State of the Environment

Maldives

2002

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FOREWORD

Executive Director
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United Nations Environment Programme (UNEP) is mandated to assess regularly the major environmental developments and trends at global level. The publication of the Global Environmental Outlook series, GEO-1, followed by GEO-2000, the Millennium Report on the Environment, and the most recent one, GEO-3 - Past, Present and Future Perspectives involved participatory assessment process to review the state of the world's environment and to chart a new process for global environmental policy. The diversity and magnitude of environmental problems are outlined, with a call for more complete and precise analyses of the poorly understood linkages between human actions and environmental outcomes. Although the number of policy responses is growing, low priority continues to be afforded to the environment in national and regional planning. GEO-3 stressed the need for improving policy performance monitoring at the international level and within the civil society; strengthening international environmental legislation and compliance; changing trade patterns to benefit the environment; harnessing technology for the environment; valuing environmental goods and services; and participatory resource management through strategic partnership between governments, communities, the private sector and NGOs.

While GEO-3 report provided an opportune brief for the 2002 World Summit on Sustainable Development (WSSD) recently held in Johannesburg, South Africa, the preparation process for State of the Environment of Maldives-2002 was also timed to facilitate the national input and contribution to the Summit.

In 1998, the UNEP Regional Resource Centre for Asia-Pacific (UNEP RRC.AP) collaborated with the Norwegian Agency for Development Cooperation (NORAD) to carry out a process on Strengthening National Capabilities on Environment Assessment and Monitoring towards enhancing the input for the global assessment, thus linking national to regional and global initiatives. The Ministry of Home Affairs, Housing and Environment, which is the national implementing agency, has played a very crucial role in carrying out this participatory assessment process soliciting input from various government sectoral agencies and research institutions. Around 20 agencies and over 40 individuals were involved and contributed in the process.

This State of the Environment (SoE) Report of Maldives 2002 is one of the seven national reports prepared under the above process, focusing on two Asia-Pacific subregions, namely South Asia (Bangladesh, Bhutan, Maldives, Nepal and Sri Lanka) and the Greater Mekong Subregions (Lao PDR and Vietnam). The report presents the critical challenges that the people of Maldives face in safeguarding their environment and moving towards a sustainable future.

The report aims at providing guidelines for environmental action planning, policy setting and resource allocation for the coming decades, based on a sound analysis of the state of, and trends in, the nation's environment. Five priority key issues for the state of environment report for Maldives that have been identified in consultation with the Ministry of Home Affairs, Housing and Environment and analyzed following "pressure-state-impact- response" (PSIR) analytical framework are: (1) climate change, (2) waste disposal, (3) freshwater, (4) air pollution, and (5) biodiversity conservation.

Even though the Maldives contributes less than 0.01% to global emission of GHGs, the Maldives is in fact one of the most vulnerable countries to climate change and sea level rise. The seven main areas of vulnerability to climate change observed are land loss and beach erosion, infrastructure damage, damage to coral reefs, impact on the economy, food security, water resources, and human health. Local air pollution in Malé, has become a growing concern, but the air quality of the Maldives is mainly affected by transboundary air pollution.

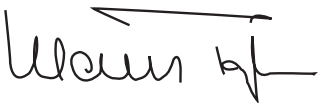
The management of solid waste has been emerged as a critical issue. Inadequate facilities to deal with solid wastes, besides access to safe water and sanitation, have hampered basic societal structure. Where freshwater is already a very scare resource, the superficial hydrogeology of groundwater aquifers have been contaminated by sewage, chemicals, and pathogens. Improper sewage disposal facilities have resulted poor groundwater quality.

While marine biodiversity is the most significant and vital resource base for the country, the livelihood has traditionally been marine based putting tremendous pressure on marine resources. The marine resources continue to be the main generator of food, earnings, employment, and shelter. Coral mining for housing construction and high demand in the international market for certain reef species has exerted enormous pressure on the islands biodiversity. Mining of corals have also resulted considerable amount of beach erosion and other adverse environmental impacts such as migration of residential reef fish communities and other living organisms.

While natural resource base such as coastal and marine resources and the tourism provide a great opportunity for economic development and prosperity in Maldives, there is a need of considering appropriate policy packages, determined actions, and ecologically sound technologies, to ensure environmental security and sustainability for the present as well as future generations.

We hope this assessment will provide a sound basis for the development of action plans, the next stage of the planning process, policy setting and resource allocation for the coming decades to improve the state of the environment of Maldives and the welfare of her people, as we progress in the twenty-first century.

UNEP will continue to provide leadership in the region for the preparation of environmental assessment reports at national, sub-regional, and regional level and the capacity building necessary to support these assessment activities.



Klaus Töpfer
United Nations Under-Secretary General and Executive Director
United Nations Environment Programme
September 2002

FOREWORD

Honourable Ismail Shafeeu
Minister of Home Affairs, Housing and Environment

This State of the Environment Report explores the environmental conditions in the Maldives now and proposes response measures that will serve the well-being of citizens in the future. There is of course no single indicator by which the health of the environment of Maldives can be assessed. However, there are several indicators of environmental conditions upon which there is universal agreement, which collectively reflect to a high degree of certainty the state of the environment in a locality, a region or a nation. This report presents several such key indicators from which decision makers and the public can derive answers to many of the questions they may have. This report presents data and graphs that make clear the state of our critical environmental assets at this time: the air, land, sea and biodiversity. The evidence presented in this report illustrates how population growth and human activities are impacting on the environment and provide an indication of the causes of both positive and negative changes in the state of the environment. The report also contains policy options and possible responses to changes in the state of the environment and indicates the willingness and effectiveness of the government and society in providing responses.

The vulnerability of Maldives to global climate change and related consequences is highlighted in the report as one of the critical issues that need to be urgently addressed. Along with climate change, beach erosion is identified as a priority environment issue and its impacts on the inhabitants of the islands, the infrastructure of the islands as well as on the major economic activities of tourism and fisheries, are highlighted in this report.
This State of the Environment Report, in its recommendations, calls for strengthening of integrated planning and administrative practices by developing principles and procedures for sustainable resource use and environmental protection.

The State of the Environment Report process was generously financed by the Norwegian Agency for Development Cooperation (NORAD). The Ministry of Home Affairs, Housing and Environment is very grateful to NORAD for this support. The Ministry also extends its appreciation to UNEP and SACEP for the advice and technical support in bringing this publication to being.

At present, the Government of Maldives is making critical investments in economic growth, social development and the environment to realise the Vision 2020 declared by His Excellency President Maumoon Abdul Gayoom. The policies and strategies of Vision 2020 are based on the knowledge that development will need to be sustainable and that investments are effective only when an integrated approach to development is adopted. This State of the Environment report presents a snapshot of the present and forecasts future challenges Maldives must rise to, for us to achieve a truly sustainable development and thus realise the goals of Vision 2020.

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PART I EXECUTIVE SUMMARY

The Maldives' State of the Environment report addresses a number of priority issues pertaining to the country's environment. The selected priority issues are: climate change and sea level rise; freshwater resources; management of solid waste and sewage; air pollution; and biological diversity conservation. The environmental protection policy of the Maldives is articulated in the National Environment Action Plan (NEAP) and the second National Environment Action Plan. (NEAP-II). The principal aims of the NEAP are to "protect and preserve the environment of the Maldives, and to sustainably manage its resources for the collective benefit and enjoyment of present and future generations".

Since the first National Environment Action Plan, the Maldives has achieved considerable progress in environmental protection and management. The greatest progress has been made in establishing the regulatory and institutional framework for environmental protection through the enactment of the *Environment Protection and Preservation Act* in April 1993. NEAP-II, released by the Ministry of Home Affairs, Housing and Environment in 1999, is the comprehensive framework that will be used for the next six years to ensure environmental protection and sustainable development in the Maldives. The priority issues that are identified in this report are also identified in NEAP-II as *"the principal and immediate issues identified as present priority in the consultations for NEAP - II".*

Although these five issues have been identified as being priority issues, a number of other socio-economic development issues that affect the environment are also addressed in this report. As in any other country, the pressures of population growth, urbanisation and housing, water and energy use, transport, fisheries, agriculture and tourism, and their effects on the environment are critically evaluated in this report. In addition, the environment of the Maldives, including the country's resources, the weather and climate and biodiversity are also described herewith.

The socio-economic development of the Maldives during the past 25 years has been truly remarkable. While the traditional mainstay of tuna-fishery has developed and diversified, the relatively new industry of tourism has taken its place as the major foreign currency earning source. The development of both these industries has, however, not come at the expense of the fragile environment of the country. Both fisheries and tourism are inseparably linked to the country's marine environment.

The Government of the Maldives places paramount importance on sustainable development, while enforcing strong regulatory measures to protect and preserve the environment.

The vision for environmental protection and preservation in the country, as stated in the "Vision 2020 of the Maldives" is:

"Maldivians will be able to take sufficient protective measures against the threats posed to the country as a result of global ecological degradation.They will be pursuing environmentally-friendly lifestyles with the aid of modern technology."

Environmental policy in the Maldives has gradually moved from a sector-based approach to one which is more integrated. All relevant Government Ministries today have an environment unit. The environmental impacts of each and every major developmental project are assessed carefully. The high degree of awareness among the people and the priority attached to the environment was personified by the President, in his address at the Asia-Pacific Ministers' Conference on Tourism and Environment in Malé, on 16 February 1997[1].

> *"The protection and preservation of the environment is a matter to which Maldivians of all walks of life attach great importance. This was demonstrated by the high level of public involvement and support for the Independent Maldives - Clean Maldives campaign and for the three-year programme to plant one-million trees, both of which were launched last year.*

[1] Gayoom, M. A. (1998)- "Maldives - a Nation in Peril", pg.89-90.

Such public concern for conservation has no doubt contributed to the success of various measures taken to protect the environment. We have, for example, designated certain marine areas as protected zones. Although turtles and dolphins live in abundance in our waters, they have been declared protected species. In order to maintain exploitation at a sustainable level, export of certain marine species, such as eels ad rays, is prohibited. Coral-mining and sand-mining have been banned in several areas. The Law on the Protection and Preservation of the Environment provides additional safeguards and protection against ecological degradation.

Despite our sensitivity to conservation, we are unable to overcome the special vulnerability of an island eco-system. We are faced with a gradual decline in the diversity of our flora and fauna."

Being a small island nation comprising of approximately 1,190 tiny low-lying coral islands, the Maldives is one of the most vulnerable to the peril of sea level rise. Without timely and concrete global efforts to curb greenhouse gases emissions levels, the Maldives could face inundation, even before the turn of this century. The irony is that, the levels of greenhouse gases that the Maldives emits are negligible, yet the country could face the brunt of the effects of climate change and sea level rise. Being a small developing nation, the challenges posed by climate change can only be confronted with the assistance and cooperation of the international community. The Maldives has been an active member of the international community and is regarded as the voice of small island states. President Gayoom has tirelessly campaigned for the security of small island states for over 15 years, and climate change and sea level rise are the toughest challenges facing the security of these countries. Thus, while domestic action to protect and preserve the environment has been coupled with active participation and vociferous campaigning at a global level.

The Maldives has achieved much in the way of environmental protection and preservation, especially in the last 15 years, however, numerous priority issues remain to be addressed adequately. This report identifies 5 key issues and analyses them using pressure-state-impact-response (P-S-I-R) framework. The report also recommends the necessary policy initiatives to address these issues

Part II

OVERVIEW OF MAJOR ENVIRONMENTAL DEVELOPMENTS AND TRENDS

PART II OVERVIEW OF MAJOR ENVIRONMENTAL DEVELOPMENTS AND TRENDS

The environment of the Maldives is extremely fragile and vulnerable to a number of domestic and external threats. The major issues faced by the Maldives in the area of environmental protection and preservation, which have been identified are: climate change and sea level rise, coastal zone management, biological diversity conservation, integrated reef resources management, integrated water resources management, management of solid waste and sewage, air pollution, management of hazardous waste, sustainable tourism development, land resources management and sustainable agriculture, and human settlement and urbanisation.

Over the past decade, a substantial amount of resources have been expended on environmental protection. While the measures that were taken have contributed to minimizing the severity of domestic threats, there remains a lot more to be done to preserve and protect country's environment. Furthermore, global environment issues, such as global warming and climate change, are serious threats to the very survival of the Maldives. These global problems require global solutions and the Maldives has been actively participating in various global and international forums and policy dialogues in search of appropriate solutions.

2.1 SOCIO-ECONOMIC DEVELOPMENT

2.1.1 Population

The relationship between population and the environment lies in the increased demand for resources as population grows. Though such relationships are complex and cannot be generalized, it is important to recognize the impacts that this increased demand for resources can have on the environment, as the population increases.

Population censuses have been regularly undertaken in the Maldives since 1910 and accurate data on the growth and distribution of population in the Maldives are available (figure 2.1). Over the last five years, the population of the Maldives has grown from 244,814 in 1995 to 270,101 in 2000, which reflects an increase of approximately 10%. The population of Malé in the same period increased from 62,519 to 74,069, and that of the Atolls increased from 182, 295 to 196,032.

Even though population is increasing, the growth rate of population is in fact declining. The population growth rate of the country declined from 2.79% per annum, over the census period 1990 to 1995, to 1.96%

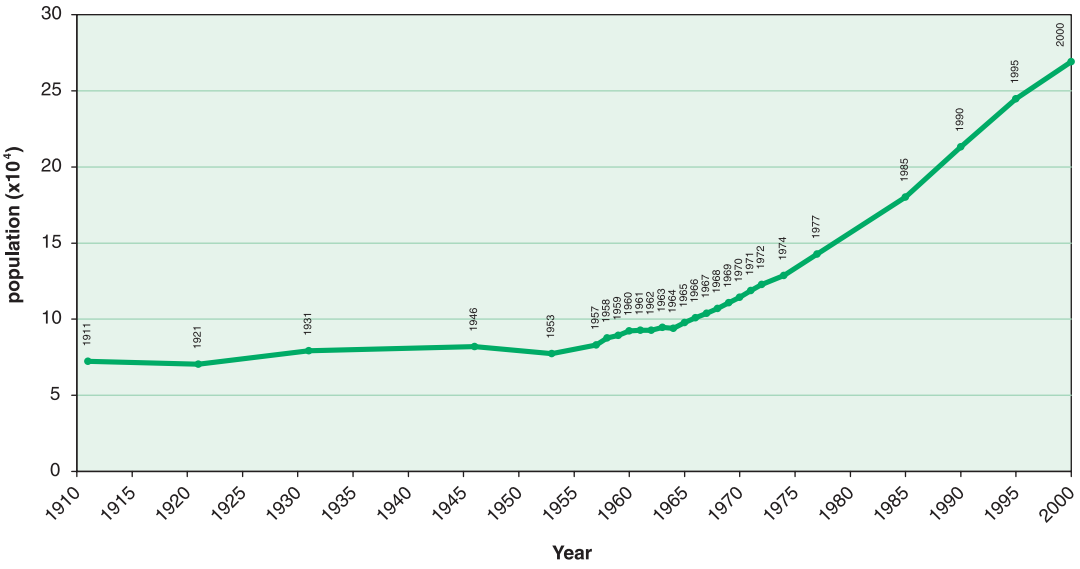


Figure 2.1: *The population of the Maldives (1911-2000)*

per annum, over the period 1995 to 2000. Though the national population growth is declining, there is a significant increase in the population growth rate of Malé, which has risen from 2.5% in 1995 to 3.4% in 2000.

Along with the changing population growth rates, there have been significant changes in the population structure over the last census period: 1995 to 2000 (figure 2.2). The changes in the age profile of the population show that approximately 50 % of the total population was between 15 and 64 years in 1995, and the population within the same age group had increased to 55%, in 2000. The percentage of the population below 15 years of age has declined from 46.40% in 1995 to 40.70% in 2000 (Census 2000). The sex ratio defined as males per 100 females has remained relatively constant. The 1995 estimate of total population was 124,622 males and 120,192 females, which was a ratio of 103. The 2000 estimate of total population was 137,200 males and 132,901 females, which was a ratio of 103.23 (Census 2000).

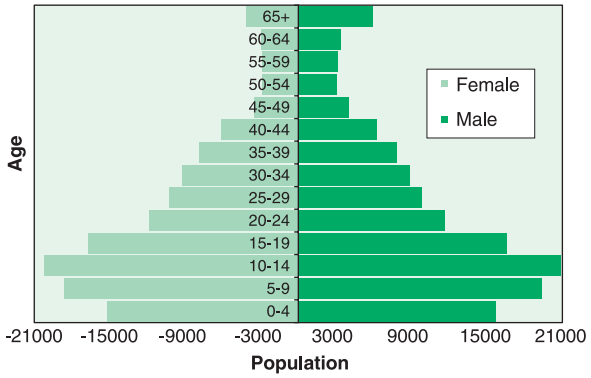


Figure 2.2: *Population structure in 2000.*

The Maldives has an extremely literate population; the adult literacy rate is 98.19%. The student enrolment numbers in educational institutions has been increasing as well. Figure 2.3 shows student enrolment in educational institutions over the last six years. Table 2.1 shows enrolment in Malé and the atolls by sex.

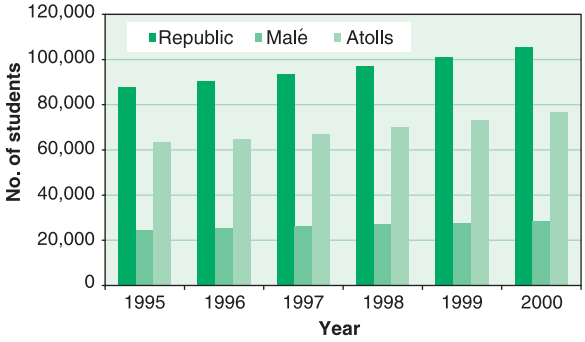


Figure 2.3: *School enrolment in 2000*
Source: *Statistical Year Book 2001*

Table 2.1: School enrolment by sex

	1999		2000	
	Male	Female	Male	Female
Republic	51,394	49,687	53,455	51,901
Malé	14,041	13,673	14,341	14,206
Atolls	37,353	36,014	39,114	37,695

Source: *Educational Statistics 2000*

In 1995, 44% of the population of 12 years of age and over was economically active, and in 2000 it was 48%.

An important observation is that expatriates form a significant portion of the labour force in the Maldives. In 1995, 21.7 % of the total labour force amounting to 18,510 were expatriates, and in 2000, there were 27,716 expatriates employed. In 2000, 30.9% of the expatriates were employed in the tourism industry.

In the Maldives, the geographic distribution of population is unequal and density among the atolls and the islands differs greatly across the country. At present, over a quarter of the population, 27.4% (74,069) live in Malé (MPND 2000). Addu Atoll has the next highest population at 18,515, while Vaavu Atoll has the smallest population at 1,753 (Census 2000). There are only three islands that have a population greater than 5,000. They

are Kulhudhufushi (6,581), Fuvahmulah (7,528) and Hithadhoo (9,461). On the other hand, there are eleven islands with populations less than 200. The overall distribution of population over the 199 inhabited islands is shown in figure 2.4. 54 islands have a population between 1000 and 5000 people, 66 islands between 500 and 1,000 people and 76 islands have a population less than 500 people (Statistical Yearbook 2001).

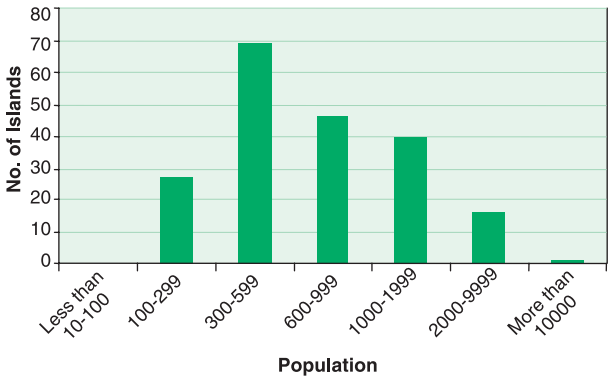


Figure 2.4: *Population distribution on inhabited islands*

In terms of population density, the most densely populated atoll is Vaavu Atoll with a population density of 41.84 persons/ha and population density is lowest in Laamu Atoll with 8.7 persons/ha. At the island level, the highest recorded population density is in Kandholhudhoo in Raa Atoll with 617.5 persons/ha, and lowest is Maafilaafushi in Lhaviyani Atoll with 2.20 persons/ha. Maafilaafushi, with a population of only 108, is the least-populated inhabited island in the country. The capital Malé has a density of approximately 383.77 persons/ha. The ten most populated islands, and the ten least populated islands, and their densities are given in tables 2.2 and 2.3 respectively.

The significance of these statistics and trends for creating environmental pressures are clear. If the trend towards growing populations on a limited number of islands continues, increasing pressure will be placed on the natural resources of those islands. A clear example of this kind of pressure is Malé, where the population has more than doubled in less than 25 years from 29,522 in 1977 to 74,069 in 2000. Although infrastructure improvements in Malé such as a sewerage system and a desalinated water supply system have reduced environmental pressures in recent years, previous groundwater over-extraction, sewage disposal and waste disposal have resulted in a severely depleted and contaminated aquifer with possibly irrecoverable damage. The lack of space for housing, social services and recreation, and severe social strains due to overcrowding have become issues that are directly related to the rapid growth of population in Malé.

Table 2.2: Ten most populated islands and densities in 2000

Island	Atoll	Population	Population density (persons/ha)
Malé	-	74,069	383.77
Hithadhoo	Addu	9,461	20.25
Fuvahmulah	Fuvahmulah	7,528	17.92
Kulhudhuffushi	Thiladhunmathi dhekunuburi	6,581	38.22
Thinadhoo	Huvadhu atholhu dhekunu buri	4,893	84.22
Naifaru	Faadhippolhu	3,707	259.78
Hinnavaru	Faadhippolhu	3212	443.65
Feydhoo	Addu	2,829	60.61
Dhidhdhoo	Thiladhunmathi uthuruburi	2,766	54.63
Kandholhudhoo	Maalhosmadulu uthuruburi	2,717	617.5

Source: *Statistical Yearbook 2001*

Table 2.3: Ten least populated islands in 2000

Island	Atoll	Population	Population density (persons/ha)
Maafilaafushi	Faadhippolhu	108	2.20
Dhidhdhoo	South Ari Atoll	113	8.43
Thinadhoo	Felidhu Atoll	114	12.53
Madifushi	Mulakatholhu	122	11.19
Berinmadhoo	North Thiladhunmathi	124	8.50
Dhiyadhoo	North Huvadhu Atoll	139	2.85
Fehendhoo	South Maalhosmadulu	149	7.23
Hathifushi	North Thiladhunmathi	150	36.59
Faridhoo	South Thiladhunmathi	159	6.83
Raiymandhoo	Mulakatholhu	171	7.92

Source: *Statistical Year Book 2001*

2.1.2 Households, housing and human settlements

In terms of possible pressures on environmental resources, the demand for some resources such as water, energy, construction materials and possibly independent means of transport are more related to the number of households than the number of people. The demand for additional housing also places pressure on vegetation and development on environmentally sensitive areas such as near beaches.

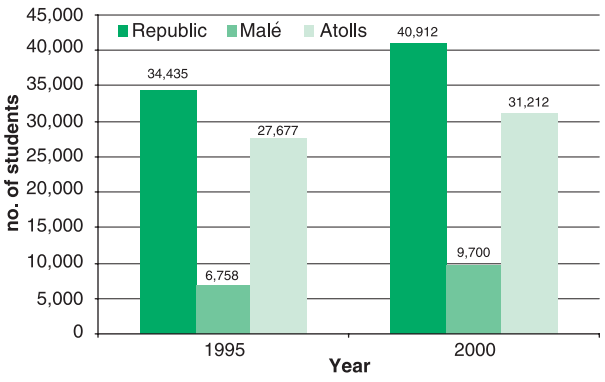


Figure 2.5: *Increase in the number of households*

Figure 2.5 shows the increase in households between 1995 and 2000. The total number of households increased from 34, 435 in 1995 to 40,912 in 2000 (figure 2.5). In Malé it increased from 6,758 to 9,700 and in the atolls, there was an increase from 27,677 to 31, 212 in the same period. Even though the number of households has increased significantly, there has been no significant change in the average household size for the same period. Between 1995 and 2000, the average household size for Malé has been 9 and 8 respectively. It is estimated that over the census period 1995 to 2000, the number of households increased at a faster rate (19%) than the increase in population (10%) reflecting a lifestyle change of people wanting to live in nuclear families rather than extended families. By the year 2020, the population of Maldives is projected to reach the half million mark. If the present distribution of population remains constant, an estimated additional 180,000 people need to be absorbed within the settlements of the atolls and almost 60,000 people will need to be added to Malé, the already dense capital of the country. With the number of households projected to increase at a faster rate than the population growth such an increase in population will have significant pressures on the resources in the Maldives.

It has also to be noted that the increase in the number of households and the population in the past have placed significant burden on the environment in densely populated islands. The starkest example of this is in Malé. The original land area of Malé covered about 100 hectares and in 1969 Malé had only 13336 people with a density of 133.36 persons per hectare. Since 1970s, there has been a rapid increase in the population and number of households in Malé. To cater for the additional households in Malé, a land reclamation programme was initiated in the south west lagoon and the land area of Malé was almost doubled to 192 hectares. But even with the doubling of land area the density has reached nearly 400 persons per hectare in 2000 with a population of about 74,069 Maldivians and several thousand expatriates. Given the land shortage, the land inheritance and subdivision patterns in Malé, housing plots have become smaller and smaller. The Malé Municipality restricts subdivision to a minimum plot size of 55.74 m^2 but in the past there have been instances of plots divided into 35 m^2. Municipality regulations also restrict heights of buildings to 10 floors or 30.48m. As a result, Malé has become divided into very small housing plots, consisting of extremely narrow buildings rising to several floors.

There are several other islands confronted with similar problems of overcrowding and congestion as in Malé. A total of 35 out of 200 inhabited islands have a density equal to or more than 50 persons per hectare. Six islands were recorded to have densities in excess of 200 persons per hectare. In Kandholhudhoo island in Raa Atoll, 2717 people live on 4.4 hectares at an estimated density of 617.5 persons/ha. In some overcrowded islands, virtually all land is occupied leaving no space for roads and recreational infrastructure.

While overcrowding and congestion remains a serious problem, the predominant problem in the atolls is housing. Housing development has taken place in the islands in two ways: by the allocation of housing plots by the government for construction of houses, and by allocation of housing in selected uninhabited islands where population has to be resettled due to problems like absence of additional land, high density or environmental vulnerability. In the first instance, housing development takes place on the initiative of the families themselves. There is no housing finance system to obtain credit or an organized provision of building materials. The house builder has to purchase and transport the building materials, and find his own finance. As a result, housing conditions in most islands and in all overcrowded islands are of poor quality. They are too small in size relative to the number of inhabitants, poor in the quality of construction and poor in accessibility to services especially water and sanitation. In the second category, housing is constructed and provided to the new settlers by the government.

Undoubtedly, there are both social and environmental consequences of such housing conditions. In some extreme instances, families have been forced to undertake their domestic chores like washing in the streets because no space is available within their houses. In many islands, roads have been reduced to narrow paths between over-extended houses. It is reported that residents of some overcrowded islands like Raa Atoll Kandholhudhoo had to travel for over one and half hours by dhoni to nearby uninhabited islands to obtain their day's supply of drinking water during dry periods. In Lhaviyani Atoll Hinnavaru, the settlement resembles a rabbit warren, with small houses and narrow paths running between them. An average house in some of the overcrowded islands accommodates over 12 persons excluding small children. However, the standards of cleanliness in even the most crowded settlements are impressive. Unclean drains, collection of wastewater, or use of roads for dumping of waste do not exist.

The impact on the environment due to the housing problems discussed above is quite severe. In many islands, demand for housing plots increases with the expansion of the population. Natural vegetation is cleared for settlement and infrastructure. In islands like Kandholhudhoo, Naifaru, Hinnavvaru, and Kihaadhoo, it is reported that the number of trees has fallen below a sustainable level, forcing the authorities to embark on tree planting exercises to replenish the vegetation stock.

2.1.3 Water use

In Malé and other islands the rapidly expanding population coupled with the changing culture of more use of fresh water has exacerbated the problems associated with the supply of water. Water usage has been far greater than the natural rate at which the aquifer is recharged. In Malé, for instance, the lens has dwindled from over 30 meter of depth in the 1970s to a mere meter to date, and the water is totally unfit for drinking or cooking. The households of Malé are now supplied with desalinated water. Since the introduction of the piped desalinated water network, the groundwater seems to have improved in different areas of Malé.

2.1.4 Energy use

In the Maldives, pressures on the environment from the energy sector arise from the generation and use of energy. According to the first Greenhouse Gas Inventory of the Maldives, it is estimated that 129 Gg of carbon dioxide was emitted to the atmosphere by the energy sector in the Maldives in 1994. This amounts to 0.54 tonnes of CO_2 per capita (MHAHE 2001). However, a very significant number of inhabited islands still do not have access to 24 hour electricity. In 1998, more than 60 islands had electricity for 24 hours, accounting for only 55% of the population (MPND & UNDP, 1998).

There is a marked imbalance in the usage of electricity between Mal? and atolls. In 2000, 14,920 MT of diesel were consumed to produce 90,479,023 KWH of electricity in Malé by State Electric Company Limited (STELCO), while in the atolls 26,421 MT of diesel was consumed to generate 116,512,316 Kwh of electricity by STELCO. The demand for electricity is on the rise as it can be interpreted from the graph on the supply of electricity (figure 2.6) (MPND 2001). Diesel is the main fuel type consumed to meet the energy demand in the Maldives. In 2000, 138760 MT of diesel were imported to the Maldives and electricity production by STELCO owned power houses consumed 30% of the imported diesel fuel. Data on the generation of electricity in the resorts, private and community generated electricity in the islands are not available.

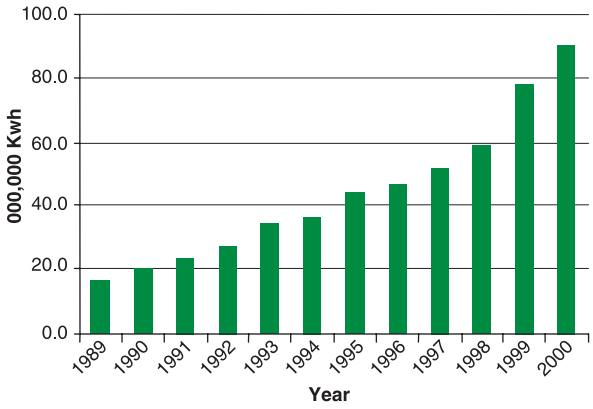


Figure 2.6: *Electricity Utilisation in Malé*
Source: *Ministry of Planning and National Development ,2001*

Firewood, kerosene and liquid petroleum gas (LPG) 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 2000 the figure dropped to 54%. To balance out this large drop, the use of kerosene for cooking increased. In 1990, only 6% of the population used kerosene for cooking while in 2000, 42% of the atoll population used kerosene for cooking (MPND, 2001). LPG is mainly used in Malé and in 2000, 52% of population in Malé used LPG for cooking, while in the atolls 4 % depended on LPG for cooking. In 1994, 3.4 Kt of LPG were used in the Maldives.

2.1.5 Transport

The isolated inhabited islands and resorts are linked by the air and sea transportation system existing in the Maldives. Air transportation consists of a network developed on the four regional airports and the Malé International Airport and a seaplane network operated in the central region of the country. The seaplane network caters mainly for the tourism industry. In 2000, 59,366 domestic passengers travelled between the regional airports on 2,183 flights. In 2000, the seaplane network carried 515,949 tourists and operated 41,291 flights (MPND 2001). The domestic air transportation sector is developing fast and the total domestic passenger

movement has increased to 575,315 in 2000 from 85,017 in 1994, (MPND 2001).

Sea transportation is still the largest mode of transportation in the country. In 2000, more than 9,372 vessels were registered and operated in the Maldives (MPND, 2001). The major transportation is between islands and Malé and between Malé and the growth centres in the atolls. It was found that 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 islands of the Maldives are well protected naturally by house reefs. This reduces the accessibility of the island by boats. In order to facilitate sea transport, the lagoons of many inhabited islands have been dredged to develop harbours. From 1995 to 2000, the lagoons of at least 53 islands have been dredged. Dredging of lagoons have pressures on environment such as loss of natural habitat, destruction of shallow lagoons, sea grass and reef flat communities and adversely affects nearby coral reef communities through suspended sediments.

2.1.6 Fisheries

The fisheries sector is extremely important in the economy since it forms the bulk of exports and is the second largest contributor to the national GDP (Table 2.4). The share of fisheries in GDP has declined further in the past 6 years from 7.8% in 1988 to around 6.0% in 2000. However, total recorded fish catch increased from 104,472 metric tons in 1995 to 118,964 metric tons in 2000 (MPND 2000). Total revenue from export of marine products was 481 million Rufiya in 2000 (MOFAMR, 2000).

Table 2.4: Fisheries Contribution to GDP (1995 -2000)

Year	% Share of Fisheries Contribution
1995	7.8
1996	7.3
1997	6.7
1998	6.7
1999	6.5
2000	6.1

Source: *Ministry of Planning and National Development, 2001*

Fishing is an economic activity that has direct impact on marine biodiversity. Fishing is widespread throughout the archipelago and local fishing practices form a large part of the traditional lifestyle. Tuna and tuna-related species comprise over 85% of the total fish catch. In the year 2000, out of the 118,963 metric tons of fish catch, tuna and tuna related species comprised 101,728 metric tons (figure 2.7).

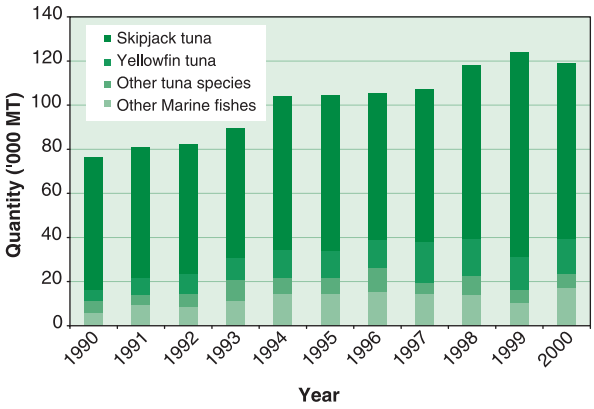


Figure 2.7: *Composition of fish catch (1990-2000)*
Source: *Ministry of Planning and National Development, 2001*

Tuna species, especially skipjack and yellowfin tuna which form the greater part of Maldivian catch, are highly migratory and thus stock status is not affected by Maldivian fisheries alone. The Indian Ocean skipjack tuna stocks are generally believed to be large (Adam and Anderson, 1996). However, some researchers are pointing to signs of potential problems in the skipjack resources that are being exploited by the Maldivian fishery. These indications include, decline in both Maldivian skipjack catch rates and average size of fish (Adam and Anderson, 1996 and Anderson, 1997).

Baitfish fishery is directly related to the tuna fishery in the Maldives. Small species of fish that school close to the reef are targeted as bait fish for the tuna fishery. The most commonly used variety of bait fish is the silver sprats (Table 2.5).

Table 2.5: Varieties most commonly used live bait in order of quantity used

Spratelloides gracilis	Silver Sprats
Apogonidae	Cardinal fishes
Caesionidae	Fusiliers
Other species include:	
Spratelloides delicatulus	Blue Sprats
Engraulidae	Anchovies

Source: *Anderson, 1997*

The status of the stocks of live bait species is not known. However they do not seem to be over fished (Anderson 1997). The total catch and catch rate of live bait species have increased greatly in recent years (Table 2.6) as a result of an increase in tuna fishing effort and increase in the quantity of bait used per day (Anderson, 1997).

Table 2.6: Estimated quantities of live bait used annually in the pole and line tuna fishery

Time Period	Live bait Used
1978-1981	3000 ± 800 t
1985-1987	4800 ± 1200 t
1993	10500 ± 2600 t
	10600 ± 2700 t

Source: *Anderson, 1997*

Table 2.7: Agricultural Contribution to GDP (1995 - 2000)

Year	% Share of Agricultural Contribution
1995	3.6
1996	3.4
1997	3.2
1998	3.0
1999	2.8
2000	2.8

Source: *Ministry of Planning and National Development, 2001*

2.1.7 Agriculture and Timber

Since soils are poor and land for agriculture is scarce in the Maldives, agricultural production is low. Unlike many other developing countries, agriculture's share of GDP is low (Table 2.7), declining from 3.6% in 1995 to 2.8% in 2000 (Census 2000).

The most widely grown agricultural product in the Maldives is coconut. Coconut production in 2000 was about 18 million (Census 2000). Some islands grow root crops such as taro, cassava and sweet potato as well as other crops such as banana, papaya, watermelon, melon, mango, cucumber, pumpkin, betel leaves, chillies, limes, breadfruit and egg plant. Some of these crops are now grown commercially at islands leased on long term basis for agriculture. Nonetheless, almost all of these are subsistence crops.

There is strong demand for locally grown agricultural products, both from tourist resorts and from an expanding local population. It has been estimated that the total arable land area is less than 30 square kilometres, with production limited to 60 specially designated agricultural islands (MPND 1998).

The threat to biological diversity from agriculture is the clearance of natural vegetation and resultant destruction of habitat and reduction in natural vegetation. In addition, increased use of chemical fertilizers in agriculture has potential to adversely affect the groundwater resources.

Introduction of pests and diseases through imported fruits, vegetables and agricultural products such as fertilizers, soil and plants adversely affect the terrestrial biodiversity (Zuhair 2000). Incidences of disease often incur considerable costs to the country. All the lime trees in the country were wiped out in an incidence of a disease (canker) about 15 years back. In 1997, the coconut trees in an island were highly affected by a species of worm. An incidence of a disease locally known as 'hudhu koodi in 1998 resulted in many trees being cut down in the country.

2.1.8 Timber

Timber is harvested mainly for construction of boats as well as buildings. In recent years, the number of requests for timber harvesting licenses has decreased (Table 2.8). The cause for this reduction has not been established. However, it is speculated that buying imported timber may be easier and cheaper or the availability of the timber trees could be decreasing (Zuhair, 2000).

2.1.9 Tourism

In 2002, the Maldives tourism industry will celebrate 30 years of tourism in the international market. Over this period, the tourism industry has been the main contributor to the economic development of the country. Figure 2.8 shows contribution of tourism to GDP as a percentage of GDP for the period of 1995 to 2000.

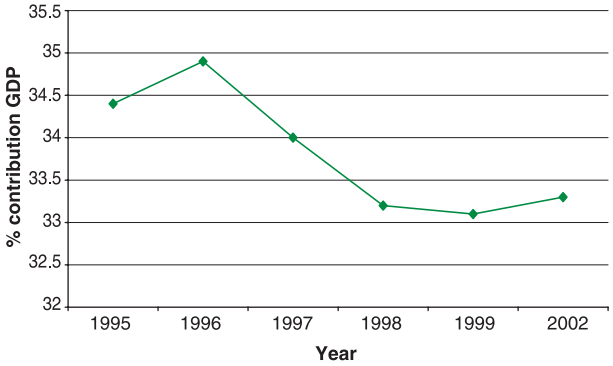


Figure 2.8: *Contribution of Tourism to GDP*
Source: *Statistical Yearbook 2001*

The importance of the tourism to the Maldives economy is also evident in the number of tourists who visit the country each year. Figure 2.9 shows the flow of tourist arrivals by nationality for the period of 1995 to 2000. The major attractions for these visitors include beaches, diving, water sports, recreational fishing, sailing and excursions.

Table 2.8: Timber harvest from uninhabited islands

Common name	Local Name		1993	1997	1998	1999	2000
Coconut Palm	Ruh	(no:s)	3363	1453	683	375	269
Iron wood	Kuredhi	(no:s)	58855	41576	52707	35975	27599
Nit pitcha, Country almond, Sea hibiscus	Uni, Midhili, Dhigga	(meters)	3121	1711	954	617	309
Alexander laurelwood tree, Sea trumpet	Funa, Kaani	(meters)	24	0	11	0	26
Banyan tree,	Nika Alhoa	(meters)	719	310	206	88	34

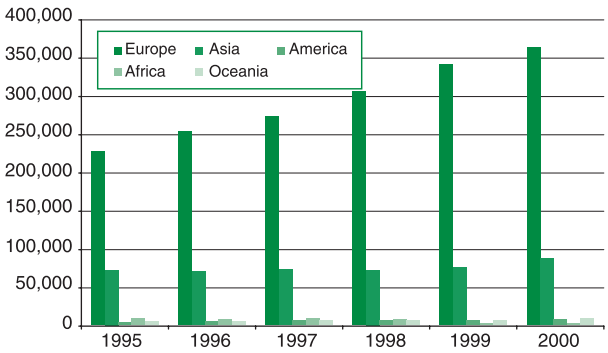


Figure 2.9: *Flow of Tourist Arrivals in Maldives by Nationality*
Source: *Statistical Year Book*

As the tourists come in search of peace and tranquillity, the main source of tourist accommodation is in resorts. Each resort is developed on a separate island and is equipped with modern amenities based on the resort's rating. The number of tourist resorts has been increasing over the past years and currently, there are 87 resorts, 60 of which are owned locally, 7 foreign owned, 10 jointly owned by foreigners and locals and the remaining 10 are government owned. These resorts are stretched over 10 atolls. Other sources of accommodation include hotels, guesthouses and vessels. Due to the ban on provision of accommodation to tourists in inhabited islands other than Malé, guesthouses and hotels are located only in Malé.

The total registered bed capacity provided by resorts, hotels, guest houses and vessels are given in table 2.9.

Table 2.9: Total registered bed capacity

	1995	1996	1997	1998	1999	2000
Resorts	10,688	11,472	11,958	13,740	15,036	15,914
Hotels	312	312	276	418	418	744
Guest Houses	400	246	313	293	321	356
Vessels	912	1,478	1484	1577	1,700	1,716

The bed capacity utilization rate is not consistent with the increase in bed capacity. Figure 2.10 shows the total bed capacity utilization rate for the period of 1995 to 2000.

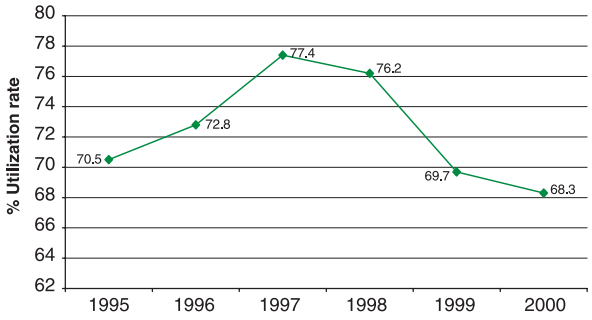


Figure 2.10: *Bed Capacity Utilisation Rate*

The average duration of stay by tourists has dropped from 9 bed-nights during the years 1996 and 1997, to 8.4 bed-nights in the year 2000. The average duration of stay by tourists for the period 1995-2000 is shown in fig. 2.11.

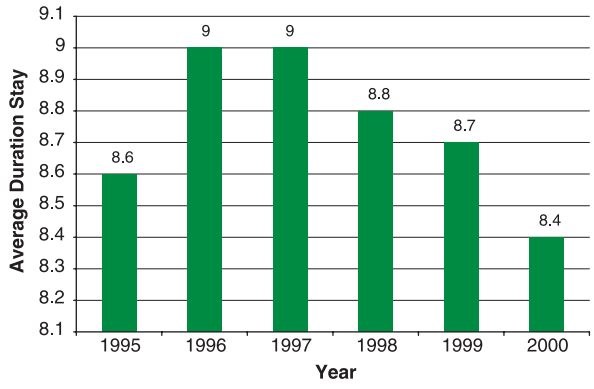


Figure 2.11: *Shows the average duration of stay by tourists for the period 1995 -2000.*

Tourism in the Maldives exists largely due to the physical and geographic features of the coral islands and the peace and security that prevail in the country. The beauty of the underwater world at the reefs, clean water in the lagoons, white and pristine sandy beaches, a rich island vegetation and ideal tropical climate are the main features that attracts tourists to the Maldives.

2.2 ENVIRONMENTAL RESOURCES

2.2.1 Geography and Land

The Maldives consists of a chain of coral atolls, 80-120km wide, stretching 860km from latitude 7°6'35"N to 0°42'24"S, and lying between longitude 72°33'19"E to 73°46'13"E. These coral atolls are located on the 1600km long Laccadives-Chagos submarine ridge extending into the central Indian Ocean from the south-west coast of the Indian sub-continent. The Maldives shares boundaries of its Exclusive Economic Zone (EEZ) with Sri Lanka and India on the northeast and the Chagos Archipelago on the south.

It is believed that the Maldives was formed about 65 -225 million years ago in the Mesozoic Era (Maniku, 1990). There is more than a single theory on how the Maldives was formed, and one of them suggests that the Maldives grew above foundered continental crustal segments (Maniku 1990). Gardiner (1902, 1903) hypothesises that the main Maldives plateau was formed by current erosion and then subsequently atolls were formed by the growth of organisms on this plateau.

The 26 geographic atolls in the Maldives vary enormously in shape and size. The largest atoll is Huvadhu Atoll with an area of approximately 2800km^2 (MPND 2000) and the smallest atoll Thoddoo Atoll has an area in the order of 5.4km^2 (MHAHE, 2001). The characteristics of the atolls, reefs and reef islands vary considerably from north to south. The northern atolls are broad banks, discontinuously fringed by reefs with small reef islands and with numerous patch reefs and faros in the lagoon (Woodroffe, 1989). In the southern atolls, faros and patch reefs are rarer in the lagoon, the continuity of the atoll rim is greater, and a larger proportion of the perimeter of the atolls is occupied by islands.

Map 2.1: *Location Map*

Map 2.2: *Map of the Maldives*

A total of 1192 islands are found in the chain of 26 geographic atolls, and the islands differ depending on location, form and topography (Woodroffe 1989). The islands vary in size from 0.5 km^2 to around 5.0 km^2 and in shape from small sandbanks with sparse vegetation to elongated strip islands. Many have storm ridges at the seaward edges and a few have swampy depressions in the centre. The largest island is Gan in Laamu Atoll with an area 5.16 km^2 (MPND 2000). A detailed land survey of the entire Maldives has not been undertaken yet and according to rough estimates, the total land area of the Maldives is about 300 km^2. The distribution of inhabited islands by island size is shown in Figure 2.12 and the ten largest islands in the Maldives are given in table 2.10.

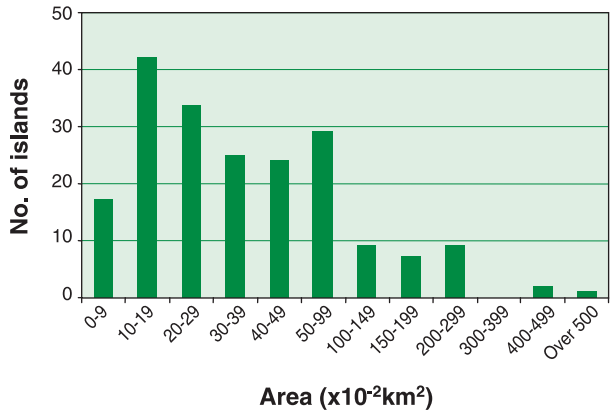


Figure 2.12: *Distribution of inhabited islands by island size*

The maximum height of land above mean sea level within the Maldives is around 3 metres and around 80% of the land area is less than 1 metre above mean high tide level (MHAHE, 1999). Figure 2.13 shows a cross-sectional profile across an island (Dhekaambaa) showing the typical height of an island with respect to the tide levels.

Table 2.10: Ten largest islands of the Maldives

Atoll	Island Name	Area (km^2)	Population (2000)
1. Laamu	Gan	5.166	2244
2. Seenu	Hithadhoo	4.673	9461
3. Gnaviyani	Fuvah Mulah	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*

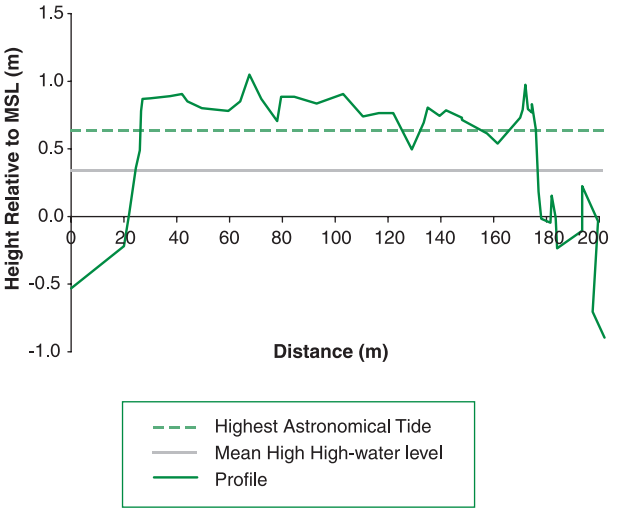


Figure 2.13: *Elevation of a typical island of the Maldives*

The 26 geographical atolls in the Maldives are grouped into 20 administrative regions. These administrative regions are also referred to as atolls. The capital, Malé forms a separate administrative unit (table 2.11). Out of the 1192 islands 199 are inhabited (MPND 2000) and 87 have been developed as tourist resorts (MoT 2001).

2.2.2 Climate and Climate Change

The Maldives has a warm and humid tropical climate. The weather is dominated by two monsoon periods: the south-west (rainy) monsoon from May to November; and the north-east (dry) monsoon from January to March when winds blow predominantly from either of these two directions. The relative humidity ranges from 73% to 85%.

Daily temperatures of the country vary little throughout the year with a mean annual temperature of 28°C. The annual mean maximum temperature recorded for Malé during the period 1967-1995 was 30.4°C and the annual mean minimum temperature for the same period was 25.7°C. The highest recorded temperature for Malé was 34.1°C on 16th and 28th of April 1973. The hottest month recorded was April 1975 with a maximum monthly average temperature of 32.7°C, the next highest being 32.6°C in April 1998.

Table 2.11: Administrative Regions, Atolls and Islands

Code of Atolls	Atoll Name	Aternative Atoll Name	Inhabited Islands	Industrial Islands	Airports	Resorts (2000)
A	Thiladhunmathi Uthuru Buri	Haa Alifu	16	2	-	-
B	Thiladhunmathi Dhekunu Buri	Haa Dhaalu	16	7	1	-
C	Milandhunmadulu Uthuru Buri	Shaviyani	15	5	-	-
D	Milandhunmadulu Dhekunu Buri	Noonu	-	13	4	-
E	Maalhosmadulu Uthuru Buri	Raa	-	15	-	1
F	Maalhosmadulu Dhekunu Buri	Baa	13	4	-	4
G	Faadhippolhu	Lhaviyani	5	8	-	4
H	Malé	Kaafu	9	-	1	43
U	Ari Atholhu Uthuru Buri	Alifu Alifu	8	-	-	11
I	Ari Atholhu Dhekunu Buri	Alifu Dhaalu	10	1	-	16
J	Felidhe Atholhu	Vaavu	5	-	-	2
K	Mulakatholhu	Meemu	9	1	-	2
L	Nilandhe Atholhu Uthuru Buri	Faafu	5	1	-	1
M	Nilandhe Atholhu Dhekunu Buri	Dhaalu	8	1	-	2
N	Kolhumadulu	Thaa	13	5	-	-
O	Hadhdhunmathi	Laamu	12	7	1	-
P	Huvadhu Atholhu Uthuru Buri	Gaafu Alifu	10	1	-	-
Q	Huvadhu Atholhu Dhekunu Buri	Gaafu Dhaalu	10	2	1	-
R	Fuvahmulah	Gnaviyani	1	-	-	-
S	Addu Atholhu	Seenu	6	-	1	-
T	Malé (Capital)		1	-	-	-
	MALDIVES		**199**	**49**	**5**	**86**

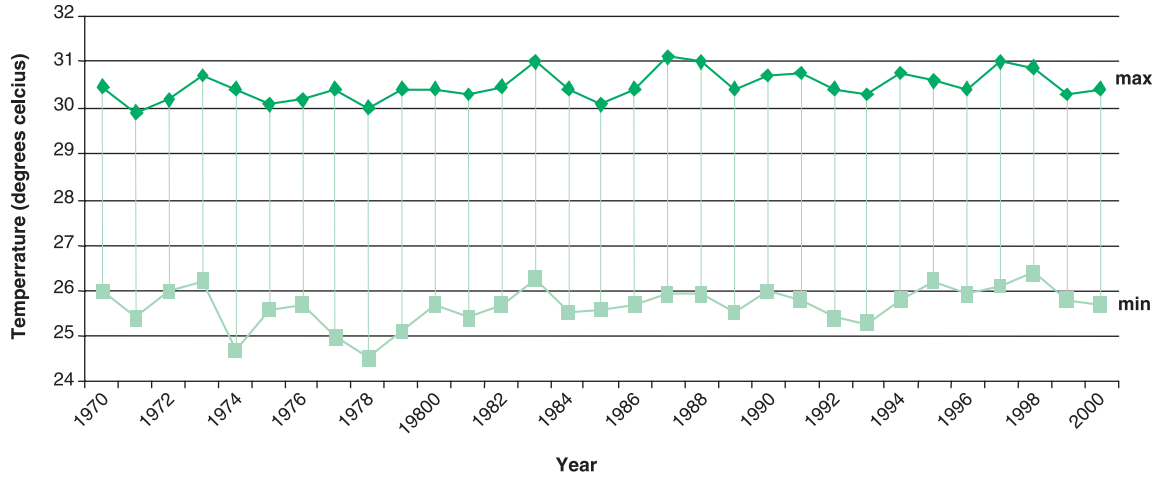


Figure 2.14: *Mean Annual Average Temperatures for Malé 1970 - 2000.*

The lowest minimum average temperature of 23.7°C was recorded in July 1992. The average annual maximum and minimum temperature for Malé is shown in figure 2.14.

Rainfall patterns are measured throughout the country by eight rainfall stations and it is evident that there are variations in rainfall from north to south through the atoll chain, with the north being drier and the south wetter. Average monthly and annual rainfall for Malé are 162.4mm and 1,948.4mm respectively. There has been considerable inter-annual variation in rainfall from 1,407mm to 2,707mm over the last 30 years. Figure 2.15 shows average annual rainfall for Malé and Gan over the last 30 years. The wettest months are May, August, September and December, and the driest January to April. The wettest year was 1978 with an annual rainfall of 2707mm and the driest 1995 with 1407mm. The wettest month on record is October 1994 with 588mm and the heaviest daily rainfall recorded was on 11th October 1999 with 200mm.

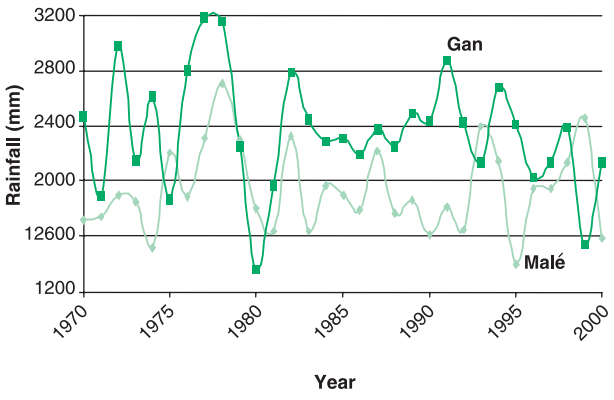


Figure 2.15: *Mean Rainfall for Malé and Gan 1970-2000*

Figure 2.16 shows the wind direction pattern for Malé International Airport. Winds from the north-east and the east-north-east are predominant during December to February. During March to April the direction varies with the general direction being westerly. Strong winds are associated with the southwest monsoon season. Gales are uncommon, and cyclones are very rare in the Maldives. The stormiest months are typically May, June and July. Storms and squalls producing wind gusts of 50-60 knots have been recorded at Malé. Figure 2.8 shows the average annual wind speeds for Malé.

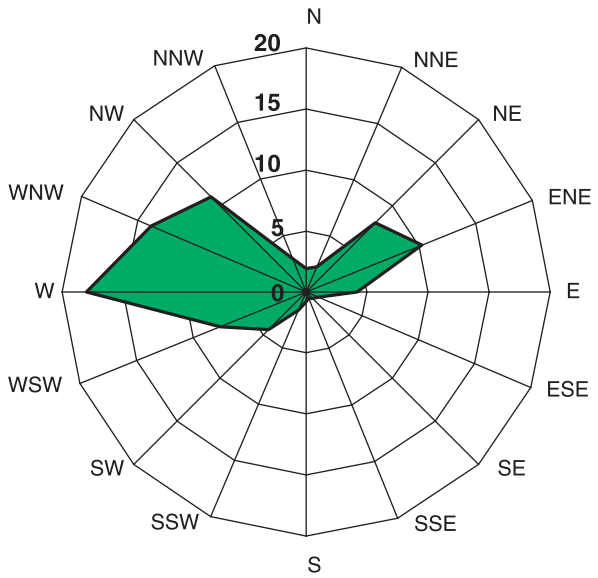


Figure 2.16: *Percentage of wind direction for the Malé International Airport (1980 - 1999)*

The current regime in the Indian Ocean is strongly influenced by the monsoon climate. In the region of the Maldives the currents flow westward during the Northeast monsoon period, and they flow eastward during the South-West monsoon period. The ocean currents flowing through channels between the atolls are driven by the monsoon winds. Generally, the tidal currents are eastward in flood and westward in ebb.

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 south-west monsoon period. During this season, swells generated north of the equator with heights of 2-3 m with periods of 18-20 seconds have been reported in the region. However, the Maldives also experiences swells originating from cyclones and storm events occurring well south of the equator. It is reported that the swell waves from south-east to south-south-east occur due to strong storms in the southern hemisphere in the area west of Australia with direction towards the Maldives. The swell waves that reached Malé and Hulhule in 1987 had significant wave heights in the order of 3 metres (JICA, 1987). Local wave periods are generally in the range 2-4 seconds and are easily distinguished from the swell waves.

The tides observed in the country are twice daily (semidiurnal/diurnal), and typical spring and neap tidal ranges are approximately 1.0m and 0.3m respectively (table 2.12). Maximum spring tidal range in the central and southern atolls is approximately 1.1m. There is also a 0.2m seasonal fluctuation in regional mean sea level, with an increase of about 0.1m during February - April and a decrease of 0.1m during September - November.

Table 2.12 Tidal recordings from Malé International Airport

Tide level	Referred to Mean Sea
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

Hydrographically the Maldives is characterised by a seasonal fluctuating mixed layer of relatively saline water from the Arabian Sea (36‰) and less saline water from the Bay of Bengal (34‰). A rapid downward decrease in temperature to below 20°C occurs at 90 -100 metres depth. The sea surface temperatures (SST) do not vary much through out the year. Average monthly SST generally ranges between 28 -29°C with maximum temperatures rarely over 30°C. Mean monthly SST rises from a low in December/January to high usually in April/May. In the central atolls the average seasonal rise is about 1.3°C. However, during May 1998 mean monthly SST was 1.1°C above the highest mean monthly SST (30.3°C) expected in any 20 year period (Edwards et al 2001).

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, 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 temperatures and rainfall patterns. The Intergovernmental Panel on Climate Change (IPCC) in their Third Assessment Report (TAR) predicted that, by the year 2100, sea levels are estimated to rise by up to 88 centimetres. When this estimate is considered in conjunction with the fact that about three-quarters of the land area of the Maldives is no higher than about 1.5 metres about mean sea level, it becomes apparent that the country faces a realistic threat of inundation sometime during this century if the issue of climate change is not concretely addressed. In addition to the possibility to inundation, the exacerbation of beach erosion and damage to human settlements and vital infrastructure are other possible serious consequences of rising sea levels. The priority vulnerabilities of Maldives to climate change: land loss and beach erosion, infrastructure damage, damage to coral reefs, impacts on the economy, food security, water resources, and human health.

2.2.3 Marine and coastal resources

The dominant natural environment of the Maldives is the marine environment. Outside the atolls the deep ocean covers a large area, and the Exclusive Economic Zone (EEZ) and the territorial waters of the Maldives cover an area of 859,000km^2 and 115,300km^2 respectively. Lagoons, reefs and to a lesser extent sea

grass and wetland areas make up the marine environment inside the atolls. The lagoon and reef areas make up about 21,300 km^2 (MPHRE, 1998).

The water depth varies considerably within the Maldivian waters. Lagoon waters within the atolls have depths ranging from 30 - 80m with the depth generally increasing from northern to southern atolls. Most lagoons of the atolls open into the Indian Ocean, and channels through the atoll margin are in some instances as deep as the lagoon itself. At the outer margins of the two atoll chains the ocean floor falls abruptly to great depths measuring up to 2000m or more. However, at the inner side of the two atoll chains the ocean floor has less depth. The main channel separating the eastern and western chain of atolls is generally between 250 and 300m deep. The east-west channels that separate the atolls are deeper with depths more than 1000m.

Atoll lagoons enclose a variety of reef structures including faros, micro-atolls, patch reefs and knolls. Faros are ring shaped reefs emerging during tidal low water, each with their own sandy lagoon and a rim of living coral consisting of branched and massive corals. Deep channels surround these reefs and faros are unique to the atolls of the Maldives. Patches rise to 30m above the lagoon floor the top of which have robust wave-breaking corals. Knolls do not reach the surface and often support profuse coral growth (Naseer, 1997).

The reefs associated with islands have the general characteristics described by Bianchi et al for the fringing reef around Alimatha island (Risk and Sluka, 2000). The island itself is sand, changing to coral rubble as the reef edge is approached. The outer slopes are very steep and area down to about 15m is covered with lush coral on a healthy reef. The outer reef slope is

characterised by a series of reef terraces at depths of 3-6m, 13-30m, and a deeper one at 50m representing past sea level still strands. The modern coral growth is veneer over older reef rock , but the existing community is constructional down to a depth of at least 50m. In the upper levels reef building is by zooxanthellate corals. In deeper zones reef building is sometimes by azooxanthellate branching coral. Boring organisms found in Maldivian corals include several species of Lithophaga , various polychaete worms and several species of boring sponges. The blue boring sponge Cliona schmidtii is very common in the Maldives.

A geochemical analysis of the reefs emphasized the relatively pristine nature of the Maldives marine environment. Analysis of coral skeletons for common heavy metals showed values that were below detection limits in all cases. Values for extraneous organics in coral tissues were found to be typically low except for hydrocarbon residues found in corals near an island which stores fuel (Risk and Sluka 2000).

The white sandy beaches and the vegetation found on the island periphery are very important in the Maldives island ecosystem. They form an important protection for the housing and infrastructure near to the shore, and are the main source of income for the tourism industry. Of the tourists visiting the Maldives, it has been identified that 70% visit primarily for beach holidays.

2.2.4 Biodiversity

The extent of biological diversity including flora and fauna present in the islands of the Maldives is not adequately documented or thoroughly researched. Therefore, the degree of understanding on biological diversity in the country is restricted to the information available.

The main types of ecosystems found are coral reefs, islands, sea grass, swamps and mangrove areas. Coral reefs are the major type of ecosystem that exists in the Maldives in terms of area as well the diversity of life that exists in the system. This diversity is amongst the richest in the region and the corals reefs of the Maldives are significant on a global scale as well, being the 7th largest in the world, covering a total area of 8,920 km^2 and contributing 5% of the worlds reef area (Spalding et al. 2001).

As the Maldives is an island nation, the extent of terrestrial biological diversity is much confined to the small island environments. The floral composition is considerable taking into account the absence of diverse terrestrial ecosystems and the poor and infertile nature of the soil. Islands in the south, particularly Fuvahmulah and Hithadhoo, demonstrate a richer diversification of plants than the north. The terrestrial faunal diversity is generally poor in the Maldives and is understandable in the absence of huge landmasses, forests and associated ecosystems.

2.2.4.1. Terrestrial

The close proximity of all land to the sea results in comparatively high soil salinity and as a consequence the natural vegetation contains a high proportion of salt tolerant species, both shrubs and trees. Based on published plant species lists and vegetation descriptions, 583 species of plants are found in the Maldives and, of these 323 are cultivated species and 260 are native or naturalized species (Adams, 1984). Over 300 plant species are known to have medicinal values, (ERC, 2001) and are utilized for traditional medicinal practices.

In comparison to the rich terrestrial faunal diversity of the region, the Maldives demonstrates a rather small proportion of the representatives. Webb (1988) noted that islands of the Maldives are not known for their abundant wildlife.

Webb (1988) described some constituents of the Maldivian reptilian fauna including: 2 gecko (Hemidactylus spp) commonly seen throughout the country; 2 agamid lizard including the common garden lizard or blood sucker, Calotes versicolar, the snake skink, Riopa albopunktata, and 2 species of snakes including the common wolf snake Lycodon aulicus and Typhlops braminus. One species of frog is known, the short-headed Rana breviceps, and a larger toad, Bufo melanostictus has also been found. During a study co-ordinated by Holmes on fruit bats and birds of the Maldives, a collection of insects, arachnids and mollusk specimens were made and spiders were found to be particularly rich. In the same study four species of

bumblebees, which were very much a feature of the islands, were also collected (Holmes, 1993).

The only native mammals endemic to the country are the two subspecies of fruit bats, Pteropus gigantus ariel and Pteropus hypomelanus maris. The latter one is very rare and has only one record from the Maldives from Addu Atoll (Holmes, 1993). The other mammals, all probably introductions, are the house mouse, black rat, Indian house shrew and cats (Webb, 1988).

Over 190 bird species have been recorded from the Maldives including seabirds, shorebirds and terrestrial birds (Zuhair and Shafeeg 1999): most of which are seasonal visitors, migrants, vagrants, introductions, and imported as pets. Very few reside in the country most of which are seabirds. Terrestrial birds are very minimal compared to other tropical islands and most are probably introductions. A complete study on the ornithology of the Maldives has not been undertaken, however, some information is available regarding the distribution and status of a few species from researches undertaken by foreign and local experts.

Seabirds are widely seen throughout the country and are extremely important to the local communities as they have been keeping a very close relationship with them. Most of them are directly related to fishing in the Maldives. Tuna schools chase small fish and other marine life such as shrimps up to the surface where they are preyed on by several species of seabirds, and as many as 90% of the tuna schools are located this way (Anderson, 1996). At least 40-50 species of seabirds are seen in the Maldivian waters, of which only 13-15 are known to nest and breed in the country. Some of them are terns Sterna sumatrana, S. albifrons, S. anaethetus, S. dauglli, S. bergi, S. bengalensis, and S. fuscata, S. saundersi; two species of noddies Anous stolidus and A. tenuirostris, the white tern Gygis alba monte which is known to breed only in Addu Atoll (Anderson, 1996). Others such as frigate birds, white-tailed tropic birds, boobies and some shearwaters are also known to breed in the Maldives (Shafeeg 1993). Most of the shorebirds found are common winter visitors to the Maldives; however, there are some resident and immigrant species.

2.2.4.2 Marine biodiversity

In contrast to the terrestrial biological diversity found in the country, marine biological diversity shows an

outstanding richness, especially in the coral reefs, making the area one of the world's most diverse marine ecosystems (Pernetta 1993). However, documented information on the species diversity is limited (Ahmed and Saleem 1999). Available literature record relatively few species compared to the high diversity that exists in the marine environment.

The two groups of marine lives that are most studied are the fishes and the corals. Most recent accounts recognize 187 species of stony corals recorded in the Maldives (Sheppard 2000). To date a total of 1090 fish species have been officially recorded (Anderson et al. 1998 and Adam et al. 1998).

Marine algae including some 21 species of Cyanophyceae (blue-green), 163 Rhodophyceae (red), 83 Chlorophyceae (green) and 18 Phaephyceae (brown) have been recorded in the country (Hackett,. 1977). Other groups include; 36 species of sponges (Thomas et al 1991 & 1992), a little over 400 species of molluscs (Smith 1906, Coleman 2000), about 350 species of marine crustaceans (Borradaile 1903a, Borradaile 1903b, Borradaile 1903c, Borradaile 1906a, Borradaile 1906b Wolfenden 1906, Walker 1906, Alcock 1906, MRS 1995

and Nomura 1996) and over 80 species of echinoderms (Joseph 1991 and Coleman 2000).

There are 5 species of turtles all of which are endangered, including loggerhead turtle Caretta caretta, green turtle Chelonia mydas, Hawksbill turtle Eretmochelys imbricata, Olive Ridley turtle Lepidochelys olivacea, and leatherback turtle Dermochelys coriacea (Frazier et al., 1984). Marine mammals recorded include 7 species of dolphins and 9 species of whales (MRC, 1998).

2.2.5 Freshwater resources

In the Maldives, water is a very scarce resource. The hydrogeology of the country is that of typical coral islands. The small islands are surrounded by large expanses of sea water, and the freshwater aquifer lying beneath the islands is a shallow lens, no more than a few meters thick, formed by the percolation of rainwater through the porous sand and coral. Freshwater being lighter than saline water, the lens floats atop the saline water. The aquifers change in volume with season and rise and fall with the tide. Such aquifers form the main source of water for human consumption and agricultural purposes. Increased extraction, exceeding natural recharge through rainfall has dramatically depleted the freshwater lens in Malé and other densely populated islands.

The water table of most of the groundwater aquifers is less then 1.2m below ground level. The traditional sanitary wastewater practices have led to the pollution of groundwater due to the close proximity of the aquifers to ground surface. Unregulated construction of septic tanks and application of agrochemicals have led to biological and chemical pollution of aquifers. In some of the islands, the salinity of the groundwater, which is caused due to over abstraction, has limited the groundwater availability to meet the demand.

2.2.6 Environmental Management and Legislations

The government has given priority to develop environmental policies, laws and institutions to deal with the major environmental issues facing the country. The Second National Environment Action Plan of Maldives was adopted in 1999 to address the pressing environmental challenges. The second National Environment Action Plan identifies the need to take an integrated approach to the management of the environment and to work towards the goal of sustainable development. The aim of NEAP II is to protect and preserve the environment of the Maldives, and to sustainably manage its resources for the collective benefit and enjoyment of present and future generations. The NEAP identifies 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 wastes; sustainable tourism development; land resources management and sustainable agriculture; human settlements and urbanization and sustainable fisheries management as the key issues to be addressed.

The Environmental Protection and Preservation Act of Maldives (Act 4/93) was enacted by the People's Majlis in 1993. This act established a framework upon which regulations and policies can be developed to protect and preserve the natural environment and resources for the benefit of present and future generations. Act 4/93 contains important provisions on environmental advice, environmental policy formulation, biodiversity conservation, environmental impact assessment, waste disposal and hazardous wastes. A programme for strengthening of national environmental legislation began in 1996.

In 1986, and Environment Section was formed in the Ministry of Home Affairs. Two years later, the Environment Section was transferred to the Ministry of Planning and Development, which then became the Ministry of Planning and Environment, elevating environment to the Ministerial status. Then, in 1993, the Ministry of Planning, Human Resources and Environment was formed and environmental affairs were entrusted to the new Ministry, from the withdrawn Ministry of Planning and Environment. The mandate for environmental protection and management was transferred to the Ministry of Home Affairs, Housing and Environment which was formed in November 1998. The Environment Research Unit which functioned under the then Ministry of Planning, Human Resources and Environment was elevated to the status of Environment Research Center and brought under the Ministry of Home Affairs, Housing and Environment.

Part III KEY ENVIRONMENTAL ISSUES

PART III KEY ENVIRONMENTAL ISSUES

3.1 CLIMATE CHANGE AND SEA LEVEL RISE

The Maldives being a fragile low lying small island ecosystem, it is very vulnerable to climate change and its associated impacts especially the predicted sea level rise. Although the Maldives contributes minimally to the global greenhouse gas emissions: 0.001% (MHAHE 2001), it is among the most susceptible to impacts of the changes in climate.

The Intergovernmental Panel on Climate Change (IPCC) in its Third Assessment Report estimates a projected sea level rise of 0.09m to 0.88m for 1990 to 2100 (IPCC 2001). With about three-quarters of the land area of Maldives less than a meter above mean sea level, the slightest rise in sea level will prove extremely threatening. This is further aggravated by the variation of the tide. Many islands already suffer inundation and shoreline erosion because of its low elevation. The inundation often leads to freshwater shortages and disease outbreaks. The magnitude of rise in sea level projected in the IPCC Third Assessment Report threatens the very existence of life and livelihood in the Maldives.

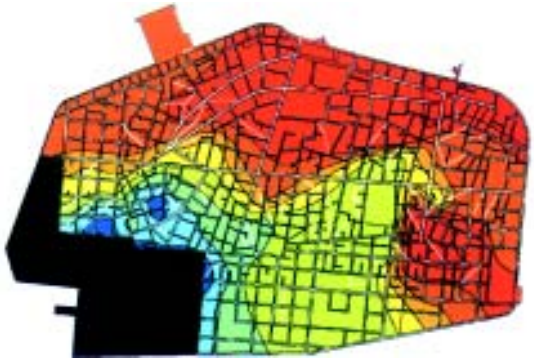
Impacts of sea level rise on Malé

A scenario depicting impact of sea level rise presented at the seventh Conference of the Parties of the United Nations Framework Convention on Climate Change (UNFCCC) based on a Case Study conducted during the preparation of the National Communication to the UNFCCC. Using a Digital Terrain Model (DTM) of Malé (Map 3.1) and a set of sea level scenarios published by the Intergovernmental Panel of Climate Change, the following findings interms of area that would be inundated are revealed:

Scenarios	% Inundated	Map
2025 (High) Scenario	15	3.1a
2050 (Low) Scenario	15	3.1a
2050 (High) Scenario	31	3.1b
2100 (Low) Scenario	50	3.1c
2100 (High) Scenario	100	3.1d

Source: *MHAHE, 2001*

Map 3.1: *Elevation contour map and street map of Malé overlaid.*



Map 3.1a: *Map showing areas that would be inundated in 2025 (high) scenario. That is 0.84m (19.7cm + 64cm*). The same map also applicable to year 2050 (low) scenario. That is 0.84m (19.9cm + 64cm)*

Map 3.1b: *Map showing areas that would be inundated in 2050 (high) scenario. That is 1.04m (39.7cm + 64cm*).*

Map 3.1c: *Map showing areas that would be inundated in 2100 (low) scenario. That is 1.13m (48.9cm + 64cm*).*

Map 3.1d: *Map showing areas that would be inundated in 2100 (high) scenario. That is 1.58m (94.1cm + 64cm*).*

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

Of particular concern for the Maldives is the impact of climate change on the groundwater availability. In the islands rainwater lenses lie atop salt water. As sea level rises, the thickness of the freshwater lens decreases, and the volume of freshwater decreases. Also sea level rise would increase the likelihood of storm over wash of the islands, causing increased incidence of saltwater contamination of the freshwater lenses.

The tourism industry relying heavily on the marine ecosystems is also under threat from the impacts of climate change. An increase in temperature can very easily bring the reef growth and reef ecosystems to an alarmingly poor status. Although almost all the reefs have recovered from the coral bleaching event of 1997, the impacts of bleaching were felt on around 90% of the reefs of Maldives, bleaching them totally or partially (Naeem et al 1998). The corals already growing at highest tolerable temperatures (approximately 30°, Celsius) have a very grim possibility of survival given the predicted rises in temperature of 1.4 to 5.8°C for the period of 1990 to 2100 (IPCC 3nd Assessment Report).

The islands of Maldives are reef-based and coral reefs serve as natural breakwaters. With damage to the coral reefs comes the bigger danger of loosing the natural protection of the islands from the waves and currents. An island with a degraded reef is more open for coastal damages such as beach erosion and more susceptible to inundation by uncontrolled waves reaching the shore.

Fishery is also expected to suffer from the impacts of climate change. Tuna fishery is the main fishery and tuna is a migratory species. A possible change in temperatures can drive the tuna stock to more favourable temperatures. This can lead to a decline in the fisheries industry as the fishermen loose their fishing grounds. The tuna fishery is based on pole and line method using bait fish. Any changes to the availability of bait fish caused by damage to the reefs would also affect the tuna fishery.

A major concern in the country related to the climate change phenomenon is the lack of knowledge and awareness on the issue as well as the lack of necessary resources to properly assess the possible impacts. There is a need for research on localised climate changes and its impacts. There is also an urgent need for the development of resources to adapt to possible impacts of climate change.

El-Nino events and other climate variations also have considerable pressures on the fragile ecosystem of the Maldives. One of the major threats to coral reef biodiversity is coral bleaching associated with increased seawater temperature. The Maldives experienced large-scale coral bleaching during 1998 El-Nino event. Reef monitoring show that live coral cover decreased to a mean of 2.1% from pre-bleaching levels of 30-45% (MRC 1999). Subsequent observations in 1999 showed early signs of recovery with recruitment of highly affected varieties such as acroporids and pocilloporids (Edwards et al 2001). The study states that "despite the severity of mortality, recovery appears to be proceeding much faster in the Maldives than in the species poor eastern Pacific after the 1982-1983 ENSO warming event".

3.1.1 Natural Disasters and Episodic Events

In April 1987, a storm centre in the southern Indian Ocean resulted in long-distance wave transmission that passed through much of the Maldives archipelago. The waves caused enormous economic losses through damage to infrastructure, land and vegetation. Malé and the International Airport were among the worst hit with extensive flooding and erosion.

While the rehabilitation work on this damage was still in progress, the country again was faced with storm surges in June and September the same year. Although these surges was less extensive than the one in April that year, many of the agricultural fields were inundated by seawater and some causeways linking islands were badly damaged.

The island of Thulhaadhoo faced inundation in 1988. This was caused by high SW waves (2-2.5m high; duration 12-15 seconds) in association with a high spring tide and south-westerly winds.

The most severe recorded storm event in the Maldives so far was on 30th of May 1991. During the storm, the atmospheric pressure fell down to 997 hpa and the maximum squally winds reached 90 kts per hour (DoM, 2001). The most severe weather from this storm was experienced in the southernmost atoll, Addu Atoll. However, most parts of the country were affected, with 4,081 houses in 13 atolls damaged (SAARC 1992).

The resort island of Bolifushi was hit by similar but a very much more localised freak storm in 2000. This storm lasted about 12 hours and caused US$ 1.2 million worth of damages

Coastal flooding has been experienced in the past and the risks of flood damage resulting from high tides have not reduced in recent years. The degree of severity of some of these events has been thought to have increased due to improper coastal zone management and construction of poorly designed coastal structures. Proper management methods of the coastal zone are now gradually being introduced in the Maldives, and some research and consultations are now carried out in the construction and design of seawalls and coastal structures, as well as in the reclamation of land. The country still needs to increase its capacity in such research and design.

With the prediction by the IPCC of possible increase in extreme events of weather, there is a growing need for enhancing the local capacity in predicting such events as well as for preparedness to face them.

Photos of 1988 sea swells to be included here. And the 1991 High Winds in Addu.

3.1.2 Beach Erosion

Beach erosion is now among the most serious environmental issues facing the islands of Maldives. On many islands, the sand at the beach and shoreline are being washed off at a greater rate than it is accreted. The process of coastal erosion and accretion is extremely complex with interrelations to climatic, geological, oceanographic, biological and terrestrial processes affecting the growth and stability of the reefs

and island structures. As the beach systems are highly dynamic in nature, the prevailing seasonal conditions may gradually shift the shape as well as the position of the island by strong beach erosion and accretion on either side of the island. The general and natural movement of sand and sediment is that during one monsoon the sand and sediments are gradually washed off (eroded) from one side of the island and are carried along the shoreline to the other end of the island. This process reverses during the next monsoon with sand being deposited (accreted) at the previously eroded side of the island.

Since, almost all human settlements, vital infrastructure and industry lie very close to the beach, coastal erosion threatens to damage houses, schools, and other infrastructure. According to records kept by the Ministry of Home Affairs Housing and Environment, at present nearly 50 percent of all inhabited islands and nearly 45 percent of tourist resorts suffer varying degrees of coastal erosion (MHAHE 2000). Resorts that have reported severe beach erosion is listed in table 3.1, and islands that have reported severe beach erosion since 1990 are given in table 3.2.

Table 3.1: Resorts that have reported severe beach erosion

South Thiladhunmathi	**Faadhippolhu**	**Mulakatholhu**	**Hadhdhunmathi**
Neykurendhoo	Felivaru	Kolhufushi	Kalhaidhoo
Nolhivaranfaru	Gaaerifaru	Mulaku	Kunahandhoo
	Kurendhoo	Naalaafushi	Mundoo
North Miladhunmadulu	Maafilaafushi	Raiymandhoo	
Bilehfahi	Vavvaru		**North Huvadhu Atoll**
Firubaidhoo		**North Nilandhe Atoll**	Dhevvadhoo
Funadhoo	**Malé Atoll**	Biledhdhoo	Kanduhulhudhoo
Komandoo	Thulusdhoo	Bodu Finolhu	Kolamaafushi
	Guraidhoo	Feeali	Kooddoo
South Miladhunmadulu	Huraa	Magoodhoo	Villigili
Holhudhoo	Maafushi	Nilandhoo	
Kuredhivaru	Villigilli		**South Huvadhu Atoll**
Maalhendhoo		**South Nilandhe Atoll**	Hoadedhdhoo
Velidhoo	**North Ari Atoll**	Meedhoo	Nadallaa
	Bodufolhudhoo		Rathafandhoo
North Maalhosmadulu	Himandhoo	**Kolhumadulu**	
Angolhitheemu	Mathiveri	Buruni	**Fuvahmulah**
Fainu	Rasdhoo	Dhiyamigili	Fuvahmulah
Inguraidhoo	Thoddoo	Gaadhiffushi	
Maduvvari	Ukulhas	Guraidhoo	**Addu Atoll**
Meedhoo		Hirilandhoo	Feydhoo
Vahfushi	**South Ari Atoll**	Kandoodhoo	Hulhudhoo
	Dhangethi	Kibidhoo	
South Maalhosmadulu	Dhigurah	Madifushi	
Dhonfanu	Hangnaameedhoo	Omadhoo	
Eydhafushi	Maamigili	Thimarafushi	
Hithaadhoo	Mahibadhoo	Vandhoo	
Kamadhoo	Omadhoo	Veymandoo	
Kendhoo		Vilufushi	
Kihaadhoo	**Felidhe Atoll**		
Kudarikilu	Felidhoo		
Maalhos	Fulidhoo		
	Thinadhoo		

Source: *MHAHE*

Table 3.2: Islands that have reported severe beach erosion

North Maalhosmadulu
Pearl Island

South Maalhosmadulu
Coco Palm Resort
Kihaadhuffaru Tourist Resort
Reethi Beach Resort

Faadhippolhu
Kanuhuraa Beach and Spa Resort
Komandoo

Malé Atoll
Banyan Tree
Club Rannalhi
Emboodhoo Village
Fun Island Resort
Hembadhoo
Ihuru Tourist Resort
Makunudhu Island Resort
Olhuveli View Hotel
Paradise Island Resort
Fun Island Resort
Reethirah Resort
Rihiveli Beach Resort
Taj Lagoon Resort
Tari Village

North Ari Atoll
Nika Hotel
Velidhu Island Resort
Gangehi Island Resort
Veligandu Island Resort
Maayafushi Tourist Resort
South Ari Atoll
Angaga Island Resort
Ari Beach Resort
Athurugau Island Resort
Lily Beach Resort
Mirihi Island Resort
Moofushi Island Resort
Sun Island Resort
Thundufushi Island Resort
Vilamendhoo Island Resort

Felidhe Atoll
Alimatha Aquatic Island
Dhiggiri Tourist Resort

Mulakatholhu
Hakuraa Huraa

South Nilandhe Atoll
Vilu Reef Resort

3.1.3 Major Policy Responses and Initiatives

In order to reduce the emission of greenhouse gases, the Maldives has started pilot projects on alternate sources of energy. Solar power has been used to power telecommunication sets, navigational aids and government office buildings and mosques in the islands. The main constraint to the widespread use of solar energy is the lack of technical backup and high installation costs. While wind is a regular feature of the Maldives, existing wind speeds are considered marginal for electricity generation, unless high towers are erected at high capital cost. Supplementing conventional energy supply by alternate energy sources, wherever viable, has been included in the energy sector objective and strategy in the National Development Plan.

As the Maldives is very vulnerable to the predicted climate change and sea level rise, attention is given to adaptation measures. Various programmes have been designed and implemented in areas such as coastal protection, freshwater management and coral reef protection. The Government has taken very important measures to protect the coral reefs by reducing import duty on cons-truction materials and prohibiting use of coral for government buildings and tourist resorts and by banning of coral mining from house reefs.

The flooding in 1987 triggered concern in the Maldives about the possible impacts of climate change. President Maumoon Abdul Gayoom played a pivotal role in bringing the issue of climate change and sea level rise and the vulnerability of small island states, to the attention of the international community. He has addressed at numerous important international gatherings, including Commonwealth Heads of Govern-ment meetings the UN General Assembly, the Earth Summit in Rio in 1992, the UN Millennium Summit in 2001, as well as regional SAARC Summit meetings. On the request of the President, the Commonwealth and the SAARC established expert groups to study the impacts of greenhouse effect and global warming. A United Nations Environment Programme mission visited the Maldives and recommended training of local personnel to monitor and evaluate impacts of expected environmental changes and the development of strategies that would permit sustainable development.

The Maldives has played a leading role in encouraging the small island states to band together to devise a unified stance on global climate change problems among small island states. In 1989, with the help of the Commonwealth Secretariat, the Maldives hosted the Small States Conference on Sea Level Rise at Ministerial Level, the outcome of which was the Malé Declaration on Global Warming and Sea Level Rise. This declaration called

for negotiations for a framework convention on climate change to start as soon as possible after the adoption of the interim report of the IPCC. It also called upon all states to reduce or limit the emission of greenhouse gases and called upon the international community to assist small states to tackle environmental problems.

The Maldives participated in the Second World Climate Conference in 1990 and was instrumental, along with other small island states, in ensuring that the resulting Ministerial Declaration mentioned the special problems faced by small states. The Declaration notes that the present rate of climate change "could even threaten survival in some small island states" and recommends that "adequate and additional financial resources should be mobilised and best environmentally sound technologies transferred expeditiously in a fair and most favourable basis."

The Maldives was instrumental in the formation of the Small Island Action Group that eventually at the Second World Climate Conference in Geneva, in 1990, became the Alliance of Small Island States. The Alliance of Small Island States commonly known as AOSIS is a group of developing countries that share common objectives on environment and sustainable development. The group comprises of small island and low-lying coastal developing countries which are members of island regional groupings or organisations. The members of AOSIS are particularly vulnerable to the adverse consequences of climate change such as sea level rise, coral bleaching and the increased frequency and intensity of tropical storms.

The Maldives is a party to the United Nations Framework Convention on Climate Change (UNFCCC). The Maldives signed the Convention on 12th June 1992 and ratified the same on 9th November 1992. The Maldives played a very important role with AOSIS in the negotiation process that started in Berlin and culminated in Kyoto. The Maldives, though disappointed with the low targets agreed for in the Kyoto Protocol, looks for early implementation of the Protocol. The Maldives was the first country to sign the Kyoto Protocol on 16th March 1998 and it ratified the Protocol on 30th December 1998. The first National Communication of the Maldives to UNFCCC was submitted at the 7th Session of the Conference of the Parties to UNFCCC held in Marrakesh in 2001. The National Greenhouse Gas Inventory, National Mitigation Plan, Vulnerability Assessment and Adaptation Options are included in the national communication of Maldives.

3.2 FRESHWATER RESOURCES

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 well 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.

The quality of groundwater varies seasonally and across the islands. The superficial hydrogeology of the groundwater aquifers result in ease of pollution by sewage, chemicals and pathogens. Water quality testing carried out to date shows that bacterial contamination of point source water supplies (dug wells) is widespread and that faecal contamination exists in many of these sources on the inhabited islands. The level of faecal contamination is higher on the more densely populated islands, Malé being regarded as having the highest level of bacterial contamination of the groundwater aquifer. However, the controlling factor is not the size of the population of the island, but the house plot size in combination with the presence of cesspits and their interaction with the groundwater aquifer. On the basis of WHO drinking water guidelines there are few groundwater sources in the Maldives fit for potable use without disinfection.

The microbiological quality of well water in many growth centres of the Maldives is usually above 50 coliforms per 100ml which renders the water even unfit for bathing under World Health Organisation recreational or bathing water quality guidelines. Improper sewage disposal facilities are the major cause of poor groundwater quality in these islands.

Chloride and electrical conductivity varies both from island to island and within an island. On a few islands chloride exceeds the WHO guideline of 250mg/l. Data collected in the past points to the fact that the chloride concentration is not necessarily related to the level of extraction or population density, but also to underlying hydro geological aspects of the aquifer. Islands without wetland areas show low chloride levels than those with wetlands, as wetlands contribute to the increased chloride levels of the true groundwater lens of the

island. Generally, however, the greater the extraction, the higher is the chloride from island to island and within an island. Chloride levels of the groundwater aquifer may not be particularly important in many islands because well water is hardly used for potable needs. During early 2000 about 60% of the wells in the country were reported to have freshwater (MWSA).

The groundwater in Malé is severely depleted. The 5600 household wells have been supplying the water needs of the population of Malé, in the past. At present the water provided by these wells is so saline that it is not fit even for bathing and washing purposes. The situation is further aggravated by the amount of chemicals in the water such as hydrogen sulphide and hydrocarbons. A recent chemical analysis of ground water in Malé shows that it contains high amounts of nitrates and sulphates. In a few wells ammonia was detected at elevated levels (0.4 - 0.6 mg/l) indicative of sewage pollution and raised pH levels (7.5 - 8.0) tended to confirm that the results were significant (WHO, 1995). Hydrogen sulphide or sewer gas has also been a major threat to well water users in Malé resulting in acute poisoning of two and death of one person in 1997. Hydrogen sulphide makes the water stink and poses different health risks at different levels of exposure. Many household wells have shown elevated levels (0.5 to 3.5 ppm in water and above 100 ppm in the air) of hydrogen sulphide. Hydrogen sulphide in the sewers has also been a major problem for people living near pumping stations around Malé. The situation has improved in many areas since household venting started in 1999.

Hydrogen sulphide has also been detected in some wells in Kulhudhuffushi and Hithadhoo, the designated growth centres under the first Regional Development Project.

The quality of groundwater in Gan, Addu Atoll has also rapidly declined in the past few years. Gan has a few garment factories and a regional airport. However, as almost all general purpose water used on Gan originates from two boreholes located on the western side of the island, there is excessive extraction above the demand. Leakages in the distribution network also contribute to the problem in Gan.

Increased extraction exceeding natural recharge through rainfall has dramatically depleted the freshwater lens in Malé and other populated islands. This increased extraction is linked with technology and lifestyle. Although, many households in Malé and in other islands of the Maldives use low flush toilets and other water saving devices, water conserving lifestyles can be said to be rare.

3.2.1 Rainwater

In many islands, rainwater is mainly used for drinking and cooking purposes. Recent and past water quality tests on rainwater have shown that rainwater in the Maldives is of acceptable potable quality. However, a full analysis of rainwater may be required before impacts of trans-boundary air pollution can be assessed.

Many people practice safe collection and storage of rainwater. However, there have been a few incidents when rainwater has been tested positive for faecal coliforms. Rainwater is hardly disinfected, and very few people boil it.

Rainwater collection is also encouraged in resorts islands by the Ministry of Tourism to reduce the need for desalination.

3.2.2 Desalinated water

Desalination or desalting became necessary when the sustainable yield of the existing groundwater aquifer on some islands was exceeded. Desalinated water is now supplied to almost all households in Malé and Villingilli, the fifth ward of Malé. Malé produces about 4,000 tonnes of desalinated water everyday using the reverse osmosis (RO) process to serve a population of about 74,000 people (figure 3.1).

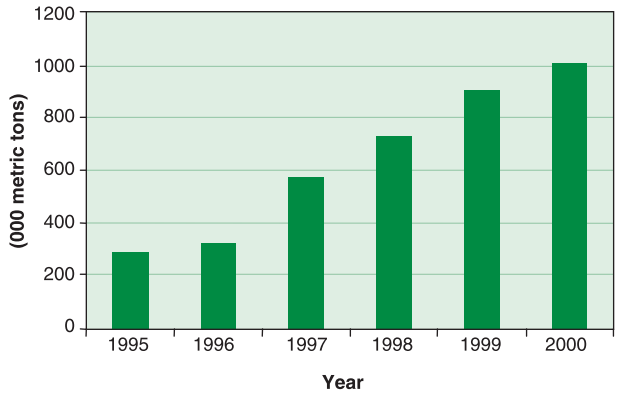


Figure 3.1: *Annual Supply of Desalinated Water in Malé*

At present, Kandholhudhoo is the only other inhabited island that is served with desalinated water via taps in standbays. The need for desalination arose during the dry season of 1998 when the inhabitants of Kandholhudhoo had to fetch water from nearby islands. Kandholhudhoo, the most densely populated island in the Maldives, is served by a reverse osmosis desalination plant with a capacity of 50 cubic meters. The island community operates and maintains the plant. When the population of Kandholhudhoo was served by desalinated water in May 1999, about 28% of the population of the Maldives had access to desalinated water and over 20% of the population almost entirely depended on desalinated water.

All tourist resorts rely on desalination to cater for their water needs as the island aquifers could not be tapped and also would not provide sufficient yield. In most resorts, a total production capacity based on 250 litres per capita per day is established.

3.2.3 Fresh or brackish water ponds

Surface freshwater is generally lacking throughout the archipelago with the exception of a few swampy areas, shallow freshwater lagoons, and some fresh or brackish water ponds in some of the islands in the northern and southern atolls (Table 3.3). In heavily

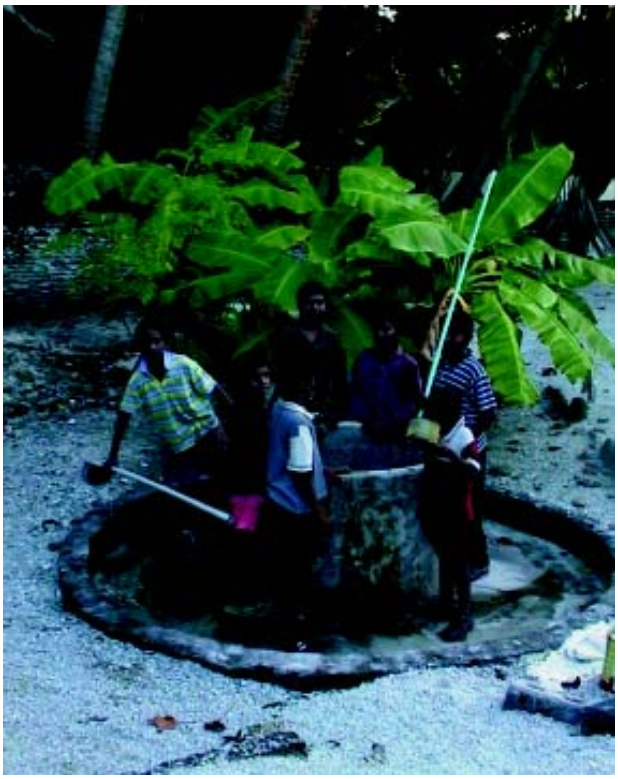


Table 3.3: Islands with wetlands in the Maldives

Island	Atoll	Size of Wetland (hectares)
Filladhoo	Haa Alifu	3.6
Thakandhoo	Haa Alifu	1.8
Baarah	Haa Alifu	5
Mulhadhoo	Haa Alifu	-
Maafari	Haa Alifu	0.8
Nolhivaranfaru	Haa Dhaalu	0.35
Neykurendhoo	Haa Dhaalu	-
Finey	Haa Dhaalu	-
Nolhivaramu	Haa Dhaalu	4
Kulhudhuffushi	Haa Dhaalu	16.1
Maakandoodhoo	Shaviyani	8.28
Feydhoo	Shaviyani	-
Funadhoo	Shaviyani	-
Maroshi	Shaviyani	-
Nalandhoo	Shaviyani	2.49
Milandhoo	Shaviyani	1.6
Medhukuburudhoo	Shaviyani	7.88
Farukolhu	Shaviyani	1.3
Eriadhoo	Shaviyani	1.1
Eskasdhoo	Shaviyani	29
Bomasdhoo	Noon	2.3
Kedhikolhudhoo	Noon	31.1
Tholhendhoo	Noon	3.7
Medufaru	Noon	5.9
Karinmavattaru	Noon	0.3
Kuredhdhoo	Lhaviyani	2.4
Kolhufushi	Meemu	5.3
Gan	Laamu	-
Isdhoo	Laamu	-
Gaadhoo	Laamu	-
Viligili	Gaafu Alifu	-
Kadulhudhoo	Gaafu Alifu	-
Madaveli	Gaafu Dhaalu	4
Nadallaa	Gaafu Dhaalu	3.7
Thinadhoo	Gaafu Dhaalu	3
Fuvahmulah	Gnaviyani	8.5
Hithadhoo	Seenu	11.9
Hulhudhoo	Seenu	2.8
Meedhoo	Seenu	-
Herethere	Seenu	4.7
Viligili	Seenu	2.3

Source: *MHAHE : 2002*

populated islands such as Thinadhoo and Kulhudhuffushi, the marshy area has been used for waste disposal and to create land. In Baarah, the wetland or brackishwater ponds became a nuisance by being a breeding ground for certain mosquitoes. Freshwater ponds like the one in Fuvahmulah could serve as an important reservoir for freshwater supply.

3.2.4 Major Policy Responses and Initiatives

To face the challenges, an integrated national water resources management master plan is to be developed, in addition to the development and strengthening of monitoring and assessment capabilities. However, this process is currently in its draft stages. Draft regulations on water supply, plumbing, waste disposal, sewerage systems, etc. have been developed. Desalination plants cannot be installed and operated in the country without written permission from MWSA. Therefore, a draft standard for the operation and maintenance of desalination systems has been developed. Strict measures are in places to reduce the amount of pumping for excavation and foundation works. As such, dewatering guidelines have been developed. The tourism regulations have ensured that the groundwater lens of newly developed resort islands are truly conserved and protected. All restaurants and cafes are required to have grease/oil traps according to MWSC specifications.

Optimizing rainwater catchment is a priority policy of the government. Rainwater collection tanks are procured and delivered at public and household levels. Household/private tanks are sold on monthly installment basis. The programme is carried out under a revolving fund generated with the assistance of UNICEF.

In 1995, the Government of Maldives transferred the water supply and sewerage management of the city of Malé from the Maldives Water and Sanitation Authority (MWSA) to a private company, Malé Water and Sewerage Company Ltd., which was set up for this purpose. MWSC is a joint venture company with Government majority shareholding. In order to protect the interests of consumers as well as the environment, the Maldives Water and Sanitation Authority was given the mandate to act as a regulatory body for the company. The regulatory body is responsible for setting standards and regulations for water quality in the Maldives and to monitor and enforce them.

MWSC is improving the performance of the existing sewerage system in Malé. Efforts are underway to reduce the level of hydrogen sulphide gas in sewers by sewer ventilation. Leaking catchpits are being replaced by plastic (HDPE) ones to ensure strength and longevity and to virtually eliminate leaks and reduce groundwater contamination.

Local traders are introducing different water saving devices into the country. Energy efficient technologies are also being introduced. However, currently there are no tax cuts on environment safe or environmentally friendly products.

Inappropriate selection of excreta disposal methods coupled with lack of management skills at community level has resulted in ill-health or other related problems. Small bore sewerage systems installed on 7 islands have had several problems related to design, construction and maintenance. Consequently, a study to find practical options and develop selection and management criteria is now underway. The study is being developed by National Development Consultants of Pakistan and would be completed in early 2002.

Water quality surveillance is given special focus by the Maldives Water and Sanitation Authority. The Public Health Laboratory carries out daily tests on desalinated water produced in Malé and Villingilli by MWSC.

Water test kits have also been provided to regional hospitals. Appropriate training on how to use these test kits have also been given to concerned persons at the Regional Hospitals.

Bathing water quality in Malé Swimming Track (or fathaa sarahaddu) is tested regularly to protect swimmers who swim in the area, which is close to sewer outfalls for PS2 and PS9 behind Dharubaaruge. At times when faecal contamination exceeds 100 per 100ml, notice has been given.

Water quality monitoring is also carried out for 64 groundwater wells in Malé and water resources of selected islands of selected atolls are assessed every year.

A storm water management system is being developed by the Ministry of Home Affairs, Housing and Environment. However, the health concerns of such a plan have not been adequately addressed.

Water and sanitation component of the Regional Development Project would provide the venue and forum for detailed investigation and understanding of appropriate technologies and means of water supply and sanitation.

3.3 MANAGEMENT OF SOLID WASTE AND SEWAGE

A major pressure on the environment arises from the wastes and pollutants produced as a by-product of domestic and industrial activities. Solid waste disposal is now one of the most critical environmental issues in the Maldives. The amount and the rate of solid waste generated vary throughout the country and there is a significant difference between the amount of waste generated in Malé and that of in the atolls. The amount of solid waste generated in Malé has been increasing at an alarming rate over the past 10 years. Figure 3.2 shows that the solid waste generated almost doubled within the period 1990 to 1995 and in the next five years (1995 to 2000) the amount of waste generated increased by eight fold

On average 2.48 kg of waste are generated per capita per day in Malé while in the atolls this value is around 0.66 kg of waste per capita per day. Average waste generation in the resorts stands at 7.2 kg per guest per day (JICA, 1998). Figure 3.3 shows the composition of solid waste generated in Malé. The rapidly developing construction industry is contributing significantly to the composition of the waste.

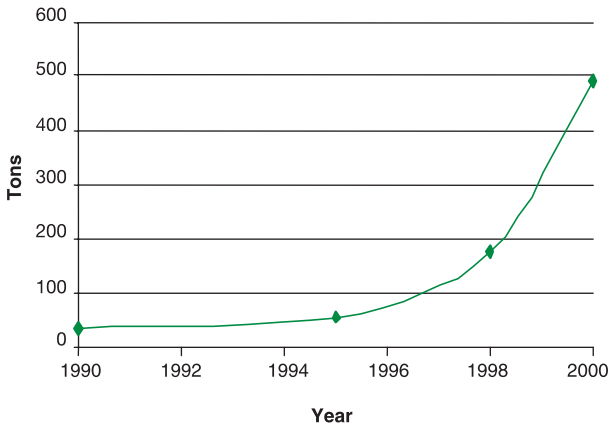


Figure 3.2: *Amount of Solid Waste Generated Daily in Malé*
Source: *Waste Management Section, MCPW*

The large quantity of waste generated coupled with limited land area and technology makes the disposal of waste a challenge for the country. Until 1991, solid waste generated in Malé was used for land reclamation in Malé. Presently, solid waste generated in Malé is collected and taken to a transfer station. From the transfer station, the waste is transported to Thilafushi, a municipal landfill, located 5 km away from Malé. The Thilafushi landfill site has now become a landfill

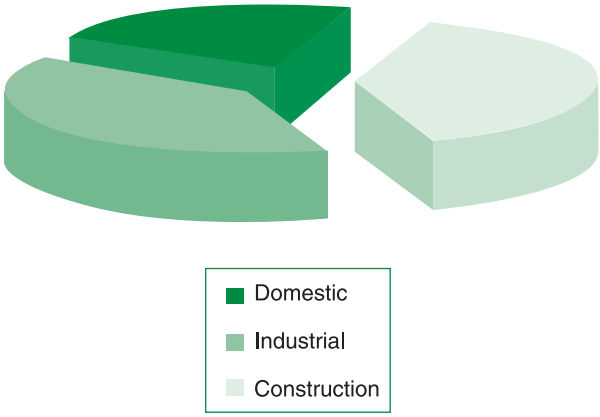


Figure 3.3: *Sources of Solid Waste for Malé*
Source: *The study on solid waste management for Malé city in the Maldives, JICA, 1998*

for the central region of the country. In addition to waste from Malé, it now receives waste from islands in Malé atoll, the resorts and the Malé International Airport.

Solid wastes generated in the atolls are disposed using various methods. Organic wastes are composted at home backyards in most of the islands. Non-biodegradable waste such as plastics is dumped near the beach in many islands and buried in a few islands. Burning of combustible waste at designated areas in the islands is also widely practised in many islands.

Current waste disposal practices adversely affect the environment through habitat destruction and pollution. Often, wetland areas such as swamps and mangroves are considered as "useless" areas and therefore dumping of solid waste in such areas is acceptable practice and reclamation of such areas to increase land space often

takes place. Dumping of solid waste near beaches also has adverse effects on the reefs and lagoons of the islands.

The amount of hazardous waste generated in the Maldives is very small. In 1998, it was estimated that 0.4 ton of hazardous waste was generated daily in Malé. Though figures for hazardous waste generated for the atolls have not been estimated, it is believed that the generation of hazardous waste would be very small. Hazardous waste mainly includes clinical wastes and waste oil from electric generators and vehicles. At present, hazardous waste generated in Malé are transported to Thilafushi.

3.3.1 Sewage and wastewater

Like many small coastal communities of the world, Maldivians also traditionally used the "bush or the beach" for human excreta disposal. A designated area in the household backyard for shallow burial of faeces (handas buri or gifili) and defecation along the beach (athirimathi) have been common practice in the past.

These practices, especially the defecation in the gifili, are known to damage the environment through contamination of groundwater aquifers which were directly used (especially during dry period) for potable purposes.

One of the main concerns surrounding such sewage or excreta disposal practices in the past was the morbidity and mortality from diarrhoea, which still continues to be so. With the construction of rainwater tanks both in Malé and the atolls, and the introduction of a comprehensive sewerage scheme in Malé and intensive health education on the use of oral rehydration, the situation has improved tremendously. Deaths from diarrhoea have dropped considerably, although the morbidity situation has not improved significantly. Serious epidemics of diarrhoea occurred in 1978 (Cholera) and in 1982 (Shigella) claiming several lives. The cholera epidemic affected 50% of the islands with more than 15000 cases reported and 200 deaths. Between 1992 and 1993, there has been a reduction in the reported cases of diarrhoea in the country as a whole.

Although almost universal access to sanitation has been achieved in Malé and a comprehensive sewerage system is in place, there are critical design and long-term maintenance concerns that has contributed to rapid faecal contamination of Malé groundwater aquifer. Malé Water and Sewerage Company is working to rectify these problems and bring the system to an acceptable level of performance.

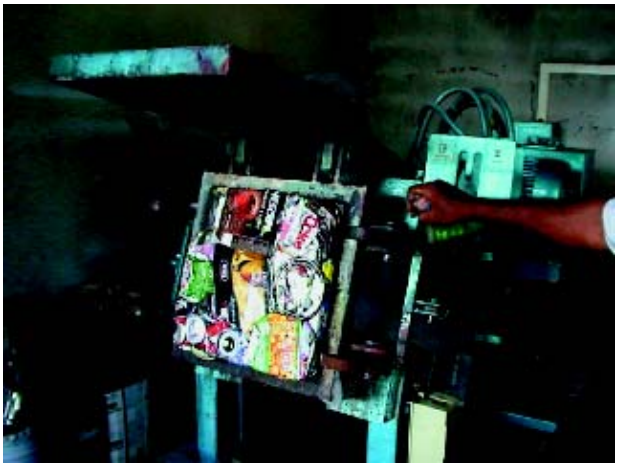
Pollutants reaching the water resources, especially groundwater aquifers come from point sources and non-point sources. Point sources that mainly include sewage disposal and discharges from sub-industrial activities have contributed to contamination of groundwater aquifers in Malé and other industrial or populated islands. A study carried out by MWSA in Malé showed that petro-chemical pollution of the groundwater aquifer is quite prominent in many areas of Malé. This pressure is due to vehicle washing garages and engine repair and maintenance workshops scattered all over Malé. The oil spillages in Malé had contaminated the ground water to the point where tests conducted by MWSA showed the water at the area unfit for any use (MWSA, 1995). The scale and significance of water pollution problems caused by the power stations and oil storage at other islands has yet not been assessed so far. However, spillage had been observed in many oil handling areas (such as in powerhouses) in other islands too.

The agricultural sector in the Maldives does not use a significant amount of chemical fertilisers and pesticides. Thus groundwater and seawater contamination from agricultural run-off is at present not a problem. However, in the last few years there has been a marked increase in the amount of fertilisers and pesticides used although it is not significant.

Issues facing coastal waters are mainly related to disposal of untreated sewage and wastewater effluent. Of the seven islands provided with central small bore sewerage systems, only three islands have secondary treatment facility (i.e. septic tanks). The rest disposes raw sewage into the coasts making coastal waters unsuitable for bathing or general use. In Malé, the capital, sewage is disposed untreated into the nearshore waters via nine outfalls at six locations. The pollution load from these sewer outfalls probably exceeds the dilution capacity of the receiving waters. The Malé sewers not only carry sewage but also different chemicals and potentially harmful substances.

3.3.2 Major Policy Responses and Initiatives

Environmentally unsound practices in solid waste and sewage disposal pose the most serious threat from tourism to the delicately balanced coral reef ecosystem of the Maldives. Though solid waste is a cause of environmental concern, at current levels it is more of an aesthetic problem. In the past, waste and garbage which could not be burned was dumped into the sea. This practice is now prohibited by law and waste incinerators and crushers have to be used in all resorts. Sewage effluent is discharged into the sea by the resorts. However, the discharges from resorts are very small and the evidence on reef degradation from sewage



discharges is inconclusive. Some of the resorts are now turning to the latest technology in sewage treatment using ultra violet radiation to produce virtually pure water.

The Maldives has developed a very suitable form of tourism, appropriate for the small island environment. The present form of tourism development has not generated any serious environmental impacts. This has been accomplished through appropriate policies, legislation and plans and instituted mechanisms to apply strict standards and regulations. However, the increasing number and magnitude of coastal modifications on the islands, including reclamation, harbour dredging and beach replenishment are serious environmental issues that need to be addressed in the tourism sector.

The management of solid wastes is identified as a key environmental issue in the Second National Environment Action Plan. In 1998, a study on The Solid Waste Management for Malé City in the Republic of Maldives was carried out with the assistance of Japan International Co-operation Agency (JICA), to assess the solid waste disposal problems in inhabited islands and resorts.

The Ministry of Home Affairs, Housing and Environment is currently in the process of developing a national waste management strategy for the country. An interagency technical committee was formed in April 2000 to advice the Ministry on the national waste management strategy.

Under the South Regional Development Project, and with the guidance of the technical committee, work is underway to develop a solid waste disposal site in Hithadhoo. A similar site is being developed under the Northern Regional Development Project in Kulhudhufushi. These waste disposal sites are expected to become operational in 2002.

Barging of solid waste collected at the transfer station from Malé to Thilafushi has proved practical and efficient. The experience gained from this operation is planned to be utilised in all the inhabited islands of Malé Atoll in 2002. Plans are underway to barge the solid waste collected from the inhabited islands in Malé atoll to the Thilafushi landfill. When this project is implemented, the problem of solid waste disposal in Malé Atoll would be significantly improved.

Maldives is party to the Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal. The Environment Protection and Preservation Act of the Maldives (Law 4/93) provides a statutory framework enabling the control and regulation of the transboundary movement of hazardous waste controlled under the Basel Convention in the Maldives.

3.4 AIR POLLUTION

Air quality of the Maldives is generally considered to be good and is in pristine state. As the islands of the Maldives are small, the sea breezes flush the air masses over the islands and keep air over the islands fresh from the sea. However, recently it has been observed that transboundary air pollution is affecting the air quality of the Maldives. Local air pollution in Malé is also a growing concern.

Transboundary air pollution in the Maldives became first known in 1997, when large parts of the country were affected by haze caused by forest fires in Indonesia. The haze layer blanketed the country between October 1997 and December 1997 and significantly affected the routine lives of the Maldivians. The actual state of the transboundary movement of air pollutants over the Maldives was measured in the Indian Ocean Experiment (INDOEX). INDOEX was carried out by a team of more than 200 international scientists and was led by the Centre for Clouds, Chemistry and Climate (C4) of the University of California. INDOEX results showed widespread pollution over large sections of the Indian Ocean. In March and April 1999, the scientists were surprised to find a dense brownish pollution haze layer stretching an area of more than 10 million square kilometers over the Indian Ocean tropical region. Because of the pollution, visibility over the open ocean dropped below 10 km, a visibility which is typically found near polluted regions in the eastern United States and Europe (C4 2000).

Local air pollution in Malé is mainly due to particulate emission from vehicles, power generation, and construction related activities. Particulate includes a range of materials such as soot and coral dust. High rise buildings and congestion in Malé has disrupted cross circulation of air and emissions from the increasing number of motor vehicles on the roads are deteriorating the urban air quality of Malé. Though the pollution is visible in certain times, no numerical measures of the level of pollution are available. Elevated particulate levels are implicated in a range of respiratory problems such as asthma, allergic respiratory responses, bronchitis and emphysema. The Health Master Plan identifies outdoor air pollution as a major contributor to respiratory problems in the Maldives (MoH 1998).

From the health records, it is seen that the number of cases reported with respiratory problems has been on the increase for the past 5 years (figure: 3.4).

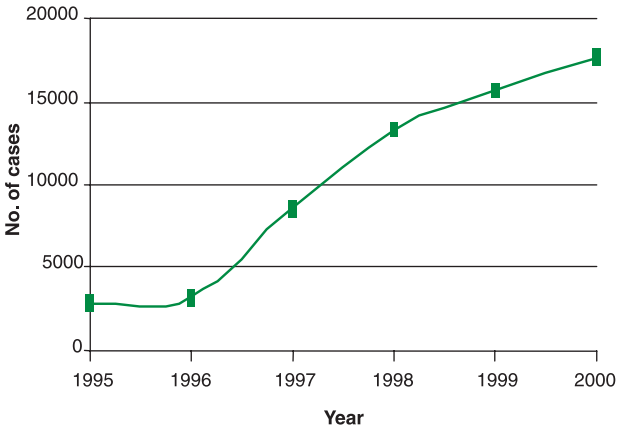


Figure 3.4: *Acute Respiratory Infection Cases Reported from Malé.*

Source: *Department of Public Health, 2001*

Land transport exerts pressures on the environment in many ways. Vehicles emit carbon dioxide, carbon monoxide, oxides of nitrogen, sulphur dioxide, lead, particulate materials and volatile organic compounds (VOCs). Traffic noise is also a nuisance associated with land transport. As can be seen from the figure, in a period of not more than two and half years from 1996 the population of vehicles registered in the Maldives more than doubled (figure 3.5). Cars represent a very significant number among the registered vehicles and in 1994, 128 new cars were registered and this grew to 315 in 2000 (MPND, 2001). From 1990, the import of motorcycles has increased at an average of

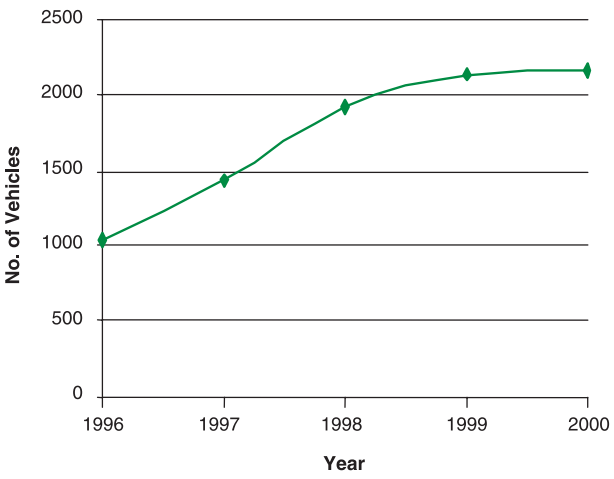


Figure 3.5: *Registered New Vehicles*

14% per annum. In 2000 alone, 1860 motorcycles were registered (MPND, 2001). The smallness of the islands and infancy of the land transportation sector has limited the land transport system mainly to Malé and some regional growth centres such as Hithadhoo and Kulhudhuffushi. The increased use of vehicles in Malé is causing not only congestion on the narrow street system but is deteriorating the urban air quality as well.

3.4.1 Major Policy Responses and Initiatives

As air pollution is an emerging environmental issue in South Asia, on the initiative of United Nations Environment Programme a declaration to promote regional co-operation in the area of air pollution was agreed in 1998. The Malé Declaration on Control and Prevention of Air Pollution and its Likely Transboundary Effects for South Asia was adopted by Ministers of Environment at the seventh meeting of the Governing Council of South Asia Co-operative Environment Programme (SACEP) in Malé.

In 2001, the Government adopted, Addressing Air Pollution - National Strategy for Action with the aim to establish the necessary framework for addressing air pollution to protect the environment of the Maldives. The action plan calls for regular monitoring of air pollution and to assess the impacts of air pollution on human health and assets, introduction of preventive and management measures for air pollution at the source level, development of suitable coordinating mechanisms for the successful implementation of the air pollution action plan and for building adequate capacity to address the issue of air pollution.

As a means of reducing the traffic problems and improving the air quality in Malé, the Government has banned in December 2000, the import of reconditioned motorcycles which have an engine capacity of less than 150 cubic meters into the country. Similarly, a ban was introduced on the import of cars more than 5 years old into the country.

In 1998 and 1999, the Maldives contributed to the Indian Ocean Experiment (INDOEX) which was carried by an international group of scientists. A climate observatory was established at Kaashidhoo in 1998 as part of the Indian Ocean Experiment (INDOEX). The station was developed as a model station for frontline atmospheric research in the tropics. It was aimed at providing an excellent venue for scientists to study a range of critical issues of general interest to the climate research community. The station was shutdown in July 2000 due to technical problems. The observatory is planned to be relocated in Hanimadhoo to continue the climate research under the second phase of INDOEX as Asian Brown Cloud (ABC) with assistance from UNEP. This station will monitor the impact of pollutant emissions in the region.

3.5 BIODIVERSITY CONSERVATION

Due to the lack of natural resources and wealth, biodiversity particularly marine biodiversity is the most significant and vital resource base for the country. The livelihood has traditionally been marine-based as well and marine resources still continue to be the main generator of food, earnings, employment, protection and shelter.

3.5.1 Coral Mining

Coral mining for housing, although declining, has been another cause of environmental degradation. In addition to having adverse impacts on the reefs itself, it affects the islands as well as biodiversity. Coral reefs offer strong coastal protection against ocean currents, waves and tides. Mining of corals have resulted in the destruction of this protection layer in some islands causing considerable amount of beach sand to wash away from the island into the sea. As the protection layer is destroyed, waves and tides directly enter into the island causing damage to the vegetation and intruding into the freshwater aquifer. The other associated impacts on the reefs include loss or migration of residential reef fish communities and other living organisms, loss of bait fish that are important for the local tuna fishery, and reduced coral percentage cover. Most importantly, these reefs may take several years to recover.

Cement blocks are increasingly replacing the use of coral for housing. In addition, alternatives such as cement and sand bags are being utilized for construction of seawalls and harbour walls. However, the practice of using coral for buildings and for sea walls does continue to some extent.

As population grew in crowded islands and when available land area was no longer sufficient to meet the demand for housing, reclamation of shallow reefs adjacent to the islands has been carried out. Land reclamation activities have negative implications such as destruction of shallow lagoons, sea grass and reef flat communities, and adverse effects on nearby coral reef communities through suspended sediments.

Therefore, housing issues and congestion in the face of a growing population continues to deplete the natural resources such as stock of ground water, plants and coral reefs of the fragile ecosystem. Additionally, it has increased the variety and magnitude of pollution created by human settlements.

3.5.2 Fish resources

Although tuna has historically been the major fish resource and little use was made of reef fish resources, over the last decade or so, exploitation of reef resources in the Maldives has become an important component of the country's fisheries sector. Demand for marine products such as lobsters and reef fish increased locally with increase in demand for the tourist resorts. High demand in the international market for certain reef species has increased pressure on these reef resources. Reef resources that are exploited mainly for export include groupers, sea cucumber, sharks and ornamental varieties.

A specific fishery for grouper started in the Maldives in 1992. The maximum sustainable yield for all grouper species is estimated at 1800+700 tons (Shakeel, 1994). However, these are crude estimates to be used cautiously. Export figures show a declining trend in the quantity of groupers exported as well as total value of exports (figure: 3.6). Given the pressure on the grouper resources, it is highly likely that grouper resources are being over fished.

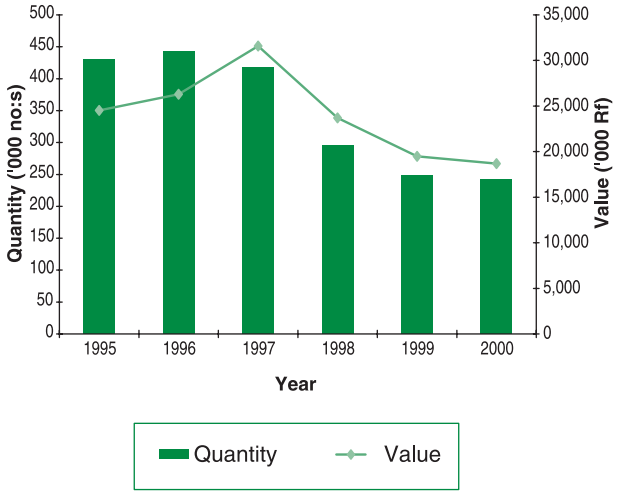


Figure 3.6: *Live Grouper Exports and their Value (1995 - 2000)*

Export figures for dried sea cucumber show a much lower bulk of exports in mid and late 1990's compared to the peak years during early 1990's, with correspondingly low value for exports. However, the total value increased considerably in 2000 (figure 3.7).

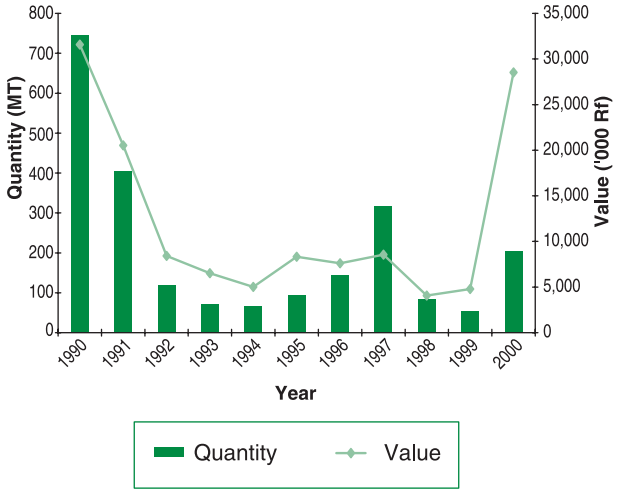


Figure 3.7: *Dried Sea Cucumber Exports (1990 - 2000)*

The live ornamental species export trade (Aquarium Fish) exploits about 100 species of marine organisms, majority of which are reef fish. Of these, about 20 species contribute to more than 75% of the catch (Adam, 1997). The total quantities of ornamental species exported by the "Ornamental Fish" industry too have declined in recent years.

Edwards and Shepherd (1992) found that some species were being, locally over- exploited or exploited close to maximum sustainable levels in the area around

Malé. Some species exploited by the aquarium fish trade are known to be limited in distribution or rare or not yet described for the Maldives. The Clown Fish (Amphiprion nigripes) is quasi-endemic with the Maldives as its centre of abundance (Adam, 1997). The species is quite commonly exported from the Maldives and 8000 Maldives Clown Fish and 500 anemones were exported in 1994 alone. The angel fish Apolomichthys armitagei is known to be rare in the Maldives.

Reef sharks as well as oceanic sharks are exploited mainly for the fins. Dried shark fins fetch good prices in the international market. Anderson and Ahmed (1993) suggested that reef sharks were being fished at moderate levels of fishing effort, which was probably sustainable at the time of study. However, an increase in fishing effort from that of 1993 levels would adversely affect stocks. The current status of reef shark stocks is unknown.

Threat of over-exploitation is the biggest environmental problem posed by commercial exploitation of reef resources. The export quantities of most of the reef species have declined. Since stock status is not monitored regularly it is not known if stocks are over-exploited.

3.5.3 Fishing methods

Fishing methods generally practised in the Maldives are not destructive for the environment. Figure 3.8 provides details of fish catch by fishing methods. Although the fisheries industry expanded through the mechanisation of the traditional fishing fleet, fuel distribution and fish collection systems, the fishing practice remained traditional. Most fish are caught using lines which target a certain species and thus by-catch which is wasted is almost non-existent. The tuna fishery is largely based on pole and line fishing from mechanised

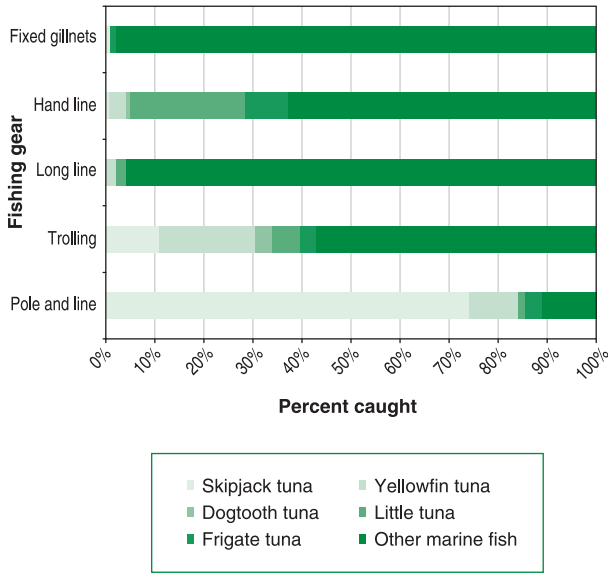


Figure 3.8: *Fish Catch by Gear*

dhonis, thus producing a "dolphin friendly" product. Other species such as groupers are caught using hand lines and sea cucumbers are collected by hand or using lines. Gillnets are mainly used for targeting reef sharks.

Some bait fishing practices are known to have adverse effects on the habitat. When catching species closely associated with the reef, sometimes poles or a "scarer" (palm fronds or steel chain) are used to chase the fish. This can result in damage to the coral (Anderson 1997). In recent years, the method of catching live bait have changed from the traditional method of collecting bait during the day to using light at night to attract bait. The environmental implications of this change are being studied. Although not widely practised, some isolated cases of illegal use of chemicals, which can be detrimental to the reefs, are reported. These include use of household bleach or chlorine to catch octopus.

3.5.4 Major Policy Responses and Initiatives

Recognising the importance marine biological diversity plays in sustainable development, the government has adopted a number of measures for protection and conservation of biodiversity.

The second National Environment Action Plan adopted in 1999, recognises biodiversity conservation as one of the priority issues to be addressed to achieve environmental protection and sustainable development. Other related priority issues identified in NEAP II include coastal zone management and integrated reef resources management.

The first National Biodiversity Strategy and Action Plan (NBSAP) of the country has been adopted in 2001. It was undertaken with extensive stakeholder participation throughout the country, and the draft NBSAP was discussed and endorsed at a national level workshop in April 2001. The first country report on biological diversity will also be published in 2001.

Recognising the importance of healthy coral reefs to the two major industries of the Maldives, tourism and fisheries and the need to address the problems resulting from increased reef resource usage, the Maldivian Government commenced promoting a policy of integrated reef resources management. The Ministry of Fisheries, Agriculture and Marine Resources with assistance from the Bay of Bengal Programme (BOBP) initiated the Integrated Reef Resources Management programme. Under this programme, a workshop was held in Malé in March 1996 with extensive stakeholder participation and national and international advisors, to "identify key issues and objectives for the IRRM process, and make recommendations for its implementations" (BOBP, 1997). The Fisheries Advisory Board endorsed the recommendations made at this workshop, in 1996.

The Government has also initiated several measures for the protection of important habitats and threatened species. Since 1 October 1995, 25 marine areas have been declared protected. All forms of fishing except bait fishing with traditional methods have been banned in these areas. These are popular dive sites and 14 are popular for shark-watch diving. Turtles have also been protected since 24th June 1995.

(Table 3.4). Other measures include banning export of important bait fish as aquarium fish; banning fishing from the house reefs of tourist resorts; and the protection of threatened marine resources such as sharks, sea turtles, giant clams, and black coral (tables 3.5 and 3.6).

Table 3.4 List of the marine protected areas in Maldives

1.	North Maalhosmadulu	Vilingili Thila
2.	South Maalhosmadulu	Dhigali Haa/ Horubadhoo Thila
3.	Faadhippolhu	Fusheevaru Thila
4.		Kureddhoo Kandu Olhi
5.	Malé Atoll	Makunudhoo Kandu Olhi
6.		Rasfaree and the enclosed reef
7.		Thamburudhoo Thila
8.		Gaathugiri/Ad'dhashugiri
9.		Giraavaru Kuda Haa
10.		Dhekunu Thilafalhuge Miyaruvani
11.		Kollavaanee in the centre of Gulhifalhu
12.		Emboodhoo Kandu Olhi
13.		Guraidhoo Kandu Olhi
14.		Lankan Thila
15.	Ari Atoll	Maayaa Thila
16.		Orimas Thila
17.		Mushimasmigili Thila
18.		Kudarah Thila
19.		Karibeyru Thila
20.		Faruhuruvalhibeyru
21.	Felidhu Atoll	Miyaru Kandu
22.		Vattaru Kandu
23.	Mulaku Atoll	Lhazikuraadi
24.	North Nilandhe Atoll	Filitheyo Kandu
25.	South Nilandhe Atoll	Fushi Kandu

Protected Marine Areas of the Maldives

The following areas are protected under the Environment Protection and Preservation Act (4/93). Anchoring (except in an emergency), coral or sand mining, waste disposal, removal of any natural object or living creature, fishing of any kind (example: for sharks, reef fish or aquarium fish) with the exception of traditional live bait fishing, capturing of birds, any activity which may cause damage to the area or its associated marine life are prohibited in these areas.

Raa Atoll
- Villigili Thila

Baa Atoll
- Dhigalihaa/Horubadhoo Thila

Laviani Atoll
-Kuredhdhoo Kandu
-Fushivaru Thila

Male' Atoll
-Makunudhoo Kanduolhi
-Rasfari Faru
-Giraavaru Kuda haa
-Dhekunuthilafalhuge Miyaruvani
-Gulhifalhu/Kollavani
-Thamburudhoo thila
-Gaathugiri/Adhdhashugiri
-Emboodhoo Kanduolhi
-Guraidhoo Kanduolhi
-Lankan thila

Alifu Atoll
-Maya Thila
-Orimas Thila
-Mushimasmigili Thila
-Karibeyru Thila
-Faruhulhuvaru Beyru
-Kudarah Thila

Vaavu Atoll
-Miyaru Kandu
-Vattaru Kandu

Meemu Atoll
-Lhazikuraadi

Faafu Atoll
-Filitheyo Kandu

Dhaalu Atoll
-Fushi Kandu

Map 3.2: *Protected Marine Areas of the Maldives*

Your might consider including these three tables in place of tables 3.4, 3.5 and 3.6. (same source)

The 25 marine protected areas, under the Law on Protection and Preservation of the Environment are given in the table 3.4.

All fishing or collection of these animals in the Maldives is prohibited.

The items listed in the table 3.6 may not be exported in any form, whether as souvenirs, souvenirs products or for commercial use.

Protected species include the bird White Tern Gygis alba monte in 1996 and 22 additional bird species protected in 1999 under the Environmental Protection and Preservation Act, of which some are important for the local tuna fishery and others are endemic to the Maldives at subspecies level (table 3.7 and table 3.8).

Taking into consideration the importance of sharks to the fisheries and tourism sectors, on 8 September 1998, the Government banned all forms of shark fisheries for a period of 10 years, within the 12 mile zone from the atoll rim in the following atolls. (table 3.9)

Two islands, Hithaadhoo (North Huvadu Atoll) and Hurasdhoo (South Ari Atoll), have been declared as protected islands because of their unique avain population and geological formation, respectively.

Table 3.5 List of the marine animals prohibited for fishing and collection

Black coral
Conchs
Giant Clams
Berried and small lobsters
Turtles
Napolean Wrasse
Dolphins
Whale Sharks
Whales

Table 3.6 List of marine Products Prohibited for Export

Black corals
Stony corals
Triton shell
Pearl Oyster
Lobsters
Turtles
Turtle shell
Eel
Puffer fish
Parrot fish
Skate and ray
Bigeye scad under 15 centimetres
Bait fish used in tuna fishery
Dolphin
Whale

Table 3.7 Protected species of birds

SCIENTIFIC NAME	ENGLISH NAME
1- Anous tenuirostris	Lesser Noddy
2- Anous stolidus	Brown Noddy
3- Sterna fuscata	Sooty Tern
4- Sterna anaethetus	Birdled Tern
5- and 6- Sterna hirundo (2 different species of the common tern)	Common Tern
7- Sterna bengalensis	Lesser/crested Tern
8- Sterna bergiii	Great Crested Tern
9- Saunder's little tern	Sterna Crested Tern
10- Sterna sunmatrana	Black-naped Tern
11- Sterna nilotica	Gull-villed Tern
12- Puffinus iherminieri	Audobon's Shearwater
13- Puffinus pacificus	Wedge-tailed Shearwater
14- Puffinus carneipes	Fiesh-footed Shearwater
15- Fergata ariei	Lesser Frigatebird
16- Fergata minor	Great Frigatebird
17- Phaethon lepturus	White-tailed Tropicbird

Table 3.8 Birds specific to and living only in the Madives

SCIENTIFIC NAME	ENGLISH NAME
1-Ardeoia graii Phillipsi	Maldivian Pond Heron
2-Butorides striatus albidulus	Maldivian Little Heron
3-Butorides striatus didii phillips	Central Maldivian Little Heron
4-Phoenicurus maldivus	Maldivian water Henq Amouronis
5-Eudynamys scolopacea scolpacea	Asian Koel

Table 3.9 Atolls in which there is a shark fishery moratorium

1. South Maalosmadulu Atoll
2. Faadhippolhu
3. Malé Atoll
4. North Ari Atoll
5. South Ari Atoll
6. Felidu Atoll
7. Addu Atoll

A tree planting programme was launched nation-wide during the year 1996 with the aim of adding a million trees to the island ecosystems within 3 years. The "Million Tree Programme" was initiated by the President on 15 January 1996. The tree planting programme was a concerted effort to conserve, rehabilitate and manage the environment. The Ministry of Fisheries and Agriculture was selected as the nodal agency for the implementation of the program under the guidance of the President's Office. Due to the extensive support the programme received the initial target of one million trees was almost achieved by the end of 1996 itself. Therefore a new target of 2 million trees was set.

Following on from the two million-tree programme, a 3 year fruit tree planting programme was launched nation-wide in June 2000 by the Ministry of Fisheries, Agriculture and Marine Resources, in an effort to increase fruit trees in the country. The objectives of the programme include increasing awareness and interest in growing fruit trees, increasing local production and generating the spirit of growing trees in all islands.

In order to protect and conserve biological diversity of the country, a pilot project on the establishment and management of protected areas has been initiated with the assistance of the Government of Australia through AUSAID. The Maldives Protected Area Systems (MPAS) project aims to assist the Government with establishment of a replicable and sustainable system for the protected area management.

Legal measures for protection of timber resources were established through regulations under the Law on Uninhabited Islands (Law no: 20/98). Under this law timber from uninhabited islands can be logged only after getting written approval for the purpose from the Ministry of Fisheries and Agriculture, and in the presence of a representative from the atoll office and a representative of the lessee. In addition, every coconut palm that is logged has to be replaced with 2 coconut palms and every tree that is logged has to be replaced by a tree under the direction of the Ministry of Fisheries and Agriculture.

The Marine Research Centre of the Ministry of Fisheries Agriculture and Marine Resources has undertaken three different coral reef monitoring programmes in collaboration with different institutions or agencies. Coral reef monitoring to assess the extent of coral bleaching has been carried out in collaboration with the Global Coral Reef Monitoring Network (GCRMN) since 1997 and Coral Reef Degradation in Indian Ocean (CORDIO) project, particularly initiated with the support from Swedish Government, to study the bleaching effects since 1998. The overall objective of the Maldives/GCRMN project is to improve management and sustainable use of coral reefs and related ecosystems by providing information on the trends in biophysical status, social cultural and economic values of these ecosystems (Anon 1999). Marine Research Centre (MRC) has also participated in the Reef Check programme since 1997, a volunteer effort carried out world-wide by recreational divers and led by experienced marine scientists. In addition MRC has an ongoing program on identification and cataloguing of fish species in Maldivian waters.

PROTECTED BIRDS

WHITE TERN
(*Gygis alba monte*)

PUBLIC NOTICE NO: 1-96/34 *as of* 05 *June* 1996

GREAT CRESTED TERN
(*Sterna bergii*)

BLACK-NAPED TERN
(*Sterna sumatrana*)

WEDGE-TAILED SHEARWATER
(*Puffinus pacificus*)

FLESH-FOOTED SHEARWATER
(*Puffinus carneipes*)

LESSER CRESTED TERN
(*Sterna bengalensis*)

LESSER NODDY
(*Anous tenuirostris*)

GULL-BILLED TERN
(*Sterna nilotica*)

WHITE-TAILED TROPIC BIRD
(*Phaethon lepturus*)

SOOTY TERN
(*Sterna fuscata*)

AUDUBON'S SHEARWATER
(*Puffinus lherminieri*)

BRIDLED TERN
(*Sterna anaethetus*)

SAUNDER'S LITTLE TERN
(*Sterna saundasi*)

BROWN NODDY / COMMON NODDY
(*Anous stolidus*)

GREAT FRIGATE BIRD
(*Fregata minor*)

LESSER FRIGATE BIRD
(*Fregata ariel*)

ASIAN KOEL
(*Eudynamys scolopacea scolopacea*)

COMMON TERN
(*Sterna hirundo*)

ROSEATE TERN
(*Sterna dougallii*)

MALDIVIAN POND HERON
(*Ardeola grail phillipsi*)

CENTRAL MALDIVIAN HERON
(*Butorides striatus didi phillipsi*)

MALDIVIAN WATER HEN
(*Amaurornis phoenicurus maldivus*)

MALDIVIAN LITTLE HERON
(*Butorides striatus alhikalusi*)

The above birds are protected under the Environment Protection and Preservation Act, (4/93)
Their capture, sale and captivity is prohibited.

Ministry of Home Affairs, Housing and Environment

PUBLIC NOTICE NO: 10 C99/24 *as of* 11 *July* 1999

Part IV CONCLUSIONS AND RECOMMENDATIONS

PART IV CONCLUSIONS AND RECOMMENDATIONS

Being a low-lying island nation, the environment is particularly vulnerable to climate change and its associated ill-effects; particularly sea level rise. In addition to the long-term concern of inundation, the immediate effects climate change, such as the reduction in the precious freshwater aquifers beneath the islands, the increased frequency and intensity of stormy weather, the destruction of the rich coral ecosystem, the negative repercussions on the two main economics mainstays of fisheries and tourism and severe beach erosion are issues that have to be addressed urgently.

Beach erosion can in fact be singled-out as being one of the priority environment issues in the Maldives. At present, nearly 50 percent of all inhabited islands and nearly 45 percent of tourist resorts are facing varying degrees of coastal erosion (MHAHE 2000).

The topography of the Maldives makes the country extremely susceptible to stormy and high wave occurrences. The high wave incident of 1987 flooded nearly a third of the capital Malé, as well as the country's only international airport on Hulhule'. The incident not only took the country by surprise, but it also highlighted the urgent need to develop an effective disaster-preparedness framework. The strong winds and stormy weather experienced across the country in 1991, and in particular the southern-most atoll, added further clout to this point.

In the Maldives, the water resources comprise of freshwater that occurs in the porous coral sediments on many islands. The people have traditionally relied on groundwater from shallow wells dug in the ground. At present, the groundwater in Malé and many other populous islands are only a fraction of what it was before. In recent years, desalination has become necessary when the sustainable yield of the existing groundwater aquifer on some islands was exceeded. In addition, in many islands, rainwater is extensively used for both drinking and cooking. While quality tests have shown rainwater in the Maldives to be of acceptable potable quality, a full analysis maybe required before the impacts of trans-boundary air pollution can be determined.

A major pressure on the environment arises from the wastes and pollutants produced as a by-product of domestic and industrial activities. Solid waste disposal is now one of the most critical environmental issues in the Maldives. The amount and the rate of solid waste generated vary throughout the country and there is a significant difference between the amount of waste generated in Malé and that of in the atolls. The amount of solid waste generated in Malé has been increasing at an alarming rate over the past 10 years. Environmentally unsound practices in solid waste and sewage disposal pose the most serious threat from tourism to the delicately balanced coral reef ecosystem of the Maldives. Though solid waste is a cause of environmental concern, at current levels it is more of an aesthetic problem. The management of solid wastes is also identified as a key environmental issue in the Second National Environment Action Plan.

Air quality of the Maldives is generally considered to be good and is in pristine state. Trans-boundary air pollution in the Maldives became first known in 1997, when large parts of the country were affected by haze caused by forest fires in Indonesia. The actual state of the trans-boundary movement of air pollutants over the Maldives was measured in the Indian Ocean Experiment (INDOEX). In March and April 1999, the scientists were surprised to find a dense brownish pollution haze layer stretching an area of more than 10 million square kilometres over the Indian Ocean tropical region. Local air pollution in Malé is mainly due to particulate emission from vehicles, power generation, and construction related activities. As air pollution is an emerging environmental issue in South Asia, on the initiative of United Nations Environment Programme a declaration to promote regional co-operation in the area of air pollution was agreed in 1998. The Malé Declaration on Control and Prevention of Air Pollution and its Likely Tran-boundary Effects for South Asia and the 'Air Pollution - National Strategy for Action', which was adopted by the Government in 2001 were two important responses to the problem.

Due to the lack of natural resources and wealth, biodiversity particularly marine biodiversity is the most significant and vital resource base for the country. The second National Environment Action Plan adopted in 1999, recognises biodiversity conservation as one of the priority issues to be addressed to achieve environmental protection and sustainable development.

The first National Biodiversity Strategy and Action Plan (NBSAP) of the country has been adopted in 2001. Recognising the importance of healthy coral reefs to the two major industries of the Maldives, the Ministry of Fisheries, Agriculture and Marine Resources with assistance from the Bay of Bengal Programme (BOBP) initiated the Integrated Reef Resources Management programme. The Government has also initiated several measures for the protection of important habitats and threatened species. 25 marine areas, 2 islands and numerous birds and marine species have been protected. A number of marine species have also been banned for export and shark fishery has been regulated as well. In order to protect and conserve biological diversity of the country, a pilot project on the establishment and management of protected areas has been initiated with the assistance of the Government of Australia through AUSAID.

In a competitive and uncertain global economy, the need to achieve the best possible return from the limited resource base of Maldives remains strong. This enhances the vulnerability of the fragile ecosystem in the Maldives. The preservation of the ecosystem and the natural resources will require to look into the environmental dimensions of socio-economic development and the socio-economic dimensions of environmental degradation. The Government will have to regulate the unsustainable exploitation of the country's resources to ensure the sustainability of development.

The domestic policy alone can not protect the Maldives's environment from threats such as global warming and sea level rise that are mainly caused by activities elsewhere. Global warming and associated sea level rise would subject Maldives to frequent natural disasters and a number of environmental problems.

In order to effectively deal with the issue of climate change and sea level rise, this chapter has recommended a number of project proposals for consideration by the Donor Agencies (See in Annex 2).

RECOMMENDATIONS

Contribute to the international efforts to find solutions to global environmental threats, especially those pertaining to the vulnerable Small Island Developing Nations

- Utilise opportunities to address the international fora to call attention to the fragile nature and the vulnerability of Small Island Developing Nations.
- Continue the timely implementation of commitments by the Maldives under international conventions and organizations to which Maldives is a party.
- Promote wider participation of the community in research, data collection and awareness creation regarding the fragile environment of the Maldives.
- Develop long term mitigating and adaptive response strategies in dealing with the question of possible sea level rise and climatic change.
- Set up a National Task Force, equipped with appropriate expertise, to conduct international negotiations relating to the environment as they impinge on the interests of the Maldives.

Promote integrated planning and administrative practices by developing meaningful principles and procedures for sustainable resource use and environmental protection

- Strengthen the implementation of a comprehensive framework of laws pertaining to natural resources and environment, together with means for enforcement.
- Establish ownership of resources through establishment of property rights and the introduction of
- resource rent.
- Review the adequacy of institutional mechanisms and administrative arrangements and promote wider participation in the implementation of environmental policies and strategies.
- Incorporate the principles of sustainable regional development into the mandates and procedures of all institutions dealing with developmental planning and resource management.
- Strengthen the submission of proposed policies, development programs and projects for Environment Impact Assessment (EIA) procedures.

Ensure adequate water supply, sanitation, safe and environmentally sound management of sewage and solid waste disposal facilities to all islands

- Formulate a plan to provide safe water, sanitation and waste disposal to all islands with defined needs and priority actions
- Develop a national waste management strategy and facilitate its enforcement

- Encourage and facilitate private sectors to become more involved in providing sanitation and waste management services
- Promote the inclusion of sanitation issues not only in planning health services but also in planning and provision of education, infrastructure development and construction activities
- Promote land use planning to protect freshwater aquifers
- Continue to raise awareness on solid waste management
- Promote the use of cleaner technologies and encourage safe use and disposal of hazardous materials
- Develop and enforce guidelines and operational procedures for sewerage projects

Ensure the availability of safe drinking water throughout the country

- Prepare a strategic plan for the development, improvement and construction of public water supplies.
- Encourage and promote community participation in water management.
- Ban the use of harmful materials for roofing, gutters, pipe works and for storage tanks.
- Enforce guidelines and standards and address complaints regarding the misuse of water.
- Continue to monitor the quality of drinking water in all islands.
- Formulate and enforce regulations, standards and guidelines for the design, construction and maintenance of water supply services.
- License all water supply undertakings that supply water to more than 500 people and require such supplies to monitor the performance of the water supply system and to keep records of the monitoring process.
- Monitor all water supply undertakings by periodic inspection, sampling and analysis.
- Eliminate/ban the collection of rainwater from roofs with asbestos cement sheets.
- Regulate and control abstraction and dewatering.
- Strengthen the regulator to enforce standards and monitor compliance.

Develop and manage the marine resources of the country in a sustainable manner

- Strengthen the Ministry of Fisheries, Agriculture and Marine Resources (MOFAMR) to effectively co-ordinate the regulation and management of offshore and coastal fisheries.
- Explore the possibilty of assigning the responsibility for offshore fisheries licensing, monitoring control and surveillance to MOFAMR.
- Establish a unit in the MOFAMR to support local management, at the island and atoll level, of reef and bait fish resources, coral reef management and protection.
- Participate in regional fisheries management bodies to present the interests of Maldives a genuine stakeholder in the pelagic marine resources of the Indian Ocean.
- Revise and implement management plans for marine protected areas.
- Formulate and adopt an integrated marine policy that will harmonise policies and strategies formulated by different Government Ministries/ Departments with respect to the marine resources and environment.
- Develop and strengthen the existing marine research centre.
- Ensure the availability of the most current scientific knowledge and advice to enable the conservation, sustainable management and development of marine resources and the habitats, which sustain those resources.

Promote environmentally sound disposal of solid waste

- License all solid waste collection and disposal undertakings that serve a community of more than 500 people.
- Require all solid waste undertakings to monitor the performance of the waste management system and to keep adequate records.
- Maintain surveillance of all solid waste undertakings by periodic inspection of facilities and records.
- Minimize import of non-biodegradable plastic products.
- Provide incentives for biodegradable packaging, composting and recycling, as well as utilization of innovative technologies.
- Designate waste disposal areas at atoll and island levels.

Ensure safe management of hazardous waste

- Develop and enforce appropriate environmental health codes as well as guidelines and operational
- procedures for collection, handling, sorting, use and disposal of solid waste.
- Monitor and control the movement of hazardous waste and prevent illegal traffic.
- Establish a national reporting system to report information on the generation and movement of hazardous waste.
- Empower a regulatory authority to oversee the disposal of hazardous waste.
- Develop institutional and technical capabilities by soliciting regional and international cooperation
- for training and technology transfer.
- Develop emergency procedures and measures to deal with accidental spills.

Recognise and protect the natural environment including the biological diversity of the regions identified for development

- Map the significant nature conservation areas in the regions and continue to maintain and update
- relevant data.
- Develop regional conservation strategies and facilitate conservation.
- Undertake detailed flora and fauna surveys of the regions, and use this information to develop management plans for vulnerable and endangered species and habitats.
- Develop lists of sites requiring re-vegetation and rehabilitation, and provide information on local trees and their suitability for different areas and landscape settings.
- Provide financial and technical assistance to NGOs, CBOs and other regionally active organizations involved in habitat management and rehabilitation activities.
- Promote the establishment of regional nurseries to produce locally occurring native trees for habitat rehabilitation programs.

Promote sustainable resource management through preservation of natural resources and biodiversity

- Continuously monitor and update the natural resources inventory including flora and fauna, in order to preserve the biodiversity of the nation.
- Implement an Integrated Resources Management Strategy to ensure sustainable use of extractive and non-extractive resources.
- Promote the use of alternative materials for economic and infrastructure development inorder to minimize damage to the environment.
- Strengthen policies and implementing procedures to protect and preserve the environment by establishing protected area management systems.
- Develop and implement a Forest Resources Management Strategy, which promotes reforestation schemes including agro-forestry.
- Develop and implement management plans to protect the productive capacity of mangrove areas, mass spawning marine habitats, roosting sites and such unique and vulnerable habitats.

REFERENCE

Adam S. and Anderson R. C. (1996) Skipjack tuna (Katsuwonus pelamis) in the Maldives pp. 55-69. In: MRS (1996) The Maldivian Tuna Fishery: A collection of Tuna Resource Research Papers, Maldives Marine Research Bulletin 2: 176pp

Adam, D.D. (1984) Report to the Government of the Maldive Islands on Floral Identification. Report No. RAS/79/123. Rome: FAO. 40p.

Adam, M.S., Merrett, N.R. and R.C. Anderson. (1998) Additions to the fish fauna of the Maldive Islands: Part I: And annotated checklist of the deep demersal fishes of the Maldive Islands. Ichthyological Bulletin of the J.L.B Smith Institute of Ichthyology, No. 67, pp1-19.

Adam, S. (1997) The aquarium fishery of the Maldives. Pp: 93-115. In: Nickerson, D. J. and M. H. Maniku (eds) Report and Proceedings of the Maldives/FAO National Workshop on Integrated Reef Resources Management in the Maldives. Malé, 16-20 March, 1996, BOBP, Report No. 76, Madras. Pages 250+VI.

Ahmed, A.H. and M.R. Saleem, (1999) Marine Flora and Fauna of the Maldives. Biodiversity theme paper prepared for the Ministry of Home Affairs, Housing and Environment. Unpublished manuscript.

Alcock A. (1906) Marine crustaceans. XIV. Paguridae. In Gardiner (1903-06), 2: 827-835.

Anderson (1996) Sea birds and the Maldivian tuna fishery. Rasain 16: 134-147

Anderson R. C. (1997) The Maldivian tuna livebait fishery. 69-92pp. In: Nickerson, D.J. and M. H. Maniku (eds) Report and Proceedings of the Maldives/FAO National Workshop on Integrated Reef Resources Management in the Maldives. Mal é, 16-20 March, 1996, BOBP, Report No. 76, Madras. Pages 250+VI.

Anderson R.C. and H. Ahmed (1993) The shark fisheries in the Maldives. Min. of Fisheries and Agriculture, Malé and FAO Rome. 73pp.

Anderson, C (1997) "Sharks Mean Business" Scientific American. pp: 72-73

Anderson, R.C., Randall, J.E. and R.H. Kuiter. (1998). Additions to the fish fauna of the Maldive Islands: Part II: New records of fishes from the Maldive Islands, with notes on other species. Ichthyological Bulletin of the J.L.B Smith Institute of Ichthyology, No. 67, pp 20- 32, 4 plates.

BOBP (1994) An Environmental Assessment of the Bay of Bengal Region. In Staffan, H. (eds) SWEDMAR-BOBP XII

BOBP (1997) Report and Proceedings of the Maldives/FAO National Workshop on Integrated Reef Resources Management in the Maldives. Nickerson, D. J. and M. H. Maniku (eds) Madras BOBP, Report No. 76. Pages 250+VI.

Boehlert, G.W. (1987) A Review of the Effects of Sea Mounts on Biological Processes, Geophysical Monograph 43:405

Borradaile, L. A. (1903a) Marine Crustaceans. I on varieties II. Portunidae. In Gardiner (1903-06), 1: 191-208.

Borradaile, L. A. (1903b) Marine Crustaceans. III The Xanthidae and Some Other Crabs. In Gardiner (1903-06), 1: 237-271.

Borradaile, L. A. (1903c) Marine Crustaceans. Some Remarks on the Classification of the crabs. V. The Crabs of the Catometope families. VI. Oxystomata. VII. The barnacles. In Gardiner (1903-06), 1: 424-443.

Borradaile, L. A. (1906a) Marine Crustaceans. IX The sponge-crabs (Dromiacea) In Gardiner (1903-06), 2: 574-578.

Borradaile, L. A. (1906b) Marine Crustaceans. XIII. The Hippidea, Thalassinidea and Scyllaridea. In Gardiner (1903-06), 2: 750-754.

C4 (2000) C4- INDOEX Final Report. California: University of California.

Coleman N. (2000) Marine life of the Maldives. Atoll Editions. Australia. 328 pp

Customs (1994) Statistical Year Book 1994. Malé: Customs.

DoM (2000) Meteorology Data. Malé: Department of Meteorology

Edwards A. J., S. Clark, H. Zahir, A. Rajasuriya, A. Naseer and J. Rubens (2001) Coral bleaching and mortality on artificial and natural reefs in Maldives in 1998, sea surface temperature anomalies and initial recovery. Marine Pollution Bulletin. Vol 42: 7-15.

Edwards, A.J. (1989) The Implications of Sea Level Rise for the Republic of Maldives. Commonwealth Secretariat.

Frazier J., Salas S. and Didi N.T.H. (1984) Marine turtles in the Maldive Archipelago. Unpublished report, Min. of Fisheries, Maldives. 58pp.

Gardiner J. S. (ed) (1903-6) The fauna and geography of the Maldive and Laccadive archipelagos, being the account of the work carried on and the collections made by an expedition during the years 1899 and 1900. Cambridge University Press. 2 vols.

Gardiner, J.S. (1902) Expedition to the Maldives: Narrative and Route of the Expedition. Tropical Agriculturalist, Volume 21.

Gardiner, J.S. (1903) The Fauna and Geography of The Maldive and Laccadive Archipelagoes, being the account of the work carried out and collections made by an expedition during the years 1899 and 1900. Volumes 1 & 2. Cambridge University Press

Hackett, H. E. (1977). Marine algae Known from Maldive Islands. Atoll Research Bulletin. 210: 1-30

Hanson, H.B. (1995) Republic of Maldives Land Study. Maldives: Ministry of Planning, Human Resources and Environment

Holmes, M (1993) The Maldives Archipelago, Indian Ocean, a report on an investigation of fruit bats and birds. Malé, Maldives. (Unpublished report)

Hoyle W. E. The Cephalopoda. In Gardiner (1903-06) 2: 975-988.

IPCC (1998) The Regional Impacts of Climate Change, An Assessment of Vulnerability. In Watson, R.T., Zinyowera, M.C. and Moss, R.H. (eds). New York: Cambridge University Press.

JICA (1999) The Study on Solid Waste Management for Malé City in the Republic of Maldives. Malé: Japan International Cooperation Agency Joseph, L. (1991) Study of Beche de Mer (sea cucumber) Fishery in Maldives. FAO/Bay of Bengal Programme. (Unpublished report). 44pp.

Maniku, H.A. (1990) Changes in the Topography of the Maldives. Malé: Forum of Writers on Environment

MHAHE (1999) Second National Environment Action Plan. Malé. Ministry of Home, Affairs, Housing and Environment.

MHAHE (2001) First National Communication of the Republic of Maldives to the United Nations Framework Convention on Climate Change. Malé. Ministry of Home, Affairs, Housing and Environment. , 2001, Malé Republic of Maldives Check programme since 1997, a volunteer effort carried out world-wide by recreational divers and led by experienced marine scientists. In addition MRC has an ongoing program on identification and cataloguing of fish species in Maldivian waters.

MHAHE (2002) Island database

MOFAMR (2001) Direct communication with Ministry of Fisheries, Agriculture and Marine Resources.

MoH (1998) Health Master Plan 1996- 2005. Malé: Ministry of Health

MoH (2000) Maldives Health Report 2000. Malé: Ministry of Health

MoT (1999) Tourism Statistics: 25 Years of Sustainable Development of Tourism. Malé: Ministry of Tourism

MPHRE (1995) Statistical Yearbook of Maldives. Malé: Ministry of Planning, Human Resources and Environment

MPHRE (1996) Statistical Yearbook of Maldives 1996. Malé: Ministry of Planning, Human Resources and Environment.

MPHRE (1998) Fifth National Development Plan 1997- 2000. Malé: Ministry of Planning Human Resources and Environment.

MPND (2000) Statistical Yearbook of Maldives. Malé: Ministry of Planning and National Development.

MPND (2001) Statistical Yearbook of Maldives 2001. Malé. Ministry of Planning and National Development.

MPND and UNDP (1998) Vulnerability and Poverty Assessment 1998. Malé: Ministry of Planning and National Development and UNDP

MRC (1999). Maldives/GCRMN pilot coral reef monitoring study. Unpublished report, Marine Research Center, Ministry of Fisheries, Agriculture and Marine Resources. Maldives 28pp.

MRS (1997) Review of the Status of Maldivian Living Marine Resources, 1996-1997. Unpublished report, Marine Research Section. 25pp.

Naeem, I. Rasheed, A. Zuhair, M. and Riyaz, M. (1998) Coral Bleaching in the Maldives- Survey Carried out in the North and South Malé Atolls. Malé: Marine Research Section and Environment Research Unit.

Naseer, A. (1997) Status of Coral Mining in the Maldives: Impacts and Management Options 169-186. In Nickerson, D. J. and M. H. Maniku (eds) Report and Proceedings of the Maldives/FAO National Workshop on Integrated Reef Resources Management in the Maldives. Malé, 16-20 March, 1996, Madras BOBP, Report No. 76. Pages 250+VI.

Nomura K. (1996) A preliminary List of Shallow Water Polychaetous Annelids Decapod Crustacea in the Vadoo, South Malé Atoll, Maldives Islands, Collected by K. Nomura during 17-22 April 1996. (Unpublished Report) Kushimoto Marine Park Center, Japan.

Pernetta, J. C. (1993) ed. Marine Protected Area Needs in the South Asian Seas Region, Vol 3: Maldives, IUCN Marine and Coastal Areas programme, Gland, Switzerland.

Pratt E. M. (1906) The Alcyonaria of the Maldives. II. The genera Sarcophytum, Lobophytum, Sclerophytum and Alcyonium. In Gardiner (1903-06), 2: 503-539.

Randall, J.E. and R.C. Anderson. (1993). Annotated checklist of the epipelagic and shore fishes of the Maldive Islands. Ichthyological Bulletin of the J.L.B. Smith Institute of Ichthyology, No. 59, pp47, 8 plates.

Risk, M. J. and R. Sluka (2000) The Maldives: A nation of atolls. Pp 325-351: In T.R. McClanahan, C. R. C. Sheppard and D. O. Obura (Eds) The Coral Reefs of the Indian Ocean. Their Ecology and Conservation. Oxford University Press.

Riyaz, M. Shareef, M. and Elder, D. (1998) Coral Bleaching Event: Republic of Maldives, May 1998. Unpublished Report.

SAARC (1992) Regional Study on the Causes and Consequences of Natural Disasters and the Protection and Preservation of the Environment. Kathmandu: South Asian Association for Regional Cooperation Secretariat.

Shafeeg, A (1993) Sea birds of Maldives. Association of Writers for the Environment, Malé, Maldives.

Shakeel H. (1994) Study of grouper fishery and live grouper holding operations in the Maldives. Unpublished report, Marine Research Section. 53pp.

Sheppard C. R. C. (2000). Coral reefs of the western Indian Ocean: An overview. Pp 3-38. In T.R. McClanahan, C. R. C. Sheppard and D. O. Obura (Eds) The Coral Reefs of the Indian Ocean. Their Ecology and Conservation. Oxford University Press.

Spalding, M.D. Ravilious, C. and Green, E.P. (2001) World Atlas of Coral Reefs. California: University of California Press

Thomas P. A., Bakus G. J. and Wright M. T. (1991) Marine sponges of North and South Malé Atoll, Maldive Islands, Indian Ocean.

Thomas, P.A., Bakus G. J., and Gulko, D. A. (1992) A second collection of Marine Sponges from North and South Malé Atolls, Maldive Islands, Indian Ocean.

Part V ANNEXS

I ACRONYMS AND ABBREVIATIONS

ABC	Asian Brown Cloud
AOSIS	Alliance of Small Island States
AUSAID	Australian Agency for International Development
BOBP	Bay of Bengal Programme
C^4	Centre for Cloud, Chemistry and Climate
CBO	Community Based Organization
CORDIO	Coral Reef Degradation in Indian Ocean
CO_2	Carbon dioxide
DOM	Department of Meteorology
EEZ	Exclusive Economic Zone
EIA	Environment Impact Assessment
ENSO	El Nino Southern Oscillation
GDP	Gross Domestic Product
GHG	Greenhouse Gas
HDPE	
INDOEX	Indian Ocean Experiment
IPCC	Intergovernmental Panel on Climate Change
IRRM	International Reef Resource Management
JICA	Japan International Cooperation Agency
LPG	Liquid Petroleum Gas
MCPW	Ministry of Construction and Public Works
MHAHE	Ministry of Home Affairs, Housing and Environment
MOFAMR	Ministry of Fisheries, Agriculture and Marine Resources
MOH	Ministry of Health
MOT	Ministry of Tourism
MPAS	Maldives Protected Area Systems
MPND	Ministry of Planning and National Development
MPHRE	Ministry of Planning, Human Resources and Environment
MRC	Marine Research Centre
MWSA	Maldives Water and Sanitation Authority
MWSC	Malé Water and Sewerage Company
NBSAP	National Biodiversity Strategy and Action Plan
NEAP	National Environment Action Plan
NEAP-II	Second National Environment Action Plan
NGO	Non Government Organisation
Rf	Rufia
RO	Reverse Osmosis
RRC.AP	Regional Resource Centre for Asia-Pacific
SAARC	South Asian Association for Regional Cooperation
SACEP	South Asia Cooperative Environment Programme
SST	Sea Surface Temperatures
STELCO	State Electric Company Limited
TAR	Third Assessment Report
UN	United Nations
UNFCCC	United Nations Framework Convention on Climate Change
VOC	Volatile Organic Compounds
WHO	World Health Organisation

II PRIORITY PROJECTS

Project Name: APPRAISING COAST L 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 through- out 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 Name: DEVELOPMENT OF PRACTICALDPTTION 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 information 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 Name: COASTL EROSION MANGEMENT 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 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 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 Malé 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 selfsustaining 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 Malé 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 Name: PROGRAMME FOR FISHERIES CONSERVTION MEASURES AND COMMUNITY-BASEDREEF 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 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 ft2 or 2 unit of greenhouse with similar built area but each unit having four compartments of 1000 ft2.

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 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 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 Name: THE USE OF SOLAR DISTILLATION AS SOURCE OF FRESHWATER FOR OUTER ISLANDS AND MALÉ

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 Name: DEVELOPMENT OF SUSTAINABLE INTERISLAND SEA BASED MASS TRANSPORT TION 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 centers 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 intraharbour network
4. Obtain efficient, large,fast ferries to set up a national ferry service network.

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 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.

III LIST OF PARTICIPANTS OF THE NATIONAL TRAINING ON SoE DATA COLLECTION AND REPORTING

Dharubaaurge, Malé, Maldives

28 June - 2 July 1999

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Malé, Republic of Maldives

7-8 August 2000

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Walker, A. O. (1906) Marine crustaceans. XVI. Amphipoda. In: Gardiner 1903-1906, 2: 923-932.

Webb, P.C. (1988) People and environment of Maldives, Novelty Press Pvt Ltd. Malé, Maldives

WHO (1995) Health and Environment in Sustainable Development. Geneva: WHO

Woodroffe, C. (1989) Maldives and Sea Level Rise: An Environmental Perspective. Australia: University of Wollongong Zahir, H., Naeem, I., Rasheed, A. and I. Haleem. (1998) Reef Check Maldives: Reef Check 1997 and 1998. Unpublished report, Marine Research Center, Ministry of Fisheries and Agriculture.

Zuhair, M., (2000) Conservation of biological diversity – Terrestrial flora. Paper presented at the regional meeting on conservation of biological diversity. 11-12 August. H.Dh. Kulhudhuffushi. Ministry of Home Affairs, Housing and Environment. Unpublished Dhivehi manuscript. 9p.