
V&A	Vulnerability and Adaptation
WHO	World Health Organisation
WMO	World Meteorological Organisation

Foreword

The Maldives is now facing an extraordinary challenge. We must make decisions now that no other Maldivian generation has ever had to contemplate before. Climate change is a threat to the very existence of our home, the low-lying small coral islands of the Maldives; it is a threat to our society, living in harmony with the fragile island ecosystem; and it is a threat to our economy based on tourism and fisheries. Maldives is among the most vulnerable and least defensible countries to the projected impacts of climate change and associated sea level rise.

The extraordinary challenge before the present generation is to make the Maldives resilient and adaptable. To do this we must be fully aware of the vulnerability and fragility of our ecosystem; we have to understand present global trends and their consequences on this ecosystem; and we have to transcend any limitations on our thinking in a truly ingenious fashion. The question is whether we have the sufficient vision and resolve to do this. I believe we do.

Twelve years ago, at the Small States Conference on Sea Level Rise held in Maldives, President Maumoon Abdul Gayoom said, "*there must be a way out. Neither the Maldives nor any small island nation wants to drown. That's for sure. Neither do we want our lands eroded or our economies destroyed. Nor do we want to become environmental refugees either. We want to stand up and fight*".

Maldives is a party to the United Nations Framework Convention on Climate Change (UNFCCC) and the first country to sign the Kyoto Protocol. Maldives believes fully in the objective of the Convention and national policies are guided by the precautionary principle. We fully subscribe to the principle of common but differentiated responsibilities to mitigate climate change.

Maldives has completed its first National Communication to the UNFCCC through the Enabling Activities Programme, funded by Global Environment Facility (GEF). This is the beginning of a process to meet the reporting obligations of the country under the Convention. The first National Communication incorporating the National Strategy and Action Plan was developed after intensive consultations among government and non-governmental organisations. It contains the results of technical studies, observations and findings of assessments conducted through field studies, and scientific studies undertaken with guidance from experts. Everyone involved in the preparations of this Communication believes the process to have been extremely useful and successful, and underscores the need to continue the managerial and technical capacity building exercise in to the future.

The first National Communication of Maldives will serve as a basis for concrete future actions. I am optimistic that it will pave the way to assist our nation in adapting to climate change impacts in a more sustainable and consolidated way. The Maldives is fully committed in implementing the policies and measures identified in our National Strategy and Action Plan to mitigate climate change. It is my sincere hope that the international community will recognise our vulnerability and will work as partners in saving our home.

Ismail Shafeeu
Minister of Home Affairs, Housing and Environment

EXECUTIVE SUMMARY

This first National Communication of the Republic of Maldives has been produced with funding from the Global Environment Facility (GEF) as part of the enabling activity project; *Maldives GHG Inventory and Vulnerability Assessment: A Climate Change Enabling Activity*.

A national country team worked closely with relevant government sectors in developing this first National Communication. It was prepared in close adherence to the guidelines provided by Decision 10/CP.2 of the Second Conference of the Parties (COP2) to the UNFCCC. This report is composed of seven main chapters: (1) National Circumstance; (2) National GHG inventory; (3) Mitigation of GHG emissions; (4) Vulnerability to climate change; (5) Adaptation to climate change; (6) Policy and measures; and (7) Project proposals.

National circumstance

The Republic of Maldives is comprised of 1,192 small, low-lying coral islands in the Indian Ocean. The islands exist as a chain of coral atolls, stretching 860 km from latitude $7^0$6'35"N, crossing the Equator to $0^0$42'24"S, and lying between $72^0$32'19"E and $73^0$46'13"E longitude. The total land area of the Maldives is estimated at around 300 km^2. The islands are surrounded by coral reefs, which protect these islands from the impacts of strong waves and other such effects.

The Maldives enjoys a warm and humid tropical climate, with the weather mainly being dominated by two monsoon periods: the southwest monsoon (the wet period, from May to November); and the northeast monsoon (the dry period, from January to March).

Indicator	1994	2000
Population	240,255	270,101
Land area (km²)	300	300
GDP (in mil. US$, 1995)	338	525.6
GDP per capita (US$, 1995)	1451	1954
Estimated Share of the informal sector in GDP %	-	-
Share of industry in GDP (%)	10.1(Including electricity)	8.5
Share of services in GDP (%)	73.4	77.2
Share of agriculture in GDP (%)	3.8	2.8
Land area used for agricultural service (km²)		
Urban population as percentage of total population	25.2 (in the year 1995)	27.4
Live stock population (chicken and ducks only)	180623	211979
Forest area (km²)	-	-
Population in absolute poverty	-	30,000 (in the year 1998)
Life expectancy at birth (years)	69.12	72.56 (in the year 1999)
Literacy rate (percentage of population)	98 (in the year 1990)	98.94 (in the year 1999)

Table 1: Summary of Maldives national circumstances

Year 1994: 1 US$ = Maldivian Rufiya 11.59
Year 2000: 1 US$= Maldivian Rufiya 11.77

The islands of the Maldives have been known to be inhabited for up to 2,500 years. The population of the Maldives, according to the census in 2000, is 270,101 with an annual growth rate of 1.96%. About 25% of the total population reside in the capital, Malé, where most of the economic and commercial development activities take place.

The main contributors to the economy are the tourism, fisheries, constructions and commercial sectors. The tourism and fisheries sectors are very much dependent on the coastal environment of Maldives. All the economic activities rely heavily on the smooth functioning of the Maldives' only international airport, on the island of Hulhulé.

National GHG Inventory

The Maldives inventory of GHG emissions has been calculated for year 1994 and is limited to the best information available for that year. It was not possible to report on emissions of all three major GHGs; carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O). The inventory was developed mainly for the energy sector using the IPCC Reference Approach.

In the Maldives, diesel is the main fuel consumed and is used to generate electricity and for transportation. It was estimated that 129 Gg of carbon dioxide was emitted from the energy sector and 1.1 Gg of methane was emitted from the waste sector.

Developing the GHG inventory highlighted the need for training in collecting relevant statistical data and modifying the IPCC guidelines to capture the small scale of GHG emissions from the Maldives.

Mitigation of GHG emissions

Maldives is a non-annex I party to the UNFCCC and is not obliged to implement GHG mitigation measures. However, mitigation measures have been developed not only to reduce the Maldives emission of GHGs, but as a step towards achieving greater energy independence for sustainable development.

The mitigation of GHG emissions is possible by lowering the demand on the imported fossil fuel. This can be achieved by increasing the efficiency in generating and utilising electricity and improving the efficiency of the transportation mechanisms.

Reducing methane (CH_4), the main source of emission of GHGs from landfills and sewage discharges, is another possibility. This can be achieved through improving the solid waste disposal methods, management practices and providing treatment of sewage discharges.

The enhancement of the Maldives natural GHG sinks by increasing the vegetation cover and improving the health of the coral reef have been considered as possible mitigation options. Land use, land use changes and forestry and the existence of natural and managed GHG sinks, were not accounted for in the GHG inventory due to lack of sufficient data.

Vulnerability to climate change

Even though the Maldives contributes less than 0.01% to global emissions of GHGs, the Maldives is in fact one of the most vulnerable countries to climate change and sea level rise. The National Vulnerability & Adaptation (V&A) assessment team identified seven main areas of vulnerability:

1. Land loss and beach erosion

Over 80% of the land area in the Maldives is less than 1 m above mean sea level. Being so low-lying, the islands of the Maldives are very vulnerable to inundation and beach erosion. Presently, 50% of all inhabited islands and 45% of tourist resorts face varying degrees of beach erosion. Climate change and projected sea level rise would aggravate the present problem of beach erosion. It is expected that even a 1 m rise in sea level would cause the loss of the entire land area of Maldives.

2. Infrastructure damage

All the human settlement, industry and vital infrastructure in the Maldives lie very close to the shoreline. Therefore, the projected rise in sea level poses a grave threat to the existence of these structures.

According to research, Malé International Airport on Hulhulé island needs to be given priority, as this is the only gateway to the Maldives. The height of the runway is only 1.2 m above mean sea level and is extremely vulnerable to climate change related sea level rise.

Other important vulnerable structures include the investments on tourist islands.

3. Damage to coral reefs

The low-lying islands of the Maldives are surrounded by coral reefs. These coral reefs not only provide protection for the islands, but are related to success of the main economic activities: tourism and fisheries.

Studies show that the corals are very sensitive to changes in sea surface temperature. Unusually high sea surface temperatures in 1998 caused mass bleaching on coral reefs in the central regions of the Maldives.

If the observed global temperature trend continues, there would be a threat to the survival of the coral reefs in the Maldives.

4. Impacts on the economy

The threats posed by climate change to the beaches, reefs and infrastructure on resort islands makes the tourism industry very vulnerable to climate change. This greatly affects the economy as tourism contributes to about a third of the GDP of the country.

Fisheries in the Maldives is another economic activity which relies on the health of the reefs. Although no conclusive links have been established between tuna fishery and climate change, it has been found that seasonal monsoon changes do in fact affect the tuna fishery in the Maldives. It has been found that in El Niño years catches of certain types of tuna increase while the others decrease, and the reverse catch pattern is seen with regard to other types of tuna during La Niña periods.

5. Food security

Due to the poor soil quality in the Maldives, agriculture is a minor industry. The lack of locally grown food items creates a high dependency on imported food, except for tuna and coconut. Therefore the Maldives is vulnerable to changes in productivity of agricultural lands beyond our borders.

The imported food items are first brought to the capital and later distributed to other islands by sea transport. The distribution of food to these islands is very vulnerable to changes in weather. Extreme storm events have led to food running scarce in certain islands. These events have been noted to last for a period of 1-30 days. With climate change and the rise in sea levels, it is expected that more storm events would occur, thereby threatening food security in this island nation.

6. Water resources

The population of the Maldives mainly depends on groundwater and rainwater as a source of freshwater. Both of these sources of water are vulnerable to changes in the climate and sea level rise.

With the islands of the Maldives being so low-lying, the rise in sea levels would force saltwater intrusion into the freshwater lens. The groundwater is replenished by bursts of rain and although there is a predicted increase in the amount of rainfall to the region, the spatial and temporal change in rainfall pattern is uncertain. Therefore, for the Maldives, climate change poses a threat to water availability.

7. Human Health

The effects of climate change and sea level rise on the health sector need to be studied further. Notable relations to changes in climate have been seen for dengue and dengue hemorrhagic fever in the country. Although malaria has been eradicated from the Maldives, with climate change there might be a threat of malaria outbreaks occurring in the country. The poor sanitation in the islands of the Maldives, combined with any future increase in rainfall, would cause more outbreaks of waterborne diseases, such as diarrhoea.

Access to health services and facilities during severe weather is a major concern for rural island communities of the Maldives. Other major concerns from climate change are poor human health due to heat stresses, and poor urban air quality. Based on the IPCC regional climate change scenarios, it is estimated that air temperatures in the region may rise by 2 - 3.8 °C by the year 2100.

Adaptation to climate change

Adaptation options in low-lying islands of the Maldives, which have been identified as especially vulnerable, are limited and response measures to climate change or its adverse impacts are potentially very costly. Adaptation in this section covers two main types of activities. The first being actual physical adaptive measures targeted at the sectors identi

fied in the vulnerability chapter. High importance is given to protecting the islands by building appropriate structures for coastal protection. Several other projects have also been identified for the various sectors.

The second activity is to enhance the capacity to adapt in the Maldives. The Maldives lacks the capacity both technically, and financially to undertake actual adaptive measures. The main areas identified are human resource development, institutional strengthening, research and systematic observation and public awareness and education.

Policies and measures

The mitigation and adaptation chapters discuss in detail measures that can be taken to deal with the implications of climate change and sea level rise in the Maldives. This section identifies how the present existing policies could be improved to include the effects of climate change in national development planning. A National Implementation Strategy is also included at the end of this chapter.

Project proposals

This section includes project proposals for some of the projects suggested in the earlier chapters. These proposals are ready for presenting to external donor agencies.

1 NATIONAL CIRCUMSTANCE

1.1 Geography

The Republic of Maldives is a chain of coral atolls stretching 860 km from latitude $7^0$6'35"N, crossing the Equator to $0^0$42'24"S, and lying between $72^0$32'19"E and $73^0$46'13"E longitude in the Indian Ocean. Its nearest neighbours are India, Sri Lanka and Chagos Islands, lying approximately 600 and 750 km to the north and north-east, and immediately south respectively (MPHRE, 1998). The width of the chain varies from 80 to 120 km at some locations. The total land area of the Maldives is estimated at around 300 km^2. The maritime area of the Exclusive Economic Zone (EEZ) amounts to more than 859, 000 km^2 (MPND, 2000).

Map 1-1: Location of the Republic of Maldives in the Indian Ocean

The chain of the atolls of the Republic of Maldives stand on the Chagos-Laccadive Plateau. It is believed that the Maldives and other features of the Indian Ocean bottom were formed about 65 to 225 million years ago in the Mesozoic Era (Maniku, 1990). There are several theories on the formation of the Maldivian atolls. One such theory is that the basin of the Indian Ocean was formed due to subsidence and oceanisation of the continental crust. "The compound atoll reefs of the Indian Ocean, of which Maldives forms the larger part, are believed to have been grown above the foundered continental (rather than oceanic) crustal segments" (Maniku, 1990). According to Gardiner (1902, 1903), the main Maldives

plateau was formed by current erosion, and the atolls were subsequently formed by the growth of deep; and later shoal water; organisms on this formation (Maniku, 1990).

The Maldives archipelago contains 26 geographic atolls, which vary in shape and size. The word "atoll" is derived from "atolhu," a native name in the Maldivian language. The sizes of the atolls vary from 1.4 to 2,800 km^2. It is estimated that the atolls of the Maldives are over 10,000 years old (Woodroffe, 1989). These atolls are grouped into 20 administrative regions. The capital, Malé forms a separate administrative unit and is centrally located. The distance between different atolls vary from 1.5 km in the channel between Kuda Kanduolhi and Kudarikilu Kandu in Baa Atoll and 96 km in the Huvadhoo Kandu (one and half degree channel).

Figure 1-1: The standard theory of atoll formation states that a volcanic island forms in deep tropical waters, giving coral polyps a foundation to grow on (above, top). In time, the volcano becomes dormant and the island begins to subside. Coral reefs, originally, fringing the edges of the island, becoming a barrier reef outlining the contour of the original coastline (above, middle). After the original island slips entirely beneath the waves, all that is left is a coral atoll (above, bottom). (NASA, 2001).

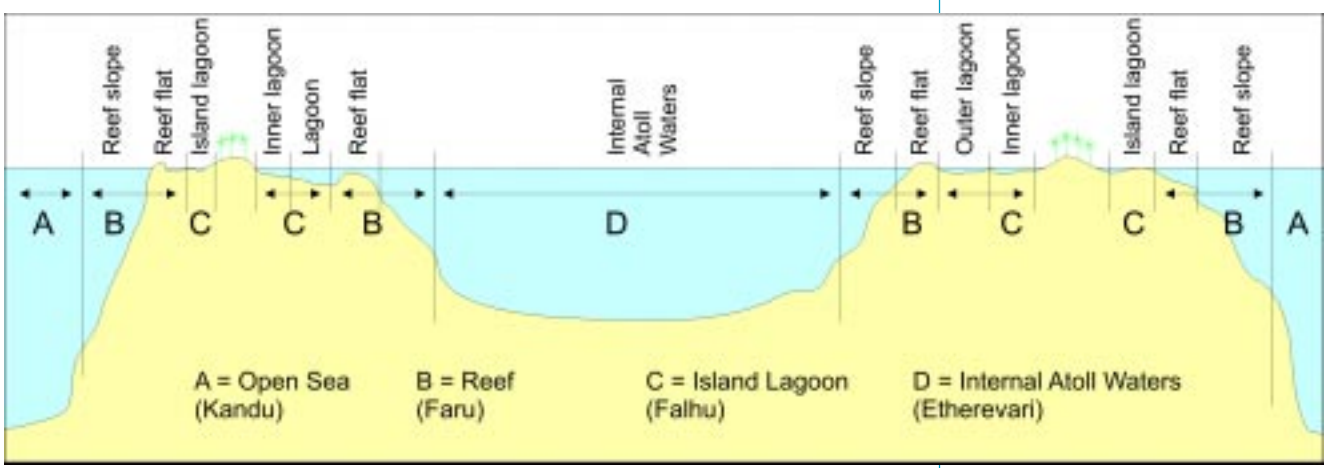
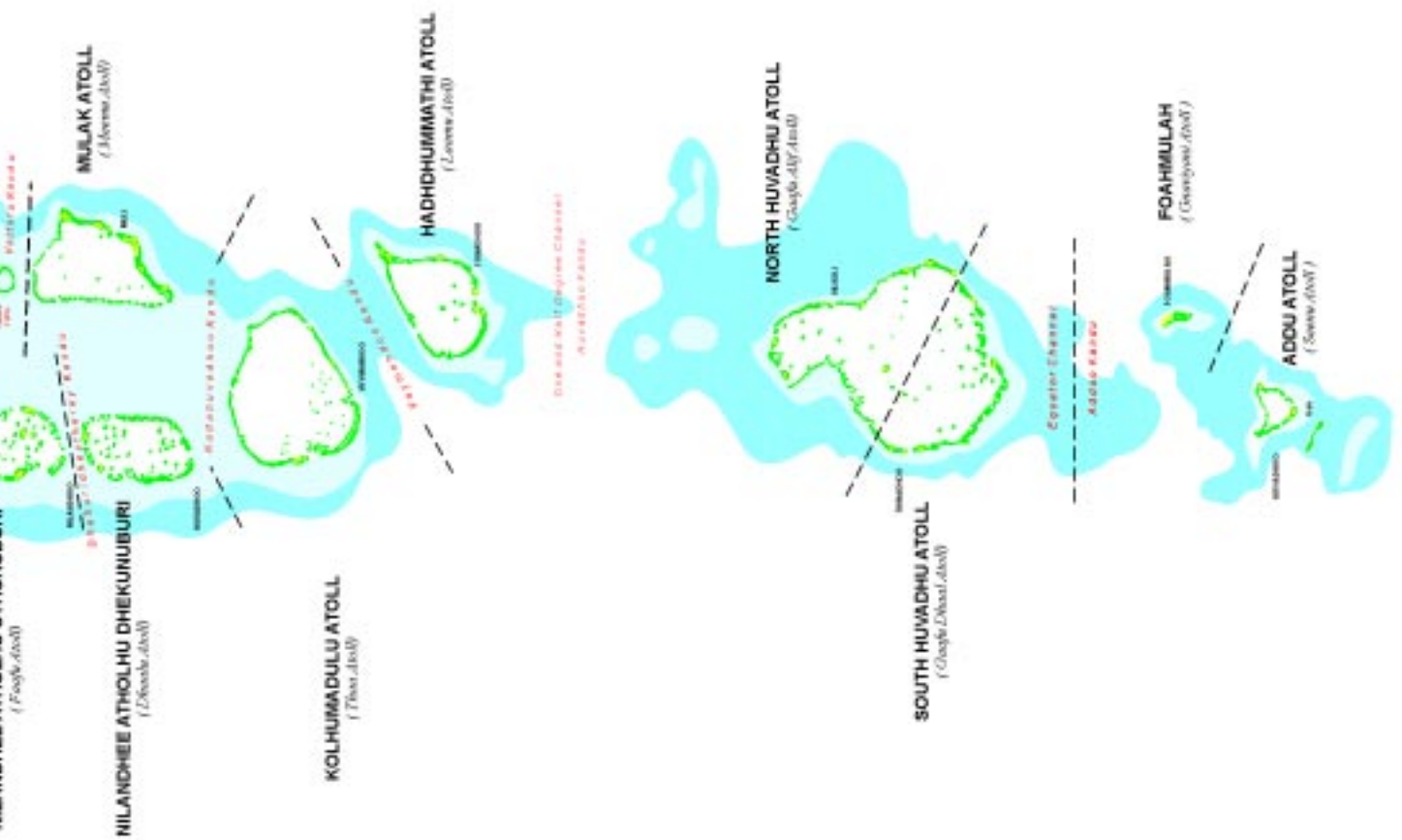


Figure 1-2: Cross section through a typical Maldivian Atoll (adapted from BoBP, 1994)


N
THILADHUNMATHEE UTHURUBURI
(Haa Alif Atoll)
THILADHUNMATHEE DHEKUNUBURI
(Haa Dhaalu Atoll)
MILADHUNMADULU UTHURUBURI
(Thaa Atoll)
MILADHUNMADULU DHEKUNUBURI
(Noonu Atoll)
MAALHOSMADULU UTHURUBURI
(Raa Atoll)
FAADHIPPOLHU
(Lhaviyani Atoll)
MAALHOSMADULU DHEKUNUBURI
(Baa Atoll)
MALE' ATOLL
(Kaafu Atoll)
ARI ATHOLHU UTHURUBURI
(North Ari Atoll)
ARI ATHOLHU DHEKUNUBURI
(South Ari Atoll)
MALE' ATOLL
(Kaafu Atoll)



Map 1-2: The Republic of Maldives

Atoll	Island Name	Area (km²)	Population (2000)
1. Laamu	Gan	5.166	2244
2. Seenu	Hithadhoo	4.673	9461
3. Gnaviyani	Fuvahmulah	4.200	7528
4. Laamu	Isdhoo	2.937	1432
5. Kaafu	Kaashidhoo	2.765	1572
6. Seenu	Gan *	2.649	-
7. Gaafu Dhaalu	Gan **	2.636	-
8. Haa Dhaalu	Hanimaadhoo	2.595	1009
9. Haa Alifu	Baarah	2.488	1270
10. Haa Alifu	Filladhoo	2.256	659

** - industrial/airport ** - uninhabited*

Table 1–1: Ten largest islands of the Maldives

The characteristics of reefs and coral islands of the Maldives vary considerably from north to south. The atolls to the north are broad banks discontinuously fringed by reefs with small coral islands and with numerous patch reefs and faroes (derived from the Maldivian word "faru") in the lagoon. To the south the depth of atoll lagoon increases, faroes and patch reefs are rare in the lagoon, the continuity of the atoll rim is greater and a large of the perimeter of the atolls is occupied by islands (Woodroffe, 1989).

The atolls of the Maldives contain a total of 1,192 islands, of which only 199 are inhabited. Over the past 12 years, 86 islands have been developed into tourist resorts (MoT, 2001). All of these islands are made up of coral and coral sand. The islands are entirely built and sustained by the continuous ecological and physical processes in the coral reef ecosystem of which the existence of the islands are based upon. The shapes of the islands depend largely upon the wave action on the shore. Islands vary in shape from small sandbanks with sparse vegetation in the centre to elongated strips and also to relatively circular islands with a large cover of vegetation.

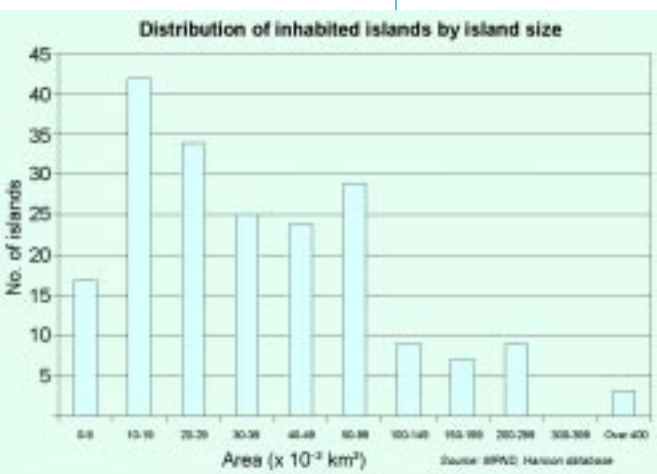


Figure 1-3: Distribution of inhabited islands by island size

The average islands vary in size from 0.5 to 2 km². Only 33 islands have a land area in excess of one square kilometre. According to Figure 1-3 below more than 85% of the inhabited islands are less than 1 km² in size and only 3 inhabited islands have an area exceeding 4 km².

All islands of the Maldives are very low lying and none exceeds the elevation of 3 m. More than 80% of the land area is less than 1 m above mean sea level (MHAHE, 1999). Combined with the small size of the islands, this means that accelerated sea level rise will have devastating effects on the islands and can threaten the very existence of all the islands of Maldives.

1.2 Climate

The Maldives has a warm and humid tropical climate. The weather is dominated by two monsoon periods: the dry northeast monsoon is from January to March and the wet southwest prevails from May to November. The southwest monsoon is the wetter of the two monsoons and is typically the period when most severe weather events occur. The annual average relative humidity is about 80% (DoM, 2000).

Although the Maldives is not located in a region of cyclone or other severe weather activities, historic evidence shows that the northern part of Maldives is affected by storms generated from cyclone activity in other regions of the world (Maniku, 1990 & Woodroffe, 1989). A listing of some of the storms is included further down the chapter, in the section on climate extremes.

	Temperature (°C) Max	Min	Wind speed (Kts)	Rainfall (mm)
Jan	30.0	25.6	11	85.7
Feb	30.4	25.8	9	44.8
Mar	31.1	26.2	7	70.7
Apr	31.5	26.6	7	125.8
May	31.0	26.3	11	232.3
Jun	30.6	26.0	11	165.6
Jul	30.5	25.7	10	166.8
Aug	30.2	25.5	10	184.2
Sep	30.2	25.3	11	215.3
Oct	30.1	25.3	10	226.9
Nov	30.0	25.3	9	211.2
Dec	29.9	25.3	10	218.1
Mean	**30.5**	**25.7**	**10**	**162.3**

Table 1-2: 33-year monthly means (1967-1999) for Hulhulé station

Climate Trends

The following section gives the trends in the general climate for the Maldives. The data for the meteorological stations in Seenu Gan are used wherever possible. As the island of Hulhulé is very close to Malé the dataset for Hulhulé is often referred to as data for Malé.

Temperature

Daily temperatures vary little troughout the year with a mean annual temperature of 28 °C. Analysis of long-term annual maximum and minimum temperatures (1969-1999) show a rising trend (Figure 1-4). Based on the analysis, the annual maximum temperatures increase by 0.17 °C every 10 years, whilst annual minimum temperatures show an increase of 0.07 °C every 10 years.

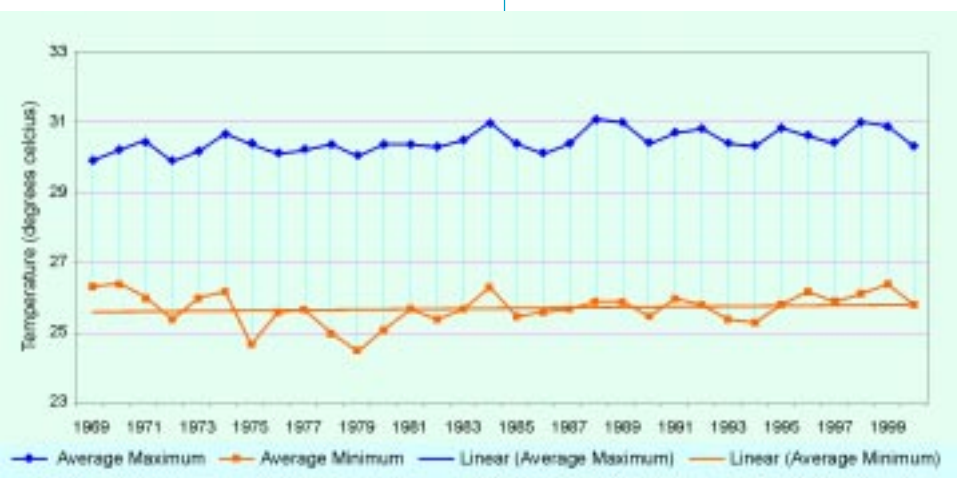


Figure 1-4: Average annual temperature variation for Malé

Highest maximum daily temperature	16th and 28th of April 1973	34.1°C
Highest monthly average maximum temperature	April 1975	32.7°C
Lowest monthly average minimum temperature	March 1974	21.7°C

Table 1-3: Measured temperature extremes for Malé (DoM,, 2001)

Based on the analysis, the annual maximum temperatures increase by 0.17 degrees every 10 years whilst annual minimum temperatures show an increase of 0.07 degrees every 10 years.

Rainfall

Rainfall in Maldives varies from north to south with the amount of rainfall increasing towards the south. This difference in rainfall patterns is primarily due to the northeast monsoon period and April being much drier in the north than in the south (Edwards, 1989).

Based on the analysis, a decrease of 2.7 mm in the total annual rainfall for every year for the central region of the Maldives has been observed.

A decrease of 7.6 mm in the total annual rainfall for every year for the southern part of Maldives has also been observed.

Figure 1-5: Annual variations of total rainfall for Malé and Gan

Wettest year recorded	1978	2707mm
Driest year recorded	1995	1407mm
Wettest month recorded	October 1984	588mm
Heaviest daily rainfall recorded	11 October 1998	200mm

Table 1-4: Rainfall extremes for Malé (DoM, 2001)

Analysis of long-term total annual rainfall data for Malé shows a decrease in rainfall. The trend shows a decrease in 2.7 mm of rainfall every year (Figure 1-5). Total annual rainfall for the station in Gan in the south shows a decrease of 7.6 mm of rainfall every year.

Wind

The wind pattern is dominated by winds from the west and northwest and winds from the northeast and east-northeast. Slightly stronger winds are associated with winds from the west typical of the southwest monsoon season. On average wind speeds vary between 7-12 knots. The sever monsoon months are typically May, June and July during the early

part of the southwest monsoon, and September and October at the latter half. Squally gusty winds of 50-60 knots have been recorded at Malé (DoM, 2000). Figure 1-7 below, shows the variation in average seasonal wind speeds over the last 30 years.

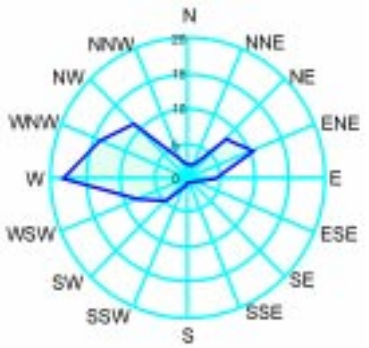


Figure 1-6: Percentage of wind direction for Malé (1980 - 1999)

Month	Wind speed (Kts)
Jan	11.2
Feb	9.2
Mar	7.1
Apr	7.5
May	10.8
Jun	11.0
Jul	10.0
Aug	9.7
Sep	11.0
Oct	10.5
Nov	8.9
Dec	10.0

Table 1-5: Average monthly wind speeds for central atolls of Maldives (1968 - 1999)

Current, tides and waves

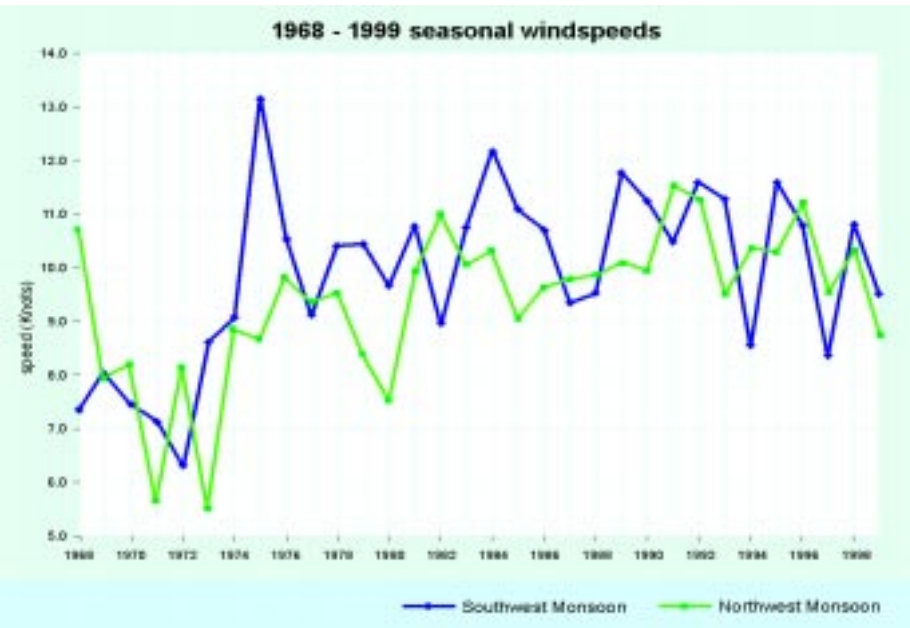


Figure 1-7: Average seasonal variations of wind speeds for Malé (DM, 2000)

The Indian Ocean current regime is strongly influenced by the monsoon climate. The swells and wind waves experienced by the Maldives are conditioned by the prevailing biannual monsoon wind directions, and are typically strongest during April – July in the southwest monsoon period.

The Maldives experiences mixed semi-diurnal/diurnal type tides. Comparison of the tide records for Gan (south), Hanimaadhoo (north) and Malé (mid) indicated that the tidal range increases slightly from north to the south of the country. The tide at Hanimadhoo is about 20 cm lower than that at Gan. The tide records also indicate that there is a phase lag from north to south.

Tide level	Referred to Mean Sea Level
Highest Astronomical Tide (HAT)	0.64
Mean Higher High Water (MHHW)	0.34
Mean Lower High Water (MLHW)	0.14
Mean Sea Level (MSL)	0.00
Mean Higher Low Water (MHLW)	-0.16
Mean Lower Low Water (MLLW)	-0.36
Lowest Astronomical Tide (LAT)	-0.56

Table 1-6: Tidal recordings for Hulhulé station

Extreme episodic events

• Historical records show that the northern part of Maldives experiences the fury of cyclones. There have been several cases of islands even being uninhabited due to damage caused by such cyclone driven storms. Historical records show that about 18 islands from the northern atolls were abandoned after being devastated by the storm events (Maniku, 1990).

• Inundation of parts of islands, usually accompanied by high waves or heavy rainfall is experienced in the islands of Maldives. These events occur mainly in the southern region and mostly in April and December which is the interim period between the northeast and the southwest monsoon. The island of Fuvahmulah had experienced 9 such events between 1977 and 1989 (Maniku, 1990).

• According to Maniku (1990) storm events that are very localised to sometimes even one island (freak storms) occur in the Maldives. The resort island of Bolifushi was hit by such a freak storm in 2000. This storm lasted about 12 hours and caused US$ 1.2 million worth of damages.

• The central part of Maldives experienced a strong tidal wave in April 1987. This caused extreme damage to the capital and the international airport.

• It is commonplace to see tide coming ashore in many islands throughout the country at high spring tide. There have been various incidents where houses, roads and trees, especially those nearer to the coastline, have been affected by floods during such tide.

• The most recent storm to affect Maldives was on 30th of May 1991. This is the most severe recorded storm event so far in which the atmospheric pressure fell down to 997 hpa and the maximum squally winds reached 90 kts per hour (DoM, 2001; WMO, 1993). Even though the sever weather system occurred at the southern most atoll, most parts of the country was affected, as 4,081 houses in 13 atolls were damaged (SAARC, 1992).

Storm	No. of islands affected
7 May 1812	33
29 Dec 1819	18
8 Dec 1821	27
9 Jan 1955	25
30 May 1991	13 (atolls)

Table 1-7: Historic storms driven by cyclone (Maniku, 1990 & SAARC 1992)

Photo: KD Ahmed Manik

1.3 Biodiversity in the Maldives

The islands of the Maldives are very small, low lying and isolated. This fact very much limits the richness of the terrestrial biodiversity. As the islands are located purely in a marine ecosystem, the Maldives is very rich and diverse in terms of its marine biodiversity.

Limited studies have been done to study the biodiversity of Maldives. From Tables 1-8 and 1-9, it can be seen that the recorded species of terrestrial flora is more diverse compared to terrestrial fauna. Because of the coastal ecosystem, Maldives has a wide variety of mangrove species.

Given the small island ecosystem, Maldives is home for many species of seabirds. Five sub-species of seabirds have been identified as endemic to the Maldives (Table 1-10). Endemicity and the frequency of unique sub-species are high in the southern part of Maldives compared to the north. From a biodiversity prospect, it is very important to protect all islands from the effects of climate change and sea level rise, especially the uninhabited islands, which are hotspots of biodiversity.

Maldives is very rich in its marine flora and fauna. Over 1200 species of reef fish, 250 species of hermatypic corals and 285 species of algae have been identified in the Maldives (Table 1-9). These marine ecosystems are very vulnerable to climate change and sea level rise.

As mentioned earlier few studies have been undertaken to study the biodiversity in Maldives. No studies have been undertaken to study the freshwater environment. There might still be many species that have not been identified. Therefore, it is important to do more studies to compile a complete listing of flora and fauna found in the Maldives.

Terrestrial Biodiversity
583 species of plants (over 75 species are endemic to Maldives)
Over 300 species of medicinal plants
Over 24 families of Fruit plants
Over 23 families of vegetable plants
Over 35 families of flowering plants
130 species of insects including spiders, flies, beetles, arachnids and ants
67 Species of Butterflies
180-200 bird species of which 70 are shore birds
2 species of native fruit bats
2 species of Snakes, 2 species of Ghekoes and 2 species of Garden lizards
1 species of Frog
1 species of Toad

Table 1-8:Terrestrial biodiversity of the Maldives (ERC, 2001)

Marine Biodiversity
1200 species of Reef Fish
Over 9 species of Whales
15-20 species of Sharks
Over 7 species of Dolphins
5 species of Turtles
250 species of hermatypic corals, 285 species of algae (21 blue-green algae, 163 red, 83 green and brown algae)

Table 1-9: Marine biodiversity of the Maldives (ERC, 2001)

English name	Maldivian name	Scientific name
Maldivian Pond Heron	Huvadhoo Raabondhi	*Ardeola grasi phillipsi*
Maldivian Little Heron	Dhivehi Raabondhi	*Butorides striatus albidulus*
Central Maldivian Little Heron	Medhu Raajetherey Raabondhi	Butorides striatus didi phillipsii
Maldivian Water Hen	Dhivehi Kan'bili	Amouronis phoenicurus maldivus
Asian Koel	Dhivehi Koveli	eudynamus scolopacea scolpacea

Table 1-10: Endemic bird sub-species of Maldives (MHAHE, 2001)

1.4 Population

Maldives has a population of 270,101 and an annual growth rate of 1.96% according to the figures of the latest census in March 2000 and

the population was counted as 244,814 in the 1995 population census. The population pyramid for the 1995 census in Figure 1-8 shows that a large proportion of the population is below twenty years of age. Maldives is a very young population living on very vulnerable low-lying islands (MPND, 2001).

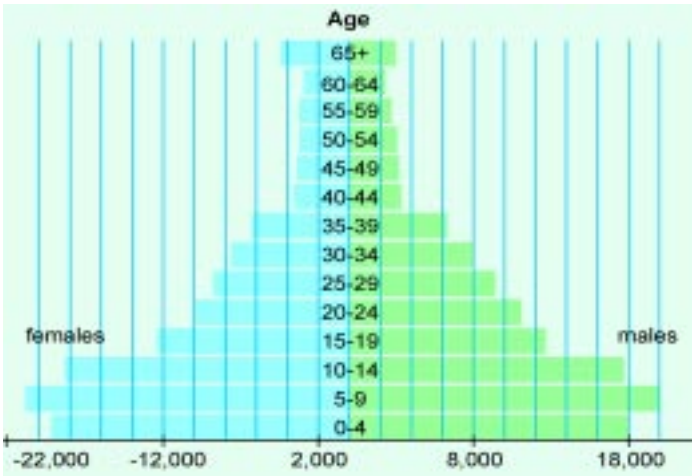


Figure 1-8: Distribution of Maldivian population by age (1995)

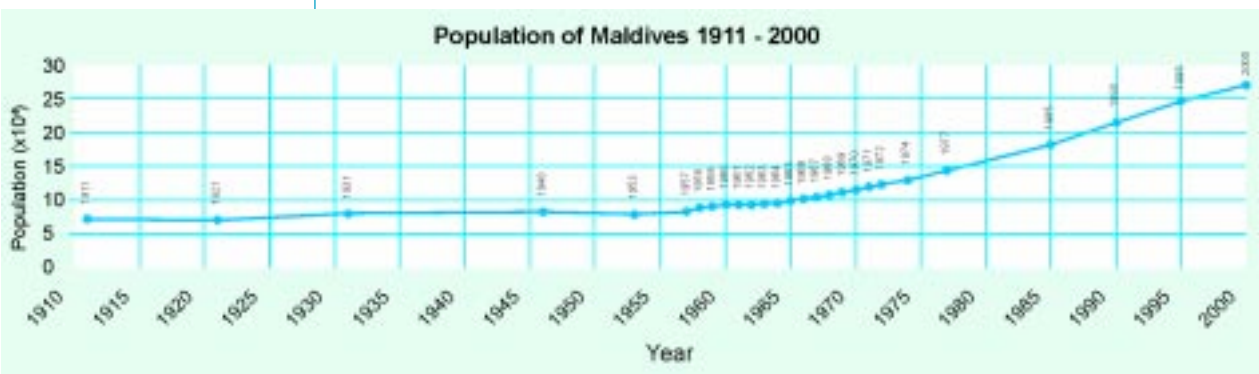


Figure 1-9:Population of Maldives (1911-2000)

Malé is the only urban centre with, a population of 74,069 (MPND, 2001). The need for education and employment is the main reason for the huge tendency for the population to move to Malé. With more job opportunities in the tourism industry, there is a tendency for a lot of the young people from outer islands to move to nearby resort islands.

The government is looking into solutions to urbanise other regions of Maldives. Currently there are islands in the southern and northern atolls of Maldives that are being developed as growth centres.

The population density on some islands is very high. Nearly half the inhabited islands have population densities over 2,000 persons/km^2. There

are three other islands with higher population density than Malé with the most densely populated island being, *Kandholhudhoo* in Raa Atoll with density over 744 persons/Ha (MPHRE, 1998). The distribution of the population in the Maldive islands is given in Figure 1-10.

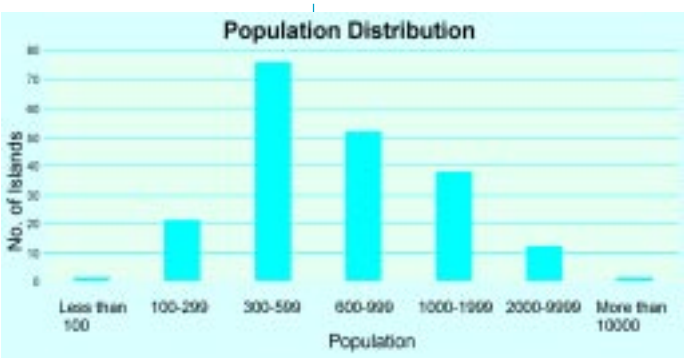


Figure 1-10: Spatial population distribution for Maldives (1995)

1.5 Socio-cultural character

Archaeological evidence indicates that the islands have been inhabited for up to 2,500 years (Woodroffe, 1989). According to historic writers the early settlers were from the Indus valley civilisations and linguistic evidence suggests a common ancestry with the Sinhalese who settled in Sri Lanka. The people originally appear to have been sun-worshippers, then later became Buddhists and were converted to Islam in the year 1153. Maldivians belong to the Sunni sect.

The distinctive Maldivian language, Dhivehi, was written down as early as the 12th century and originally written from left to right. The modern script, Thaana, was invented in the 16th century, is based on variants of 9 Arabic numerals, and is written from right to left. The Maldives thus has an ancient culture, own language and script. A whole unique culture and way of life is thus at risk from climate change and sea level rise.

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"Thaana": A script used exclusively in Maldives.

1.6 Transportation system in the Maldives

The isolated populated islands and resort islands are linked by the air and sea transportation system existing in the Maldives. An air transportation system is developed with the four regional airports and the seaplane networks, which is being operated in the central region of the country. In 1994, 151,217 domestic passengers travelled between the regional airports in 15,738 flights. In 1994, the seaplane network carried 69,279 passengers and operated 8,636 flights (MPND, 1995). The domestic air transportation sector is developing and in 1999, the total domestic passenger movements increased to 466,551 (MPND, 2000).

Sea transportation is a popular mode of transportation in the country. In 1994, more than 750 vessels were registered and operated in the Maldives (MPND, 2000). As the services and facilities are located in the regional growth centres, the major transportation is between islands and

Malé and between Malé and the growth centres in the atolls. It was found on average 18 boats travelled to the atoll capital at least three times in a month and 29 boats travelled once or twice to Malé from the atolls (MPND & UNDP, 1998).

The smallness of the islands and infancy of the transportation sector has limited the land transport system to Malé and other regional growth centres. Though motorcycles are found in all islands, the bulk of the cars are found in Malé. In 1994, 128 new cars were registered and this grew to 245 in 1999 (MPND, 2000). The bulk of these cars would add on to the already existing traffic congestion and pollution in Malé.

1.7 Energy production and usage

Energy is mainly used for electricity generation and in the transportation sector.

Year	Percentage of population without electricity
1990	33
1995	13
1998	7

Table 1-11:Percentage of population without access to electricity (MPND & UNDP, 1998)

Diesel is the main source of fossil fuel for generation of electricity in the Maldives. The total population of the Maldives does not have access to 24 hour electricity. In 1998, more than 60 islands had electricity for 24 hours, accounting for 55% of the population (MPND & UNDP, 1998).

There is an imbalance in the usage of electricity between Malé (urban) and atolls (rural areas) of the Maldives. In 1994, 2.57 million gallons of diesel was consumed to produce 42 MWh of electricity in Malé, while in atolls 4.5 MWh of electricity was generated (MPHRE, 1995). The usage of electricity is on the rise as in 1998, 68.6 MWh of electricity was produced and 3.96 million gallons of diesel was consumed in Malé (MPND, 1999).

The transportation sector is another major area where energy is consumed. The land and sea transportation system mainly uses diesel and to some extent gasoline, while the air transportation system mainly consumes jet kerosene.

Firewood, liquid petroleum and kerosene are the main sources of energy used for cooking in the country. In 1990, 94% of the population in

the atolls used firewood for cooking while in 1998, the figure dropped to 66%. However the use of kerosene for cooking increased from 6% to 40% in the same period (MPND & UNDP, 1998). Liquid petroleum is mainly used in Malé and in 1994, 3.4 Kt of Liquid Petroleum Gas (LPG) was used in the Maldives (Customs, 1994).

1.8 Water resources, usage and supply

The water resources of the Maldives comprise of fresh groundwater that occurs in the porous coral sediments on many islands of the Maldives. The population of Maldives has traditionally been dependent on groundwater from shallow wells dug in the ground. It has been estimated that currently 25% of the population depends on groundwater for drinking while the rest of the population uses rainwater and desalinated water for drinking and groundwater for other purposes (MPND & UNDP, 1998).

The quality of groundwater varies seasonally and across the islands. The amount and temporal pattern of rainfall and the size and shape of an island determines the amount of fresh groundwater that accumulates. The fresh groundwater is found as a "freshwater lens" that comprises of a freshwater zone underlying by a transition zone of a few meters thickness between the freshwater and underlying seawater. The top of each freshwater lens found in the islands of Maldives is generally 1.5 to 2 m below the land surface and changes continuously with the tide. At present mapping of the groundwater resources is not generally available for the islands of Maldives.

In general the groundwater found in the islands have very low salinity. The quality of the water in terms of bacterial content needs to be assessed further. In many of the islands where studies have been done, it was found that bacterial content is very high. The source is generally discharge and leakage from septic tanks.

For drinking purposes, rainwater is the traditional source for the Maldivians. Rainwater is harvested by individuals from roofs of houses during rain showers. The harvested rainwater is stored in tanks and other vessels. In almost all inhabited islands there are public rainwater storage

facilities. Before harvesting rainwater, the roofs and storage vessels are allowed to be cleaned by the initial burst of rain.

Presently, more than a quarter of the population depends on desalinated water for drinking and other uses. Desalinated water is used only in two inhabited islands, including Malé. Desalinated water has been available in Malé for more than a decade and all households in Malé now have access to piped desalinated water. However, rainwater is still harvested in Malé during the rainy season. In the resorts, mostly bottled water is used for drinking while desalinated water is used for other purposes.

1.9 Agriculture and food security

Primarily because of the limited area of arable land with generally poor soil and limited supplies of freshwater, agriculture is a comparatively small sector in the Maldivian economy. Share of agriculture sector of GDP declined from 5.5% in 1986 to 3.6% in 1995 (MPND, 2001). The sector's importance to the economy however, is greater than its contribution to GDP, considering its impact on generating employment and income opportunities in the outer atolls, attaining food security and greater self-reliance in part through import substitution of certain agricultural products.

The sector has always been the employer of the majority of the female labour force of the island population. About 3.4% of the Maldives labour force is engaged in agriculture and related activities (MPHRE, 1995).

A wide range of crops are grown, with a heavier concentration of root crops in the south and more field and grain crops in the north. Coconut is the most common 'plantation' crop in all the atolls, as well as the most popular home garden tree. Coconut is an integral part of the Maldivian diet and its supply is sufficient for local use. The production of banana, papaya, watermelon, chilli, pumpkin, eggplant and leaf cabbage has been increasing and they constitute a significant percentage of the grower's income. The production of root crops such as taro, cassava and sweet potato and grains is decreasing with increased consumption of imported rice and wheat flour at administered prices. Today,

such root crops are more of a delicacy than an everyday staple food.

Recently, there has also been an increasing trend in farming in resorts islands. A total of about 26 resorts have been recorded for producing a significant part of their tropical vegetables and fruits (MoT, 2001). In addition, timber forest management through traditional tenure agreements is an important component of agriculture. Livestock production is limited to goat husbandry and poultry production. The latter takes place primarily in rural islands.

The agricultural crops mainly grown are rain-fed, however, many high value cash crops like chillies and watermelon are being irrigated with water extracted from the water table.

1.9.1 Food storage and distribution

The imported rice and other food items are stored in Malé. The local small business entrepreneurs then distribute these throughout the country.

The country's traditional food distribution system is largely via *dhoni*, small boats, from the storage facilities in Malé to islands through the *ad hoc* transport system, which operates in the country. It normally takes about two to three days travel by *dhoni* from Malé to the most northern and southern islands respectively.

Storage in the islands is limited to local households and warehouses of small retail shops. The frequency of food supplies depends largely on the available transport and storage facilities.

1.9.2 Heavy import dependency

At present almost all food requirements, except fresh fish and coconut, are imported. Rice is the staple food of the Maldivians and it is mostly imported from South and South East Asia. According to statistics from Maldives Customs Services, 66% of rice and 90% of wheat flour is imported from India (MCS, 2001). Maldives also imports a lot of its fresh fruits and vegetables from India, Australia and Sri Lanka.

1.10 Health

Maldivians are a healthy people and according to statistical records, the health of Maldivians has improved dramatically over the past 20 years (Figure 1-11). These improved health conditions are due to the increase in health facilities provided to the public and also awareness among the public.

Figure1-11: Infant Mortality Rate 1980-1999 (MoH, 2001)

Other indicators like the Maternal Mortality Rate (MMR) and Still Birth Rate (SBR) are also used in the health sector. Both these indicators reflect improvements in the health of the population (MoH, 2000).

1.10.1 Health care facilities and services

Table 1-12 give the types of health care facilities and services available in Maldives.

Tertiary curative care (available in Malé)		
1 Public hospital		Experienced Maldivian doctors and expatriates, wide range of specialists
1 Privately owned hospital		Assisted by nursing, paramedical and technical staff
About 16 Private clinics		Wide range of investigative facilities also available
Secondary curative care (Regional Level)		
5 Regional hospitals Located in Raa Atoll, Meemu Atoll Haa Dhaal Atoll, Seenu Atoll and Malé		Wide range of preventive and curative services including certain investigative services available
Primary curative care (Atolls and Island Level)		
Atolls	27 Atoll Health Centres	Staffed by a team consisting of: • a doctor and nurse aides • a community health worker (CHW) • a family health worker (FHW) • traditional birth attendant (TBA)
Islands	No set health centre established	Simple preventive and curative services provided by a local FHW and TBA
	In some islands a health post is set up	In islands with a large population, the government provides the services of a doctor

Table 1-12: Health care facilities and services available in Maldives (MoH, 1998)

1.10.2 Burden of diseases

Table 1-13 below gives an overall status of major communicable diseases in Maldives.

Disease	Status
Acute Respiratory Infection (ARI)	Estimated 16% of deaths aged between 0-4 years of age due to pneumonia
	In some regions, an estimated 60% of children attending hospitals affected with ARI
Diarrhoea	In the past a significant number of infants and children dying from the disease
	No decrease in morbidity as expected with increased accessibility to safe drinking water and sanitation facilities
Worm Infestations	Study done in Laamu Atoll (1992), 60% of children under the age of 3 suffering from worm infestations
	Recent estimates show 50-75% of children below 5 years infected with intestinal parasites
Malaria	A major public health problem till the early 1970s
	In the early 1960s a WHO assisted vector-borne disease control programme, specifically malaria control, was initiated
	Since 1984, the Maldives has remained malaria free
Filaria	The implementation of mosquito control activities for malaria control had a positive impact on the filarial situation
	Filaria cases still continue to show up but there have been no cases that have progressed to advanced stages
Dengue fever	The first cases identified in 1979
	Endemic in the country
	No clear-cut epidemic pattern has been observed with respect to dengue hemorrhagic fever and the last epidemic occurred in 1988

Table 1-13: Status of most common diseases in the Maldives (MoH, 1998)

1.11 Economy

The Maldivian economy shows a strong economic growth as registered in the GNP growth rate of 8.5% in 1999. This is however a slight decline from the GDP growth rate of 9.1% in 1998 (MMA, 2001).

The main contributing sectors to the GDP are tourism, fisheries, construction and the commercial sector, with the tourism sector contributing to 33.1% of the GDP and the fisheries sector contributing to 6.5% in 1999 (MPND, 2001).

GDP (at 1985 constant prices)

Year	GDP (in Million US$)
1995	115.5
1996	124.6
1997	136.0
1998	148.3
1999	161.0

Table 1-14: GDP for Maldives 1995 -1999 (MMA, 2001)

1.11.1 Primary imports and exports

Due to the growth in the commercial sector, imports and export has been increasing steadily. Table 1-15 and 1-16 shows a breakdown of the imports and exports for the Maldives. The consumer goods imported include food products such as rice, wheat flour, sugar, dairy products, etc., tobacco and beverages, and other manufactured goods. The petroleum products imported are aviation gas, kerosene, diesel, gasoline and lubricating oil. Intermediate and capital goods are inclusive of machinery, transport equipment, construction material and timber.

Cost including freight in millions of US$	1995	1996	1997	1998	1999
Total imports	267.9	301.7	348.8	354.0	402.2
Consumer goods	127	142.8	168.9	N.A	N.A
Petroleum products	30.5	27.3	38.7	N.A	N.A
Intermediate and capital goods	110.4	131.6	141.2	N.A	N.A

Table 1-15: Composition of main imports by year, 1995-1999 (MMA, 2001)

The exports constitute chiefly of marine exports and garments. Fish export is the major component of the marine exports. The fish exports are frozen tuna, frozen reef fish, canned fish, dried fish, salted fish, salted reef fish and live tropical fish, out of which canned fish is the biggest contributor to marine exports.

Composition of exports in millions of US$	1995	1996	1997	1998	1999
Total merchandise exports	85	79.9	92.9	95.6	91.5
Domestic exports	49.6	59.2	73.2	74.3	63.7
Total marine exports	37	48.7	58.2	56.5	38.8
Garments	12.5	10.3	14.9	17.8	24.8
Others	0.1	0.1	0.1	0.1	0.1
Re-exports	35.4	20.8	19.6	21.3	27.8

Table 1-16: Composition of main exports from Maldives (MMA, 2001)

1.11.2 Tourism

Tourism is the leading economic sector in the Maldives. The annual number of long staying visitors in the Maldives far exceeds the size of the resident population, contributing to about one third of GDP of the country (Table 1-17). Tourism is also the largest single foreign currency earner and a significant source of employment in these islands. Since Maldivian tourism industry is almost entirely dependent on physical and geographic factors, such as good weather and activities associated with sea and coral reefs, climate change will have very serious implications on the nation's main economic sector.

Annual tourist arrivals have increased from 1,097 in 1972 to 467,155 in 2000. Tourist bed capacity has also increased to over 17,500 beds in 1999 (MoT, 2001). Over 85% of these beds are developed on resort islands within a 145 km radius around Malé International Airport.

Year	Tourism revenue (Million Rufiyaa)	Tourism receipts (Million US$)	Percentage share of GDP
1990	141.7	88.7	18.1
1991	159.7	95.3	17.4
1992	191.1	138.0	17.7
1993	217.1	146.4	17.1
1994	307.8	180.7	17.8
1995	372.0	210.7	18.4
1996	406.9	265.6	19.1
1997	480.8	286.0	18.7
1998	527.2	303.0	18.3
1999	628.5	334.1	18.5

Table1-17: Tourism contribution to economy, 1990-1999 (MoT, 1999)

According to tourism legislation, resort islands need to be developed on uninhabited islands, which are kept separate from the other islands where the locals dwell. Such regulations are primarily to protect the local culture and religion from external influences.

The Ministry of Tourism has specified several regulations and standards to ensure maximum protection of the island environment. Some of these include:

- *Maximum island area to be occupied by buildings is 20%*
- *For building purposes a minimum setback limit of 5m from the vegetation line of the island.*

All resort islands are self sufficient in terms of the electricity, water and other essential items needed for efficient running of the resort. The electricity demand is met by the electricity generation facilities on the island itself and the resorts have their own water desalination systems to cater to the water requirements.

The staff working at the resort are accommodated on the resort island during the weeks or months of their work-shift. Building up of an island as a resort has to comply with guidelines set by the Ministry of Tourism. Standards that are set include that coral from the reefs of Maldives shall not be used for any construction on a tourist resort and that not more than 20% of an island may be cleared of bushes and vegetation for construction.

Box 1-1: A Typical Resort Setting in the Maldives

1.11.3 Fisheries

The main types of fishery in the Maldives are tuna, reef, grouper, aquarium, sea cucumber, shark and giant clam. The fisheries sector contribution to the GDP has shown a declining trend compared to the tourism sector. In 1978, the fisheries contribution to the GDP was estimated at about 22% (MPD, 1983) and by 1999 this figure had decreased to 6.5% (MPND, 2001).

Maldivians rely heavily on tuna resources as a source of protein. It is assumed that a constant per capita consumption rate of 85 kg/yr was consumed during the mid 1980's (Doulman, 1992). However, not all the tuna catch are used for home consumption. Frozen round tuna is exported to Thailand and Japan while the traditionally processed products of smoked tuna, dried tuna and salt dried tuna are exported to Sri Lanka.

The Felivaru Tuna Processing Plant produces canned tuna in the Maldives. Tuna is packed in brine and oil as chunks and steak and exported to countries such as the UK, Germany, Netherlands and Greece. Export of canned tunas stagnated during the past five years due to the fall in the world market prices. The unit price for a metric ton of canned tuna has decreased from Rf 24,000 to Rf 16,000 (US$ 2031-US$ 1356) over the past six years.

The livelihood of the communities in the atolls depends on the income generated from the fisheries sector. The total percentage of people engaged in the fishing industry consists of about 25% of the total population (MPHRE, 1998). This also includes employment sought in fishery related areas such as Felivaru Tuna Processing Plant, export of various fish products and land based freezer facilities at Koodoo in Gaaf Alif Atoll and Maandhoo in Laamu Atoll.

Figure 1 - 12: Tuna Catch in Maldives (MOFAMR, 2001)

1.11.4 The International Airport

All economic sectors rely heavily on the international airport. Malé International Airport on the island of Hulhulé about two kilometres from Malé is the gateway to the Maldives for tourists and the world. The airport handled 49,726 flights, 1,497,559 passengers, and 25,326 tonnes of freight in 1999 (MPND, 2000). The airport is a key installation as far as the economy is concerned. The revenue from the tourism sector, which contributes 33% to the government revenue (MPND 2001), is dependent on the continued operation of the airport.

1.12 Research and systematic observations

Maldives has been involved in some of the global programmes of research and systematic observation. Maldives continues to take part in such programmes. Below are some of the programmes that Maldives is involved in:

Coral reef monitoring

- *International Coral Reef Initiative (ICRI).*
- *Global Coral Reef Monitoring Network (GCRMN).*

Impacts of aerosols on climate change

- *Indian Ocean Experiment (INDOEX)*

Box 1-2: Some of the global programmes of research and systematic observations participated by the Maldives

All climatic data in the Maldives is being measured by Department of Meteorology (DoM). Climatological measurements are limited to tide levels, rainfall, wind speeds and direction, and temperature measurements. Such measurements over a period of approximately 30 years are available for Gan in Addu atoll and the island of Hulhulé, the international airport that is in northeast of Malé. Since the two islands are so close, this data is often referred to as measurements for Malé. In addition to these two stations, the National Meteorological Centre now relies on data from three other stations. The Department of Meteorology relies on eight rain gauges to measure rainfall patterns throughout the country. (DoM, 2000).

Due to the absence of basic measurement instruments and the lack of human resources necessary to carry out such research, there have been no measurements taken for radiation levels, evaporation rates and, upper atmospheric measurements on the atmospheric side.

For measurements related to the ocean, there is no recording of sea surface temperatures, current patterns and speeds, salinity, wave observations and actual sea levels. The latter is with the exception to measurements of tide levels being taken at three meteorological stations in the northern, middle and southern parts of Maldives (DoM, 2000).

There is a low-resolution satellite recovery system in place in the meteorological observatory at the international airport island of Hulhulé. Satellite imagery of the region is available at a very low resolution.

1.13 Maldives in the international arena

The Maldives gives high importance to taking part in the international agenda. Maldives is a member of many international organisations. Some of these organisations include the United Nations (UN), World Meteorological Organisation (WMO), World Health organisation (WHO), South Asia Co-operative Environment Programme (SACEP), International Maritime Organisation (IMO), International Civil Aviation Organisation (ICAO) and South Asian Association for Regional Cooperation (SAARC).

The Maldives is also party to a number of international agreements and treaties. Being a small island state, Maldives has been very actively voicing the concerns of climate change and sea level rise. Maldives is a party to the UNFCCC and was the first country to sign the Kyoto Protocol and has been actively participating since its inception and throughout the IPCC processes. Other environmental conventions signed and ratified by the Maldives include:

	Treaty / Convention / Agreement	Signature	Ratification (R) Accession (A)
1954	International Convention for the Prevention of Pollution of the Sea by Oil	-	10 April 1962
1982	United Nations Convention on the Law of the Sea	10 Dec 1982	7 Sep 2000 (R)
1985	Vienna Convention for the Protection of the Ozone Layer	-	26 Apr 1988 (A)
1987	Montreal Protocol on Substances that Deplete the Ozone Layer	12 July 1988	16 May 1989 (R)
1989	Basel Convention on the Control of Transboundary Movements of hazardous Wastes and their Disposals	-	28 April 1992 (A)
1990	The London Amendment to the Montreal Protocol on Substances that Deplete the Ozone layer	-	31 July 1991(R)
1992	Copenhagen Amendment to the Montreal Protocol on Substances that Deplete the Ozone layer	-	27 Sep 2000(R)
1992	Convention on Biological Diversity	12 June 1992	9 Nov 1992 (R)
1997	Montreal Amendment to the Montreal Protocol on Substances that Deplete the Ozone layer	-	27 Sep 2000(R)

Table 1-18: Some of the environmental conventions signed and ratified by the Maldives

2 NATIONAL GREENHOUSE GAS INVENTORY

2.1 Introduction

This section presents an outline of the first GHG inventory undertaken for the Republic of Maldives. This inventory serves as a baseline for the greenhouse gas emissions in the Maldives for 1994 and has been developed using IPCC Reference Approach.

An attempt was made to report the emission of all the three major GHGs; CO_2, CH_4 and N_2O from energy, transport, industry, agriculture, forestry and waste management sectors. However, the lack of data prevented the use of the sector approach to estimate the emissions of all the gases from all sectors. Emission of CO_2 from the energy sector has been taken as the main GHG for the Maldives. However CH_4 emissions from landfill have also been calculated depending on the availability of data.

Land use, land use changes and agriculture were considered insignificant in the development of this GHG inventory as the islands of the Maldives are sparsely vegetated. Hence, sinks of GHGs were not accounted in this inventory, as there was no available data to carry out the required estimation of sinks as described in the IPCC (1996) guidelines.

2.2 Methodology

The GHG inventory of the Maldives was developed using 1994 as the base year. The IPCC Reference Approach with default methods and factors were used to estimate CO_2 emission from the energy sector and the CH_4 emitted by solid waste. The emission of CO_2 from the energy sector for the internationally bunkered aviation and marine fuels has been reported separately in accordance with the guidelines for the preparation of the initial NC of the non-annex I countries.

In the Maldives only secondary fuels are used in the energy sector. Since an import duty is levied on fuels, the Maldives Customs Service keeps a detailed record of the amount of fuels that have been imported into the country. The quantities of fuels imported were obtained from the

Maldives Customs Statistical Year Book, 1994. Data on international aviation bunkering and marine bunkering were obtained from the Maldives Airports Company Limited and the State Trading Organisation respectively.

The availability of the data on the amount of solid waste at Thilafushi landfill, which is in operation for the central region made it possible to calculate the amount of CH_4 emitted by solid waste. Thilafushi is the only solid waste landfill operating in the Maldives.

Emission of CH_4 from landfills was calculated from the data provided by the Waste Management Section of the Ministry of Construction and Public Works. This data was based upon a study conducted by the Japan International Co-operation Agency (JICA) in 1999 on *Solid Waste Management for Malé City in the Maldives*. This study provided the data for the rate of solid waste generated and the composition of the municipal solid waste generated in the Maldives.

2.2.1 Assumptions

In applying the IPCC Reference Approach, it was assumed that the stock change for the fuels used in the Maldives was zero. The fuel in the stock is used as a reserve and it was therefore assumed that the fuel imported would be consumed in that particular year.

Although there exists one solid waste landfill in the Maldives, solid waste is disposed on open dumps throughout the country. Hence, the entire population was considered when CH_4 emissions from solid waste disposal were calculated. It was also assumed that the rate of decomposable component of the municipal solid waste generated in 1999 also applied to 1994 since only 1999 data on the waste composition was available.

The economy of the Maldives depends heavily on the tourism sector, which consumes a large proportion of the fuels imported to the country. However, no attempt was made, due to lack of availability of data, to estimate the percentage contribution of tourists to the reported emission of GHGs for the Republic of Maldives.

2.3 Results and analysis

2.3.1 Emission of CO_2 from the energy sector

The Table 2-1 shows the amount and the type of fuels consumed within the Maldives and respective emission of CO_2 from each fuel type.

Fuel type	Fuel consumed within Maldives (Mt)	Emission of CO_2 (Gg)
Gasoline	3.127	10.182
Jet Kerosene	3.541	11.175
Other Kerosene	0.013	0.043
Gas/Diesel	65.556	103.465
LPG	1.107	3.033
Bitumen	0.006	0.009
Lubricants	0.719	1.048
Total	115.246	128.995

Table 2-1: National CO_2 emissions by fuel type (1994)

In 1994, it is estimated that 129 Gg of CO_2 was emitted by the energy sector in the Maldives. This contributed 0.54 tonnes of CO_2 per capita.

2.3.2 Emission of CO_2 by fuel type

Figure 2-1 shows that diesel is the main fuel type consumed to meet the energy demand in the country. As mentioned in Chapter 1, diesel is primarily used to generate electricity and for marine vessels. Gasoline is used to power vehicles and speed boats. Although a large quantity of jet kerosene is imported, only 10% of the fuel is used within the country. 90% of the imported jet kerosene is used in intentional aviation bunkering. The large quantity of aviation fuel is internationally bunkered because a large number of tourists travel to and from the Maldives by air (MAC, 2000; STO, 2000; Villa, 2000).

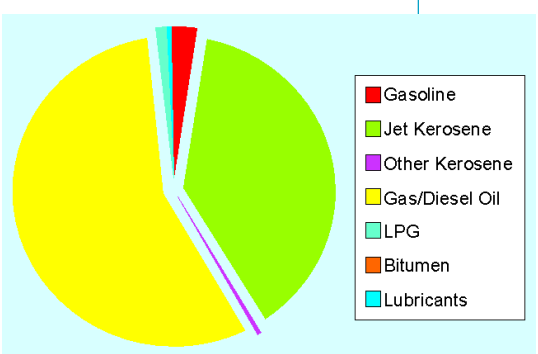


Figure 2-1: Relative contributions of fuels to meeting national energy demand

Table 2-2 shows that the consumption of diesel emits most of the CO_2 from the Maldives. This can again be linked to the importance of tourism to the Maldives. The resorts of the Maldives are self-contained and all the facilities, like the generation of electricity and production of freshwater from desalination, depends on burning of diesel. In 1994, 73 tourist resort islands were in operation (MoT, 2000). Each of these resorts would consume large amounts of diesel to provide the necessary services for the tourists in the resort islands.

Fuel Type	CO_2 (%)
Gasoline	7.90
Jet Kerosene	8.67
Other Kerosene	0.03
Gas/Diesel	80.23
LPG	2.35
Bitumen	0.01
Lubricants	0.81

Table 2.2: Relative contributions of fuels to emissions of CO_2

2.3.3 Methane emission from landfill

In 1999, it was estimated that daily generation of solid waste was at 0.518 kilogram per capita. The fraction of biodegradable organic carbon in the municipal solid waste was estimated to be at 0.12 (JICA, 1999). Using IPCC (1996) methodologies for the development of GHG inventories, it was calculated that 1.142 Gg of CH_4 was emitted from the disposal of municipal solid waste.

2.4 Bunkered fuels

According to the IPCC guidelines for the development of National GHG Inventory, the emission of GHG from internationally bunkered aviation and marine fuels is not counted in the national GHG emissions. Table 2-3 shows the amount of fuels bunkered and the emission of CO_2 from each of the fuel type bunkered.

Bunkered Type	Fuel Type	Fuel imported (Mt)	Fuel Bunkered (Mt)	CO_2 emission by bunkered fuel (Gg)
Aviation	Jet Kerosene	44.29	40.75	128.62
Marine	Gas/Diesel	65.98	0.43	1.36
	Total	110.27	41.18	129.98

Table 2-3: Internationally bunkered fuels

2.5 Shortcomings encountered when preparing the inventory

The lack of the detailed data required for the sector approach was the biggest shortfall of this initial National GHG Inventory for the Maldives. No data was available to estimate emissions of GHGs in all sectors. However, it is believed that the IPCC Reference Approach with the avail

able data is sufficient when estimating the emissions of CO_2 from the energy sector in the Maldives.

To strengthen the data analysis for any subsequent GHG inventories, it will be necessary to strengthen the relevant sections of the government departments and other agencies responsible for collecting the data necessary to prepare a more detailed GHG inventory. Institutional strengthening and other forms of capacity building will be required.

2.6 Confidence and uncertainty of data in the GHG inventory

Limitations in the statistical data on fuel imports, consumption and energy balances have led to uncertainty in emission estimates. Other sources of uncertainty may arise from the use of default emission factors not appropriate to the local circumstances. For this analysis the IPCC Reference Approach has been used, further elaboration of the uncertainties in the emission estimates is not possible until estimates using the sector based approach are also available. Such information will hopefully become available when the next inventory is prepared, and can thus be included in the next NC.

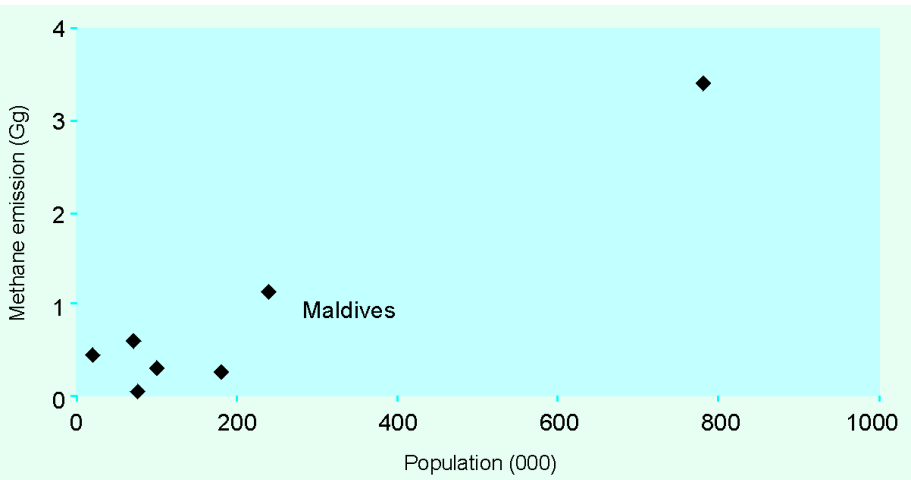


Figure 2-2: CH_4 emissions from solid waste disposal (SPREP, 2000 and Maldives GHG Inventory)

To develop an initial GHG inventory for the Maldives, the estimated amount of CO_2 emitted was validated using an inter-country comparison using CO_2 emitted from the small island countries in the Pacific. The basis of this comparison is that emission of GHGs depends on the population and the type of activities carried out in the given country. The analysis indicates that the amount of CO_2 emitted by the energy

sector in the Maldives is consistent with the range of values for the small island countries. Further, the value calculated for the CH_4 emission for the Maldives was plotted against population, along with similar data for the Pacific island countries. As seen from Figure 2-2 the calculated CH_4 emissions for the Maldives from the solid waste disposal is very similar to those values obtained for Pacific island countries.

As seen in Figure 2-3 the amount of CO_2 emitted by the energy sector in the Maldives is consistent with the range of values for the small island countries of the Pacific.

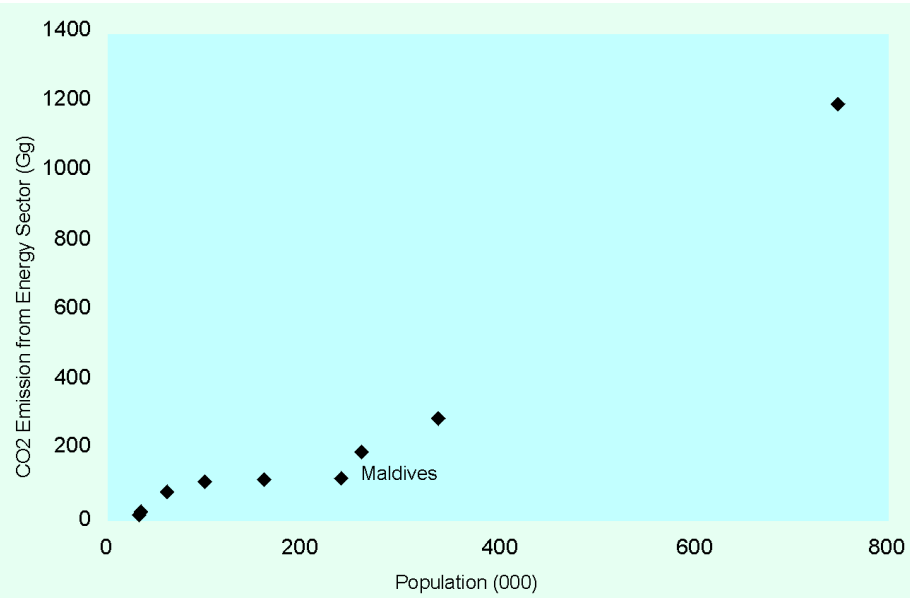


Figure 2-3: CO_2 emissions by energy sector (Gg)

2.7 Comparisons with other countries

2.7.1 The contribution of Maldives to global GHG emissions

Table 2-4 presents a comparison between the CO_2 emissions from the energy sector of the Maldives with those from groupings of other countries. The energy sector is the main contributor to GHG emissions by the Maldives. The Maldives emitted 0.13 Mt of CO_2, which is only 0.0012% of the global CO_2 emissions from the energy sector (see Table 2-5)

	Population (millions)	CO_2 emission per capita (t)	Total CO_2 emission (Mt)
Kiribati	0.08	0.23	0.19
Tuvalu	0.01	0.50	0.01
Maldives	0.24	0.54	0.13
Marshall Islands	0.04	3.54	0.16
Cook Islands	0.05	0.69	0.03
World	5624.4	4.02	22620.46
OECD	1092.3	11.09	12117.05

Table 2-4: Relative CO_2 emissions from the energy sector (Hay & Sems, 1999; GRMAIPA, 2000)

Table 2-5: Comparison of CO_2 emissions (Hay and Sems, 1999)

	% of Global Emissions	% of Global Population
Maldives	0.0012	0.004
OECD	54.0000	19.000

Table 2-6: Emission of GHG from various sectors for the Maldives

GHG source and sinks (Gg)	CO_2	CH_4	N_2O
Energy	129.0	-	-
Industrial Process	-	-	-
Agriculture	-	-	-
Land use change and forestry	-	-	-
Landfills	-	1.1	-
Total (Net) national emissions (Gg)	***129.0***	***1.1***	***-***

MITIGATION OF GREENHOUSE GAS EMISSIONS

3

The National GHG Inventory of the Maldives shows that the contribution of Maldives to global emission of GHGs is insignificant. As the Republic of Maldives is a non-annex I party to the UNFCCC, Maldives is not obliged to implement GHG mitigation measures. But implementation of such mitigation measures would not only reduce the Maldives emission of GHGs but would be a significant step towards achieving sustainable development.

The Maldives depends entirely on imported fossil fuels to meet its energy demand. According to the national GHG inventory, the generation of electricity and transportation sector contributes to the major GHG emissions from the Maldives. Hence the mitigation of GHG emissions could be based on lowering the demand on the imported fossil fuel by increasing the efficiency in generating and utilising energy and improving the efficiency of the transportation mechanisms.

Reducing CH_4, the main source of emission of GHGs from landfills and sewage discharges is another possibility. This can be achieved through improving of the solid waste disposal methods, management practices and by providing treatment of sewage discharges.

The enhancement of the Maldives natural GHG sinks by increasing the vegetation cover and improving the health of the coral reef has been considered as possible mitigation options. As sufficient data was not available on land use, land use changes and forestry and the existence of natural and managed GHG sinks, these were not accounted for in the GHG inventory.

3.1 Energy

Opportunities for immediate mitigation are small given the imbalance in energy use between the urban and rural islands of the Maldives and the importance of access to energy for social development. However, the following mitigation options would have a long-term goal of reducing the emission of GHGs and improving the standard of living for Maldivians.

The use of high efficiency generators

A significant number of inhabited islands of the Maldives do not have access to 24 hours electricity. As electricity is important for social development, the communities of the islands would develop programmes to electrify such islands. Development of such programmes with the use of energy efficient generators and good distribution networks would improve the efficiency of the national utilisation of the energy. The new generators, which have been installed in the powerhouse of Malé, have 13% higher fuel efficiency than the older generators, which have a fuel efficiency of 0.29 L/kwh. This is an important option for mitigating GHG emission from the energy sector.

Increase awareness on the use of high energy efficient appliances

All electrical appliances in the Maldives are imported. In 1994, more than 2,828 television sets were imported (Customs, 1994). Few importers are aware of the energy labelling in electrical appliances. It is common to find such appliances in the country and generally the people are not aware such energy labelling exists. The use of energy efficient appliances improves the use of electricity and this could lower the electricity consumption. Increasing the awareness of energy labelling and appliance efficiency to importers and the general public would help to improve the energy consumption pattern of the Maldives.

Increase the use of renewable energy sources

Diesel generators provide the majority of electricity in the Maldives. Diesel generators have been seen as a reliable source of electricity generation but exploring the possibility of renewable energy is important as a mitigation option for GHG emissions from electricity generation. Studies carried out in the Maldives showed that solar energy is a feasible option for the Maldives (Hurry, 1984). Since 1989, DHIRAAGU, the national telecommunication provider has successfully used the photovoltaic technology as a source of electricity to the repeater stations of the national digital microwave antenna systems. Similarly successful so-

lar water heating has been widely used in the resort islands to meet most of the hot water needs in the resort islands.

Use of solar energy for desalination

Desalination with reverse osmosis is widely used in the Maldives as a portable water resource. 28% of the population of the Maldives and all the resorts depend on desalinated water to meet their water demands (MWSA, 2001). Reverse osmosis desalination technology, is an energy intensive process that depends on diesel. Introduction and utilisation of solar distillation or desalination with solar energy would reduce the dependence on diesel for water production and hence has the potential to reduce GHG emissions from the Maldives. Changing to such technology could increase the security of water resources and make it less vulnerable to the fluctuation of the oil price on the international market.

3.2 Transport

A detailed examination of the transport sector of the Maldives was not undertaken due to constraints on the availability of necessary data. This initial assessment represents an attempt to identify options in the sector but has not undergone a cost benefit analysis. The Maldives has taken policy measures that have a bearing to reduce the emission of GHGs from business as usual scenario. These policy measures include:

Banning the import of reconditioned vehicles

A large number of old reconditioned vehicles were imported to the country because these were available cheaply within the region. From 1990, the import of motorcycles has increased to an average of 51%. In 1994, 4,443 motorcycles were registered (MPHRE, 1995). The rapid increase of vehicles has induced the traffic problem in Malé. As a means of reducing the traffic problem and improving the air quality in Malé, the government banned the importing of reconditioned motorcycles which have engine capacity of less than 150 cm^3 into the country, from December 2000 (MTCA Directive no. 9-B4/2000/94).

The increased use of cars in Malé is causing a similar problem and under the above mentioned regulation there is a ban on importing of cars which are more than 5 years old into the country (MTCA Directive no. 9-B4/ 2000/94). Importing new vehicles would have the potential to reduce the emission of GHGs from the transport sector, as the efficiency of the imported vehicle would be better than the old reconditioned vehicles.

High import duty on vehicles

As a measure to reduce the increased use of vehicles, a high import tax was levied on importing reconditioned vehicles. This measure has the potential to reduce the demand for vehicles and hence reduce the growth of GHG emission from the transport sector.

Mitigation for land and sea transport sectors

The islands of the Maldives are scattered, so sea and air transport are essential modes of transport between islands. Developing an effective integrated transport system is important to the further development of the country. Land transport demand is felt mainly in Malé and other regional growth centres in the atolls. The number of vehicles used in Malé has reached to the carrying capacity of the island, but there is potential for the number of vehicles to expand in other regional growth centres of the country.

Developing of an appropriate integrated transport system combining the land, sea and air transport system is important as the transport sector consumes a significant proportion of the imported fossil fuels to the country. On average, 18 boats travelled to atoll capitals at least three times in a month and 29 boats travelled once or twice to Malé from the atolls (MPND & UNDP, 1998).

Development of a public ferry transport system

Currently, regular ferries operate between Malé, the urban centre and Villingili, the satellite island of Malé and between Malé and Hulhulé, the

International Airport. Establishment of a regular scheduled ferry service between these islands have reduced the need for *ad hoc* hiring of ferries and have improved the efficiency of the transportation between these islands.

Developing similar ferry services in other atolls, between the growth centres in the atoll and islands, as well as between atolls, would reduce the *ad hoc* movement of boats. A detailed proposal for a study of transport practices and opportunities to reduce GHG emissions is included in Chapter 7.

3.3 Solid waste and sewage management

The reduction of solid waste generation and recovery of CH_4 from landfills through an integrated waste management system are options to mitigate the GHG emissions from the solid waste. Development of an integrated solid waste management system taking into consideration the unique environmental condition of the small islands would be a huge step for the sustainable development for all the small island countries.

Similarly, though the GHG inventory developed for the Maldives has not accounted for the GHG emissions from the sewage treatment, developing of sewage treatment facilities to remove GHG would be an important step for improving health of the marine environment of the Maldives. A detailed project proposal is included in Chapter 7.

3.4 Enhancing sinks in the Maldives

Increasing vegetation cover

Though the islands of Maldives are small, and fertile land for agriculture is scarce, efforts have been carried out to increase the vegetation cover of the Maldives. A three year plantation of one million trees was initiated in 1996 to increase the vegetation cover of the Maldives. Due to the huge success of the programme in the first year, the programme was extended to two million trees. The huge success of this programme was due to high community participation. The success of the programme can be seen by the transformation of virtually non-existent greenery to the present greenery of Malé.

The success of the million-tree programme has resulted in a similar programme for fruit tree planting. In an effort to increase the fruit trees, a three year fruit tree planting programme was launched on World Environment Day, 2000. The success of such programmes throughout the country would increase the vegetation cover of the Maldives.

Improving the health of the coral reefs

Coral reefs of the Maldives are the most important natural resources of the Maldives. It is a source of food, beach sand, building material and protection for the islands. The coral reefs are threatened by human induced and climatic related stresses. Healthy reefs not only act as a natural breakwater, but also as natural sink for CO_2. Implementing measures such as banning of coral mining and pre-treatment of sewage discharged on to the reefs would minimize the human impact on the reef and thus improve the health of the reefs.

4 VULNERABILITY TO CLIMATE CHANGE

Being a low-lying, small island state, the Maldives is very vulnerable to the impacts of climate change and associated sea level rise. Even though the Maldives contributes 0.001% to global emissions of GHGs (see Table 2-5), it is in fact one of the most vulnerable countries to climate change and sea level rise. The coastal settings of the Maldives make it vulnerable to natural disasters associated with sea level rise and the changes in the temperatures and rainfall patterns. Climate change will also impact the social and economic development of the country, as most of the economic activities are heavily dependent on the coastal ecosystem. Also, the entire population and the infrastructure of Maldives are very close to mean sea level. It is anticipated that climate change will have negative impacts on the economy and the Maldivian society; the society will be more prone to multiple stresses.

The main concern for the Maldives would be sea level rise. The rise in sea level would lead to, or exacerbate, land loss from beach erosion and inundation and also damage human settlements and vital infrastructure. Maldives would also be very vulnerable to impacts of rising air and sea surface temperatures and changes in rainfall patterns.

Identified below are some of the priority vulnerabilities of the Maldives to climate change:

- Land loss and beach erosion
- Infrastructure damage
- Damage to coral reefs
- Impacts on the economy
- Food security
- Water resources
- Human health

Climate change scenarios

IPCC emission scenarios, IS92a and IS92e were used to develop the scenarios using MAGICC and SCENGEN for the year 2025, 2050 and 2100.

The models used here predict that by the end of this century the temperature may have increased by between 2.0 ^{O}C and 3.8 ^{O}C and sea level may rise between 48 cm to 95 cm. The models were not able to indicate reliably how the rainfall pattern might change in the region as the models gave very distinct results for precipitation.

Overall, local long term climate recordings for the Maldives show that there is an increase in atmospheric temperatures and sea level while a decrease in rainfall is observed.

Year	2025			2050			2100		
Model/ Scenario	Temperature (°C)	Rainfall (%)	Sea Level (cm)	Temperature (°C)	Rainfall (%)	Sea Level (cm)	Temperature (°C)	Rainfall (%)	Sea Level (cm)
CSIRO-Mk2 IS92a(mid)	0.4	1.6	-	0.9	3.0	-	2.0	5.9	-
CSIRO-Mk2 IS92e(high)	0.6	2.5	-	1.4	3.6	-	2.8	8.1	-
HaDCM2 IS92a(mid)	0.7	12.1	9.3	1.4	23.0	19.9	2.6	44.3	48.9
HaDCM2 IS92e(high)	1.0	18.9	19.7	1.7	38.6	39.7	3.8	77.4	94.1

Table 4-1: Climate change scenarios

The Vulnerability and adaptation (V&A) assessment process

The GEF Climate Change Enabling Activity is mainly a capacity building project. Therefore, under the guidance of the International Advisory Board (IAB) of the project it was decided that a national team should undertake the V&A assessment. This was a preferred option as the Maldives lacks detailed studies required for such an assessment. It was decided that a V&A team would be established and trained to facilitate the future assessments. The Maldives National V&A Team, which included 23 members from 13 government sectors, were trained on V&A assessment.

Trainings Activities:
April 2000 – special V&A training conducted by a 4 member team from International Global Change Institute, University of Waikato, New Zealand; University of South Pacific, Fiji and Ecowise Environmental, Australia.

August 2000 - training on the use of Geographic Information Systems (GIS) conducted by the Asian Institute of Technology, Thailand.

Method:
The team was grouped into sectoral groups to focus on assessing the vulnerability of particular sectors based on the anticipated climate change impacts on the Maldives. The V&A team worked over a five-month period to produce various sectoral reports. These reports were based on previous studies done in Maldives and field data collected in seven study islands. The islands were chosen to show the various circumstances and vulnerabilities found in the Maldives.

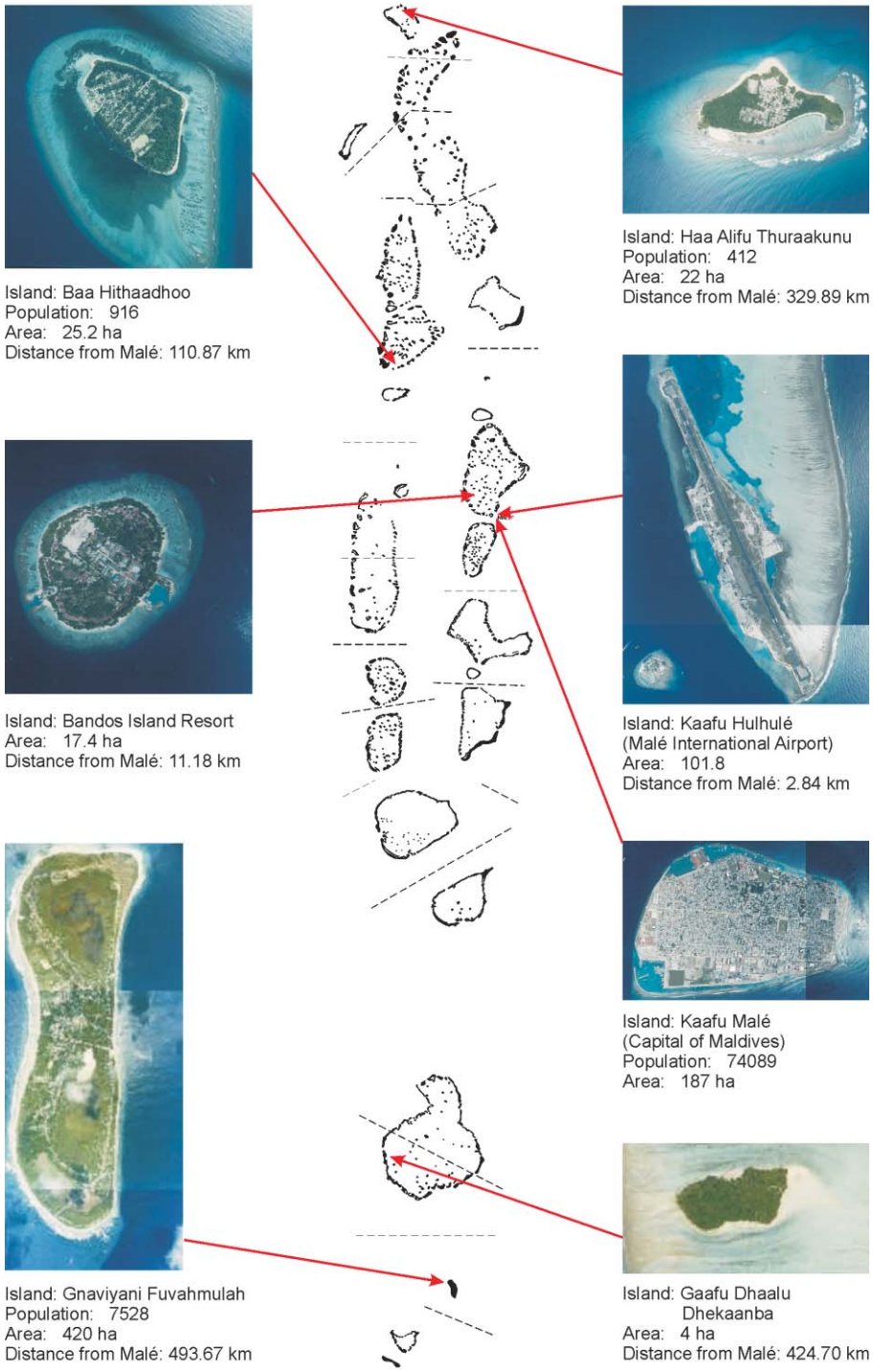
Study Sectors:

1. *Coastal Changes*
2. *Human Settlements and Infrastructure*
3. *Marine Ecosystems*
4. *Tourism*
5. *Fisheries*
6. *Food and Agriculture*
7. *Hydrology and Water Resources*
8. *Human Health*

Study Islands:

1. *Malé – the capital*
2. *Hulhulé - International Airport Island*
3. *Bandos Island Resort - resort island*
4. *Thuraakunu (Haa Alif Atoll) - inhabited islands in the north*
5. *Hithaadhoo (Baa Atoll) – inhabited island in the central region*
6. *Fuvahmulah (Gnaviyani Atoll) – inhabited island in the south*
7. *Dhekaanba (Gaaf Dhaal Atoll) - uninhabited island*

Box 4-1: V&A Assessment Process



Island: Baa Hithaadhoo
Population: 916
Area: 25.2 ha
Distance from Malé: 110.87 km

Island: Haa Alifu Thuraakunu
Population: 412
Area: 22 ha
Distance from Malé: 329.89 km

Island: Bandos Island Resort
Area: 17.4 ha
Distance from Malé: 11.18 km

Island: Kaafu Hulhulé
(Malé International Airport)
Area: 101.8
Distance from Malé: 2.84 km

Island: Kaafu Malé
(Capital of Maldives)
Population: 74089
Area: 187 ha

Island: Gnaviyani Fuvahmulah
Population: 7528
Area: 420 ha
Distance from Malé: 493.67 km

Island: Gaafu Dhaalu
Dhekaanba
Area: 4 ha
Distance from Malé: 424.70 km

Map: 4-1: Aerial photographs and location maps of the islands selected for V&A Assessment

	Malé	Hulhulé	Bandos	Thuraakunu	Hithaadhoo	Fuvahmulah	Dhekaanba
Sectorial Group	(Capital)	(International Airport)	(Resort)	(Inhabited)	(Inhabited)	(Inhabited)	(Uninhabited)
Coastal Changes	√	√	√	√	√	√	√
Human Settlements and Infrastructure	√	√	√	√	√	√	√
Marine Ecosystems	-	-	-	-	-	-	-
Food and Agriculture	-	-	√	√	√	√	-
Tourism	-	√	-	-	-	-	-
Fisheries	-	-	-	√	√	√	-
Hydrology and Water Resources	√	√	√	√	√	√	√
Human Health	√	-	-	√	√	√	-

Table 4-2:Sectoral studies done in the V&A study islands

4.1 Land loss and beach erosion

Sea level rise will have grave consequences for the Maldives. The islands of the Maldives are among the most susceptible to inundation from water rising from the ground, as well as overtopping dune ridges. Being made of coral limestone, the islands of the Maldives are also among the least defensible against sea level rise in the world.

Over 80% of the land area of the Maldives is less than 1 m above mean sea level (MHAHE, 1999). No islands have an elevation greater than 3 m. The population is scattered over 199 islands, many of which are very small, less than 1 km^2. Although 37.3% of the population is found on 5 most populated islands, the rest representing almost 62.7% of the population, are scattered over 194 islands (MPHRE, 1996).

The islands of the Maldives are also extremely vulnerable to beach erosion. The shapes and size of these small islands are characterised by strong tidal and current patterns. The beach systems found on these islands are highly dynamic and have directional shifts within the shoreline in accordance with the prevailing seasonal conditions. An estimated 50% of all inhabited islands and 45% of tourist resorts at present suffer from varying degrees of beach erosion (ERC, 2001).

Predicted climate change will aggravate the already serious problem of beach erosion and threaten homes and economic activities. It is expected

that a 1 m rise in sea level would cause the loss of the entire land area of Maldives. Even a few centimetres rise in sea level could have devastating implications for the Maldives.

Following the storm event of April 1987, the Government of Maldives has sought an engineering solution for the capital Malé, where over 25% of the population resides. The 1.2 km long breakwater constructed on the southern side of Malé cost US$ 14 million. The protective seawall on the western, eastern and southern perimeter of Malé cost US$ 30 million. The estimated cost for the northern side seawall that is under construction at present is US$ 14 million. These figures combined put the total cost of protecting Malé at US$ 58 million (MCPW, 2001).

These engineered structures have been designed for a wave of wave height, 2 metres above mean sea level and a period of 14 seconds (JICA, 1987). This solution was sought by the government in order to protect homes, businesses and lives in a crisis situation under present climatic conditions and so does not consider climate change and accelerated sea level rise. It needs to be studied further if the present seawall around Malé can withstand future predicted impact of climate change and accelerated sea level rise.

Such expensive solutions are technically feasible, but are of little use when neither funding nor adequate human resources are available. The cost of protecting 50 of the 200 inhabited islands of the Maldives with artificial structures was estimated to be over US$ 1.5 billion (Gayoom, 1998: p54)

Case study 1: Land loss and beach erosion

Objective:

To assess the vulnerability of islands selected for V&A assessment, with varying characteristics, to land loss and beach erosion by measuring their elevation above sea level.

Methodology:

Standard levelling technique was used to measure the beach profiles and transects across the study islands. The number of profiles taken for each island varied from about 10-40 depending on the size of the island. These levelling surveys provided information on their vulnerability to a rise in sea level.

The water level at a staff point was measured at a given time interval and the mean sea level for these water levels were estimated by taking into account the tidal predictions and the difference in time from when the mean sea level was recorded.

Observations/preliminary findings:

All of the islands surveyed had elevations of less than 1m above mean sea level, except for Fuvahmulah, which has a slightly higher elevation than the rest of the islands. Figures 4.1a-c below gives the traverse across some of the study islands and these show the effects of sea level rise on these islands.

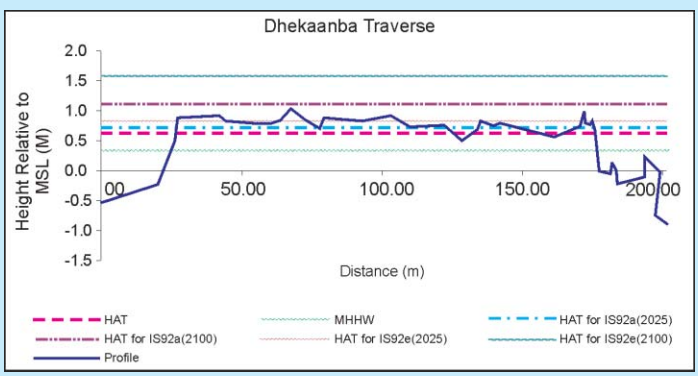


Figure 4.1a: Transaction of Dhekaanba

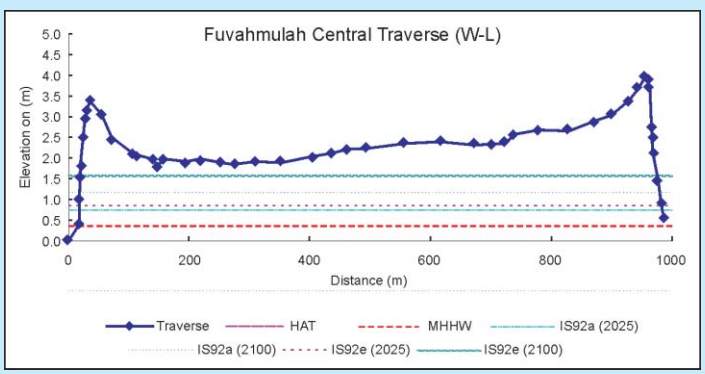


Figure 4.1b: Transaction of Fuvahmulah

Box 4.3: V&A case study 1

Box 4.3: V&A case study 1 continued

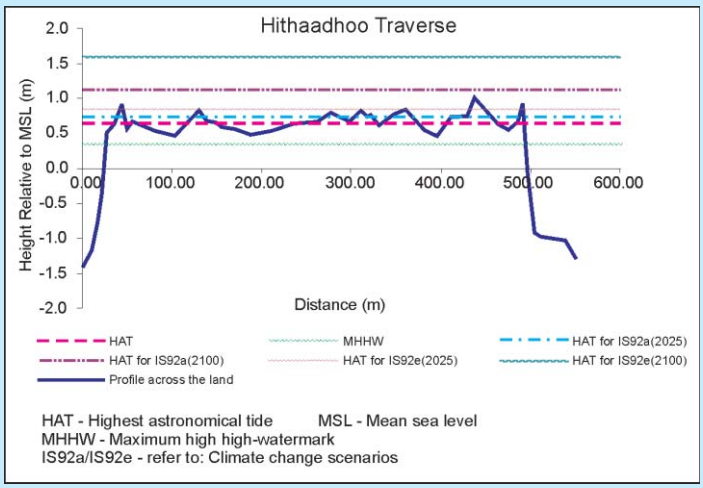


Figure 4.1c: Transaction of Hithaadhoo

Difficulties encountered:

Due to errors, it was not possible to use all the profiles for analysis. Given the short study period it was not possible to run any sea level recorders. There were no baseline data on these islands to which the field data could be compared with. The little information available for comparison were the aerial photographs taken in the 1960's. Furthermore, the field data collected under the study does not represent the conditions at the sites throughout the year, but only gives a snapshot at the time the data were collected.

Study islands:

- *Gaaf Dhaalu Dhekaanba*
- *Gnaviyani Fuvahmulah*
- *Baa Hithaadhoo*

Impacts on Malé

Malé has experienced enormous change to its shoreline. The island's lagoon and reef flat have been reclaimed and the land has been extended almost up to the reef. The total reclaimed area of Malé is about 45% more the land in 1969. The increase in the population of Malé and the demand for housing led to the reclamation of Malé. Reclamation was initiated by the private sector and later this was done under the supervision of the government. Reclamation of land up to the reef has made the island more vulnerable to wave attacks, as the wave dissipation zone and reef flat do not exist anymore.

Case Study 2: Impacts of sea level rise on Malé

Objective:

To show the impact of various predicted sea level scenarios on Malé, in terms of area that would be inundated.

Methodology:

Digital Terrain Model (DTM) of Malé was constructed in a Geographical Information System (GIS) by interpolation of elevation data collected using a Differential Global Positioning System (DGPS). Elevation contours were derived and converted into regions. 1995 National Census enumeration districts (ED) of Malé were digitised and converted into polygon areas. Average elevation derived from the contours was assigned to each ED (see Figure 4.2a). For each of the sea level scenarios highest astronomical tide level was added and all EDs below this height level were identified as inundation areas for the particular scenario.

Observations/preliminary findings:

The model constructed for the case study reveals the following:

- *2025 (high) scenario – 15% of Malé inundated (see Figure 4.2b)*
- *2050 (low) scenario – no change (see Figure 4.2b)*
- *2050 (high) scenario – 31% of Malé inundated (see Figure 4.2c)*
- *2100 (low) scenario – 50% of Malé inundated (see Figure 4.2d)*
- *2100 (high) scenario – inundated completely (see Figure 4.2e)*

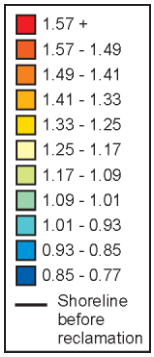
Difficulties encountered:

Malé being over crowed with buildings proved difficult when collecting elevation data using GPS as the signal gets distorted at certain locations due to heavy tree coverage and dense buildings.

Study islands:

- *Kaafu Malé*

Box 4.4: V&A case study 2 (based on study by Manik, 2001)



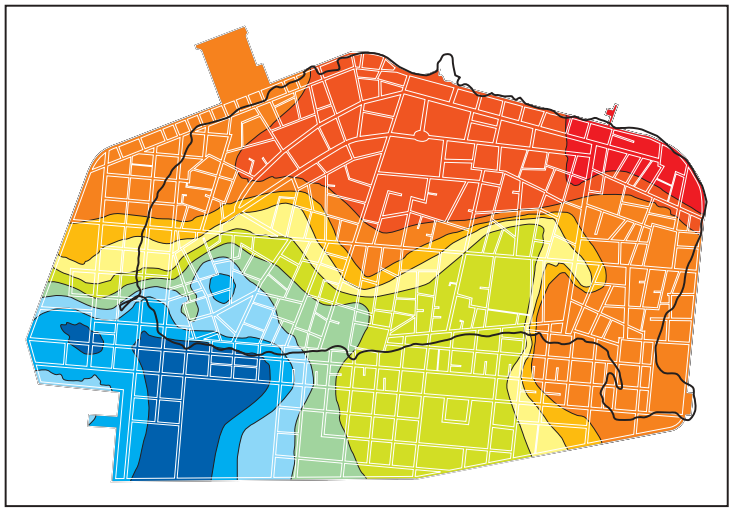


Figure 4.2a: Elevation contour map and street map of Malé overlaid

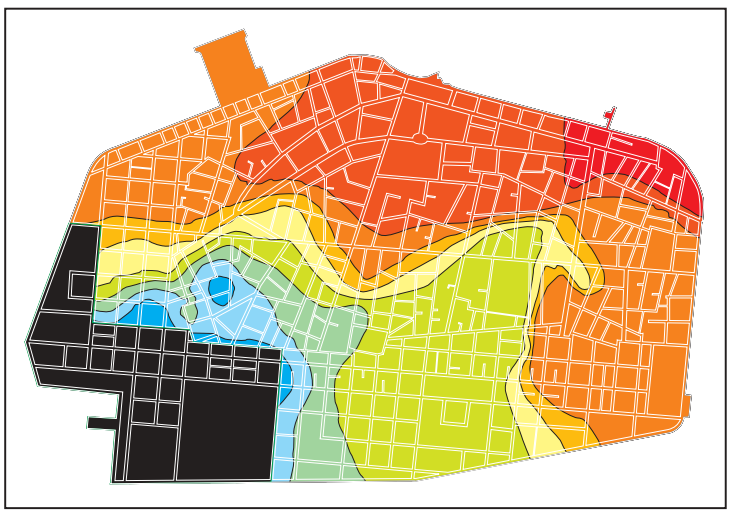


Figure 4.2b: Map showing areas that would be inundated in 2025 (high) scenario. That is 0.84m (19.7cm + 64cm). The same map is also applicable to year 2050 (low) scenario. That is 0.84m (19.9cm + 64cm*)*

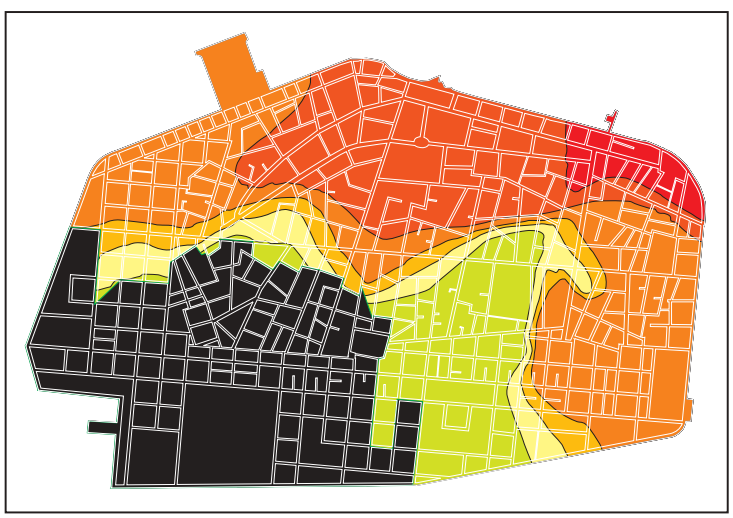


Figure 4.2c: Map showing areas that would be inundated in 2050 (high) scenario. That is 1.04m (39.7cm + 64cm)*

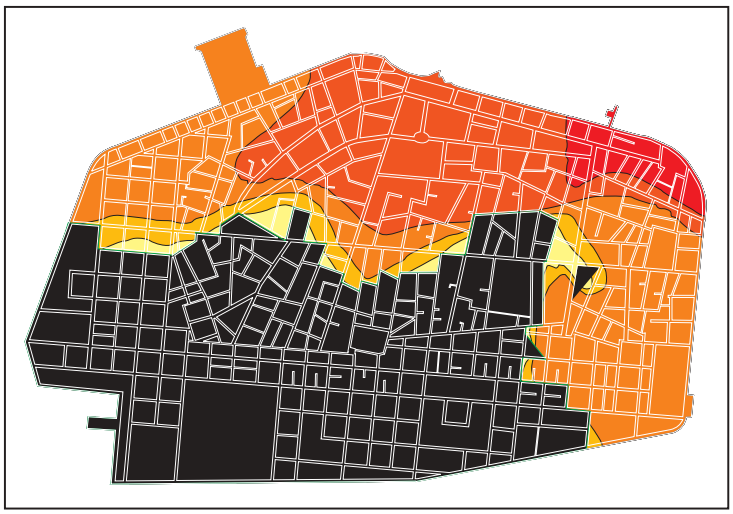


Figure 4.2d: Map showing areas that would be inundated in 2100 (low) scenario. That is 1.13m (48.9cm + 64cm)*

Figure 4.2e: Map showing areas that would be inundated in 2100 (high) scenario. That is 1.58m (94.1cm + 64cm)*

**Highest astronomical tide for Maldives (Woodroffe, 1989)*

4.2 Infrastructure damage

All of the human settlement, industry and vital infrastructure of the Maldives lie very close to the shoreline, within 0.8 – 2 m of mean sea level.

Being so close to the shoreline, these infrastructures are very vulnerable to change in climate and accelerated rise in sea level. The islands of the Maldives will disappear if the rate of sea level rise exceeds the rate of coral growth and sand generation. Even now some islands are seriously affected, with loss not only of shoreline but also of houses, schools and other infrastructure, compelling the government to initiate urgent coastal protection measures.

One of the most vulnerable structures in the Maldives is the Malé International Airport on Hulhulé island. This is the only international airport in Maldives and the gateway to the Maldives for tourists and the world. Other important vulnerable structures include investments on resort islands, which are discussed in detail in section 4.4.1 of this chapter.

Case study 3: Infrastructure damage to Malé International Airport

Objective:

To assess the vulnerability of major infrastructure of the Malé International Airport, to damage from extreme climatic events and sea level rise.

Methodology:

The methodology involved survey of coastal area and shore, analysis of patterns of use of the runway, desktop review of existing literature on value of capital investment and of losses caused by past extreme weather events.

Observations / preliminary findings:

At the Malé International Airport no point appeared more than about 1.7 m above highest high water level. The height of the runway is 1.2 m above mean sea level and thus has only about 0.5m clearance at highest high water level. The edge of the turning apron and shoulders are lapped by the sea at high water in several places and on the northeast end, which is comparatively sheltered, the retaining wall consists of loose piled coral blocks.

The total investment in the airport by the Maldives Airports Company to date is estimated at almost US$ 57 million and the insurance premium for the year 2000 was about US$ 0.4 million (MAC, 2001). This does not include other investments, such as the recently opened Hulhulé Island Hotel, Maldives Inflight Catering Services and other investments by local businesses. Therefore, a total investment of more than US$ 57.4 million is in need of protection from effects of climate change and associated rise of sea level.

During the high waves incidence of 10-12 April 1987, the southern end of the runway was partly flooded and much coral debris was washed onto the runway. Extensive damage was done to the approach landing lights on the southern end of the runway and other service lights near the turning points on the southern end. The protective breakwater and containment wall on the southern and eastern side of the runway were either fully destroyed or extensively damaged. On the western side, the breakwater protecting the harbour suffered severe damage and the fuel jetty was also damaged. Almost 4000 m of containment wall and breakwater required renewal. This incident caused an estimated physical damage of over US$ 4.5 million.

Due to flight cancellations and diversions inestimable damages were also caused to the tourism industry questioning the security and reliability of the international airport to support the tourism industry.

Upgrading the sea defence of such a long, thin island will be a considerable, but essential undertaking. It had been estimated that just to secure sea defences up to the year 2000 would require a minimum of US$ 2-3 million (Edwards, 1989).

Difficulties encountered:

Due to the busy flights operating schedule of the airport, access to all parts of the airport were not possible, as a result the GPS survey was restricted to measuring elevations of the shoreline of the island. Hence, a Digital Terrain Model (DTM) of the Airport was not possible, which would have been invaluable in producing sea level rise impact models. To carryout a through GPS survey of the island would require the Airport to suspend its operations for a day, which would incur a substantial cost.

Study islands:

- *Malé International Airport (Hulhulé island)*

Box 4.5: V&A case study 3

4.3 Damage to coral reefs

Coral reefs have shaped the lifestyle of the people of the Maldives since its habitation and the modern economy depends on the health of the reefs. Two major economic driving forces, the tourism and fishery industries depend heavily on the reef resources. Due to the low elevation of the islands, they are vulnerable to extreme storm events. The protection provided by the coral reefs has reduced the storm damage, coastal erosion and flooding by extreme storm events. Today, a key concern of Maldivians is how the reefs will respond to the predicted accelerated sea level rise.

Corals from reefs have been used as climatic indicators to study the changes to the climate in the past. Similarly, due to the potential vulnerability of the reefs to high temperature, they may be the first to show signs of ecological stress from global warming (IPCC, 1998). Detecting this change requires extensive monitoring for biological and physiological changes throughout coral reef regions of the world.

The most critical impact on coral reefs is likely to be due to the increase in sea surface temperature as observed by the series of coral bleaching and mortality events in the Maldives associated to the elevated sea surface temperature in the Indian Ocean. Coral bleaching has been observed in the Maldives in 1977, 1983, 1987, 1991, 1995, 1997 and 1998. The 1998 event was the most severe causing unprecedented damage to coral reefs in the central tourism region of the Maldives, with more than 90% of corals wholly or partially bleached (Naeem *et al*, 1998; Riyaz *et al*, 1998; Ali & Manik, 1989).

If the observed global trend in temperature rise continues, there will be an increased probability of a recurrence of the phenomenon observed in 1998 on the coral reefs of the Maldives in coming years. The latest climate model released from the Hadley Climate Centre predicts a seawater temperature increase of 2°C within 50 years due to global warming (Wilkinson *et al* 1999). If these predictions are correct, and all other factors remain equal, then the immediate future of coral reef systems is threatened unless global warming is reversed or corals naturally adopt.

Case study 4: Damage to coral reefs

Objective:

To gather existing data on the impact on the coral reefs of selected islands of an extreme rise in mean sea surface temperature that took place in 1998. This is especially important as Maldives consists of 8,920 Sq Km of reef area, which represents 3.14% of the total reef area of the world (Spalding et al, 2001).

Methodology:

Data was gathered from studies of a range of islands representing diverse sectors or areas and including local inhabited islands, tourist resorts and the international airport.

Data from the sites that were surveyed prior to bleaching allowed direct comparison of the data for several sites. The Marine Research Centre in the Maldives has also been actively monitoring sites for the Global Reef Check Programme, University of California at Los Angeles, that compare pre and post bleaching live coral cover at the survey sites.

Observations / preliminary findings:

During the northeast monsoon, the mean monthly sea surface temperature rises from a low during January/December to high in April/May. In the central atolls, the average seasonal rise is about 1.3 °C and the mean monthly sea surface temperatures rarely exceed 30 °C. During the southwest monsoon the temperature slowly declines. In 1998, the monthly mean sea surface temperature was 1.2 - 4.0 ^{0}C above average during the warmest months (March - June).

The post bleaching survey in 1998 showed a significant reduction in live coral cover at all study sites to include the entire stretch of Maldives from north to south. As shown in Table 4 -3, the average live coral cover decreased from 42% to 2% for the sites surveyed.

Difficulties encountered:

Little or no baseline data specific to these sites exist. The baseline data used in this section has been collected elsewhere in the country, which may include the fishery and agricultural sectors, tourist resorts and the international airport.

Study islands:

- *Kaafu atoll – Bandos and other sites*
- *Vaavu atoll - Patch Reef, Fotheyo, Wattaru*
- *Ari atoll: various sites*
- *Meemu atoll: Thuvaru, Maduvvaree*
- *Haa Alif atoll – various sites*
- *Haa Dhaal atoll – various sites*
- *Addu atoll – various sites*
- *Huvadhu atoll – various sites*

Box 4.6: V&A case study 4

	Percent live coral cover			
	Pre-bleaching		Post-bleaching	
Survey sites	MRC/ERC (various reports)	MRC Reef Check August 1997	GCRMN August-October 1998	MRC Reef Check 1998
Bandos (Malé Atoll)	37.3 ± 11.0	-	4.1 ± 5.7	-
Other sites (Malé Atoll)	40.2 ± 8.0	-	1.3 ± 0.7	-
Patch reef (Vaavu Atoll)				
3 meters	-	57.5 ± 11.7	1.3 ± 1.0	0.0 ± 0.0
10 meters	-	-	-	2.5 ± 3.2
Fotheyo (Vaavu Atoll)	-	-	4.6 ± 2.4	-
Wattaru (Vaavu Atoll)	-	-	2.7 ± 2.2	-
Various sites (Ari Atoll)	-	-	1.1 ± 0.8	-
Thuvaru (Meemu Atoll)				
3 meters	-	28.1 ± 17.9	-	0.0 ± 0.0
10 meters	-	40.0 ± 8.6	-	1.3 ± 4.0
Maduvvaree (Meemu Atoll)				
3 meters	-	53.8 ± 17.6	-	5.0 ± 7.3
10 meters	-	33.8 ± 9.5	-	3.8 ± 2.3
Central Atolls	42.0 ± 4.0		2.0 ± 0.6	

Table 4-3: Post and pre bleaching survey results for the 1998 mass bleaching event

Atoll / Area	1998	1999	2000
Haa alif, Haa Dhaal	1.0 ±0.75	1.62 ± 2.18	0.95 ± 1.37
Ari atoll	1.0 ±1.36	0.33 ± 0.41	3.85 ± 1.67
Male' atoll	2.6 ±2.71	3.04 ± 2.67	3.91 ± 2.89
Vaavu atoll	2.9 ±1.82	2.37 ± 1.29	2.63 ± 2.32
Addu, Huvadhu atoll	3.1 ±2.21	2.28 ± 1.92	3.10 ± 1.90

Table 4-4: Coral cover at the survey sites after bleaching in 1998 (National Reef Monitoring Programme, MRC)

4.4 Impacts on the economy

4.4.1 Impacts on tourism

The tourism industry in the Maldives is almost entirely dependent on physical and geographic factors, such as good weather and activities associated with sea and coral reefs. The predicted climate change would have very serious implications on the nation's main economic sector; tourism. The main impacts of climate change and associated sea level rise to the tourism industry, and in particular to the tourist resort islands of the Maldives are:

- Impacts on marine dive sites due to reef degradation as a result of elevated sea surface temperature.
- Decrease in value of the tourism product due to changes to the beach as a result of increase in sea level and wave action.
- Damage to tourist infrastructure due to coastal erosion and innundation.
- Changes to the image of the Maldives as a tourist destination due to alteration of climate and weather patterns.

Impacts on reefs and tourist dive sites

The coral reefs of the Maldives are one of the most highly ranked reefs of the world and Maldives is a world-renowned diving destination. It is estimated that about 25% to 35% of tourists visit the Maldives primarily for its excellent diving opportunities, while snorkellers at any one time on a resort can be averaged at 75% to 80% (Westmacott, 1996). It is not only Maldives, but also the world that is going to lose one of its favourite diving destinations if climate change trends continue.

An estimate by Anderson (1997) suggests the annual number of dives made by visiting tourists at more than half a million; each dive earning roughly US$ 35. From the Maldivian perspective, US$ 17.5 million a

year earned through diving is a considerable amount since about 20% of tourism earnings contribute to the nation's GDP (Table 1-17).

The species diversity of Maldivian reefs also contributes a valuable asset to the country's economy. A survey conducted in 1992 estimated that the money spent by divers on shark dives alone amounted to some US$ 2.3 million a year. It was found that as a result of coral reef damage to a popular shark dive site, "Fish Head", in 1995 and 1996, the shark population was reduced, as was the number of divers visiting the site, resulting in a loss of revenue of US$ 500,000 a year (Anderson, 1997). This indicates that the loss of tourism value due to coral reef degradation is profound in the Maldivian economy.

Impacts on beaches

The white sandy beaches of the Maldives are an important attraction for tourists. It has been identified that 70% of tourists visit the Maldives primarily for beach holidays. Erosion of these beaches is rapidly becoming an urgent problem in many resort islands. An estimated 45% of tourist resorts at present suffer from varying degrees of coastal erosion (ERC, 2001). Higher rates of erosion and coastal land loss are expected as a consequence of the projected rise in sea level.

Impacts on tourism infrastructure and support facilities

Resorts in the Maldives as dictated by tourism regulations, are developed on uninhabited, small, low-lying, coralline islands. Most of the tourist bungalows and tourist facilities are located around the island with an average setback of about 5m from the vegetation line. Some of the water based resort concepts have their tourist facilities over the lagoon on stilts. Other support facilities are located in the middle or separated on one end of the island. The location of these facilities alone renders them highly vulnerable to predicted future sea level rise due to the low elevation and the narrowness of the islands.

The current resort islands represent a considerable capital investment averaging US$ 41,964 per tourist bed. An average investment for a tourist

resort with 200 beds is over US$ 13 million and for a modern 700 bed resort US$ 43.5 million (MoT, 2001). Therefore, loss of beaches and infrastructure due to accelerated sea level rise will devastate the Maldivian economy.

Over 99% of the tourists arrive into the Maldives by air and Malé International Airport is the only entry point to the country by air. Any damage to the international airport by climate change and sea level rise, will cause extreme loss to the tourism sector *(Refer Section 4.2)*.

Case study 5: Impacts on tourism (Bandos Island Resort)

Objective:

To assess the impact of reef die-off, beach erosion and airport closure on a well established resort in the Maldives.

Methodology:

Bandos Island Resort, which is the second resort developed at the beginning of the tourism industry in the Maldives, was selected for the case study because of its uninterrupted operation since its inception; due to its key location within Malé Atoll and due to the extensive developments that has taken place in the past years.

The case study was conducted through desktop reviews of existing reports and interviews with the management.

Observations / preliminary findings:

Impacts on reefs

Bandos Island Resort earns about US$ 1 million through reef related activities such as diving and snorkelling. The coral bleaching event of 1998 had caused a 30% drop in the revenues of the resort.

Impacts on beaches

According to reports from Bandos Island Resort, a considerable amount of beach had been eroded over the past 20 years. Building of sea walls around the resort had been the immediate response to the erosion problem. It costs about US$ 60,000 a year to maintain these structures.

Impacts on the international airport

Bandos Island resort has thus far been very lucky as the brief interruptions to the running of the international airport had not affected the resort.

Box 4.7: V&A case study 5

Box 4.7: V&A case study 5 continued...

Difficulties encountered:

No baseline data was available on the status of the beach of the island.

Study islands:

- *Bandos Island Resort*

4.4.2 Impacts on fisheries

An understanding of the changes in the distribution and abundance of the tuna around the Maldives requires an understanding of the variations in the oceanographic conditions in the central Indian Ocean. There are spatial variations in the abundance and distribution of tuna in relation to the atoll chain, as well as associated seamounts. Oceanographic conditions vary along the length and so does the distribution of tuna. Upwellings associated with seamounts encourage productivity (Boehlert, 1987). The best-known seamounts in the Maldives are *Dheraha* in Laamu Atoll and *Satoraha* in the one and a half degree channel between Laamu and Gaafu Alifu Atolls. It is well known that these seamounts support high and regular tuna catches. The spatial variations of seamounts, tuna migration and interactions need to be studied in order to better understand the industry's vulnerability to climate change.

Event	Skipjack Catch	Yellow fin Catch
El Niño	Low	High
La Niña	High	Low

Table 4-4: Variation of tuna catch during ENSO events

The Maldives tuna fishery is affected by the seasonal monsoon and their associated currents (Stéquert & Marsac, 1989). Maldivian tuna catches are also affected by El Niño Southern Oscillation (ENSO) events. During the El Niño years of 1972-73, 1976, 1982-83, 1987 and 1992-94, the skipjack catches and the catch rates were noticeably decreased, while the yellowfin and other tuna species increased. During La Niña years, the skipjack catch rates increased while those of the other major tuna species decreased.

Over longer (decadal) time scales, cyclical shifts occur in the oceanographic climate regime with associated shifts in biological productivity and species composition. The Maldivian tuna catches show signs of being affected by decadal scale variation and the skipjack catches tend to go up while those of yellowfin catches go down.

The oceanographic processes that promote these decadal scale variations in tuna abundance in the Maldivian waters are not yet known. Also the stock structure of the skipjack and yellowfin in the Indian Ocean is not well known. More research needs to be undertaken in order to find any direct affects of climate change onto the fishery sector.

4.5 Food security

4.5.1 Agriculture

Clearly sea level rise, accompanied by saltwater intrusion of groundwater, will pose a threat to the little agriculture practised by rural farmers in the Maldives. Already there are problems with freshwater aquifers on several islands including Malé, where most of the mango trees have died. Saltwater intrusion of groundwater will affect deeper-rooted trees with low salt tolerance on the island. Particularly affected will be trees such as mango, banana and breadfruit.

The crop perhaps most vulnerable to rising sea levels, taro is grown in the southern atolls. This is grown in taro pits dug in and near the wetlands, about 40 cm above mean sea level. However, these pits are already below the highest tidal levels. Flooding of pits by seawater already occurs in Fuvahmulah as the storm water drainage systems in the pits are accidentally opened at high spring tides.

Heavy import dependency

At present, almost all food requirements, medicines and goods, except fresh fish and coconut, are imported from other countries; perishable foods by air and non-perishable by sea transport. As mentioned in Chapter 1, most of our main food items such as rice, wheat flour and sugar are imported from countries such as India, Thailand and even as far off as Germany. Thus the vulnerability of Maldives to climate change extend to the agricultural vulnerability in other countries. The predicted climate change for South and South East Asia has indicated a reduction of rice production (Sinha, 1991). The Maldives is vulnerable to the changes in productivity of agricultural lands beyond our borders and will have to compete on the international market for access to the food products produced elsewhere.

4.5.2 Food storage and distribution

Imported rice and other food items are stored in Malé and distributed through out the country by the local, small business entrepreneurs using small boats and seaplanes.

The country's traditional food distribution system is largely via boat from the storage facilities in Malé to islands through the *ad hoc* transport system which is operating in the country. The transport system from Malé to the other islands is via small boats called *dhonis*. The quantity that can be transported across on one trip is therefore very small. The frequency of food supplies in particular islands depends on the transport vessels, the distance from Malé and the demand for replenishment. Islands with their own travelling vessels have a more frequent supply of food, whereas those islands with limited travel vessels have to depend on nearby islands for their food supplies.

Most of the islands in the country have no proper storage facilities for rice and other food items other than in the small warehouses of the small businesses.

According to the poverty assessment study (MPND & UNDP, 1998), food was in short supply in a number of islands due to the difficulty in transporting the food from Malé to the islands. The period of short supply ranges from 1 to 30 days in different regions of the country.

In 1990, due to the high winds and storm the transport system in the country got disrupted and many islands in the country faced a shortage of food for 10 days in June. The air lifting of emergency supply of food to the affected regions cost more than US$ 120,000. Thus, it is clear that the predicted climate change would have enormous problems for food security in the Maldives.

Case study 6: Food security

Objective:

To access the vulnerability of the food security of selected islands to a breakdown in food distribution system due to extreme weather events.

Methodology:

The V&A Team circulated questionnaires to the inhabited islands to gather information on food security and distribution issues on these islands.

Observations / preliminary findings:

The results are shown below.

		Food Supply		Food Storage		
Islands	Agriculture	Obtained from	Frequency	Local	Public	Food Shortage
Ha.Thuraakunu	Little	Male'	Twice monthly	Households/Shops	No	-
Baa.Hithadhoo	-	Male'	Weekly	Households	No	-
Gn.Fuvahmulah	Yes	Male'/S. Gan	Monthly	Households/Shops	Yes	Yes

Table 4-5: Case study for food security

Agriculture

Of the three inhabited islands visited in rural areas, Fuvahmulah is one island where agriculture contributes very much to the local economy. The main crop grown in Fuvahmulah is taro. Mango and other local fruits are also grown on this island.

Food storage and distribution

For all of the study islands, food items are obtained from Malé and are supplied from weekly to monthly depending on the storage capacity of the island and the distance from Malé. Fuvahmulah is larger compared to the other study islands and has the most number of shops, while Hithaadhoo with a much lower population, has only a few shops. Only the island of Fuvahmulah has a public storage facility where food items are stored in the warehouses of State Trading Organization.

According to the island office of Fuvahmulah, there had been two episodes of food shortage due to extreme weather conditions. In terms of travel by sea, Fuvahmulah is the furthest from the capital. The government had to provide emergency supplies during the one week food shortage in 1982. Another episodic event occurred in 1993 when emergency supplies were brought from the nearby atoll, Addu.

Difficulties encountered:

Lack of time to carry out a detailed survey to find out the storage capacity in each study island.

Study islands:

- *Haa Alifu Thuraakunu*
- *Baa Hithaadhoo*
- *Gnaviyani Fuvahmulah*

Box 4.8: V&A case study 6

4.6 Water resources

Future changes in climate and sea level will have impacts on the water resources. To the Maldivian community, the effect on water resources would mean changes to freshwater availability.

The climate and hydrology, sea level movement and human activities influence the groundwater in the islands of the Maldives. Inundation of land and associated saltwater intrusion due to the predicted sea level rise would reduce the size of the freshwater lenses and thus reduce the available fresh groundwater of these islands. The groundwater is also very vulnerable to pollution by solid waste and other pollutants.

Unsustainable withdrawal of water from the water lens has depleted the freshwater lens in a few of the densely populated islands in Maldives. It is estimated that 9% of the population has no access to safe drinking water (MPND & UNDP, 1998).

Changes to the temporal and spatial patterns of rainfall as a result of climate change are believed to have impacts on the water resources of the islands like the Maldives (Falkland, 1997). The precipitation scenarios generated by different climate models predicted, with low confidence, the precipitation will increase for the Maldives. A change of temporal rainfall pattern may have an impact on the amount of rainwater harvested if the precipitation occurs as frequent short bursts and there is no chance to clean roof catchments. The change of temporal pattern and amount of rainfall to the country may cause more frequent flooding when the islands receive heavy rainfall to the freshwater lakes found in some islands.

The Centre for Clouds, Chemistry and Climate (C4) showed that the region is severely affected by transboundary air pollution (C4, 2000). The level of air pollutants found has raised concern about the impact on the rainwater quality collected from the roof catchments. This needs to be further analysed to quantify the extent of transboundary air pollution on the water resources of the Maldives. Currently, Maldives does not have the capacity to test the quality of rainwater in this region.

Desalinated water has become the major source of water for the capital, Malé. The present technology used for desalination is highly energy intensive and depends on diesel for the production of water. Thus the production costs of water depends on the market oil price. In the year 2000, the production of water with current desalination technology was very vulnerable to the oil price in the world market. Desalinated water is used by 28% of the country's population now (MWSA, 2001) and this carries a significant risk to water security and sustainable development in the Maldives.

Although desalination is a prospective alternative to groundwater and rainwater, more efficient technology that can be used for desalination needs to be explored. STELCO, the Maldivian electricity company uses waste heat from energy generation to produce desalinated water for use within the company. This operation started in 1991 and has a daily production capacity of 200 m^3 (STELCO, 2001). Such options need to be assessed for use by the whole of the nation.

Case study 7: Water resources

Objective:

To assess the vulnerability of selected islands to shortage of freshwater resources due to saltwater intrusion or shifts in rainfall patterns.

Methodology:

The islands chosen for the assessments were of different sizes, population densities and had differing economic activities. For this assessment, water demand and supply of different water resources were determined in the field through interviews and further information was drawn from existing studies. The quality of the groundwater was assessed using salinity, ammonia and pH as the indicators. The freshwater lens of the island was tested from wells.

Observations / preliminary findings:

Salinity measurements showed that the groundwater is very fresh on all of the study islands except Malé and Hulhulé. However elevated levels of ammonia and pH were seen in some regions of the study islands, indicating pollution by sewage (WHO, 1995).

The following table gives the water consumption and water storage figures for the inhabited islands under study.

Box 4.9: V&A case study 7

	Bandos	Dhekaanba	Fuvahmulah	Hithaadhoo	Hulhulé	Malé	Thuraakunu
Population	-	-	7,004	936	-	74,089	449
No. of houses	-	-	1,049	146	-	6,758	55
Percentage of rainwater usage	-	-	33	40	-	-	55
Percentage of groundwater usage	-	-	67	60	-	-	45
Sewers / septic tanks	Sewers	-	Septic tanks	Septic tanks	Both	Sewers	Septic tanks
Desalination	Yes	-	No	No	Yes	Yes	No
Groundwater salinity	No	No	No	No	Yes	Yes	No
Is ground water polluted?	No	No	Some areas	Some areas	Yes	Yes	Some areas

Table 4-6: Case study for water resources

The case study island of Fuvahmulah gets flooded with each heavy rainfall. The water in the freshwater lakes in the island burst from the banks and floods a large part of the island extending to the residential areas. The predicted change of temporal pattern and amount of rainfall to the country may cause more frequent flooding when the islands receive heavy rainfall to the freshwater lakes.

In addition to the public rainwater storage facility, the study results also showed that there were rainwater storage facilities in some of the private homes. Of the surveyed 37 houses, 12 have their own rainwater tanks with an average storage capacity of 5.7 m3.

From interviews with the people of Thuraakunu it was found that the private and public rainwater tanks run out in the dry season during the northeast monsoon. Sometimes the tanks ran out for weeks before being filled with rainwater in the rainy season. In the dry season, groundwater is used for all purposes and, due to the high extraction rate, the groundwater turns saline in some parts of the island.

The groundwater of Hulhulé Island is mostly used for flushing. Desalination plants using reverse osmosis technology are used as the main water resource on the island. It was found that the wells that are in use were relatively saline compare to the few wells that were not in use. The high salinity levels observed were due to over-pumping.

The Malé Water and Sewerage Company has provided running water to the people of Malé since early 1980's. The MWSC has seven desalination plants with a daily total production capacity of 3,800 m^3 fresh water and a rainwater storage capacity of 4,800 m^3. Six years ago, it was estimated that 4000 private rainwater tanks have a total storage capacity of 14,000 m^3 (DANIDA, 1995).

Box 4.9: V&A case study 7

These private rainwater tanks are not sufficient to meet the water demand at households in the dry periods.

Difficulties encountered:

Ground water was sampled at the surface due to unavailability of equipment to carry out an in depth study of the water lens of the study island.

Study Islands:

- *Haa Alifu Thuraakunu*
- *Gnaviyani Fuvahmulah*
- *Kaafu Malé*
- *Kaafu Hulhulé (airport)*

Box 4.9: V&A case study 7 continued...

4.7 Human health

Changes in climate affect human health in various ways. Changes in air temperature, rainfall patterns, humidity and sea level rise are the main factors that indirectly affect health through vectors and or the transmission of diseases through water and air. The more direct impacts would be due to extreme weather events and thermal stress.

Heat stress related health problems are identified as very much affected by climate change. Looking at the climate change scenarios, it can be estimated that air temperatures in Maldives may rise by 2 - 3.8 °C by the year 2100 (see Table 4.1). No studies have been conducted yet to find the effects of heat stress on the health of the Maldivian population. The population affected would mainly be the young and the elderly. As the population pyramid in Chapter 1 shows, the Maldives consists of a very young population.

Another direct impact on health would be physical injury due to extreme weather events. Although there have been historically recorded storm events, not many records have been kept of physical injuries or spread of epidemics. To date, no studies have been conducted in the Maldives to find the relationship between extreme weather events and physical injury and the spread of epidemics.

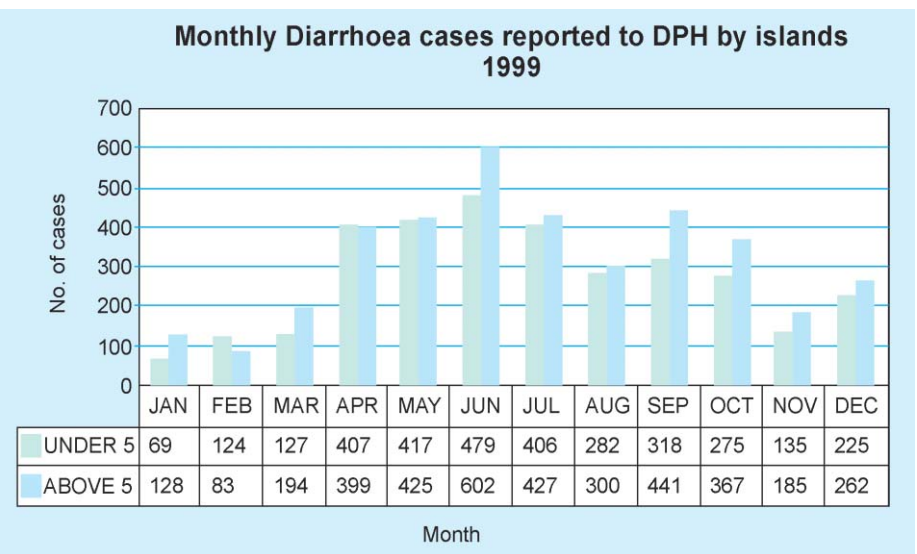
The major impact of increases in extreme weather events for the rural islands of the Maldives would be to limit access to health facilities and other services. The available facilities at the island level are very limited

and the nearest facilities would be at the Regional Hospitals or the Atoll Health Centres. The main mode of transport to these facilities is by boat and during severe weather storms it is virtually impossible to travel to these health care centres. Therefore it is important to improve the health care facilities available at the island level.

Indirect health effects of climate change includes secondary effects caused by changes in ecology and social systems. Transmission of some infectious disease patterns, such as malaria is extremely sensitive to climate change. But changes in climate as predicted by climate models may cause a comeback of malaria to the Maldives.

Flooding incidents are on the increase, and this may cause more outbreaks of waterborne diseases. Certain islands, like Fuvahmulah, due to the shape of the island are more susceptible to flooding caused by heavy rains. This, combined with the poor sanitation systems in most islands, make these islands easy prey to waterborne diseases. If sanitation conditions are not improved, this would be a major problem in the future.

Figure 4-3 below shows that the monthly cases of diarrhoea reported from the outer islands increase during the rainy season.



	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
UNDER 5	69	124	127	407	417	479	406	282	318	275	135	225
ABOVE 5	128	83	194	399	425	602	427	300	441	367	185	262

Figure 4-3: Reported diarrhoea cases for 1999

Table 4-8 below gives the specific death rates for Maldives from 1995 to 1998. The major causes of death are old age, diseases of the circulatory system, unknown causes and respiratory diseases. Recorded mortality due to vector borne diseases remained nil throughout the period.

Although Table 4-8 shows no mortalities due to vector borne diseases, dengue fever and dengue hemorrhagic fever have been identified as major health problems in the Maldives. The first epidemic was reported in 1979 and later in 1983. In 1988, a major outbreak occurred with 2,054 reported cases and 9 children below the age of 10 died of dengue and dengue hemorrhagic fever. In 1998 and 1999, reported cases of dengue and dengue hemorrhagic fever have been increasing. The majority of the cases occurred from March to June 1999 during the southeast monsoon when heavy rainfall occurred (Shaheem & Afeef, 1999; DANIDA, 1991; MoH, 1998). No studies have yet been done to determine the causes of the outbreak or to understand the possible links with climatic factors.

Cause Specific Death Rate (percent) 1995 - 1998

Cause / condition of death	1995	1997	1998
Undiagnosed death at old age	20.10	22.04	21.05
Diseases of circulatory system	18.10	22.38	20.96
Not stated	15.90	12.43	15.98
Respiratory diseases	6.40	9.02	8.30
Blood and blood forming organs and disorders of immune mechanism	5.80	3.57	2.53
Conditions relating to prenatal period	4.40	7.15	4.37
Parasitic infections	3.70	4.00	3.58
Diseases of digestive system	3.00	2.55	3.06
External cause of morbidity and mortality	3.00	2.98	2.71
Clinical signs, symptoms not elsewhere classified	2.60	0.34	0.17
Diarrhoea and gastroenteritis	2.50	0.43	0.17
Diseases of nervous system	2.00	1.70	4.10
Tuberculosis	2.00	1.28	0.87
Endocrine, nutritional and metabolic diseases	1.90	0.94	0.96
Diseases of genito urinary system	1.80	1.96	3.41
Septicemia	1.50	1.19	0.79
Neoplasm	1.50	3.66	4.10
Pregnancy, childbirth and puerperium	1.30	1.02	0.70
Vaccine preventable diseases	1.00	0.26	0.35
Congenital and chromosomal abnormalities	0.40	0.51	1.05
Mental and behaviour diseases	0.30	0.17	0.26
Meningococcal infection	0.20	0.17	0.00
Vector borne diseases	0.00	0.00	0.00
Diseases of skin and subcutaneous tissue	-	0.00	0.26
Diseases of the musuloskeletal and connective tissue	-	0.26	0.26

Table 4-8: Cause specific mortality (MoH 1996, MoH, 2000)

It is not easy to assess the impacts of climate change on human health in the Maldives. Even with the present data management methods, it is difficult to use existing health records to research into the effects of climate change.

Case study 8: Human health

Objective:

To assess the impacts of climate change on human health, for the islands selected for V&A assessment.

Methodology:

Health records of three inhabited islands were studied. In addition, interviews were conducted with health officials and elderly people of the islands.

Observations / preliminary findings:

To facilitate any climate related studies on the health sector, a more accurate data management system needs to be set up.

Difficulties encountered:

Efforts to establish any links to health patterns and changes in climate were very unsuccessful, the main reason being the lack of proper record maintenance. If a person from these islands had a serious illness they would go to either the regional hospitals or to Malé the capital. Records of these people would be entered as from Malé with no indication of their original location. These records would also not be included in the island records. This would be true for all other islands of the Maldives.

Study islands:

- *Haa Alifu Thuraakunu*
- *Baa Hithaadhoo*
- *Gnaviyani Fuvahmulah*

Box 4.10: V&A case study 8

ADAPTATION TO CLIMATE CHANGE

5

As has been explained in the previous chapter, its low-lying islands makes the Maldives among the most vulnerable and least defensible countries to the projected climate change and associated sea level rise. This is mainly due to its low elevation and fragile ecosystems, smallness, remoteness, geographical dispersion, lack of natural resources, small human resource base, vulnerability to natural disasters, a highly limited internal market and an extremely sensitive and competitive external market. Further, rising sea levels associated with a warmer climate could submerge or erode coastal properties and endanger the economy by affecting tourism and fishery.

Adaptation options in the low-lying islands of Maldives, are limited and response measures to climate change or its adverse impacts are potentially very costly. Adaptation in this context covers two main types of activities. Firstly, there are adaptive measures involving activities targeted at specific sectors, where climate change impacts have been identified. Secondly, another important group of adaptive measures will enhance the capacity of the Maldives to effectively implement adaptations.

5.1 ADAPTIVE MEASURES

5.1.1 Land loss and beach erosion

The beach system found on the islands of the Maldives are highly dynamic, and thus land loss and beach erosion is already a very widespread and a significant problem on inhabited, uninhabited and resort islands. Some are seriously affected, with loss of not only shoreline, but also of houses, schools and other infrastructures, compelling the Government to initiate urgent protection programmes. The extent of erosion and land loss may be exacerbated by consequences of the projected rise in sea level. Though it is important to protect all the islands of the Maldives, including uninhabited islands, priority has been given to protect the human settlement and infrastructure by focusing first on protecting the inhabited and resort islands.

Coastal Protection

Project 7.1a-c: Dealing with coastal erosion in the Maldives

A 3-phase project proposal has been developed to quantify the magnitude of erosion, and determine the importance of natural versus human induced erosion, as well as quantify changes in the mechanisms promoting erosion.

The three response options recognized by the Coastal Zone Management Subgroup (CZMS) for the IPCC Second Assessment Report include retreat, accommodation or protection. However, when responding to land loss and beach erosion in tiny islands, where physical space is already very scarce and the land is very flat and low lying adaptation measures such as retreat, raising the land and using building setbacks may not be viable solutions, as these involve abandoning the coastal zone and shifting the associated ecosystems inland. These options are only possible where land availability permits and where the ecology, society and economy can afford to do so.

Hence, applying solid protection structures such as seawalls may seem the only realistic option along well-developed coasts, where vital infrastructure and human settlement are at immediate risk. A seawall has been constructed along the coast of Malé with the assistance of the Japanese Government, to protect the high investments and the resident population. Similar protective structures will be needed in almost all the inhabited islands to protect the rest of the population. This will require enormous financial investment, and technical capacity, which will have to be obtained from international aid agencies and donors. The initial cost estimate has been projected at US$ 1.5 billion for 50 of the inhabited islands (Gayoom, 1998) and this would mean approximately US$ 6 billion for the 200 inhabited islands. Compared to the total GDP (US$ 161 million in 1999) of the country this would mean an expenditure of more than 30 times the GDP in 1999.

Population consolidation

Project 7.2: Feasibility study for a national population consolidation strategy and programme

A project proposal to undertake a feasibility study for a national population consolidation programme is presented in Chapter 7.

Population consolidation may be considered as another adaptive strategy for the Maldives. In the past, population consolidation has occurred for various reasons such as damage from natural disasters, religious reasons and others.

Based on the cost of protection and the population status of islands, building seawalls around the 199 inhabited islands is not a feasible option. If the population can be consolidated into fewer islands with an assessed lower vulnerability to climate change, protection will be less costly, and more practical given the high cost of building sea walls.

The government has already committed to reduce the number of inhabited islands by developing regional growth centres to provide significant benefits including health and education facilities and employment opportunities to attract migration from smaller and less populated islands. Long-term climate change considerations can also be factored into this policy position.

Ban on coral mining

Coral mining is an activity practiced in the Maldives as a result of the lack of alternative locally available building materials. The practice has increased the vulnerability of the islands to the projected sea level rise. Modern building practices have the potential of reducing if not eliminating this traditional practice.

Introducing a complete ban on coral mining on reef flats is an adaptive measure since coral reefs provide natural coastal protection to the islands. As coral is used as a construction material in the islands, change of user behaviour by providing incentives to promote the use of imported construction materials is an important factor. This can be achieved by providing imported construction materials as an alternative to traditional coral rock, at a reasonable price in all the inhabited islands. The Government can reduce or exempt import duties on construction materials to facilitate this process of changing traditional habits.

Removal of coral by mainly coral mining may collapse the protective barrier function of the reef, which could result in greater coastal erosion, increased vulnerability and an increase in the stress on the natural coral systems. The government of the Maldives has already banned coral mining from the house reefs of islands and has designated specific sites for coral mining. However, a complete ban on coral mining is considered.

5.1.2 Infrastructure damage

As mentioned in the vulnerability section, human settlements and vital infrastructure lie very close to the shoreline in the Maldives. Therefore, it is very important to develop adaptation measures to protect the human settlement and infrastructure.

Protection of the International Airport

The case study reveals clearly that, at present, the airport's sea defenses are barely adequate. Indications are that the entire shoreline protection of the airport, using an engineered solution by building a proper sea-wall, is critical to sustain the country's economic activities and other services provided by the airport. No possible alternatives to the protection of the international airport are foreseen, as the existing domestic airports currently do not have the capacity to accommodate international flights.

Upgrade existing airports

Project 7.3:Upgrading of Gan Airport for international operations

Upgrading the airport at Gan for international operations would increase the international passenger, freight transport and communication lines, facilitating faster self-sustaining atoll development. It would also enable uninterrupted international air traffic in case of a closure of the Malé International Airport, the only gateway to the Maldives.

The two existing domestic airports in the north (Haa Dhaal Hanimaadhoo) and south (Seenu Gan) need to be upgraded to accommodate international flights to be used in the case of emergencies. This is especially important since most of the food supply is imported by airfreight from other countries. A project proposal for upgrading Gan Airport for international operations is given in Chapter 7.

Increase elevation in the future

There is a need to gather complete and comprehensive information on the elevations of the islands of the Maldives. The impacts of sea level rise can be better assessed by establishing a national elevation reference system for the country and long term sea level monitoring programmes. This will also enable future development projects to expand the international airport and convene better adaptive measures. The sea level monitoring programme could take into account the projected, as well as the local changes in sea level, with respect to the true elevations of the islands.

5.1.3 Damage to coral reefs

Coral reefs perform crucial environmental functions in the formation, maintenance and protection of coral islands, while contributing significantly to the economic resource base of the Maldives. This vital ecosystem is highly sensitive to changing sea surface temperature and other climatic factors. Therefore, proper adaptive measures to protect the coral reefs are essential.

Reduction of human impacts on coral reefs

The climate change impacts, such as elevated sea surface temperatures and sea level rise, are beyond the control of resource managers. However, the impact of these can be minimised indirectly by reducing the human impacts on coral reefs. Healthy reefs are more resistant to stresses and are likely to recover faster than damaged reefs after coral bleaching events. Further, healthy reefs accrete faster, and are more likely to keep up with the rising sea level without significant damage. In contrast, corals that are already under stress will succumb more readily to coral bleaching stress and are more likely to die. Careful planning and implementing of strict management procedures are therefore required to protect the reefs from anthropogenic stresses, so that they are in a position to respond optimally to global climate change. Continuous monitoring of the health of the reef should also be incorporated into the planning process.

Reduction of land based sources of pollution through strict policies, particularly on sewage treatment and safe disposal of sewage and solid waste, can be considered as an adaptive measure to protect the reef from anthropogenic stress.

Assigning protection status for more reefs

Assigning a protection status for more coral reefs and coral species may also reduce anthropogenic stresses. Currently, the government has designated 25 reefs as protected areas. These reefs are protected from human activities except bait fishery and diving. The creation of a national park and protected areas system of the Maldives will go a long way towards establishing a long term protection, management, and monitoring system for the Maldives as well as provide for the recovery of stressed systems across the archipelago.

5.1.4 Damage to Tourism Industry

Coastal protection of resort islands

Shoreline protection of resort islands is critical to safeguard the tourist facilities, which represent massive capital investments. Stressing the importance of beaches for retaining the tourist attraction, beach nourishment by pumping sand from the lagoon seems a better option for re-

sort protection, rather than building coastal structures such as sea walls and groynes. Beach nourishment is relatively cheaper and aesthetically more pleasing than man-made structures.

Nonetheless, beach nourishment may not be the ideal solution for Maldives as sand is often a scarce resource and the amount of sand required to maintain a beach in the face of long-term sea level rise is uncertain. In addition, the implication of removing near shore deposits must be carefully considered in terms of its effect on the coastal sediment budget and the near shore wave climate. Moreover, beach nourishment requires maintenance in the form of periodic sand replenishment, sometime every 5-10 years or less. Such a requirement could prove to be unsustainable in small economies. Hence, a more feasible and practical option to protect the resort islands needs to be explored.

Reduce dependency on diving as a primary resort focus

The Maldives has been advertised as a diving destination on the international market. Since coral reefs are highly vulnerable to the changing climatic factors, the Maldives should try to reduce the dependency on a single product through product diversification, as well as presenting the islands as a premium destination by offering better quality of services. It may be difficult to find alternative tourism products to beaches and reefs. However, exploring the feasibility of other options on a commercial scale would help to diversify tourism product.

Product diversification is essential for the sustainability of the tourism industry. It could include cultural components and adventure activities, such as traditional sailing, as well as establishing convention centres to host international meetings and promoting ecotourism.

Climate change can be used as a positive impact on tourism by focusing on ecotourism. Diving in the Maldives could be promoted as an opportunity for divers to participate in the long-term monitoring of changes on the health of the reefs. In this way, climate change can be used to attract the sophisticated, educated divers of the world. Research and training centres could be established on the dive resorts.

Economy Diversification

Currently, the economy of the Maldives is highly dependent on the tourism industry and its associated activities. Economy diversification is an essential adaptation measure to reduce dependency on the tourism industry since the main assets of the country are climate dependent products. Introducing new economic activities is therefore required. Also, existing industries such as fisheries need to be explored further to assess the expansion possibilities and how they can adapt to climate change. For this, it is wise to explore the current and future opportunities and their feasibility. A detailed project proposal to undertake a programme for fisheries conservation measures and community-based reef resource management is given in Chapter 7.

Project 7.4: Programme for fisheries conservation measures and community-based reef resource management

This project would provide more consistent methodologies and a more systematic information base required for the development of Integrated Reef Resources Management (IRRM)- related concepts of fisheries conservation and management and increase awareness among groups of the importance of reef resources and the need for their more effective management.

5.1.5 Agriculture and Food Security

As mentioned in Chapter 4, due to poor soil characteristics, agriculture is very poor in the islands of Maldives. Therefore, there is a huge dependency on imported foods, fruits and vegetables in the Maldives. Alternate methods and technologies of growing fruits, vegetables and other foods need to be explored.

Crop production by using a hydroponics system, can increase the local output of fruits and vegetables to reduce the present level of imports. The Ministry of Fisheries, Agriculture and Marine Resources are exploring this option. A proposal to expand this research is included in Chapter 7.

5.1.6 Water Resources

Intrusion of saltwater and a reduction in the sustainable yield from the freshwater lens is seen as an impacts associated with climate change and sea level rise. Some of the water resources, especially in the low-lying atolls, may be degraded beyond their ability to recover and may not be exploiable by residents in the short term. Additionally, changes in the average annual and temporal patterns of the rainfall would also lead to localised water stress on some islands requiring augmentation by desalination alternatives.

Protection of groundwater

As a means of adapting to water availability, it is important to protect the groundwater lens from all kinds of pollution. The groundwater lens in most of the islands is fresh. These lenses have the potential to be exploited sustainably as a source of water. Appropriate technologies to extract water sustainably from the groundwater lens, such as developing water galleries, which has proved successful in the Pacific (Falkland, 1999), can be used in some islands of the Maldives. A possible application of such galleries could be its long-term use in the Hulhumalé reclamation site to establish a stable freshwater lens.

In addition, establishing regular monitoring of groundwater is important to ensure the sustainable use of the groundwater resource of the islands. Water reuse and recycling on tourist islands needs to be examined to reduce the demand for freshwater and the heavy dependence in resorts.

Increasing the rainwater harvesting and storage capacity

The V&A field study show that Maldivian island communities faced a shortage of rainwater during the dry season and they had to depend on the groundwater to meet the drinking water demands for weeks. Since rainwater is one of the main sources of freshwater, it is vital to ensure that rainwater is harvested to its maximum. Increasing the rainwater harvesting roof catchments and the water storage capacity would ensure a more reliable supply of water in the dry period of the northeast monsoon. The usability of the collected water need to be increased by educating the island communities on safe collecting procedures and the importance of treating the collected water. Solar disinfecting units can be used to treat the collected water at the island community rainwater tanks.

Use of solar distillation

Desalination could be an adaptation option as a source of freshwater for the densely populated islands. Desalination technologies that are currently used in the Maldives depend on fossil fuel. The introduction and use of alternative technologies, such as solar powered desalination, or desalination using waste heat from powerhouses, is an attractive option to secure water availability to the population. This takes into account the country's vulnerability to the fluctuating oil prices as well as from a cli-

mate change perspective. Hence, the feasibility and the applicability of such technologies in the Maldives needs to be further researched.

Management of storm water

Although the climatic models have not been able to predict the change in precipitation pattern to the region, the increase of precipitation could make some of the islands prone to flooding in heavy storms. At present, islands like Fuvahmulah, due to its topography, get flooded during heavy rainfall. A positive temporal change in the climatic models (i.e. more frequent occurrences of heavy rainfall) would increase the occurrence of flooding. Developing an effective storm water management system needs to be considered as an adaptive measure that could prevent local flooding in flood prone islands.

Allocation of groundwater recharge areas in the islands

The freshwater lenses in most of the islands have the potential to sustainably supply water to the island community. An increasing demand for groundwater could be met sustainably by improving the recharge rate of the water lenses of the islands. Allocation of football grounds and parks, with appropriate land use change, could increase the groundwater recharging capacity of the islands by acting as catchments or recharge areas. Water quality and detailed hydrogeological analysis will be required to assess this option on a case by case basis.

5.2 Capacity to adapt

Though possible adaptation strategies have been identified, the Maldives lacks the capacity to adapt both financially and technically. Hence, for the Maldives to respond successfully and implement appropriate adaptation strategies, financial resources and technological capability, including human resource development in various fields, are urgent requirements.

5.2.1 Human resource development

Human resources capacity building in all major sectors is identified as a critical component in successfully responding to the impacts of climate change. However, the emphasis has been given to the most immediate requirements of the coastal sector since coastal erosion and land loss

has been identified as potentially life-threatening to the inhabitants of the Maldives.

The Maldives lacks technical capacity in all areas of coastal zone management. Therefore, training is required in specific fields, such as surveying and coastal engineering, to develop effective coastal zone management and to implement adaptation projects.

Some of the other areas expertise is required include:

- physical oceanography;
- climatology;
- environmental ocean modeling of tuna stock;
- Environment Impact Assessment;
- Energy;
- hydrology; and
- decision making.

The government of the Maldives has given priority to enhance the existing capacity of human resource development, especially in the field of coastal zone and environmental management. In this regard, postgraduate training has been given to six members of the climate change project team under the GEF Climate Change Enabling Activity. The project has further trained 63 local residents in monitoring and assessing the changes in their island environment. Details of these trainings are given below in Box 5-1 and 5-2.

Overseas Training

The GEF Climate Change Enabling Activity facilitated a special postgraduate level training for six members of the project staff in the following interest areas of the project. The contributions from these trained staff to the completion of the first national communication of Maldives shows the success of such training programs.

Training Area	Staff Trained
Integrate Coastal Zone Management	2
Geographic Information Systems	2
Environmental Economics	2

Box 5.1: Overseas Training

Coastal Zone Management - (island training)

One of the objectives of the Climate Change Enabling Activity was to train 75 local residents from selected islands (out of a total of 199 inhabited islands) in coastal management issues, with practical instruction in beach surveying and other monitoring and data collection procedures. This was aimed to build the capacity required to measure and monitor baseline environmental conditions against which to assess vulnerability to future changes on outer islands. This objective was integrated into an existing program of training local residents.

There have been three training rounds conducted under the project. A total of 63 locals have been trained so far. This number includes at least one person from each of the 20 administrative atolls.

The project now aims to train one person from each of the 199 inhabited islands of Maldives. Presently, four atolls have at least one trained local on each of the inhabited islands. The training courses would be continued through 2001.

The third training round was conducted as a joint activity with the Southern Regional Development Management Office in Addu Atoll. The third training round not only included beach surveying and other monitoring techniques, but also aimed to increase awareness of locals on environmental issues. The course content was improvised and covered the following main modules:

- *Basic meteorology*
- *Basic oceanography*
- *Solid waste management*
- *Beach surveying*
- *Coastal zone management*
- *Reef surveying*
- *Biodiversity*
- *Environmental law*

Training Round	Date	No. of participants	No. of Participating Atolls	Location
1	26 April - 1 May 1999	10	5	Male
2	2 - 21 September 1999	25	14	Male
3	18 - 28 February 2001	31	4	S.Gan

Box 5-2: CZM island training

5.2.2 Institutional strengthening

Strengthening the institutional capacities is an essential requirement for the successful implementation of the adaptation strategies. This includes the legal, institutional and administrative arrangements of the agencies, that are either related to climate change activities, or need to respond the effects of such changes.

Since activities related to climate change involve various government and private agencies, a mechanism to strengthen the coordination and cooperation between the departments is essential. Each concerned department can designate focal points to liase and communicate, as well as ensure effective participation of all related agencies when their input is required. The focal points will also be responsible for providing the necessary data and reporting the information gaps that need to be addressed to the climate change project team.

The lack of available data and data management has been identified as one of the main issues when assessing the vulnerability of the Maldives to climate change. Hence, a standard procedure for data collection and management needs to be established in all concerned agencies to provide easy access to required information. This will avoid omissions, duplication and repetition in data collection. This will require educational and training support for professional and technical support staff.

Establishing a collaborative research capability is needed for the Maldives to effectively implement the identified adaptation measures. The Maldives can advertise internationally for expressions of interest from universities wanting to establish a research base in the Maldives.

The environmental research capacity of the Maldives can also be enhanced by developing certain long-term partnership with overseas universities. If, for example, it were possible for the Government to offer one or more overseas universities access to modest support, it would be a relatively simple task to organise regular research visits from overseas university staff and research students. These visits could also provide the opportunity for specialised short courses to be given by visiting professors, and for Maldivian research students to do the fieldwork component of their advanced degrees at home, rather than being “lost” to their employers for long periods.

As climate change is a global issue, coordination and cooperation programs at international and regional level is also viewed as an integral part of institutional capacity building.

5.2.3 Research and systematic observation

Understanding general climate change and sea level rise impacts on Maldives, requires extensive study of oceanographic and meteorological parameters. Presently, Maldives has only three stations that measure sea level. Several stations to measure sea surface temperature, sea level and salinity need to be placed at various locations in the Maldives. There are also five meteorological stations that measure only the basic parameters required for general weather forecasting. These stations need to be equipped with facilities to do detailed research on radiation changes and early warning systems.

Rainfall patterns vary greatly at different locations in the Maldives. Therefore more stations need to be set up to study the patterns in rainfall and their spatial variation. At present, the Maldives does not have the capacity to test the quality of the rainwater, the meteorological stations need to be equipped with facilities to monitor air pollution levels and to conduct water chemistry-based research.

Research to understand the process contributing to beach erosion in the Maldives and how to effectively manage such problems are very important to facilitate adaptation to these problems. In this respect, it is very important to know the topographic variation patterns in the Maldive islands. Mapping and survey data are currently inadequate for planning purposes and there is a need to collate topographical data and use aerial photographs and field survey to build up a proper database. This would be very useful in dealing with problems such as beach erosion management.

Research and monitoring also need to be done to study the growth patterns of coral reefs and how they adapt to the rise in sea level and changes in sea surface temperature. Permanent monitoring sites need to be established to assess the recovery of coral reefs from bleaching events and to study how coral reefs adapt to changes in climate and sea level and to develop an adequate in-country database.

Other research areas include the effect of climatic variation on fisheries and the effects of climate change on human health. Dengue and dengue hemorrhagic fever have been identified as potential climate change related diseases in the health section of the vulnerability assessment. A project could be developed to further study the effects of climate change on the spread of dengue and dengue hemorrhagic fever.

It is very important to establish partnerships with other international research institutions and also with other small island countries in research related to climate change and sea level rise.

5.2.4 Public awareness and education

Raising public awareness about environmental issues is a high priority for the Government of Maldives. A number of initiatives have been undertaken with the specific aim of encouraging environmental awareness and education. These include, but are not limited to, the following activities undertaken over the past 15 years:

- Incorporation of Environmental Studies in the primary and middle school curricular to create environmental awareness in children;
- The President's Environmental Award Programme, which is an annual award recognising outstanding contributions made by individuals and groups involved in environmental protection;
- World Environment Day celebrations, where organised activities, such as tree planting and clean up programmes, are undertaken on June 5th every year;
- The World Clean-up Day Programme, the Clean Maldives and the Independent Maldives campaign, designed to involve people in the cleaning up of litter;
- A large-scale tree planting programme (the "Two Million Tree" Programme) launched in 1996 with the strong involvement of schools;
- The encouragement of a strong environmental NGO sector where

voluntary organisations have conducted a number of environmental awareness programmes both in Malé and on other inhabited islands.

- Hosting of the 13th session of the IPCC in the Maldives in September, 1997.

- Hosting of the Small States Conference on Sea Level Rise in Malé, in November, 1989. The outcome of the conference was the "Malé Declaration on Global Warming and Sea Level Rise." which paved the way for the establishment of an Action Group among small island states, to co-ordinate a joint approach on the issues of climate change, global warming and sea level rise, and to pursue and follow up on global and regional response strategies. This Action Group later transformed into the Alliance Of Small Island States (AOSIS) at the Second World Climate Conference.

- Participation in the SAARC Regional Study on the Causes and Consequences of Natural Disasters and the Protection and Preservation of the Environment in 1992.

- Participation in the Commonwealth study on the Implications of Sea level rise for the Republic of the Maldives in 1989.

- Development of national sustainable development policy statement, which includes the National Environment Action Plan (NEAP) and the National Development Plan (NDP). The NEAP is the comprehensive policy framework that is used in a six-yearly cycle to ensure environmental protection and sustainable development in the Maldives. This complements the NDP, which is policy framework for the development issues for five-year period.

As a result, environmental awareness among the public is considered as reasonably high. However, more awareness programmes need to be conducted specifically to create awareness among the public on climate change issues. This would include issuing basic information on climate change, the likely impacts of climate change on Maldives, what can be done at the community level to reduce these impacts and how to deal

with the expected changes. Translation of material on climate change issues into the local language is a very important step that needs to be undertaken for better public awareness.

In any kind of awareness campaign, the media plays the most critical role in information dissemination. Therefore, journalists need to be well informed about the climate change science, policy and the most recent developments in the international arena on the issue to deliver accurate information to the public. Likewise, teachers need to be well educated on the issue to pass the information on to the students. Also, the policy makers need to be provided and regularly updated with the most recent information on all the issues related to climate change, including the science and policy, as well as the most recent developments of negotiation and the response of other countries.

These can be achieved by launching education and awareness schemes in the form of seminars and workshops at different levels. Technical experts from abroad can be the resource persons and would provide relevant materials. The approach would be to train the trainer, with the training activities aimed at MHAHE and the schools of the Maldives.

Policy Workshop on Climate Change

The GEF Climate Enabling Activity hosted a policy workshop on climate change targeted at policy makers from various government sectors. This workshop was held on 15 March 2001 and 27 participants from 22 government offices took part in this workshop. The panel of experts included:

- *H.E. Ambassador T.N. Slade Ambassador*
  Permanent Mission of the Independent State of Samoa to the United Nations
- *Prof. John Hay*
  Director of Profesional Training, International Global Change Institute
- *The members of the International Advisory Board for the project*
  1. *Mr. Espen Ronneberg*
     Inter-regional Advisor for SIDS
  2. *Dr. Richard Warrick*
     Director, International Global Change Institute
  3. *Dr. Tibor Farago*
     Chief Advisor on International Affairs and National Focal Point for Climate Convention, Ministry for Environment, Hungary
  4. *Mr. Jacob Werksman*
     Senior Lawyer
     Foundation for International Environmental Law and Development

Presentations were made on the latest science of climate change, the latest policy developments of climate change, the preparation of Maldives GHG Inventory and Mitigation Options, Maldives Vulnerability and Adaptation Assessment and the Clean Development Mechanism.

Box 5-3: Climate Change Policy Workshop

POLICY AND MEASURES

6

The chapters on mitigation and adaptation discussed the actions and measures that can be taken to begin to deal with the implications of climate change on the Maldives. The Government, public and the private sector, as a whole needs to acknowledge the reality of climate change and associated sea level rise. The Maldives, being one of the countries most vulnerable to climate change, needs to incorporate effects of climate change in national development plans. New policies need to be developed and existing policies need to be strengthened.

The rest of this Chapter focuses on identifying policies required to address the actions and measures identified in the earlier chapters.

6.1 Current environmental policies

In addition to local environmental concerns, the Government has continued to work in the wider international context because of the potential threats posed by externally generated problems and the collective responsibility for sustainable development at the global level. The Second National Environment Action Plan (NEAP II) emphasises climate change and associated sea level rise as a primary concern of the Maldives. Thus, the Maldives has continued to participate in international fora, calling attention to the fragile nature and special vulnerability of small islands.

"The economic, technical and technological resources are available collectively. It is not too late to save the world. It is not too late to save the Maldives and other low-lying island nations. Only the vital collective commitment is missing."

Maumoon Abdul Gayoom, President of the Republic Maldives, in his speech "Death of a nation – What can be done?" at the Commonwealth Heads of Government Meeting, 15 October 1997, Vancouver.

Current national environmental policies are based on the need to take an integrated approach to environmental management and to work towards the goal of sustainable development. This is reflected in the NEAP II, which is the main guiding document for developing national environmental polices.

The NEAP-II has set its strategies and priorities with the aim to "protect and preserve the environment of the Maldives, and to sustainably manage its resources for the collective benefit and the enjoyment of the present and future generations."

The NEAP-II further indicates the need for strengthening the environmental law, environmental administration, education and public aware-

ness, science and research, and the human resource capacity of the country. The issues identified as priorities are:

- *climate change and sea level rise;*
- *coastal zone management;*
- *biological diversity conservation;*
- *integrated reef resources management;*
- *integrated water resources management;*
- *management of solid wastes and sewage;*
- *pollution control and managing hazardous waste;*
- *sustainable tourism development;*
- *land resources management and sustainable agriculture; and*
- *human settlements and urbanisation.*

Apart from the polices and measures outlined in the NEAP II, the importance of sound practices for environmental and natural resources management is stressed in various parts of the fifth National Development Plan (NDP-5). The NEAP II and the NDP-5 have been developed with the view to maximise the sustainable use of natural resources, while paying due attention to the constraint that the island communities are small and widely dispersed over the country.

6.2 Recommended policy measures

This section builds on the recommendations from previous chapters to identify ways of strengthening the present national development policies and developing new policies or regulations, taking into account the effects of climate change and associated sea level rise.

The main policy elements can be identified as follows:

1. Participate in international advocacy;

2. Reflect climate change concerns in regulatory processes;

3. Create sustainable financing mechanisms for programmes related to climate change activities;

4. Build, strengthen and enhance national capacity to adapt to climate change;

5. Incorporate adaptive measures to climate change into national development planning; and

6. Develop appropriate measures to mitigate greenhouse gas emissions

A National Implementation Strategy had been developed to accommodate the main policy elements into our national planning. Through such policies, the Maldives should aim to benefit from the arrangements, such as the Global Environment Facility, activities implemented jointly under the Convention, and the Clean Development Mechanism under the Kyoto Protocol, resulting from the international climate change negotiations. Detailed objectives and actions for the above policy elements are included below.

NATIONAL IMPLEMENTATION STRATEGY FOR ADDRESSING CLIMATE CHANGE – POLICY MATRIX

1. Participating in international advocacy

Strategy/Objective	Actions/Programmes/Activities	Resources	Lead Agency	Time Frame
Voicing the nation's concern internationally	▪ Ensure continued active participation in regional and international climate change related activities	Finance	MHAHE	Immediate
	▪ Strengthen participation in portraying a collective voice for all small island states at international forum	Finance	MHAHE	Immediate
	▪ Strengthen negotiation skills for participating team members	Finance	MHAHE	Immediate
	▪ Dissemination of outputs and decisions of regional and international climate change forum to all foreign missions and local stakeholders		MHAHE	Immediate

2. Reflect climate change concerns in regulatory processes

Strategy/Objective	Actions/Programmes/Activities	Resources	Lead Agency	Time Frame
Strengthen and developing laws and regulations as appropriate	▪ Incorporate climate change implications into present environment impact assessment processes	-	MHAHE	Immediate
	▪ Integrate climate change related policies/issues in the national audit of government organizations	-	MHAHE	Immediate
	▪ Establish a National Energy Agency responsible to formulate and review policies on energy resources management and establish an effective regulatory framework, to encourage innovation and response to energy issues and needs in a timely manner.	Human resources Technical assistance Finance	Presidents Office	Immediate

3. Create sustainable financing mechanisms for programmes related to climate change activities

Strategy/Objective	Actions/Programmes/Activities	Resources	Lead Agency	Time Frame
Facilitate effective access to external funding	▪ Seek financial and technical assistance from related bilateral and multilateral sources	-	MHAHE, MOFT, DER, MPND	Immediate
	▪ Create trust funds to facilitate climte change related activities	-	MOFT	Short term
Generating internal funding	▪ Allocate explicitly for climate change related programmes from the annual budget of related government agencies and ensure these funds are utilised fully for the purpose	-	MOFT, DER, MPND	Immediate

4. Building national capacity to adapt to climate change

Strategy/Objective	Actions/Programmes/Activities	Resources	Lead Agency	Time Frame
Human resources development	▪ Short and long term higher education and professional training in the field of costal zone management	Finance	MHREL MHAHE	Immediate
	▪ Integrate climate change and other environment issues into present island chief training programme	Finance	MOAA	Immediate
	▪ Continue ongoing in-country Coastal Zone Management training programme	Finance	MHAHE	Immediate
	▪ University level training in climatology, oceanography, coastal engineering, hydrology, water resources, cartography, tropical marine biology, physical geography, environmental science and other related fields	Finance	MHAHE MHREL	Immediate
	▪ Develop national capacity for emergency disaster relief, establish national coordination mechanism, develop national disaster management plan and an appropriate national response strategy	Finance	MHAHE	Immediate
	▪ Training in data collection, information management and analysis to support V&A process	Finance	MHAHE, DM, MRC	Immediate
	▪ Sustain the national climate change team in the preparation of subsequent national communication	Finance	MHAHE	Immediate
Institutional Strengthening	▪ Dedicate staff to carry out climate change related work within the Environment Section and the Environment Research Centre of the Ministry of Home Affairs, Housing and Environment	Finance Human Resource	MHAHE	Immediate
	▪ Improve coordination among stakeholders	-	MHAHE	Immediate
	▪ Appoint environmental focal points in all relevant institutions both in government and the private sector	-	MHAHE	Immediate
	▪ Facilitate effective information and resource sharing among stakeholders	Finance Human Resource	MHAHE MCST	Immediate
	▪ Introduce effective mechanisms and procedures for data collection, management, analysis and reporting process	Finance Human Resource	MCST Individual agencies	Short term
	▪ Establish standard procedures for data collection and management in all concerned agencies in order to provide easy access to required information	-	MCST All concerned agencies	Short term
	▪ Ensure continuous assessment of vulnerability to climate change by integrating into mandates of relevant government agencies	-	President's Office	Short term
	▪ Enhance data collection and monitoring capacity through acquisition and upgrading of climatological, surveying, mapping, hydrological and GIS equipment and software	Finance Human Resource	MHAHE Respective agencies	Short term

Research and monitoring	▪ Enhance capability, coordination and collaborative research among existing research institutions	Finance Human Resource	ERC	Short term
	▪ Establish links and initiate collaborative research with overseas research institutions	Finance Human resource	MCST ERC MRC	Short term
	▪ Expand and strengthen the current coverage of climatic, hydrological, coastal and coral reef monitoring in the country	Finance Human Resource	DM ERC MRC	Short term
	▪ Initiate monitoring of solar radiation, water chemistry and oceanographic parameters	Finance Human Resource	DM	Immediate
	▪ Initiate the research of the impact of climate change on fisheries and human health	Finance Human Resource	MOH MOFAMR	Immediate
	▪ Development of climate impact models	Finance Human Resource	ERC	Immediate
Public Awareness	▪ Development of public awareness campaigns on climate change	Finance Human Resource	MHAHE	Immediate
	▪ Conduct climate change awareness workshops targeted to policy makers, media, educators and the public	Finance Human Resource	ERC	Immediate
	▪ Review education curricula to include climate change and related environment education for the national education system	Finance Human Resource	MOE	Immediate

5. Incorporate adaptive measures to climate change into national development planning

Strategy/Objective	Actions/Programmes/Activities	Resources	Lead Agency	Time Frame
Marine Ecosystem	▪ Evaluate the adaptability of marine ecosystems to climate change	Finance Human Resource	MRC	Short term
	▪ Develop mechanisms for coordination and cooperation amongst all stakeholders in developing strategies concerned with coral reef management	Finance Human Resource	MRC	Immediate
Coastal zone management	▪ Development of feasible engineering solution for coastal protection	Finance Human Resource	MCPW ERC	Short term
	▪ Provide incentives to promote the use of imported construction materials to reduce the use of coral in construction	Finance	MHUDB Ministry of Trade	Short term
	▪ Work towards the goal of complete ban on coral mining	-	MOFAMR	Short term
Land use management	▪ Develop guidelines for land reclamation projects taking into consideration climate change and associated sea level rise	-	MHAHE MPND	Immediate
	▪ Continue ongoing population consolidation programmes to reduce the number of inhabited islands for cost effective coastal protection and development	Finance	MPND	Immediate
	▪ Produce and maintain land use maps and detailed maps of coastal areas to assist in planning of coastal zone development and management	Finance Human Resource	MPND MHUDB ERC	Immediate
Infrastructure protection	▪ Incorporation of engineered coastal protection solutions in future development of the International Airport	Finance Human Resource	MPND MTCA	Medium
	▪ Extension of the current insurance policies to cover all equipment and infrastructure of the International Airport for climate related incidents	Finance	MOFT MTCA	Immediate
	▪ Promote insurance of resort investments to adequately cover by insurance policies for natural disasters and episodic events	Finance Human Resource	MoT MATI	Immediate
	▪ Advocate for measures to safeguard properties from climate change impacts	Finance	MHUDB	Immediate

Economic activities	▪ Identify feasible economic activities for diversification in order to reduce dependency on tourism	Finance Human Resource	MPND MOFT	Immediate
	▪ Expansion of current fisheries industry	Finance Human Resource	MOFAMR	Immediate
	▪ Product diversification in the tourism sector to reduce dependency on marine environment	Finance Human Resource	MoT	Short term
Food security	▪ Promote local food production through sustainable agriculture practices and fisheries	Finance Human Resource	MOFAMR	Immediate
	▪ Introduce new technologies for food production	Finance Human Resource	MOFAMR	Immediate
	▪ Diversify sources for importing food products	-	MOTI	Immediate
	▪ Develop and maintain emergency relief measures	Finance	NSS	Short term
	▪ Strengthen food distribution and enhance capacity of food storage throughout the country	Finance Human Resource	Ministry of Trade MPND	Short term
	▪ Upgrading of domestic airports as backups for continued international links	Finance Human Resource	MPND MTCA	Long term
Water Resource Management	▪ Develop a water resource management strategy taking into consideration the impact of climate change and sea level rise on the precipitation patterns and groundwater salinity	Finance Human Resource	MWSA	Immediate
	▪ Protect the available groundwater resources by strengthening guidelines for development of sewerage, wastewater management systems, handling of hazardous waste and solid waste disposal methods	Finance Human Resource	MWSA	Immediate
	▪ Introduce alternate distillation and desalination technologies as a water resource for the high density populated islands to reduce dependency on fossil fuel desalination technologies	Finance Human Resource	MWSA	Short term
	▪ Develop effective storm water management mechanisms	Finance Human Resource	MHUDB	Immediate
Energy	▪ Ensure decision makers have most current and comprehensive information on the adequacy and reliability of energy resources available to meet the Maldives long-term consumer demand	Finance	MCST Energy Agency	Short term
Waste Management	▪ Consider greenhouse gas emissions when developing national solid waste management strategy	Finance Human Resource	MHAHE	Immediate
Human health	▪ Identify climate change implications on human health and incorporate such implications into health master plans	Finance Human Resource Technical	MOH	Short term
Natural disaster	▪ Establish a contingency plan for effective mechanisms for disaster reduction	Finance	MHAHE	Immediate

6. Develop appropriate measures to mitigate the greenhouse gas emissions

Strategy/Objective	Actions/Programmes/Activities	Resources	Lead Agency	Time Frame
Demand side management	▪ Promote energy efficiency and conservation through standards, regulations, pricing policies and public awareness	Human Resources Finance	Energy Agency	Short term
	▪ Enhance the use of energy efficient technologies and efficiency of the present technologies	Human Resources Finance	Energy Agency MCST	Immediate
	▪ Promote environment friendly technologies for household, industrial and business appliances	Finance	Energy Agency MCST	Immediate
	▪ Promote the use of environment friendly modes of transport and public transport	-	Energy Agency MTCA	Immediate
	▪ Introduce sustainable public transportation systems for land and sea transport, to minimize the use of fossil fuels	Finance	Energy Agency MTCA	Medium term
Supply side management	▪ Convert conventional sources of energy to more environment friendly sources, in transportation and electricity generation	Finance Human Resources	Energy Agency MCST	Medium
	▪ Introduce more efficient technologies in energy production	Finance Human Resources	Energy Agency	Short term
	▪ Introduce hybrid energy systems	Finance Human Resources	Energy Agency	Medium term
	▪ Introduce renewable sources for energy and electricity generation	Finance Human Resources	Energy Agency MCST	Long term
Sink enhancement	▪ Strengthen measures of increasing vegetation cover	Finance	MOFAMR	Immediate
	▪ Acknowledge coral reefs as carbon dioxide sinks and strengthen present coral reef protection measures for its healthy growth	Finance Human Resources	MRC	Immediate

7 PROJECTS

The chapters on mitigation of GHGs and adaptation have identified various actions that need to be carried out to deal with the effects of climate change and sea level rise. As mentioned in Chapter 5, the government does not have the financial capacity to undertake such actions. Therefore, this chapter contains a collection of developed project proposals to be submitted for external funding.

Project 7.1a

Project Name: APPRAISING COASTAL EROSION IN THE MALDIVES: LAYING THE FOUNDATION FOR ADAPTATION TO SEA LEVEL RISE AND CLIMATE CHANGE

This three-phase project is designed to address the issue of coastal erosion in the Maldives. The initial phases are aimed to enhance the capacity required to formulate a coastal erosion management strategy.

Project rationale and objectives:

The Maldives face severe constraints in adapting to increased erosion expected with the rising sea level. A major constraint is the lack of capacity to evaluate the magnitude of erosion and identify quantitatively the major causes of erosion. Without such knowledge, appropriate adaptation strategies cannot be formulated.

The aims of this project are to build capacity of the Environment Research to:

1. *quantify the magnitude of erosion on islands in the Maldives;*
2. *determine the importance of natural vs. human induced erosion on islands in the Maldives; and*
3. *quantify changes in process mechanisms promoting erosion.*

Expected outcomes:

1. *A trained Environment Research Centre that has instigated a network of erosion studies and is actively assessing the magnitude and causes of erosion throughout the Maldives.*
2. *Technical summaries quantifying long-term rates and importance of natural vs human induced erosion on representative islands in the Maldives*
3. *Quantitative summaries of the process regimes (waves currents, sediment budgets) that characterise representative types of islands in the Maldives.*

Planned activities and outcomes:

1. *Provide Environment Research Centre with technical capacity to undertake erosion studies.*
2. *Train Environment Research Centre in design, implementation and analysis of erosion studies.*

ERC to establish a network of monitoring sites that reflect differences in island morphology and undertake detailed studies to document changes in island morphology and the process controlling island change.

Project 7.1b

Project Name: ***DEVELOPMENT OF PRACTICAL ADAPTATION MEASURES TO COMBAT EROSION IN THE MALDIVES***

Project rationale and objectives:

A major constraint to effective adaptation to climate change and sea level is a lack of appropriate and tested practical solutions to coastal erosion. The history of erosion management in the Maldives is dominated by use of inappropriate hard engineering solutions designed without regard to natural processes. The aim of this project is to develop a range of practical solutions to combat coastal erosion on the islands of the Maldives. The specific objectives are to:

1. *use systematically collected environmental data as a basis to design a range of environmentally appropriate solutions to manage coastal erosion;.*

2 *test and monitor each management tool to determine the effect of environmental processes and effectiveness in combating erosion; and*

3. *develop technical guidelines for the design and construction of different management tools and appropriateness for representative island types.*

Expected outcomes:

1. *Establishment of an Engineering Support Unit with joint membership from Environment Research Centre, Ministry of Construction and Public Works and Ministry of Atolls Administration, to provide technical guidance on design and construction of specific erosion management tools.*

2. *Identification of preferred hierarchy of solutions based on field tests and studies of the effects of each option on the environment.*

3. *Production of technical guidelines on range of options available, design considerations in different island settings and construction.*

Planned activities and outcomes:

1. *Formulation of an Engineering Support Unit to undertake investigations into appropriate erosion management techniques. The Engineering Support Unit will act in an advisory capacity alongside Environment Research Centre to assist evaluate erosion management problems and solutions.*

2. *Use process information on environment (generated by the Environment Research Centre) as a basis to design a range of non-structural and hard structural solutions to erosion.*

3. *Undertake physical trials on designed solutions- on a limited number of islands. Trials will qualify the influence of management solutions (e.g. groynes) on coastal processes (waves, currents, sediment transport). Results will provide valuable infor mation to feedback into the design phase. Field investigations of suitable sand aggregates for beach nourishment will be undertaken.*

4. *Develop technical guidelines that outline the range of solutions appropriate for erosion management in islands in the Maldives. The guidelines will also provide guidance on the actual design, construction and monitoring for different island settings.*

Project 7.1c

Project Name: A COASTAL EROSION MANAGEMENT STRATEGY FOR THE MALDIVES

Project rationale and objectives:

Effective erosion management in the Maldives is currently constrained by a weak evaluation process that is not mandatory. Improvement of the process must be based on development of a robust series of steps that is integrated within the existing legislative framework and which gains support of all stakeholders. The specific objectives of this project are to:

1. *develop a Coastal Erosion Management Strategy that provides clear and practical guidance on steps that need to be undertaken to properly assess an erosion issue and formulate appropriate management solutions;*

2. *integrate the Coastal Erosion Management Strategy within existing environmental institutional framework and seek legislative support for the Coastal Erosion Management Strategy;*

3. *raise awareness of all stakeholders (government to community) of the importance of effective erosion management for sustainable economic development; and*

4. *implement the Coastal Erosion Management Strategy using planned regional networks in the Maldives*

Expected outcomes:

1. *Production of a Coastal Erosion Management Strategy to guide effective erosion management.*

2. *Government endorsement and support of the Coastal Erosion Management Strategy through legislative recognition of the strategy allowing mandatory enforcement of the strategy.*

3. *Increased awareness and support at all levels of government and community of the importance of appropriate erosion management.*

4. *An operational network of erosion management officers that co-ordinate the strategy at the regional atoll hubs.*

5. *Examples of where the Coastal Erosion Management Strategy has been successfully implemented.*

Planned activities and outcomes:

1. *Development of the Coastal Erosion Management Strategy. This strategy will largely be built on outputs of the previous two programmes and will identify linkages to specific agencies (Environment Research Centre and Engineering Support Unit) to facilitate effective management.*

2. *Training focused at a range of stakeholders (government agencies, private sector, and local community) to raise awareness of the erosion issue and advantages of following a consistent process for erosion management.*

3. *Train-the-trainer component so Environment Research Centre can deliver ongoing awareness programmes on erosion.*

4. *Identify and appoint a network of officers throughout the Maldives to act as liaison on erosion issues and who have the capacity to trigger the process on the Coastal Erosion Management Strategy.*

5. *Provide subsidies for erosion works to 5 islands to trial the Coastal Erosion Management Strategy and monitor its success. Outcomes can be used to raise awareness of the issues and solutions.*

Project 7.2

Project name: ***FEASIBILITY STUDY FOR A NATIONAL POPULATION CONSOLIDATION STRATEGY AND PROGRAMME***

Major efforts have been and are continuing to be made to provide populations with the social and physical infrastructure required to raise standards of living and to improve the quality of life. Although major progress has been recorded, the costs of providing and maintaining infrastructure and services are extremely high and there are still many islands in which populations are inadequately serviced and, as a consequence, are both disadvantaged and vulnerable.

Project rationale and objectives:

The main objective of the project is to undertake a feasibility study to identify the main elements of a National Population Consolidation Strategy and Programme with particular attention being given to:

1- *increasing the opportunities of small, isolated and vulnerable island communities;*

2- *assessing the social implications, social acceptance and social costs of resettlement initiatives;*

3- *identifying of inhabited and uninhabited islands that could serve as the basis for settlement consolidation, taking into account the longer-term carrying capacity of alternative locations;*

4- *assessing the environmental implications of settlement consolidation and measures required to protect island populations from the negative impacts of predicated climate change and sea level rise.*

5- *identifying of the main alternatives for population consolidation, taking into account initiatives in respect of the nations capital and the development of regional growth centres;*

6- *developing of recurrent costs associated with different settlement alternatives;*

7- *formulating of guidelines for sectoral investment programmes and the programmes of line ministries involved in the provision of infrastructure and services in atolls and islands.*

Expected outcomes:

The project will result in a report, to be entitled National Outline Population Consolidation Strategy and Programme, that will serve as a basis for political discussion and decision-making at the national, atoll and island levels. The selected alternative will be finalized following the process of review and consultation.

Planned activities and outcomes:

The project will consist of four main interrelated phases covering:

1- Output oriented review and analysis of databases and existing sources of information;

2- Thematic and issue-oriented studies and analysis;

3- Identification and evaluation of main population consolidation alternatives; and Elaboration of selected alternative and preparation of provisional investment priorities and guidelines.

Project 7.3

Project name: ***UPGRADING OF GAN AIRPORT FOR INTER NATIONAL OPERATIONS***

Upgrading the airport at Gan in Addu Atoll, for international operations would lead to higher use of the existing infrastructure at Gan airport. Increasing the international passenger and freight transport and communication lines, would facilitate faster atoll development. It would also enable uninterrupted international air traffic in case of a closure of the Male' International Airport, the only gateway to the Maldives.

Project rationale and objectives:

The proposed project has 2 main objectives, which are to:

1. *provide the infrastructure required for international medium to long haul aircraft charter operations; and*

2. *train the staff of government agencies responsible for providing aircraft handling, clearance, passenger handling, clearance, customs and security services.*

Expected outcomes:

The upgrading of the airport will have positive effects on efforts to achieve self-sustaining growth at Addu Atoll, adding to the attraction of the atoll for investors, especially in the tourism and garment sectors.

In addition, the Maldives will have an alternative international airport in the event of an accident or other events leading to the temporary closure of Male' International Airport.

Planned activities and outcomes:

1- *Upgrading the terminal building, including the terminal security service, to handle up to 350 passengers at one time.*

2- *Upgrading fuel storage facilities.*

3- *Equiping the airport with ground handling equipment, upgrading rescue and fire fighting services to CAT 7, and increasing the power generation capacity.*

Project 7.4

Project name: ***PROGRAMME FOR FISHERIES CONSERVATION MEASURES AND COMMUNITY-BASED REEF RESOURCE MANAGEMENT***

The nation's rapid social and economic change, combined with open access to coastal aquatic areas and the lack of sufficient management, is one of the main causes for environmental damage being inflicted on the nation's fragile resource base. The absence of an efficient strategy for managing reef resources is leading to a decline in catch rates throughout the country, especially in reef areas. The Government of the Maldives has taken many individual measures to protect marine life, often being ready to surrender short-term economic gains to ensure effective environment protection.

Project rationale and objectives:

The main objectives of the project are to:

1- *develop appropriate methodologies for assessing the biological impacts and cost effectiveness of fisheries conservation and management measures, such as closed areas for resource enhancement purposes;*

2- *conduct a baseline survey of areas identified for reef enhancement to continue a well developed monitoring programme; and*

3- *increase awareness of the fishing community and the general public about the importance of reef resource management.*

Expected outcomes:

1- *More consistent methodologies and a more systematic information base to develop Integrated Reef Resources Management related concepts of fisheries conservation and management.*

2- *Increased awareness among groups of the importance of reef resources and the need for their more effective management. This awareness should increase the feasibility of conservation and enhancement measures.*

3- *The methodologies and information base developed under the project will be replicated throughout the Maldives as a means for actively promoting community-based Integrated Reef Resources Management.*

Planned activities and outcomes:

The proposed project will have four distinctive components covering methodology development, baseline surveys of selected areas, and increasing public awareness and training of key personnel at the atoll and ministry levels.

1- *Development of appropriate methodologies for assessing of biological and economic affects of reef resource management measures.*

2- *A baseline survey will be conducted in Vaavu and Meemu atolls.*

3- *Support for the public awareness programme through the design of a fisheries information package that will be distributed to different population groups.*

4- *A series of training workshops at the atoll level as well as at the national level in the research, monitoring, surveillance and enforcement techniques associated with Integrated Reef Resources Management.*

Project 7.5

Project Name: ***DEVELOPMENT OF FOOD SECURITY IN THE MALDIVES***

Soil characteristics in the Maldives are major constraints towards the development of successful conventional agricultural production systems. Limited availability of arable land also suggests that an alternative crop production system should be looked into. Hydroponics is one method that can increase the production of agricultural products.

Project rationale and objectives:

Hydroponics agriculture in the Maldives on a sustainable basis, at a commercial and household level can improve food security and reduce dependence on imports of various types of vegetables and fruits. It will also enhance income and employment opportunities for the new generation in rural islands, and direct domestic investment towards promoting food security.

Expected outcomes:

- *Development of hydroponics production systems on a commercial scale; and*
- *Reduce dependence on imported vegetables and fruits to achieve accessibility and availability.*

Planned activities and outcomes:

1. *Train the staff already working in established hydroponics systems in Hanimaadhoo Agriculture Centre as trainers. The trainers will train the required staffs for the projects by using the training facilities in Hanimaadhoo Agriculture Centre.*

2. *Set up three greenhouses with hydroponics systems in three different regions of the country, each with a total built up area of 8,000 ft^2 or 2 unit of greenhouse with similar built area but each unit having four compartments of 1000 ft^2.*

Project 7.6

Project Name: ***THE USE OF INFILTRATION GALLERIES TO SUPPLY GROUND WATER IN THE ISLANDS***

Project rationale and objectives:

The groundwater in the islands of the Maldives is found in shallow and relatively thin water lens. In some islands, a large quantity of groundwater is pumped from a few wells in the island. Due to the high extraction rate and associated draw down effect, the pumped water becomes very saline. It becomes more saline in the dry periods as the demand for groundwater increases. Increasing the area available for extraction of groundwater can reduce the draw down effect and improve the quality of the supplied groundwater.

To develop an appropriate design system for centralised infiltration galleries to supply the fresh groundwater to meet the water demands for the island communities through out the year.

Expected outcomes:

A properly designed, constructed and operating infiltration gallery for extracting large amounts of freshwater from the water lens of the islands.

Planned activities and outcomes:

1. *Construction of a designed infiltration gallery in a densely populated island to supply groundwater.*

Project 7.7

Project Name: ***CLIMATIC INFLUENCES ON THE SPREAD AND TRANSMISSION OF VECTOR BORNE DISEASES***

Project rationale and objectives:

The vulnerability and adaptation assessment done on the effects of climate change on the health sector identifies vector borne diseases as an area where further research is required. Dengue and dengue hemorrhagic fever, both transmitted through vectors, have been identified as endemic in the country and in recent years morbidity has increased. Therefore, this project proposes to undertake a study with the main objectives to:

1. *systematically collect and manage climatic and health data for use in a climate impact analysis; and*
2. *undertake a study on the effects of climate change on the spread and transmission of vector borne diseases based on the collected data.*

Expected outcomes:

1. *Enhanced capacity at the Ministry of Health to undertake an analysis of the climatic influences on the spread and transmission of vector borne diseases.*
2. *Continuous, short term and long term reporting on the status of vector borne diseases in the Maldives.*

Planned activities and outcomes:

1. *Provide Ministry of Health with the technical capacity to undertake such a study.*
2. *Train Ministry of Health personnel in design, implementation and analysis of such a study. Specific trainings to be given on the use of GIS, data analysis and background on climate change and vector borne diseases.*
3. *Establish and maintain a database of vector borne diseases in a climate change context.*
4. *Ministry of Health to establish a network with the Department of Meteorology, and other environment related agencies, to incorporate relevant climate information into the health database.*
5. *Produce short term and long term reports on the effects of climate change on vector borne diseases in the Maldives.*

Project 7.8

Project Name: ALTERNATE/RENEWABLE ENERGY SOURCES FOR THE OUTER ISLANDS OF THE MALDIVES

This project is aimed to introduce renewable energy sources in outer islands and thus help the nation in achieving its objective of economic and social development. Demonstration projects will be run in one or more of the selected islands making appropriate reference to similar projects being run in other island nations.

Project rationale and objectives:

Although the Maldives does not contribute much to the production of GHGs, we will be one of the most effected places in the world when climate change occurs. Since the use of diesel in energy generation system is not environmentally sound, the Maldives is seeking alternative sources of energy that are environmentally sound and sustainable.

This project identifies the alternate power generation system(s) in the Maldives. The main focus of the project is aimed at producing energy with minimal emissions of GHGs and due consideration to price and social acceptability. The project investigates the current technologies for efficient energy generation with emphasis on cost and environmental factors. Finally, recommendations and futures scopes will be proposed. This project will provide alternate / renewable sources of energy such as solar energy, biogas and photovoltaic systems.

Expected outcomes:

1. *Provision of energy on a sustainable basis and at an affordable price.*
2. *Further savings on running costs like fuel and lubricants.*
3. *Minimisation of GHG emission.*
4. *Reduction of co-production of other sources of pollution such as noise and waste.*

Planned activities and outcomes:

1. *Carry out survey and campaign to estimate and reduce energy consumption from domestic use.*
2. *Review the ongoing atoll electrification programme.*
3. *Introduce renewable energy options as a source of energy to the industrial sector, resort owners and other related committees in the Maldives.*

Project 7.9

Project Name: ***THE USE OF SOLAR DISTILLATION AS A SOURCE OF FRESHWATER FOR OUTER ISLANDS AND MALE'***

This project is aimed at acquiring appropriate technology to provide freshwater to populated islands in the Maldives.

Project rationale and objectives:

Acquiring appropriate technology to provide portable freshwater to populated islands is a priority area identified in the NEAP II. The Maldives lies on the equator and receives on average seven hours of daily sunshine. Populated islands have limited space for harvested rainwater storage. The groundwater cannot meet the demand for water for these islands.

To acquire appropriate technologies for solar distillation for desalination as a source of freshwater, which can meet the demand in the dry season for the population of the islands.

Expected outcomes:

1. *The islands will have desalinated water as a source of water even in the dry season.*
2. *The amount of GHG emission will be reduced*
3. *The risk of diesel polluting the groundwater will be reduced.*
4. *The production of water would be less vulnerable to the fluctuating price of diesel.*

Planned activities and outcomes:

1. *Carry out a study on the water demand in the medium densely populated islands.*
2. *Quantifying the water demand, taking into consideration the increase of demand for water for the predicted climate change for the region.*
3. *Identifying the appropriate technology for the Maldives and educating the communities for their acceptance for the new technology.*

Project 7.10

Project Name: ***DEVELOPMENT OF SUSTAINABLE INTER-ISLAND SEA BASED MASS TRANSPORTATION SYSTEM***

One of the main sectors, which contribute to CO_2 emission, is the transport sector. The sea transport system, which currently exist, is not operated on a scheduled basis. The National Development Plan identifies regions to be developed as regional centres in the Maldives. Establishing a mass transportation network between these regions can develop a sustainable transport system in the Maldives.

Project rationale and objectives:

The development of a scheduled transport system would reduce the need for the ad hoc movement and has the potential to reduce the emission of carbon dioxide from the transport sector. Development of such network work would help to achieve the goals of sustainable development. The main objective of this project is to establish a mass transportation network for passengers and cargo between the regional centres in the country.

Expected outcomes:

1. *Availability of goods and services to far away islands.*
2. *Reduction of GHG emissions in the transport sector.*

Planned activities and outcomes:

1. *Build up to nine harbours across the nation, with the capacities to handle cargo and accommodate passangers.*
2. *Establish a feeder service from neighbouring islands to the harbours using the existing fleet of small dhonis and vessels.*
3. *Select medium size vessels from the existing fleet to establish an intra-harbour network*
4. *Obtain efficient, large, fast ferries to set up a national ferry service network.*

Project 7.11

Project Name: ***DEVELOPMENT OF SEWAGE TREATMENT FACILITIES***

The current system of sewage disposal constitutes a serious threat to prospects for sustainable development and, in many densely populated islands, it has become a critical problem.

One of the few sewerage systems that exist in the Maldives is the sewerage system on Malé. This system consists of nine pumping stations that pump untreated sewage into the sea. Growing population pressures in Malé combined with the technical deficiencies in the present system, pose increasing serious threats to public health, ecologically fragile ecosystems and marine life in coastal areas.

Project rationale and objectives:

The present GHG inventory does not account for the production of methane from sewage treatment, as sewage is not treated in the Maldives. Sewage contributes to the emission of national GHG and the development of sewage treatment facilities would reduce the emission of GHGs.

The main objectives of this project are to review different technological alternatives for raw sewage treatment with methane recovery capabilities and to design the model that would provide the best long-term solution for sewage disposal for the islands of the Maldives.

Expected outcomes:

Establishment of proper sewage treatment facilities with methane recovery units in the densely populated islands.

Planned activities and outcomes:

1. *Carry out a review of different technologies available for the sewage treatment for the Maldives.*
2. *Survey the densely populated islands to design an appropriate sewerage treatment facility.*
3. *Carry out an education campaign to address the issue of conserving water.*

Project 7.12

Project Name: ***THE INTEGRATED WASTE MANAGEMENT SYSTEM DESIGNED TO MITIGATE GHG EMISSIONS***

An integrated waste management system has been identified in the National Development Plan and NEAP II as a national priority. An integrated waste management system will improve the existing methods of solid waste disposal thereby not only reducing GHG emissions into the atmosphere, but also improving the quality of the environment.

Project rationale and objectives:

The small size of the islands, the rapid growth in population and changing consumption patterns has increased the problem of solid waste management in the Maldives. The lack of effective solid waste disposal methods has caused serious constraints to sustainable development. The GHG inventory of the Maldives has identified that 0.061 tonnes of methane were produced in 1994 from solid waste disposal.

The main objectives of this project include removing the barriers to implementing an environmentally sound and sustainable integrated waste management system for the Maldives. This is achieved by reducing waste generation by creating awareness on the value of resource use reduction, reuse and recycling. Also, the introduction of effective disposal methods with methane recovery will reduce the emission of GHGs.

Expected outcomes:

The reduction of GHG emissions, as a result of reduced volumes of waste being sent to landfill, more environmentally sound management of waste and the operation of methane recovery and processing systems at key landfill sites.

Planned activities and outcomes:

1. *Carry out a waste survey to assess the composition of the waste stream and identify the amounts that can be reduced, reused and recycled.*
2. *Carry out a waste survey to assess the solid waste disposal problems and opportunities in the inhabited islands, tourist resorts and industrial islands.*
3. *Identify locations for regional disposal areas and waste transfer facilities in the atolls and islands.*

4. *Develop fiscal and policy incentives and other measures to encourage importation of environment friendly products and minimal waste or degradable waste content.*

5. *Design and develop regional landfills with appropriate technology to recover and use the methane produced.*

6. *Design transfer stations in islands and transport the waste from the islands to the central landfill.*

7. *Formulate and implement public awareness and education campaigns through the grass root organisations such as the Island Development Committees, designed to enhance local recognition of the value of reducing and re-using waste.*

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