STATE OF THE ENVIRONMENT
2016

Ministry of Environment and Energy
Republic of Maldives

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The Ministry is grateful to all atoll and island councils for taking time in completing the surveys for the purpose of this report. The inputs from these surveys were invaluable in compiling this report. Special thanks and appreciation goes to the staff of the Environment Department who assisted greatly from the beginning in developing this report.

The Ministry acknowledges the work undertaken by Ms. Majeedha Mohamed for her dedication and various efforts in producing this report.

Foreword

The Maldives is highly dependent on our natural environment – from our economy to our social well-being and indeed our entire way of life, is inherently dependent on our environment. The government of Maldives recognises the critical role of the environment in national development and continues to make every effort to ensure the protection and preservation of our environment.

To design and implement effective environmental policies, it is important to obtain reliable and quality data on the state of the environment. It is then imperative that we develop national capacity and mechanisms to this regard. The State of the Environment reports is part of the government's efforts to institutionalise such mechanisms. In addition to this, the government is also taking necessary steps to further develop and strengthen the environmental reporting through enhancing the technical and human capacities. These will be critical as we seek to enhance the science-policy interface in our policy interventions.

The State of the Environment 2016 presents the most up-to-date information on the current status and trends related to the environment sector. It encompasses various aspects including biodiversity, climate change, energy and the coastal environment, amongst others. In this manner, the report takes stock, tracks the progress we have made over the years, and also highlights the challenges and areas where interventions are necessary to ensure the environmental integrity for current and future generations.

The compilation of a report of this magnitude requires the co-operation and participation of multiple stakeholders. As such, I take the opportunity to express my gratitude to all participants involved in the process. It is my sincere hope that all stakeholders utilise the information presented in this report and integrate these into relevant policies.

Thoriq Ibrahim
Minister of Environment and Energy

Acronyms

ABC	Atmospheric Brown Clouds
ADRC	Asian Disaster Reduction Centre
AGE	Acute Gastro Enteritis
AOSIS	Alliance of Small Island States
ARI	Acute Respiratory tract Infection
BACP	Baa Atoll Conservation Project
BOBLME	Bay of Bengal Large Marine Ecosystem
BOD	Biological Oxygen Demand
CBD	Convention of Biological Diversity
CCAC	The Climate and Clean Air Coalition
CCAP	Climate Change Adaptation Project
CCTF	Climate Change Trust Fund
CITES	Convention on International Trade in Endangered Species of Wild Fauna and Flora
CO2e	Carbon dioxide equivalent
CoTs	Crown of Thorns Starfish
EC	Elemental Carbon
EEZ	Exclusive Economic Zone
EIA	Environmental Impact Assessment
EPA	Environmental Protection Authority
EPPA	Environment Protection and Preservation Act
FAO	Food and Agricultural Organization
GCM	Global Climate Model
GDP	Gross Domestic Product
GWh	Giga Watt Hour
HCFC	Hydrochloroflorocarbon
HPA	Health Protection Authority
IMO	International Maritime Organization
INDC	Intended Nationally Determined Contribution
IOTC	Indian Ocean Tuna Commission
IPCC	Intergovernmental Panel on Climate Change
IUCN	International Union for Conservation of Nature
IWRM	Integrated Water Resource Management
kWh	Kilo Watt Hour
kWp	Kilo Watt Peak
Ltr	Litre
MCCPF	Maldives Climate Change Policy Framework

MCOH	Maldives Climate Observatory of Hanimaadhoo
MCS	Maldives Customs Service
MEA	Maldives Energy Authority
MEE	Ministry of Environment and Energy
MEEW	Ministry of Environment Energy and Water
MHAHE	Ministry of Home Affairs Housing and Environment
MHE	Ministry of Housing and Environment
MHTE	Ministry of Housing Transport and Environment
MNDF	Maldives National Defence Force
MoFA	Ministry of Fisheries and Agriculture
MoH	Ministry of Health
Gg	Giga Grams
GHG	Greenhouse Gas
MT	Metric Tons
MVR	Maldivian Rufiyaa
MW	Mega Watt
MWSC	Maldives Water and Sewerage Company
NAPA	National Adaptation Plan of Action
NBS	National Bureau of Statistics
NBSAP	National Biodiversity Strategy and Action Plan
NCMF	National Coral Monitoring Framework
NDMC	National Disaster Management Centre
NOAA	National Oceanic and Atmospheric Administration
OC	Organic Carbon
PM	Particulate Matter
POPs	Persistent Organic Pollutants
PV	Photo Voltaic
RCM	Regional Climate Model
RIMES	Regional Integrated Multi-Hazard Early Warning System
SD	Standard Deviation
SIDS	Small Island Developing State
SLCP	Short Lived Climate Pollutants
SNC	Second National Communication
SoE	State of Environment
SREP	Scaling-up Renewable Energy Project
SRES	Special Report on Emission Scenarios
SST	Sea Surface Temperature
MoT	Ministry of Tourism
MRC	Marine Research Centre
TCM	Total Carbonaceous Matter
TEQ	Toxic Equivalence
UNEP	United Nations Environment Program

UNESCO	United Nations Educational, Scientific and Cultural Organization
UNFCCC	United Nations Framework Convention on Climate Change
WHO	World Health Organization

Protected area of *Kottey*, Addu City

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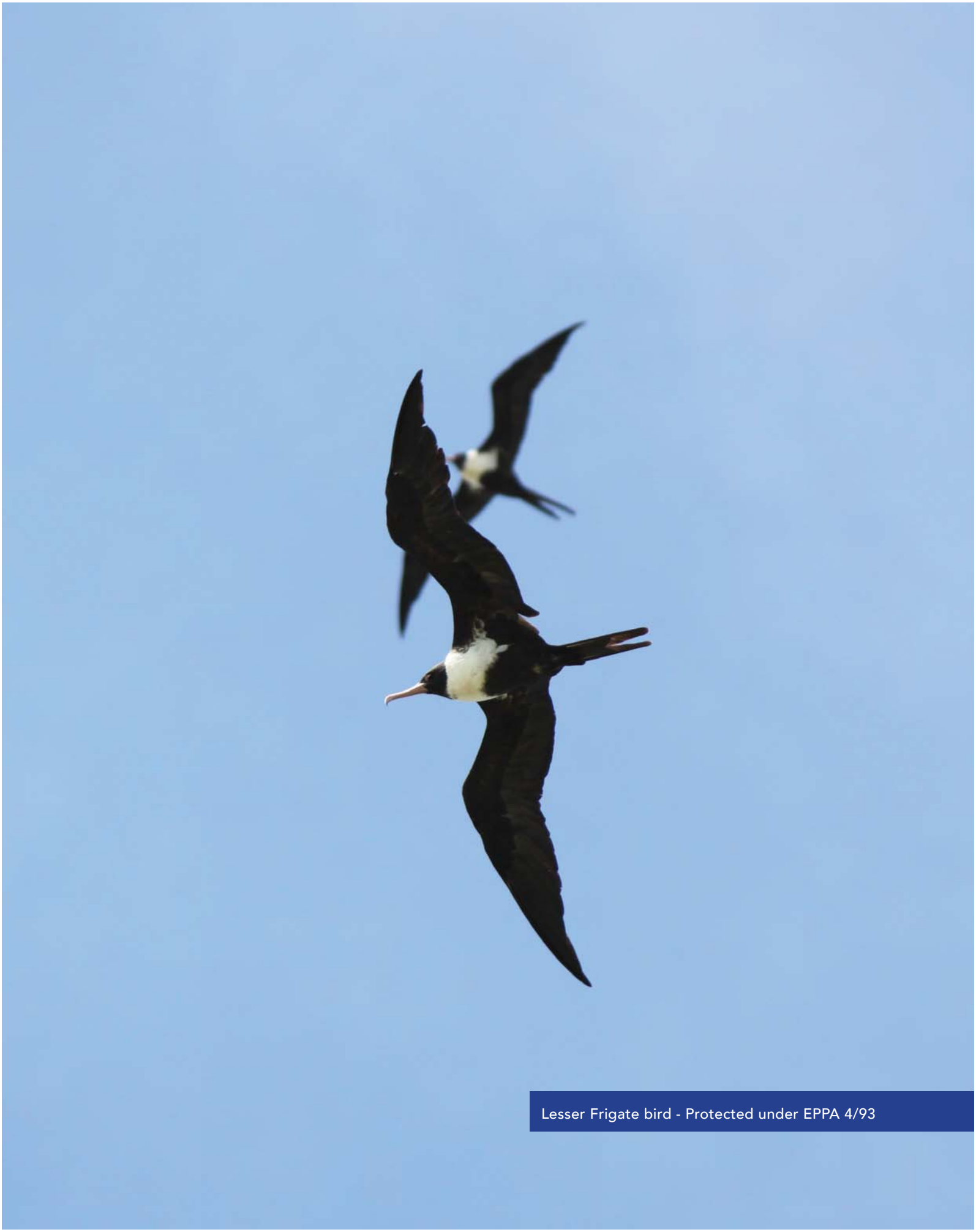


Lesser Frigate bird - Protected under EPPA 4/93

Executive Summary

Introduction

Geography and location

The Maldives is an archipelago of 1,192 small coral islands grouped into 26 natural atolls located in a north to south direction on the Laccadives-Chagos submarine ridge in the Indian Ocean, between 7°6'35''North to 0°42'24''South and 72°33'19'' East to 73°14'36'' West. The chain is 860 km long and the width varies between 80 to 120 km. The total reef area of Maldives is 4,513 km^2. The Maldivian atolls form the seventh largest reef system in the world. Over 80% of the land area is less than 1m above sea level.

Climate

Maldives has a tropical monsoon climate. The southwest monsoon (the wet-season) extends from May to November, while the northeast monsoon (dry-season) extends from January to March. The daily temperatures of the country vary little throughout the year with a mean annual temperature of 28°C. Rainfall in the Maldives varies seasonally with more rainfall during the southwest monsoon, mid-May to November. Variations in rainfall exist from north to south of the country, with the north being drier compared to the south.

Socio-economy

The population of Maldives has grown from 298,968 in 2006 to 338,434 in 2014. The population growth rates have declined from 2.69% to 2.65% over the same period. In 2014, the GDP of Maldives reached MVR26,044 million and the per capita GDP of Maldives is MVR77,655. With 29.9% share, tourism is the main player of the national GDP. In addition, the share of sectors such as communication, government administration, transport, construction and real estate also remain high. The fisheries sector contributed 1.3% to GDP. Tuna varieties, mainly skipjack and yellowfin tuna constitute the dominant catch. Agriculture sector contributed 1.6% to annual GDP in 2014.

Drivers

The main drivers influencing environmental changes in Maldives are climate change, population growth, urbanization and economic growth. These factors directly or indirectly impact the environment and bring about habitat destruction, biodiversity loss and deteriorate air and water quality. Factors such as population growth and economic development result in increased use of resources and waste generation.

Climate change

Climate change is a direct driver of environmental change. Increased greenhouse gas emissions is considered to cause global climate change. The total emission from Maldives in 2011 was 1,226GgCO_2e, accounting for 0.003% of global emission. The per capita emission from Maldives in 2011 is 3,697kgCO_2e. Carbon dioxide was the main GHG emitted, contributing to 94.8% of the total emissions from Maldives.

Population growth and urbanization

According to the 2014 census, Maldives has a population of 338,434 excluding expatriates. The population growth rate is 2.65%. With a total 129,381 people accounting for 38% of the total population residing, the Male' City is the most densely populated in the country.

Economic development

The Maldives economy has shown remarkable growth over the decade, with the GDP reaching MVR26,043.7 million in 2014. With 29.9%, tourism sector is the largest contributor to GDP. The tourism sector of the Maldives continued to grow robustly over the past decades. In 2014, the total tourist arrival was recorded at 1.2 million, with arrivals growing by 7% on an annual basis. There are 111 resorts currently operating in Maldives. While the GDP contribution by the fisheries sector is low (1.3%), it plays a key role in food security and livelihood. Fish and fish products have also remained as the primary export in Maldives. Trends in fish landing shows a decline since 2006, mainly due to changes in environmental conditions and the rising cost of ice and fuel. The limited opportunities for agriculture cause the country to heavily depend on imported food products. Agriculture sector's contribution to national GDP is 1.6%. However, it is a significant source of income for atoll population. Attempts are ongoing to diversify the agriculture sector and increase the food security of the country.

State and trends of environment

Air quality

Rapid urbanization and increased economic growth have significantly contributed to the deterioration of the air quality in densely populated islands such as Male'. Male' is facing increased air pollution due to growth of land and sea vessels, diesel power generation, construction and open burning in the neighbouring waste island Thilafushi. In islands, waste burning at dumpsites and backyards contribute to air pollution. In addition to local pollution, transboundary pollution also impact air quality of the Maldives.

At present, local air pollution monitoring is extremely weak, with no empirical data to illustrate ambient emission levels. The deteriorating air quality of Male' is reflected by the growth of pressure indicators. Significant pollutants affecting ambient air quality include $PM_{2.5}$ and GHGs. The National GHG Inventory of 2011 reports that the main GHGs are CO_2, CH_4 and N_2O. While no studies have been conducted in Maldives to determine the link between health impacts and air quality, the morbidity of respiratory diseases remains high and shows an increasing trend from year to year.

Maldives is signatory to a number of international conventions relating to air pollution control, however at the national level legal frameworks are weak. Maldives do not have a national air quality policy and national ambient air quality standard has not been established. The main policy initiative for emission reduction includes implementing an investment plan to achieve low carbon development, particularly in the energy and transport sector.

Coastal and marine environment

Coral reefs, seagrass beds, lagoons, beaches and areas of mangrove form the coastal ecosystem of the Maldives. The reef systems of the Maldives are the seventh largest globally and are highly rich and diverse, hosting several species which are globally significant. The economy of the Maldives, including tourism and fishery entirely depends on the coastal and marine environment. It also place an important role in providing food security, livelihood and income. The beaches are highly dynamic and beach erosion is one of the most significant challenges faced by islands. Wetlands or mangrove areas are found in about 74 islands.

The main threats to coastal and marine environments include increase in SST brought by climate change, pollution and coastal modification. Warming of ocean's temperature due to climate change is a key factor impacting corals and

altering coral reef communities. High SST is known to cause coral bleaching and is also associated with CoTs outbreak. Coastal and marine pollution can arise from land-based sources such as solid waste and untreated sewage disposal, or sea-based sources such as oil pollution and ballast water. Coastal modification including sand mining, cutting channels, reclamation and harbour development are identified as significant threats to the marine and coastal environment.

Some efforts towards protection and conservation of coral reefs include establishment of the Inter-Agency Task force on Coral Bleaching and a coral reef monitoring program. The Maldives consider coastal protection a high priority and importance is given for coastal protection and coastal development.

Biodiversity

The biodiversity sector of the Maldives contributes to 71% of the nation's employment, 49% of public revenue, 62% of foreign exchange, 98% of exports and 89% of GDP.

Various studies conducted in the Maldives report 429 to 583 plants including at least 14 species of mangroves. Among significant terrestrial faunal species include the Maldivian Black Turtle. The only native terrestrial mammals found in Maldives include two sub species of fruit bats, the *Pteropus giganteus ariel* and *Pteropus hypomelanus maris*. Some 167 species of birds are known to be found in Maldives. Only five sub species of birds have been identified as endemic.

The marine diversity is outstandingly rich and highly diverse and includes internationally threatened species. Five species of turtles are known from the Maldivian waters including the critically endangered hawksbill turtle and endangered green turtle. The fish diversity comprise of over 1,200 species of which gobies are the most diverse group. Recorded endemic species include Maldivian Cardinalfish, Maldivian Grubfish, Maldives Triplefin and Little Combtooth Blenny. Significant species, among others include the whale shark, the oceanic manta ray and the reef manta ray.

Loss of habitats associated with dredging of harbours and reclamation, exploitation of resources, invasive alien species, pests and pathogens and climate change are the main threats to the biodiversity.

International agreements related to biodiversity conservation include the Convention on Biological Diversity (CBD), Cartagena Protocol on Biosafety, the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) and the International Plant Protection Convention. In addition, Maldives is a member of the Indian Ocean Tuna Commission (IOTC). The National Biodiversity Strategy and Action Plan (NBSAP) prepared under the commitments to CBD serves as an instrumental policy and planning document towards protection and conservation. In addition, 42 protected areas and one biosphere reserve are designated under the Environmental Protection and Preservation Act (EPPA 4/93). Efforts are being made to designate the Maldives as a UNESCO biosphere reserve. Furthermore, 103 bird species, species of turtles, rays and skates and the Black turtle *(Kanzu kahanbu)* have been protected under EPPA 4/93. Species protected under the Fisheries Act include dolphins, Napoleon wrasses, giant clams, black coral, whale shark, conch, whales lobster (berried females and those smaller than 25cm in length) and sharks.

Water resources

The conventional freshwater resources available in Maldives mainly are in the form of rain fed shallow groundwater lens, small fresh or brackish water ponds in few islands and rainwater. Non-conventional freshwater resources available include desalinated water and bottled drinking

water. Groundwater aquifers on islands lie at an average depth of 1-1.5m below the ground surface. In many inhabited islands of Maldives, freshwater lens have been depleted as a result of salt water ingress due to extraction of groundwater from shallow aquifers. The quality of groundwater has been further deteriorated due to disposal of untreated wastewater into the ground and unplanned disposal of solid waste on land.

In addition, development projects including paved roads decreases the ground surface availability for groundwater recharge. Due to the current status of groundwater, rainwater and desalinated water are the most important sources of drinking water used in the islands and Male' respectively. The lack of space in highly consolidated islands such as Male', does not allow for water storage expansion. The majority of the atoll population use rainwater for drinking purposes. The continuous annual requests for emergency water shipments shows that the amount of rainwater harvested is not sufficient to last the dry season.

Currently, nearly 58% of the total population has access to improved sanitation systems. The various type of sewerage systems in place, among others include bore sewerage, conventional deep sewer gravity and sewerage vacuum sewerage systems. At present, Maldives is moving towards an Integrated Water Resource Management approach to address water insecurity in a changing climate.

Key environmental issues

Climate Change

The long-term annual mean surface air temperature shows an increasing trend for Male' (0.267°C/decade) and Gan (0.168°C/decade), and a decreasing trend for Hanimaadhoo (0.086°C/decade). Mean annual temperature for 2021 to 2050 is projected to increase by 1.8°C compared to the baseline (1981-2000). A general increasing trend of 0.11 to 0.15°C/decade is seen in SST throughout the country. SST projections show increasing trends in all four geographic zones.

Long term total annual rainfall data shows a declining trend of 9.5mm, 0.02mm and 2.21mm per year for Hanimaadhoo, Male' and Gan respectively, with significant decrease in number of rainfall days. Future rainfall projections show an increase over northern and central regions, while a decrease in precipitation in the southern regions for the years 2021-2050. For the years 2082-2100 an overall increase in precipitation is projected.

Sea level records for the past 20 years shows a rise of 3.753mm and 2.933mm per year in Malé and Gan respectively. Maximum sea surface height is projected to increase between 0.40m to 0.48m by 2100.

Sea level rise is recognized as the greatest threat to Maldives as this increases the possibility of land inundation. The small size and low elevation of the islands increases the vulnerability to coastal hazards. Extreme events have become frequent over the past decades, while some events had led to significant economic losses. The natural disasters which are risky to the Maldives, as identified by the Disaster Risk Profile of Maldives done in 2006 include earthquakes and tsunamis, cyclones/thunderstorms, floods (due to rain), drought; storm surges, and strong winds and tornadoes

The vulnerability assessment of the National Adaptation Plan for Action (2007) identified the following areas which are highly vulnerable to climate change impacts: land, beach and human settlements, critical infrastructure, tourism, fisheries, human health, water resources and coral reef biodiversity.

Maldives has incorporated climate change adaptation and mitigation into sectoral planning and development and the Maldives Climate Change Policy Framework (MCCPF) is the key policy document. Maldives aims to undertake adaptation actions and opportunities and build climate resilient infrastructure to address the current and future impacts of climate change.

Energy security

Due to lack of conventional energy resources in Maldives, all its energy demands are met through imports. In 2014, approximately 667,011MT of petroleum fuel was imported. The continuous high reliance on imported fossil fuel increases the vulnerability of Maldives to external fuel price fluctuations. Limited fuel storage is a further challenge and vulnerability of the country. The high government expenditure on fuel import are also idnetified as threats to the energy security of the country.

The government recognizes the importance of promoting conservation and energy security and significant efforts are ongoing to introduce renewable energy technologies, as well as promoting energy conservation and energy efficiency programs within the Maldives. The total solar capacity installed has increased from 52.1kWp in 2006 to 4,064.91kWp in 2014.

Waste management

Over the recent decades, waste management has increased in Maldives, particularly driven by population growth, changing consumption patterns, barriers in transportation and rapid growth of the tourism sector. The per capita waste generation are estimated as 1.7Kg, 0.8Kg and 3.5Kg in Male', atolls and resorts respectively. The Male' region is responsible for a significant proportion of waste generated within the country. Organic waste constitutes the bulk of the municipal waste. Waste is generally not segregated at household levels and only few islands practice composting. Waste from the Male' region and most resorts are transported to Thilafushi, where they are stockpiled. The most common method of disposal is open burning, leading to pollution and generating conditions harmful to public health. The Maldives recognizes the importance of improving the existing methods of waste management. The first regional waste management centre established at R. Vandhoo is designed with an Integrated Waste Management concept.

Chemical Management

Maldives do not produce any chemicals. The main pattern of usage of chemicals in the Maldives is in the form of consumption of petroleum products in the energy and transport sector, the agricultural industry, construction, boat building, health sector, domestic use and a variety of other uses in the tourism industry. From 2010 to 2014, the expenditure on chemical imports has increased by 104.87%, with an average increase of 26.21% per annum.

Chemicals may have a range of adverse ecological and health effects, ranging from degradation of soil, groundwater contamination, marine pollution, to affecting fish and other biota. In addition, various health effects are associated with chemicals and their pollutants.

The high dependence on chemicals and the potential consequences, combined with limited capacity makes effective management of chemicals a key issue in the Maldives. Maldives has a cross-sectoral approach in chemical administration, where Ministry of Defence and National Security (MDNS), Ministry of Health (MoH), Ministry of Environment and Energy (MEE) and Ministry of Fisheries and Agriculture (MoFA) have mandate requirements for chemical administration. However, due to the lack of a specific legislature on chemical management,

regulatory mechanism for chemical management remains weak.

Environmental Governance

Environmental protection is fundamental to the existence of Maldives. The Maldives gives high priority to strengthen the environmental governance. The Ministry of Environment and Energy (MEE) is the primary government institution with the overarching responsibility for environmental protection and management. In addition to Environmental Protection Agency, which is a legal regulatory entity affiliated to MEE, the Maldives Energy Authority, Maldives Meteorological Services and the Biosphere Reserve of Baa Atoll are also governmental organizations affiliated to MEE. Other government institutions which play key roles in protecting the environment and natural resources are Ministry of Fisheries and Agriculture, Marine Research Centre and Ministry of Tourism. The main policies dealing with environmental governance include the Maldives National Energy Policy and Strategy (2010), The Maldives Climate Change Policy Framework (2015) and the National Solid Waste Management Policy (2015). The Environment Protection and Preservation Act (EPPA 4/93) is the main umbrella law for protection and preservation of the environment. Other important laws related to protection of environment and natural resource are The Fisheries Act of Maldives (Law No. 5/87), The Maritime Zones of Maldives Act (Law No. 6/96), Maldives Tourism Act (Act No. 2/99) and the Act on Coral and Sand Mining (2000). The Maldives has also ratified a number of regulations relating to environmental management. Among these are the Fisheries Regulation (2000), The Regulation on the Protection and Conservation of Environment in the Tourism Industry (2006), Environmental Impact Assessment Regulation (EIA) (Regulation No. 2012/R-27), Regulation on Dredging and Reclamation of Harbours (Regulation No. 2013/R-15), HCFC Regulation (Regulation no. 2010/R-19) and the Waste Management Regulation (Regulation number 2013/R-58). In the international and regional context the Maldives is party to several important conventions including Vienna Convention and Montreal Protocol, United Nations Framework Convention on Climate Change and Kyoto Protocol, The Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal, Male' Declaration on Control and Prevention of Air Pollution and its Likely Transboundary Effect for South Asia, Rotterdam Convention on the Prior Informed Consent Procedure for Certain Hazardous Chemicals and Pesticides in International Trade, Stockholm Convention on Persistent Organic Pollutants, The Climate and Clean Air Coalition (CCAC), Convention on Biological Diversity (CBD), Cartagena Protocol on Biosafety, International Plant Protection Convention (IPPC) and the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES)

State of the Environment 2016 at a glance

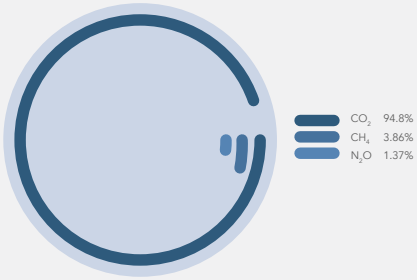
Drivers of Environmental Change

"Climate change is a direct driver and population growth, urbanization and economic development are drivers which indirectly bring about profound changes to the environment."

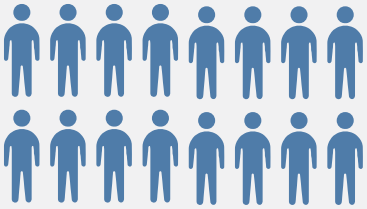
Climate change

Maldives emitted 1.226GgCO_2e in 2011

Per capita emission is 3,697KgCO_2e



Population



Local population is 338,434 in 2014

Growth rate is 2.65% in 2014

38% of population reside in Male'

Tourism

111 resorts are operational

Tourist arrival is 1.2 million in 2014

Economic Development

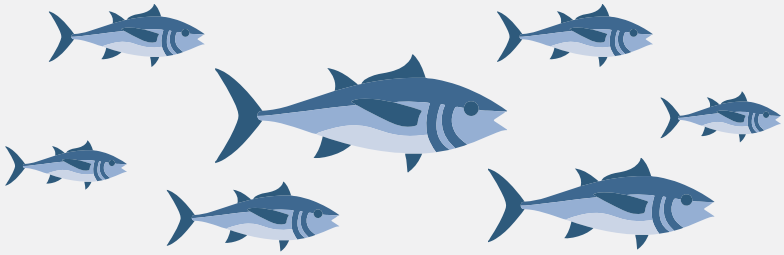
GDP is 26,044 million MVR

Tourism sector share is 29.9%

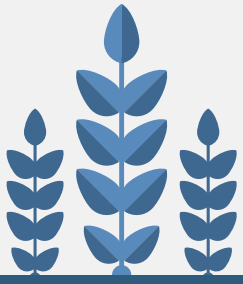
Fisheries

Fishery sector represents 1.3% of GDP in 2014

Dominant tuna catch: 53% skipjack and 40% yellowfin



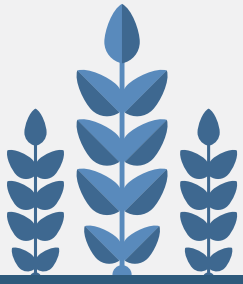
Agriculture



1.6% share in GDP

Farmer population is 7,410

49 islands leased for commercial agriculture



Air quality

"Deteriorating air quality is a high concern, particularly in the Male' region. Main indicators of local air pollution are emission from motor vehicles, vessels, construction, electricity generation and open burning of waste."

Transport

Registered motor vehicles increased 262.2% from 2004 to 2014

83% are motorcycles and 7% cars

12,074 vessels are registered

Number of aircrafts increased from 40 in 2009 to 79 in 2015

21.53% of the GHG emissions in 2011

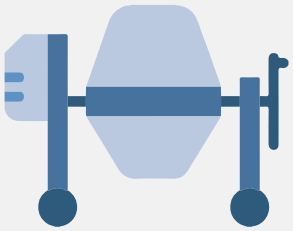
Electricity

Electricity production in Male' grew by 71% over the last decade

Largest source of GHG emission- 63.51%

Waste sector

5.9% of the GHG emission from waste incineration



Construction

3,083 buildings were authorized for construction from 2007 to 2014

"Maldives Climate Observatory-Hanimaadhoo is a receptor site for long-range transport of pollutants, Atmospheric Brown Clouds (ABC) –emissions from South Asia, Middle East and Africa region."

"Maldives does not have a national air quality policy or a national ambient air quality standard. Mechanisms for emission regulation from industries do not exist."

Coastal and marine environment

"Coastal and marine environment forms the bedrock of our economy, provide food security, employment, income and recreation".

"Strengthening coral reef monitoring is important for conservation and management of these ecosystems. Limitations in technical and financial capacity are barriers for regular monitoring".

Coral reefs

Total area of atolls including lagoons is 21,372 km^2

Reef area is 4,515.14 km^2

2,041 distinct coral reefs

Coast & beaches

Land makes up about 1% of total area

Over 80% of land area is less than 1m above mean sea level

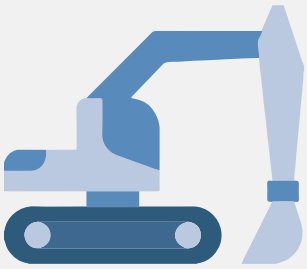
Over 80% islands face erosion issues

116 islands reported erosion in 2014

Wetlands

74 islands with wetlands or mangroves

Total area of wetlands/mangroves is 1.41km^2



Threats

High SST and bleaching is a threat to coral reefs

Coastal modification including sand mining, cutting channels, reclamation and harbour development are identified as significant threats to the marine and coastal environment

1,300 ha of reef/lagoon area have been reclaimed

Biodiversity

"Biodiversity based sectors contribute to 89% of GDP, 71% of employment and 98% of exports".

"Maldives has a rich marine diversity, with several species which are globally significant".

Mangroves

14 species of mangroves

Bruguiera cylindrica is the most common true mangrove

Birds

Over 167 species recorded, 103 species protected

Turtles

5 species of turtles, including internationally threatened hawksbill and green turtle

Fish

1200 species

Recorded endemic species include Little Combtooth Blenny, Maldives Triplefin, Maldivian Grubfish and Maldives Cardinal Fish

Globally significant populations of whale shark, manta rays, reef sharks, whales and dolphins are found

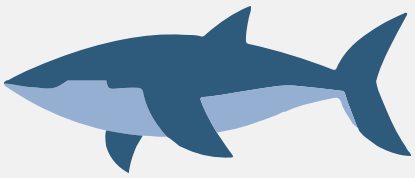
Threats

Loss of habitats, exploitation of resources, exotic and invasive alien species, pests and pathogens and climate change

"Maldives has designated 42 protected areas totaling more than 24,494ha and one biosphere reserve. Efforts are ongoing to convert entire Maldives into a biosphere reserve".

Protected species

103 species of birds
Napoleon wrasse
Black turtles
Rays & skates
All turtles
Dolphin
Giant clam
All corals
Whale shark
Conch (triton)
Whale
Shark
Lobsters (berries females & those smaller than 25cm in length



Water resources

"The limited freshwater resources make Maldives highly water insecure. Over extraction has resulted in salt water ingress and depletion of the shallow freshwater lens in most islands."

"Main freshwater resources for drinking are groundwater, rainwater, desalinated water. Poor sanitation over time has resulted pollution of groundwater."

Main type of drinking water used by the population

Atolls- rainwater: 87%
Desalinated water- 7%
Bottled water- 5%

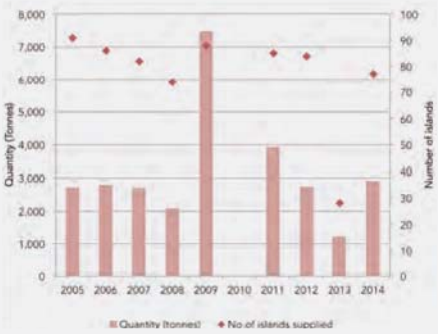
Male'- rainwater- 2%
Desalinated- 29%
Bottled water- 68%

"Majority of atoll population use rainwater for drinking. Decrease in rainfall days and lack of sufficient rainwater harvesting capacity result in water security issues in the islands. "

"With groundwater degraded to unusable quality and air quality too deteriorated for rain water collection, desalinated water and bottled water are the only sources of drinking water the Male' population depends on."

Pressures
- High water demand- 68% increase in water demand over the last 5 years
- Pollution from sanitation
- Climate change

Continuous request of emergency water by islands annually shows that the harvested rainwater is not sufficient to last the dry period



- 43% of population has access to desalination network
- 57% population has access to sewerage network

"Currently, Maldives is moving towards an integrated water resource management approach to address water insecurity in a changing climate."

Climate change

"Climate change is a cross-cutting issue which impacts multiple sectors. The vulnerability assessment of National Adaptation Plan for Action (2007) identified the following areas as highly vulnerable to the impacts of climate change: Land, beach and human settlements, critical infrastructure, tourism, fisheries, human health, water resources and coral reef biodiversity".

Temperature

Current trend: increasing trend for Male' (0.267°C/decade) and Gan (0.168°C/decade), and a decreasing trend for Hanimaadhoo (0.086°C/decade)

Projections: Mean annual temperature for 2021 to 2050 is projected to increase by 1.8°C compared to the baseline (1981-2000).

SST

Current trend: General increasing trend of 0.11 to 0.15°C/decade

Projections: Increasing trends in all four geographic zones.

Rainfall

Current trend: Declining trend of 9.5mm for Hanimaadhoo, 0.02 mm for Male' and 2.21mm per year for Gan

Significant decreasing trend in number of annual rainfall days

Projections: for 2021-2050- Increase over northern and central regions, and decrease over the southern regions for 2082-2100- Overall increase in rainfall is projected

Sea level

Current trend: Rising trend with 3.753mm per year for Male' and 2.933mm for Gan

Projection: Maximum sea surface height is projected to increase between 0.40 to 0.48m by 2100

" Sea level rise due to climate change is a high threat to the islands of Maldives".

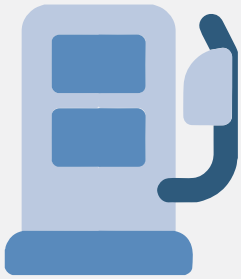
"Prevalence of extreme weather events and natural disasters in recent years serve as forewarning of the climate change impacts that are likely to occur in the future".

"Due to the small size and low elevation of islands, settlements and other infrastructure are subjected to high risk of inundation".

"Importance is given to incorporate climate change adaptation and mitigation into sectoral planning and development".

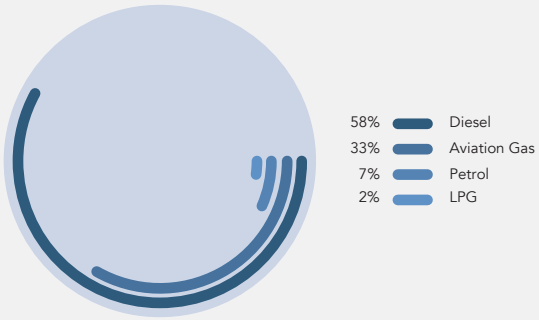
Energy security

"Due to lack of conventional energy sources such as coal, oil and natural gas, the Maldives depends entirely on imported petroleum products to meet all energy demands, making Maldives among the most energy insecure countries in the world".



Fossil fuel import: 667,011 MT imported in 2014

Net oil imports shows an increase of 164.9% over the decade



"Diesel comprises the bulk of fuel import."

4,065kWp solar capacity installed

Over 44% of imported diesel is used for electricity generation

191 powerhouses

299MW capacity for electricity generation

Energy consumption in Male' increases 7.5% per annum

Challenges to energy security:

High dependence on imported petroleum

Escalating market price of fuel

High expenditure on fuel import

"Import of petroleum fuel in 2014 accounted for 28 percent of total imports."

"Compared to 2013, expenditure on fuel rose by 13.5% in 2014."

"The National Energy Policy and Strategy include provisions, to provide all citizens with access to reliable and sustainable energy services at lowest possible cost, enhancing energy security, promoting energy efficiency and conservation, and moving towards the target of renewable energy based electricity supply."

Solid waste management

"Solid waste management is widely recognized as a pressing environmental concern in Maldives."

Waste generation

Per capita waste generation: 1.7kg for Male' , 0.8kg for islands and 3.5kg for resorts

Waste generation in Male' increased by 155% over the last decade

Waste generation in atolls increased by 57.6% over the decade

Organic waste comprise the bulk of waste generated

Recycling

7,277MT of waste was exported in 2014 for recycling

"Recycling is not common in the Maldives, particularly due to lack of sufficient financial and technical capacity in the islands."

"Inappropriate waste management situation in the country is generating significant pollution problems and risks to the environment and human health."

R. Vandhoo waste management facility is built with an advanced incineration system and a fully engineered landfill that established an integrated waste management system first ever known to the country

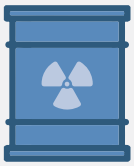
"A national waste management initiative called Saafu Raajje Initiative waslaunched in 2015."

"**Efforts are ongoing to upgrade the existing island waste management centres and build new centres.**"

"High tax is charged on import of non biodegradable plastic bags, while zero tax is levied on biodegradable plastic bags to discourage import and use of plastic bags that are harmful to the environment."

Chemical management

"Chemicals released into the environment may have potential ecological and health effects. Increase in chemical imports each year reflects the growth of chemical use within Maldives."



Chemical import

From 2010 to 2014, the expenditure on chemical imports has increased by 104.87%, with an average increase of 26.21% per annum.

Petroleum products accounts for 41% of the gross value of chemical imports in 2014.

Chemical use:

Agriculture

fertilizers, pesticides, herbicides, insecticides, plant growth regulators and weed killers

Construction & boatbuilding

solvents, paints, pesticides, glues and adhesives. Boat building involves use of toxic chemicals such as uncured resins, hardeners, glass fibre, styrene, auxillary agents and Fiberglass Reinforced Plastic dust

Tourism

Tourism sector uses 4% of HCFC blends
Accounts for a large amount of fossil fuel used within the country
Imports the highest amount of detergents

Food industry

Major sector involved in using refrigerants with reportedly 63% of HCFC use
Fisheries sector consumes 15-20% of the total refrigerants used in Maldives

Health

Policy of HPA is to minimize chemical usage where applicable and use it only during outbreaks of vector-borne diseases
Deltacide and Malathion is used for fogging

Household

Pesticides and insecticides are commonly used in households and resorts to control pests

"Awareness on impact of chemicals on environment and human health is limited among the users as well as importers."

"At the national level, there is no specific legislative means addressing chemicals. The Act no. 4/75 is the main Act concerning chemicals in Maldives, which defines the obligations and rights of MDNS to regulate the importation of chemicals."

"The first Maldives National Chemicals Profile was prepared in 2016, to assess the chemical management situation in the country, to identify gaps and prioritize issues regarding all aspects of chemicals management."

Governance

"The Maldives gives high priority to strengthen environmental governance as to effectively address the current and emerging environmental challenges and integrate sustainable development into the planning process."

Main policy documents

"Current national environmental policies are based on a sectoral approach to managing of the environment and to work towards the goal of sustainable development."

- Maldives National Energy Policy and Strategy (2010)
- The Maldives Climate Change Policy Framework (2015)
- National Solid Waste Management Policy (2015)
- National Biodiversity Strategy and Action Plan (NBSAP 2016-2025)

"Environmental Protection and Preservation Act (4/93) which is the main overarching umbrella law concerning environment is over 20 years old."

"The Maldives has continued to work in the wider international context in making commitments to global efforts in environmental protection and sustainable development. Maldives has played key roles in highlighting the special vulnerability of low-lying small islands developing states to the climate change and in getting the attention to this issue in the international forums."

CHAPTER 01
INTRODUCTION

Chapter 1 Introduction

The State of the Environment (SOE) 2016 is the sixth report of the SOE series and is developed with the objective of presenting an overview of the environmental scenario of the Maldives. It is anticipated to contribute to public awareness about the state of the environment and allow for informed decision making in all sectors. It attempts to present the most up-to-date available data and information on current environmental conditions and trends, identify driving forces and pressures influencing environmental change, identify the impacts of such changes and illustrates the existing government responses in place. Efforts have been made to make this report accessible to a wide audience, including school students, researchers, government and private sectors and the general public. SOE 2016 is presented in 5 sections: (1) the introduction, (2) drivers of environmental change, (3) state and trends of the environment, (4) key environmental issues and (5) environmental governance in the Maldives. The major drivers of environmental changes in Maldives are identified as climate change, population growth, urbanization and economic growth. These drivers affect the state of the environmental domains: air quality, coastal and marine environment, biodiversity and water resources. In addition, this report attempts to present the status of key environmental issues including climate change, energy security, waste management and chemical management. The report concludes with an overview of environmental governance with focus on national policies, laws and regulations and international and regional commitments.

Figure 1-1 presents few key statistics of the Maldives regarding geography, climate and current socio-economic status.

Farukolhu Funadhoo (Shaviyani Atoll)

Geography

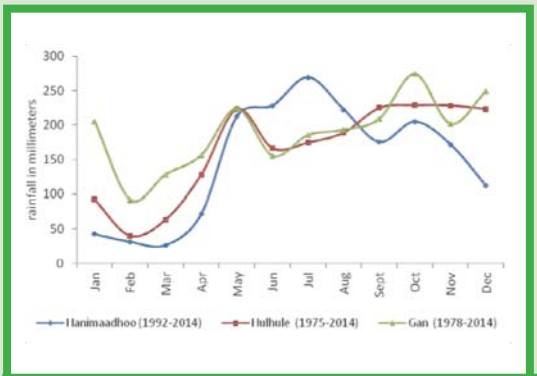
The Maldives is an archipelago of 1,192 small coral islands grouped into 26 natural atolls located in a north to south direction on the Laccadives-Chagos submarine ridge in the Indian Ocean, between 7°6'35"North to 0°42'24"South and 72°33'19" East to 73°14'36" West

The chain is 860 km long and the width varies between 80 to 120km (MEEW, 2007).

The total reef area of Maldives is 4,513km^2 (Naseer & Hatcher, 2004)

The Maldivian atolls form the seventh largest reef system in the world (UNEP, 2003).

Over 80% of the land area is less than 1m above mean sea level.

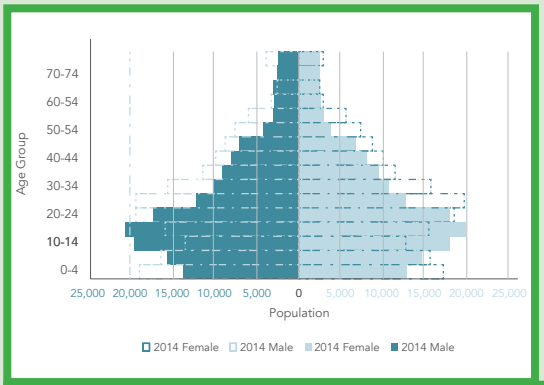


Climate

Maldives has a tropical monsoon climate. The southwest monsoon (the wet-season) extends from May to November, while the northeast monsoon (dry-season) extends from January to March.

The daily temperatures of the country vary little throughout the year with a mean annual temperature of 28°C.

Rainfall in the Maldives varies seasonally with more rainfall during the southwest monsoon monsoon, mid-May to November. Variations in rainfall exist from north to south of the country, with the north being drier compared to the south.



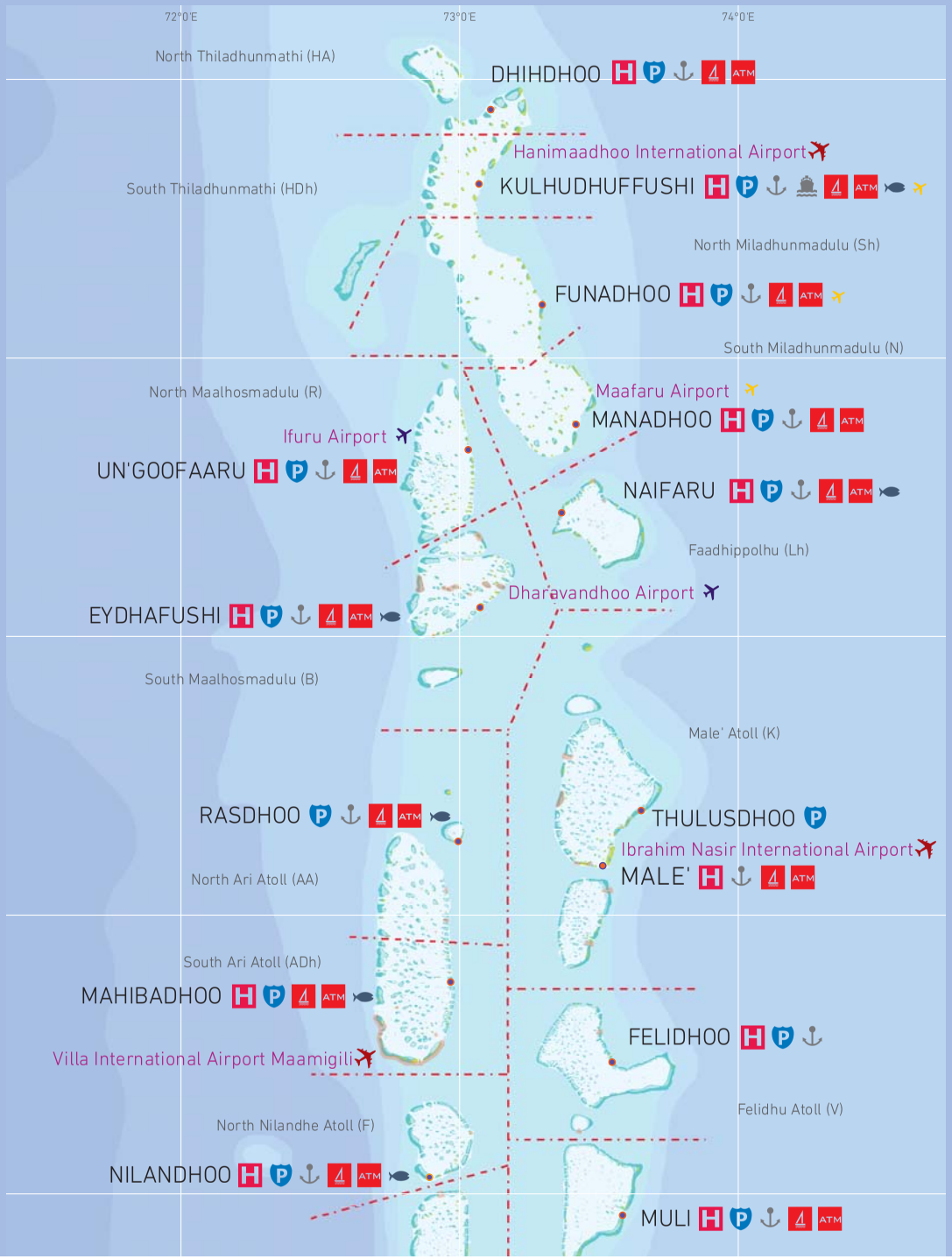
Socio-economy

According to the census 2014, local population of Maldives is 338,434, consisting of 171,962 males and 166,472 females (NBS, 2015a)

In 2014, the Maldives reached a GDP of 26,043.7 million MVR

With 29.9%, the tourism sector contributed the largest share to the national GDP in 2014

Figure 1-1: Key national statistics of the Maldives


72°0'E
73°0'E
74°0'E
North Thiladhunmathi (HA)
DHIHDHOO
Hanimaadhoo International Airport
South Thiladhunmathi (HDh)
KULHUDHUFFUSHI
North Miladhunmadulu (Sh)
FUNADHOO
South Miladhunmadulu (N)
North Maalhosmadulu (R)
Maafaru Airport
MANADHOO
Ifuru Airport
UN'GOOFAARU
NAIFARU
Faadhippolhu (Lh)
Dharavandhoo Airport
EYDHAFUSHI
South Maalhosmadulu (B)
Male' Atoll (K)
RASDHOO
THULUSDHOO
Ibrahim Nasir International Airport
North Ari Atoll (AA)
MALE'
South Ari Atoll (ADh)
MAHIBADHOO
FELIDHOO
Villa International Airport Maamigili
Felidhu Atoll (V)
North Nilandhe Atoll (F)
NILANDHOO
MULI

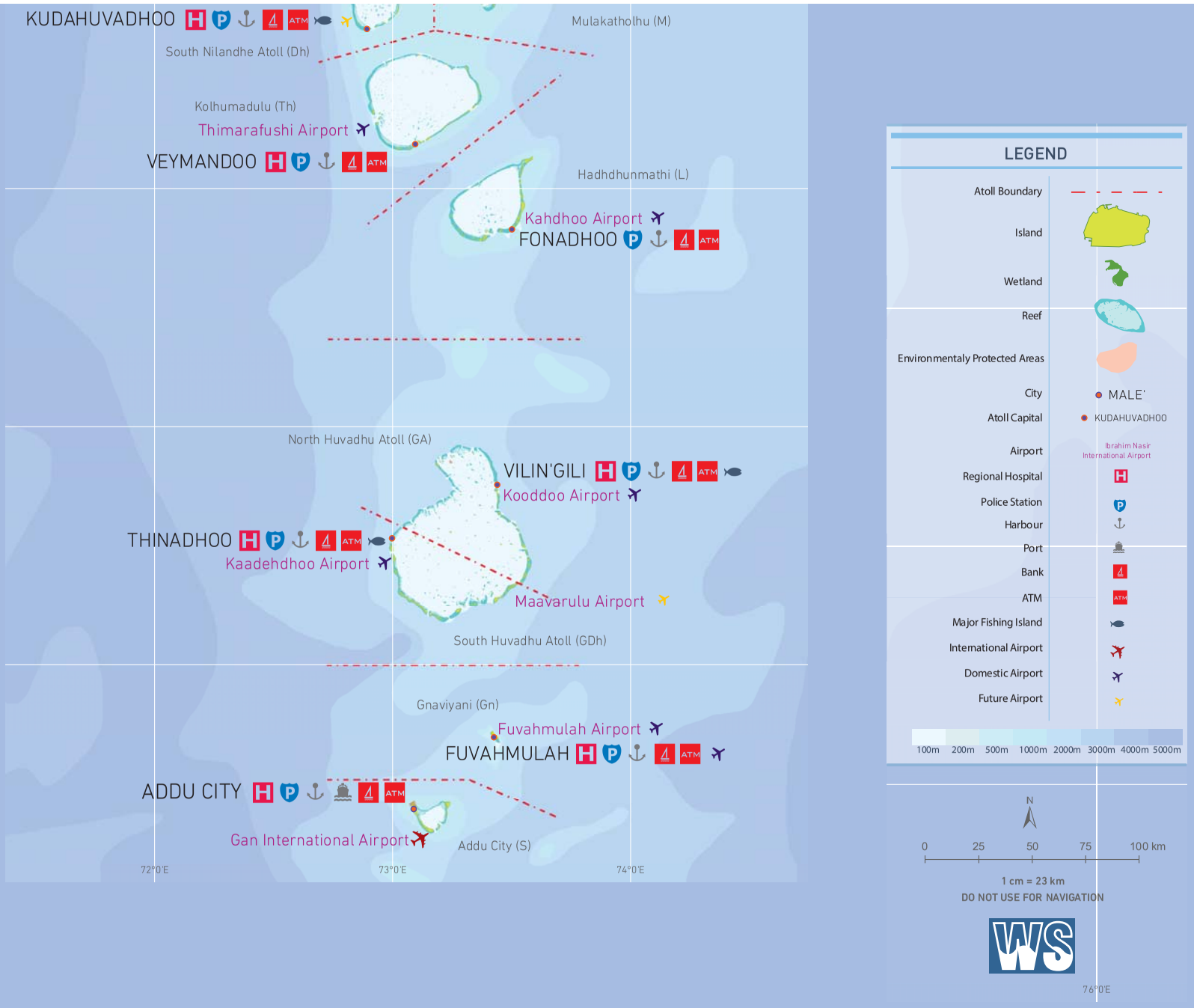
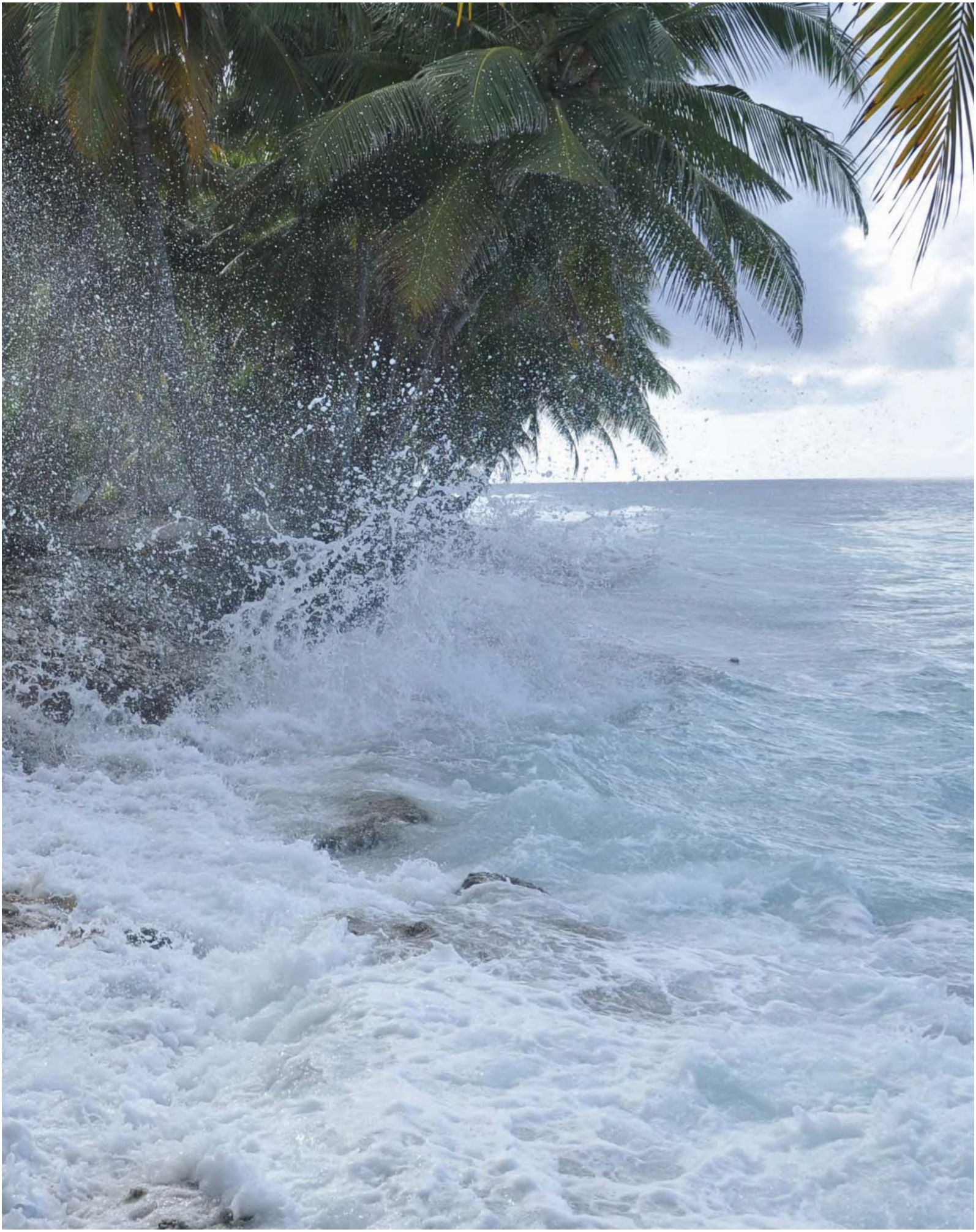


Figure 1-2: Map of Maldives (Source: Water Solutions Pvt Ltd 2016).

CHAPTER 02
DRIVERS OF ENVIRONMENTAL CHANGE

Chapter 2 Drivers of Environmental Change

The Millenium Ecosystem Assessment (2005) defines an environmental driver as any natural or man-made factor which directly or indirectly causes a change in an ecosystem. Understanding these drivers is fundamental to minimising the pressures and addressing the impacts of changes in the environment. Climate change is a key driver of environmental change. While climate change is a direct driver, population growth and economic development are drivers which indirectly bring about profound changes to the environment. These factors degrade the environment through uncontrolled and unplanned urbanization and industrialization, increased use of resources and habitat destruction.



2.1. Climate change

As a direct driver, climate change has direct and ongoing effects on the environment and is considered as one of the greatest challenge to social and economic development, particularly for small island developing states (SIDS) such as the Maldives. Climate change threatens Maldives on multiple fronts. The characteristics which make Maldives highly vulnerable to climate change impacts are numerous and inherent in its archipelagic small island states. The dispersed coral islands are small, low lying and morphologically unstable, which makes them highly susceptible to the changing climatic variables.

Similar to other SIDS, the contribution of Maldives to global GHG emission is negligible, however, they are among the least equipped to respond and adapt to climate change impacts. Maldives already has existing environmental challenges such as beach erosion and limited freshwater resources. The low lying coral islands of the Maldives are considered to be at high risk of being inundated, if sea level rise continues. Additionally, the frequency and intensity of extreme weather events are expected to increase in the future. This is expected to affect all areas of social and economic security and hence further increasing the vulnerability of the Maldives (Refer to section 4.1 for details).

Greenhouse gas emission from energy use is one of the main contributors to climate change. According to the Maldives GHG inventory, the total emission from Maldives in 2011 was 1,226GgCO_2e, accounting for 0.003% of global emission. The per capita emission from Maldives in 2011 is 3,697 kgCO_2e (MEE, 2016a). Carbon dioxide was the main GHG emitted, contributing to 94.8 % of the total emission in Maldives (Figure 2-1). Largest contribution to emissions was from energy use within the country, which corresponds to 94.1% of total emissions (Figure 2-2). This includes 63.4% from electricity generation, 21.5% from transport sector, 6.3% from fisheries sector and 2.7% from LPG use for cooking. Emission from waste sector contributed to 5.9% of total emission in 2011. It is important to mention that the tourism sector is responsible for a large amount of electricity use, transport use and waste generation within the country.

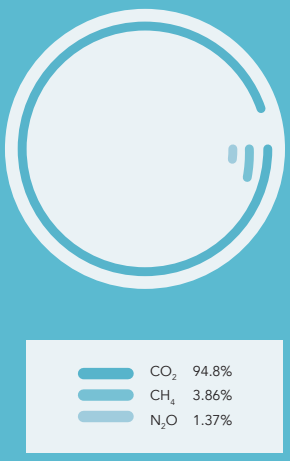


Figure 2-1: GHG emission by type of gas for Maldives in 2011. Data source: (MEE, 2016a).

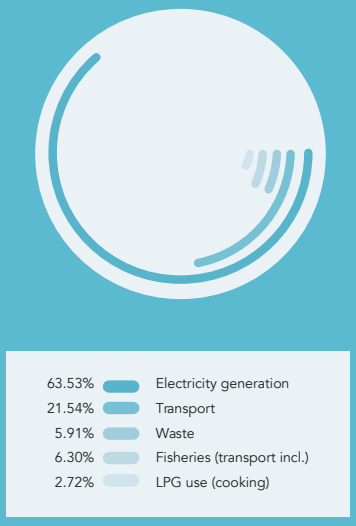


Figure 2-2: Sectoral contribution to GHG emission in 2011. Data source: (MEE, 2016a).

2.2. Population growth

Population growth and demographic transition are related to various issues such as resource depletion, deteriorating air quality, destruction of natural habitats, loss of biodiversity, deteriorating water quality and increased waste generation. Population increase is a major problem in urban islands, particularly the capital Male' City. Figure 2-3 shows the population growth of Maldives over the last century. Population of Maldives has increased from 298,968 in 2006 to 338, 434 in 2014. The population growth rates have declined from 2.69% in 2006 to 2.65% in 2014. Based on the current trend, the population is expected to reach 400 thousand by 2025 (MEE, 2016a). Population age group distribution based on 2006 and 2014 population census shows that Maldives has a youthful population, with the majority representing ages below 30 (Figure 2-4).

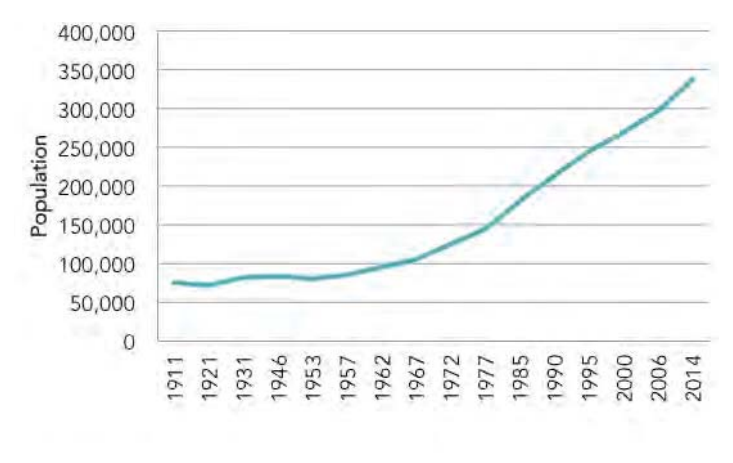


Figure 2-3: Population growth excluding expatriates: Data source: (DNP, 2010; NBS, 2015a)

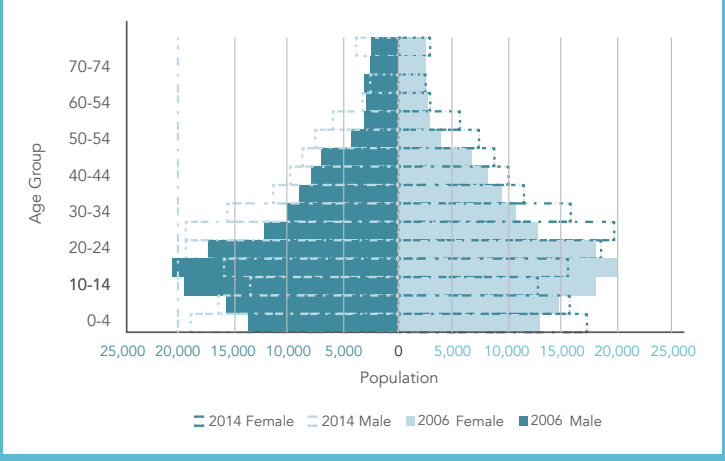


Figure 2-4: Population pyramid showing age group for 2006 and 2014 census: Adapted from (NBS, 2015b)

2.3. Burgeoning urbanization

Urbanization is a key driver of environmental change. Over the years, the increase in population of Male' has significantly contributed to the degradation of the environment. According to the 2014 census 129, 381 people accounting for 38% of the entire population resides in Male' City which is only 193 hectares, making it among the most densely populated cities in the world. Figure 2-5 shows the growth of population in Male' City from 1985 to 2014. From 2006 to 2014, the residing population in Male', excluding expatriates has increased by 27.3%. Poor air quality in Male' is associated with the uncontrolled population growth, accompanied by increase in vehicles, construction of buildings and increased congestion. In addition, increased use of groundwater has led to deterioration of water quality. The high population growth in Male' is also associated with pressure on energy use and increased waste generation. Other than Male', only three islands have a population of more than 5,000 (Table 2-1). They are S.Hithadhoo, Gn.Fuvahmulah and HDh. Kulhudhuffushi.

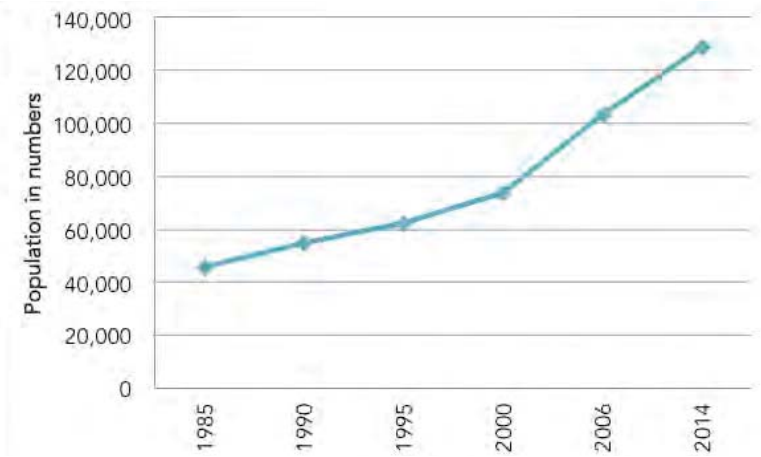


Figure 2-5: Population growth in Male' City: Data source: (DNP, 2010); (NBS, 2015b)

Table 2-1: Number of administrative islands by size of Maldivian population: Adapted from (NBS, 2015b)

Size class (total Maldivian Populatoin Size)	Census Years and number of Islands					
	1985	1990	1995	2000	2006	2014
Total	**202**	**202**	**201**	**200**	**194**	**188**
Less than 100	2	1	1	0	5	2
100 -199	17	13	11	11	11	5
200 - 299	29	20	10	15	18	10
300 - 399	39	30	26	22	18	18
400 - 499	30	25	27	28	20	21
500 - 599	19	24	23	19	18	17
600 - 699	13	19	16	14	12	15
700 - 799	10	14	16	12	11	15
800 - 899	6	7	9	13	12	11
900 - 999	12	8	11	8	6	9
1,000- 1,999	17	31	38	42	47	45
2,000 - 4,999	6	7	9	12	12	16
5,000 - 9,999	1	2	3	3	3	2
10,000+	1	1	1	1	1	2

2.4. Economic development

The Maldives economy has shown remarkable growth in recent years. Figure 2.6 shows the growth in the Gross Domestic Product (GDP) from 2003 to 2014. In 2014, the Maldives reached a GDP of MVR 26,044 million up from MVR 13,356 million in 2004. With a per capita GDP of MVR 77,655 in 2014 (NBS, 2015a), Maldives has achieved the highest GDP per capita within the South Asian region. Though the per capita GDP is high, the economy of Maldives is very small compared to the other countries of the region. Economic growth improves the quality of life. However, it also leads to increased consumption and resource use, habitat destruction for infrastructure development and increased pollution. While this is the case, growth in economy and accompanied revenue increase also presents greater opportunities to adopt more sustainable planning and development measures as to minimise the degradation of the environment.

As seen in Figure 2.7, with 29.9%, the tourism sector contributed the largest share to the national GDP in 2014. Communication, government administration, transport, construction and real estate are the other main contributors to the economy. Though the contribution of fisheries to the GDP has declined in recent years, it remains significant in terms of local employment (MEE, 2016a).

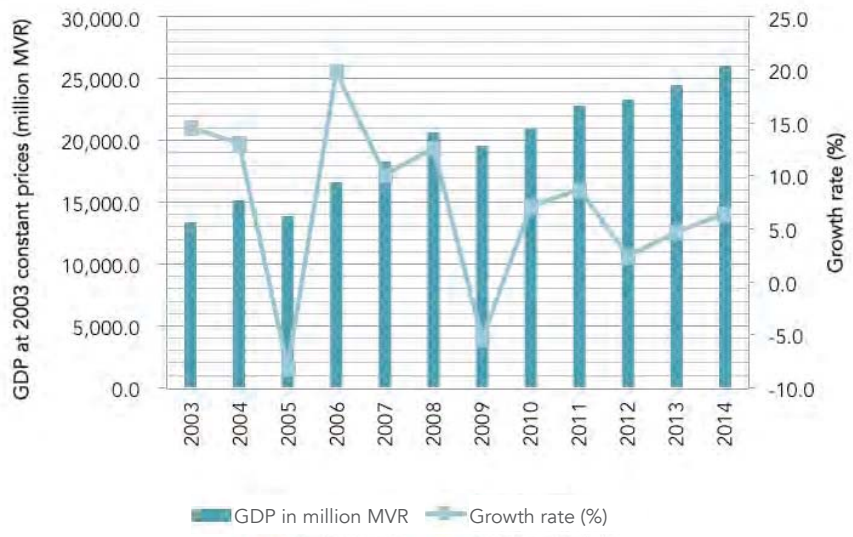


Figure 2-6: GDP at constant price (million MVR) and growth rate (%). Data source: (DNP, 2010); (NBS, 2015a)

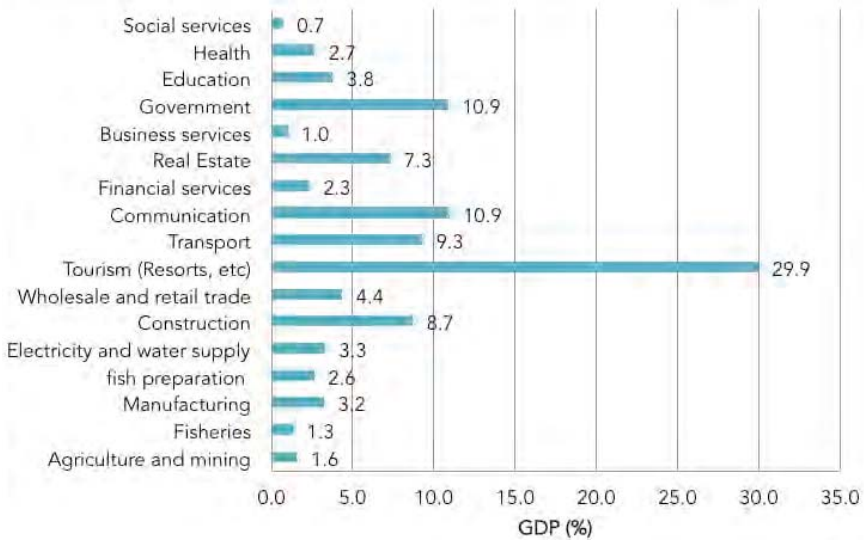
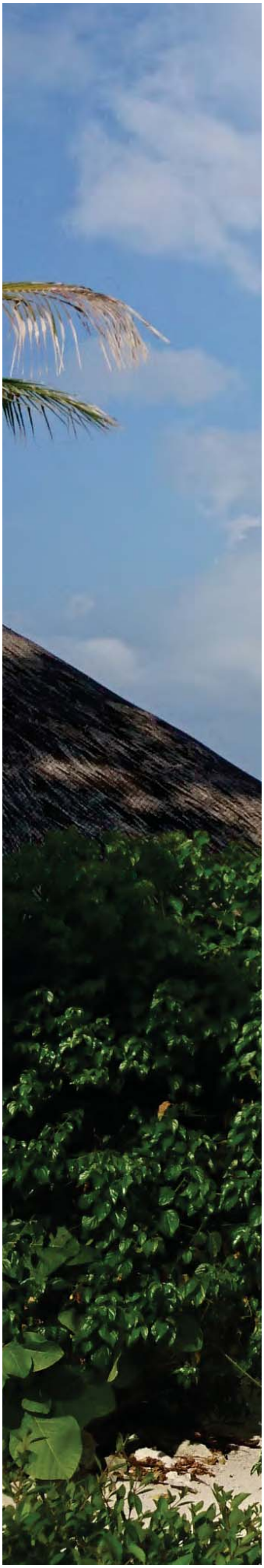


Figure 2-7: Percentage share of sectors to GDP in 2014. Data source: (NBS, 2015a).

2.4.1. Tourism

The tourism industry began in Maldives in 1972, with only 2 resorts. The tourism sector of the Maldives continued to grow robustly over the past decades, contributing 29.9% to annual GDP in 2014. A total of 111 resorts are operating at present (MoT,



Tourist Resort

2015a). In 2014, the total tourist arrival was recorded at 1.2 million, with arrivals growing by 7% on an annual basis (Figure 2-8).

According to the Maldives Visitor Survey 2016, the natural beauty of the Maldives is a main motivator for the tourists to visit the country. As seen in Figure 2-9, the uniqueness of the environment including beaches and the underwater beauty are the main reasons for choosing Maldives as a holiday destination.

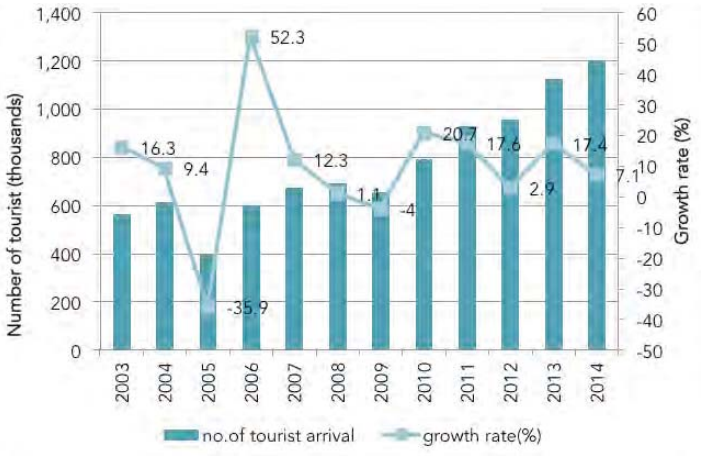


Figure 2-8: Tourist arrivals and growth rate from 2003-2014. Data source: (DNP, 2010; NBS, 2015a)

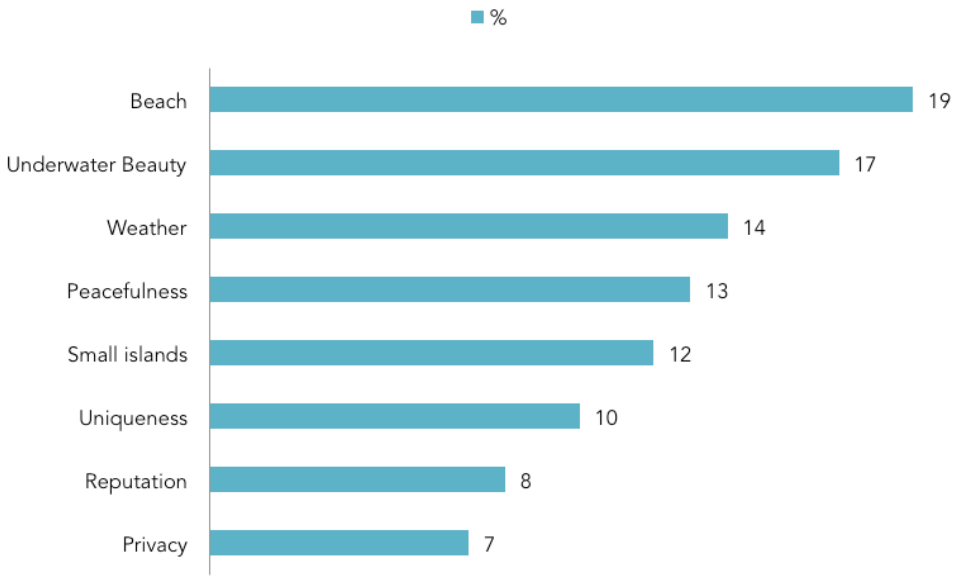


Figure 2-9: Reasons for choosing Maldives as a tourist destination. Data source: (MoT, 2016).

2.4.2. Fisheries

Prior to the development of the tourism industry, the fisheries sector was the largest contributor to GDP. However, due to the rapid growth of tourism and other sectors such as construction and other service industries, the fisheries sector contribution to GDP has declined over the years. The fishing industry represented about 1.3% of GDP in 2014 (NBS, 2015a) and is dominated by tuna varieties, mainly skipjack tuna contributing to 53% and yellowfin tuna contributing to 40% of the total fish catch .

The fisheries sector plays a vital role in food security and livelihood of the population. Despite the low contribution of the fisheries sector to the current GDP and the declining trend in fish landings since 2006, fish and fish products still remain the primary export in Maldives. In addition, reef fishery is particularly important for the tourism sector. Figure 2-10 shows the trends in total fish catch, fish exports and local consumption from 2000 to 2014. The decline in fishing activity since 2006 is particularly attributed to decline in fish landings, mainly due to changes in environmental conditions and the rising cost of ice and fuel (FAO, 2012).

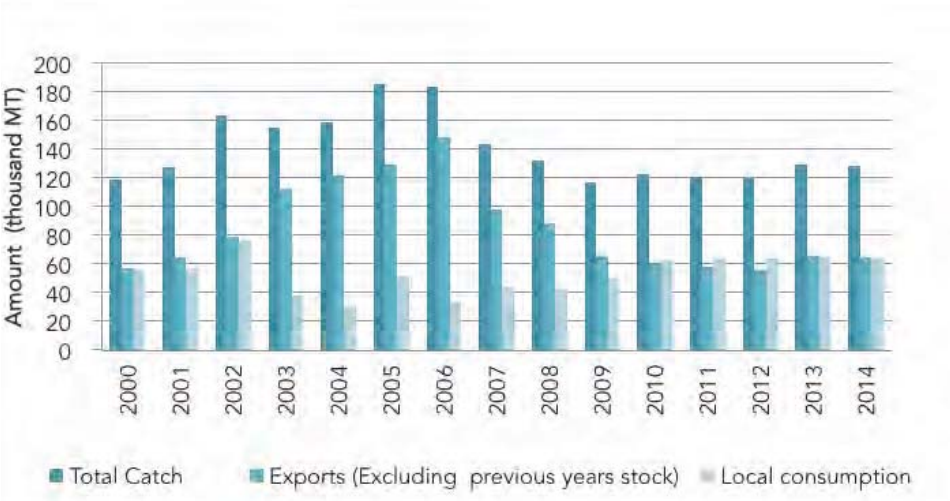


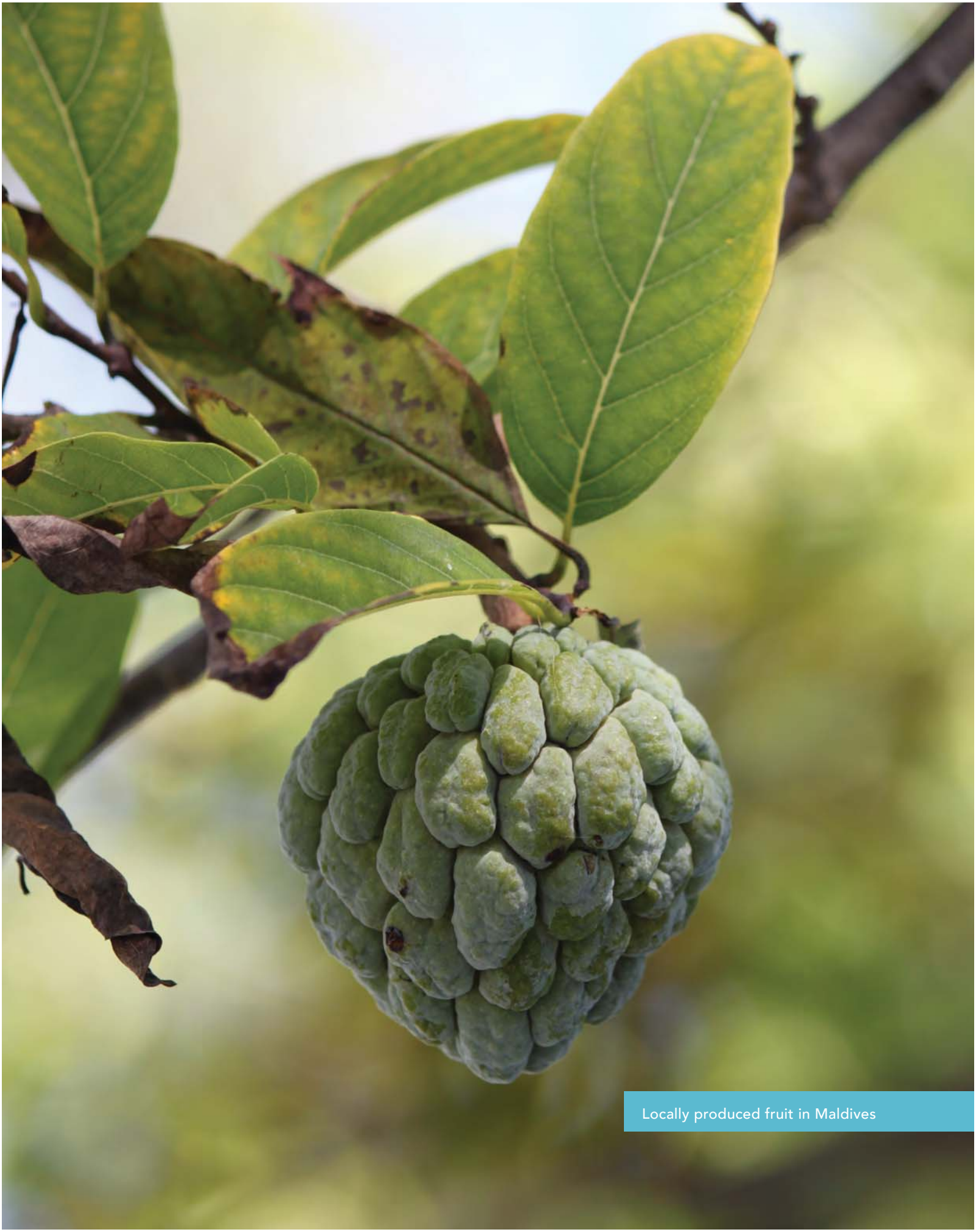
Figure 2-10: Trend in fish catch, export and local consumption. Data source: (DNP, 2010; NBS, 2015a).

2.4.3. Agriculture

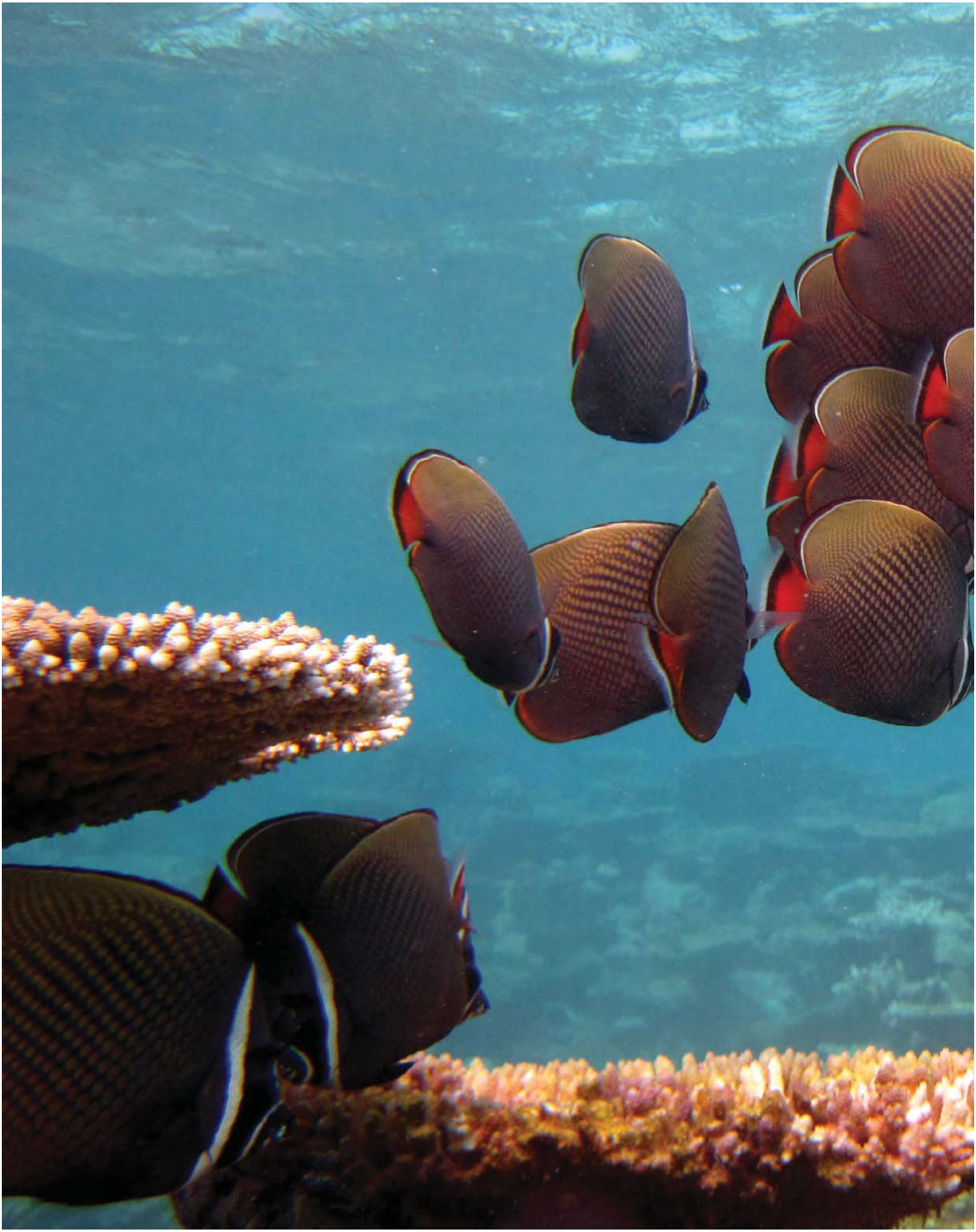
The agriculture sector of the Maldives is constrained by a narrow resource base including lack of cultivable land. Hence the contribution from the agriculture sector is significantly low, accounting for only 1.6% share of GDP in 2014 (NBS, 2015a). The limited agricultural production leads to high dependency on imported food, affecting the food security of the country.

Despite the low contribution to GDP, agriculture is a vital source for providing livelihood and employment for farmer population in the islands (FAO, 2012). The current farmer population is 7,410 of which 3,940 are females. Despite the challenges in agriculture sector, recent trend shows that the sector is strengthening its effort in production and thus the output delivered to the market is at an increase (Figure 2-11).

Figure 2-11: Agricultural productions and earnings. Adapted from (FAO, 2012)



Locally produced fruit in Maldives



CHAPTER 03
STATE AND TRENDS OF ENVIRONMENT

Chapter 3 State and trends of environment

This section presents the state and where available the trends, of the air quality, coastal and marine environment and biodiversity.

3.1. Air quality

Air quality in the Maldives is generally considered good, as the sea breeze flushes air masses over the small islands easily. However, rapid urbanization and increased economic growth in the recent years have raised air pollution as a growing concern, particularly in the Male' region. The capital island Male' is approximately 2km long and 1km wide and is occupied by high rise buildings, congested roads and few green or open spaces. Male' is facing increased air pollution due to growth of land and sea vessels, diesel power generation, construction and open-burning in the neighbouring waste-island Thilafushi. In addition to the local air pollution, transboundary air pollution is also observed to affect air quality of the Maldives.

A regional air quality monitoring station is established in H.Dh. Hanimaadhoo, which is a receptor site for long-range transport of pollutants, Atmospheric Brown Clouds (ABC) —emissions from South Asia, Middle East and Africa region. Although research on movement of transboundary air pollutants has been well conducted in Maldives, empirical measures to indicate local pollution status is limited.

Urban air pollution generated by vehicles, industries and energy production is responsible for approximately 800,000 deaths annually (WHO, 2016a). Between 2005 and 2010, the death rate linked to outdoor air pollution rose by 4% worldwide (UNEP, 2014a). Furthermore, a number of researches indicate significant relationship between urban air pollution and adverse health effects (Kjellstrom, Neller, & Simpson, 2002; Rizwan, Nongkynrih, & Gupta, 2015; Valavanidis, Vlachogianni, Fiotakis, & Loridas, 2013). Therefore, increase of motorized vehicles, growth of construction sector and increased prevalence of respiratory diseases serve as important indicators to understand the status of air quality in the Maldives.

3.1.1. Ambient air quality

In Maldives, poor air quality is a concern in urban growth centres. In particular, in the capital, Male' City air quality is visibly degraded. The main contributors to poor outdoor air quality in Male' City include emission of air pollutants from motor vehicles, vessels, construction, electricity generation and open burning of solid waste at Thilafushi dumpsite. Waste burning both at the dumpsites and backyards of islands contribute significantly to air pollution in the islands. More recently, incidences of high impact fire accidents, especially in storage warehouses, have risen in the congested capital city where industrial activities are carried in the midst of residential areas.

Although ambient air pollution is an increasing concern in Maldives, air quality status is not known due to lack of monitoring data. However, the emissions are expected to be high due to upwards trend in population, urbanization, energy use, the vehicle population, growth in economic sectors such as tourism and waste generation.

Particulate Matter

According to the WHO (2011), Particulate Matter (PM), especially $PM_{2.5}$, is the most significant source of air pollution affecting human health. PM of size 10μm is quantified as PM_{10} and can be eliminated from the body through coughing or sneezing. Fine particles ($PM_{2.5}$), including black carbon (BC), are shown to have negative effects on human health, and is currently considered a premier environmental health hazard world-wide, especially in the developing countries.

A study conducted by Budhavant, et al. (2015) attributes air pollution in the Maldives to both long-range transports from the neighbouring Indian subcontinent and local sources, particularly from incomplete combustion practices from traffic, shipping and waste burning. Based on data from Male' (urban) and Hanimaadhoo (rural), Budhavant, et al. (2015) explicated the relative contributions of local vs. long-range transported sources to the seasonally-varying levels of $PM_{2.5}$, Organic Carbon (OC) and Elemental Carbon (EC). It is seen from Table 3-1 that the annual average $PM_{2.5}$ levels in Male' are higher (19 μg/m^3) than at Hanimaadhoo. The difference is larger during the dry season (Figure 3-1) when local emission plays a larger role. The annual averages of $PM_{2.5}$ levels for both Male' and MCOH are higher than the annual guideline value of 10 μg/m^3 suggested by World Health Organization (WHO).

The concentrations of OC and EC also showed a similar patter as bulk mass $PM_{2.5}$. In Male' 17% of Total Carbonaceous Matter (TCM) contributed to bulk mass $PM_{2.5}$, whereas at MCOH the relative contribution of carbonaceous matter was 13% (Table 3-1). Incomplete combustion practices in the Male' local region could be the cause of larger contribution of carbonaceous matter in this area.

Table 3-1: Summary of the concentrations (µg/m3) and percentages of carbonaceous species in $PM_{2.5}$ in Male' and MCOH. Adapted from (Budhavant, et al., 2015).

	PM_{25} (µg/m³)		Rainfall (mm)		OC(µg/m³)		EC (µg/m³)		OC/EC ratio		% of TCM in PM_{25}	
	Male'	MCOH	Male'	MCOH	Male'	MCOH	Male'	MCOH	Male'	MCOH	Male'	MCOH
Dry season (Jan-Apr-Nov-Dec)	21.2	19.5	606	4530	1.88	1.31	0.76	0.49	2.27	2.81	18	16
Pre-transitional period (May)		10.3	493	323		0.16		0.13		1.22		4
Wet season (June-Sept)	14.7	7.42	618	1024	1.12	0.17	0.40	0.08	2.76	2.45	15	6
Post Transitional period (oct)	20.9	12.7	364	121	0.67	0.15	0.51	0.12	1.34	1.24	8	3
Total average	18.6	13.00	2082*	1898*	1.49	0.73	0.60	0.29	2.70	2.51	17	13
Total rainfall (2013)												

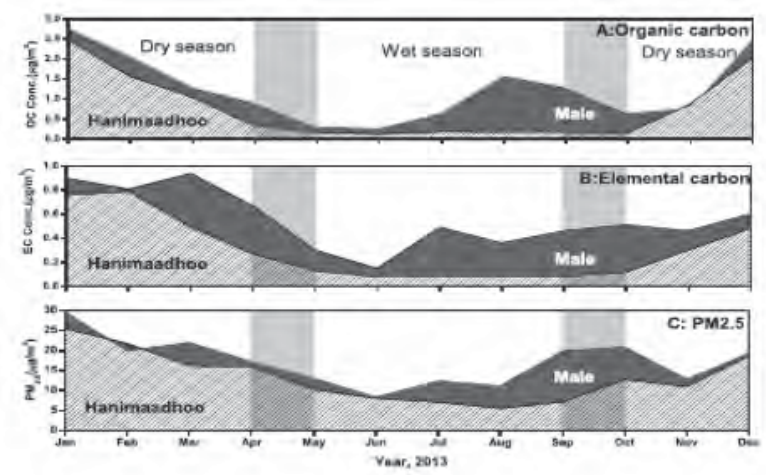


Figure 3-1: Monthly average variations of A. Organic Carbon (OC), B. (EC) and C. $PM_{2.5}$ concentrations in Male' and Hanimaadhoo. Vertical shaded bars indicate the monsoonal transition periods, May and October. Adapted from (Budhavant, et al., 2015).

3.1.2. Greenhouse Gases

The main greenhouse gases (GHGs) reported in the National GHG Inventory of 2011 are CO_2, CH_4 and N_2O from the energy and waste sectors (MEE, 2016a). The Maldives, energy sector accounts for the largest contribution to national GHG emission (includes burning of fossil fuel for electricity generation, transport, and other energy sector such as tourism and fisheries, and domestic utilization of fuel for cooking). Consumption of fossil fuel mainly in tourism and power generation sector accounts for major source of GHG emissions, followed by urban sector such as municipal waste, transport sector and industrial activities. Contribution from the waste sector, including waste incineration and open burning of biomass is the next largest source of GHG emission. Figure 3-2 shows the GHG inventory from energy use from 2002 to 2012.

Vessels docked at jetty

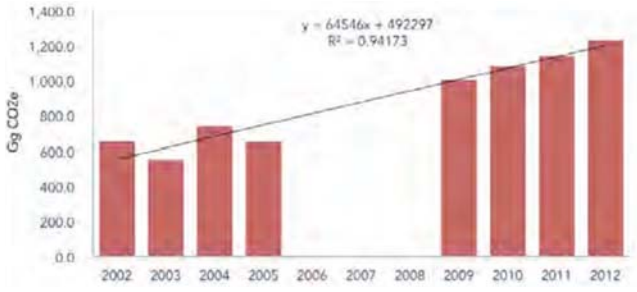


Figure 3-2: GHG Inventory from energy use- 2002 to 2012. Adapted from (MEE, 2016a).

3.1.3. Pressures

Transport sector

Transport involves the combustion of fossil fuels to produce energy translated into motion. Maldives is heavily dependent on the transport sector, which is a main contributor to ambient air pollution. In addition, GHG is emitted as a by-product of fossil fuel combustion in transport vehicles and vessels. Transport sector is the second largest source of GHG emission in Maldives, and accounts for 21.53% of the GHG emissions in 2011 (MEE, 2016a).

Following the trend of population growth and urbanization, an increase in number of vehicles is observed within the country, particularly in Male'. The total number of registered motor vehicles in Maldives from 2004 to 2014 is 68,208 showing an increase of 262.2% over the decade. Figure 3-3 shows an increasing trend for the number of registered motorcycles and cars, which represents the two most popular forms of land transport in Maldives. As can be seen in Figure 3-4 in 2014, 83% of registered vehicles were motorcycles, followed by cars (7%). Considering the small size of islands, the fleet size is significantly higher, thus suggesting the possibility of high levels of pollution in Male' City.

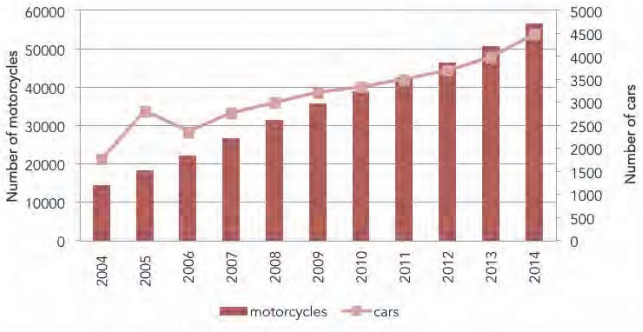


Figure 3-3: Growth of motorcycles and cars from 2004 to 2014. Data source: (DNP, 2010; NBS, 2015a)

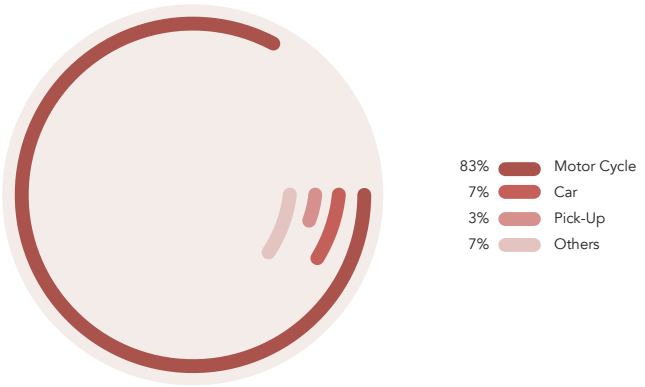


Figure 3-4: Percentage share of vehicles in 2014. Data Source: (NBS, 2015a).

Due to the dispersed nature of the islands, sea transport is the most popular mode of transportation used within the islands. The growth of the two major industries, tourism and fisheries has led to an increase in the use of different types and sizes of sea transport vessels. Furthermore, the introduction of the decentralized ferry system in 2009 has also resulted in the increase of ferries used within the country. Emission from sea transport contributed to 12.4% of total national GHG emission in 2011 (MEE, 2016a). The growth of registered number of vessels is shown in Figure 3-5. Over the years, an increasing trend is seen, with the number of vessels reaching a total of 12,074 by the year 2014.

Over the recent years, the domestic aviation sector has expanded, mainly driven by the rapid development in the tourism industry. While in 2009 there were only 40 aircrafts, by 2015 the number has increased to 79 (Figure 3-6). In addition to 3 international and 8 domestic airports, there are 73 floating platforms for sea planes currently in operation.

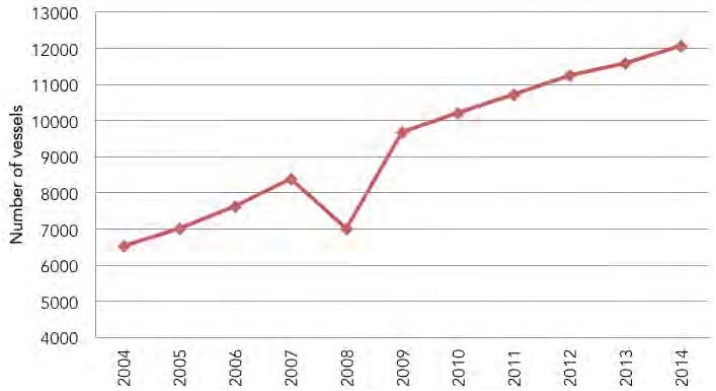


Figure 3-5: Number of registered sea transport vessels in Maldives. Data source: (NBS, 2015a).

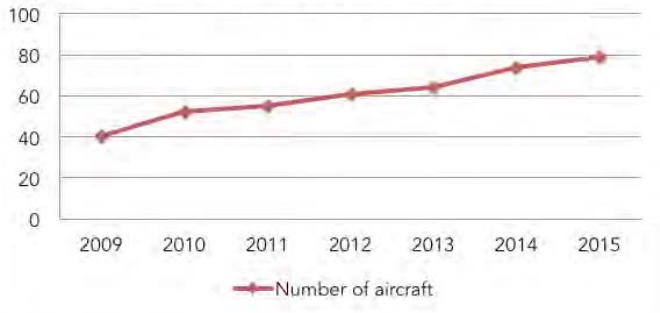


Figure 3-6: The number of aircrafts in operation from 2009 to2015 (Data provided by: Maldives Civil Aviation Authority, 2016).

Electricity generation

The production of electricity is the fastest growing energy consumption sector accompanied by increasing demand from inhabited islands and growth in the tourism industry. Maldives had gained universal electricity in 2008. According to the GHG inventory of 2011, electricity generation is the largest source of GHG emission, accounting for 63.51% of the national emission (MEE, 2016a). From 2005 to 2014, the total electricity production in Male' City has grown by 71%, with an average of about 7.1% increase per annum. Electricity generation is discussed in details in Section 4.2 of this report.

Emission from waste sector

Rapid population growth, changing consumption patterns and the booming tourism sector have contributed to growing quantities of waste in Maldives. Maldives generates an estimated 860MT of solid waste per day (MoT, 2015b). Household waste segregation is not a common practice in the Maldives. Therefore, waste disposed at the management site or landfills largely contains mixed waste which is frequently burnt to reduce the volume, thus significantly contributing to air pollution. Waste indicators are discussed in detail in Section 4.3.

The National GHG Inventory reports 5.9% of the GHG emission from waste incineration (MEE, 2016a). Waste sector is also responsible for 96.3% methane emissions and 72.2% nitrous oxide emissions in Maldives (MEE, 2016a). According to the Preliminary Inventory Report on Persistent Organic Pollutants (POPs), the burning of mixed waste in landfills emits dioxins and furans in the range of approximately 1,000 micrograms toxic equivalence/ton (TEQ/ton) of material burnt (MEE, 2016b). Furthermore, incomplete combustion from Thilafushi dumpsite is also known to have significant impact on the particular matter concentration in the urban region (Budhavant, et al., 2015).

Pollution from the construction industry

Construction industry is a major source of pollution, responsible for a significant proportion of particulate matter emission and high level of noise pollution. Dust generated from construction site (typically from concrete, cement, wood and silica) can be carried for large distances

over long durations, and is responsible for causing a wide range of respiratory diseases, asthma and bronchitis. The construction industry in Maldives has shown an increased growth over the recent years, with 104 construction companies registered at present. The lack of space and increased congestion has led to an increase in the construction of high rise buildings in Male'. From 2007 to 2014 a total of 3,083 dwellings have been authorized for construction in Male' (Figure 3-7). Consequently, closely built high rise buildings also prevent the natural flushes of air over the island.

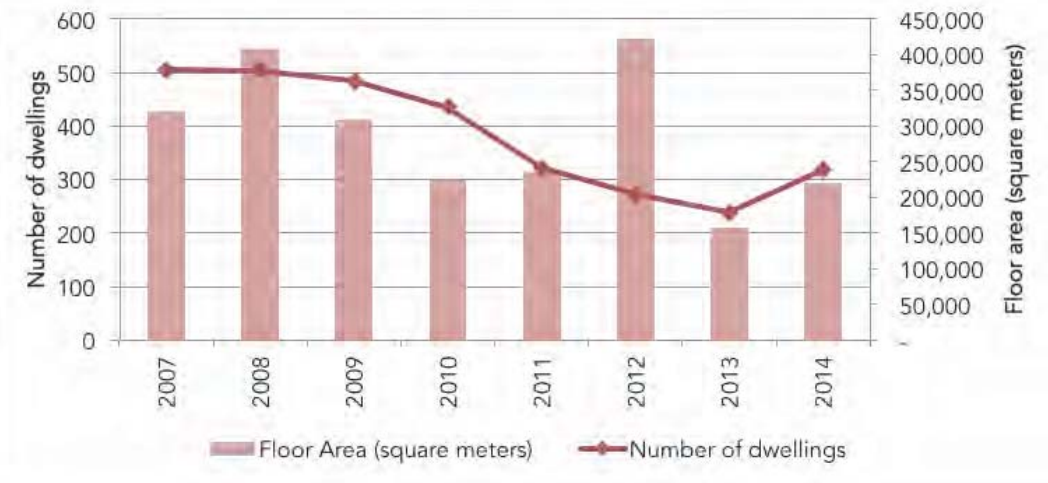


Figure 3-7: Number of dwellings authorized for construction. Data source: (NBS, 2015a).

3.1.4. Transboundary Air Pollution

A receptor observatory to study long range transboundary pollution is strategically located in the island of Hdh. Hanimaadhoo in the Maldives. The super observatory, Maldives Climate Observatory of Hanimaadhoo (MCOH), owned by the Government of Maldives is jointly operated by the Maldives Meteorological Services and the MCOH International Science Team through an MoU with UNEP.

Measurements made at MCOH have played a fundamental role in augmenting our understanding of gaseous and particle-borne pollutants from the Asian continent and their impact on climate. The perennial information of extensive urban like plumes of gases and particulate matter over a vast area of the Indian Ocean was detailed by the 1999 Indian Ocean Experiment (INDOEX), showing that emissions from mainland South Asia can be transported long distances over the ocean (Budhavant, et al., 2015). Figure 3-8 depicts a MODIS satellite image of high loadings of aerosols over South Asia. The dominating air-mass transport pathways of winter-time Indian subcontinent outflow which are intercepted at MCOH are shown by the black arrows.

To a large degree it was the result of the ABC research and efforts of the UNEP and a group of nations in February 2012 that inspired to inform the Climate and Clean Air Coalition (CCAC), with the aim to reduce short lived climate pollutants and its impacts on the climate. Based essentially on the knowledge gained from studies in Southeast and South Asia, with MCOH as the key Super-Observatory, leading ABC scientists have introduced the concept of Short Lived Climate Pollutants (SLCPs), particularly emphasizing the role of black carbon.

Studies conducted at MCOH during December 2010 to February 2013 shows that long term mean mass concentrations were higher in 2011 and 2012 (18μg/m^3 for each year) than the WHO guideline value for annual mean of 10μg/m^3 (Figure 3-9).

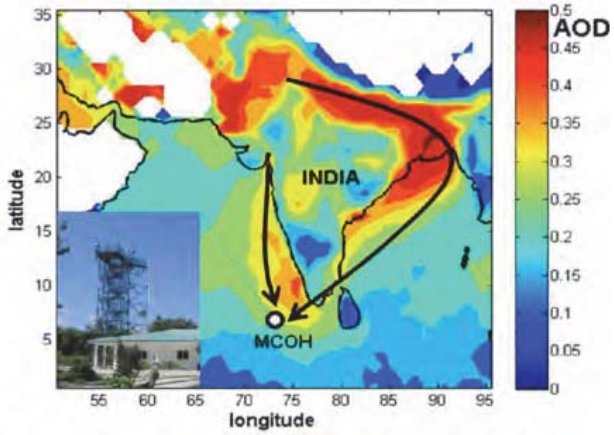
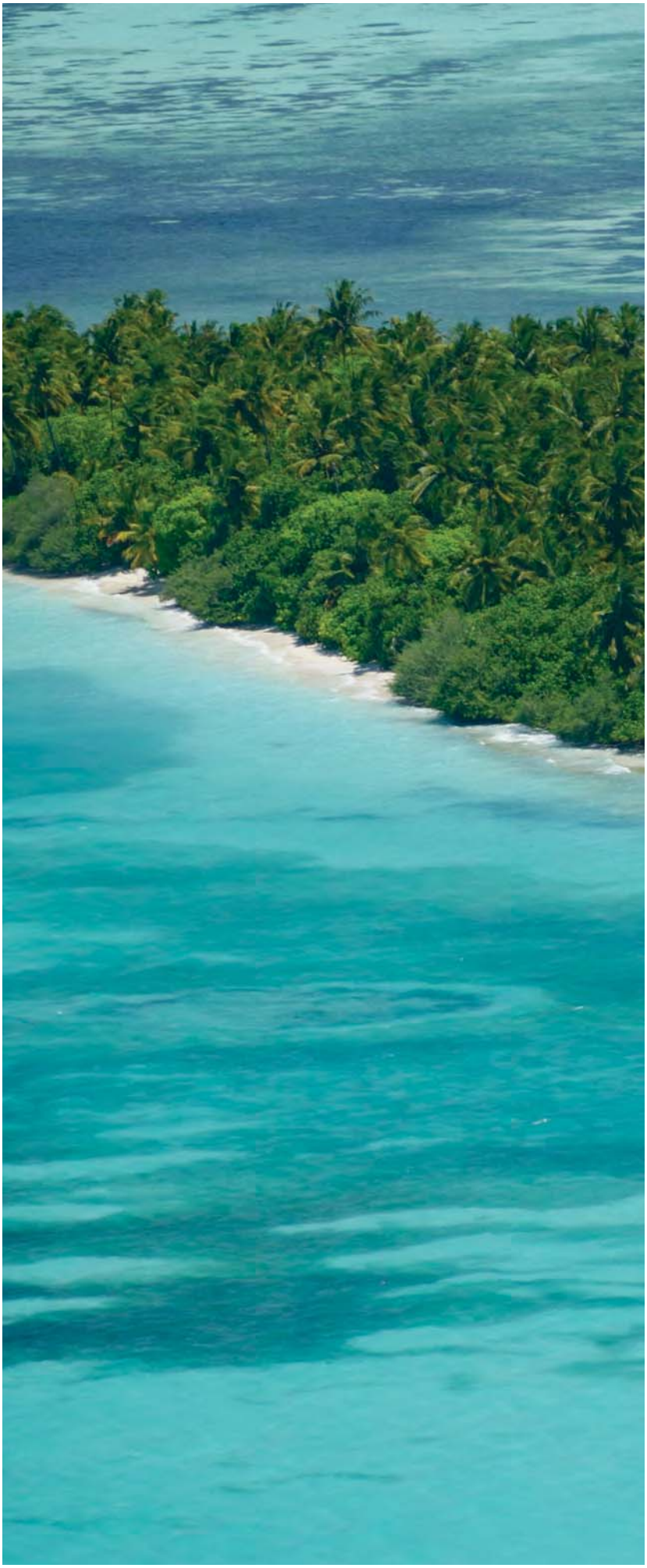


Figure 3-8: MODIS satellite image showing typical high loadings of aerosols (aerosol optical depth- AOD) over South Asia. The air mass-transport pathways of winter-time Indian subcontinent airflow which are intercepted at the Maldives Climate Observatory at Hanimaadhoo (MCOH) are shown by the black arrows Adapted from (Budhavant & Gustafsson, 2013).

Box 3.1: Atmospheric Brown Clouds

The atmospheric brown clouds (ABCs), seen as widespread layers of brownish haze, particularly over South Asia, are caused by regional scale air pollution mainly from sub-micron aerosol particles including black carbon and precursor gases that produce aerosol and ozone (UNEP, 2014b) The brown clouds can weaken the subsequent monsoon circulation, decrease rainfall and significantly influence the regional climate, hydrological cycle and glacial melting.



Dometic aviation: A growing sector in Maldives

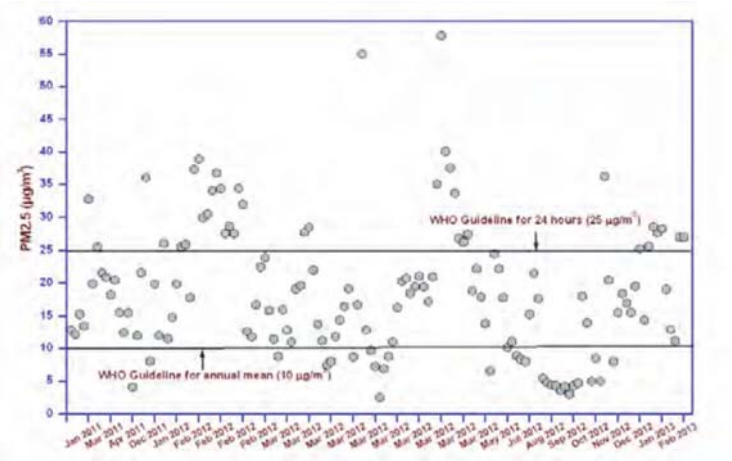


Figure 3-9: $PM_{2.5}$ levels at MCOH from December 2010-February 2013. Adapted from: (Budhavant & Gustafsson, 2013).

3.1.5. Health Impacts

Air pollution is a significant issue, globally as well as regionally and is known to be a significant cause of many health problems. In both developing and developed countries, millions of premature deaths associated with prolonged exposure to air pollutants occur each year. According to WHO estimates, around 7 million premature deaths resulted from air pollution in 2012, which is more than double compared to previous estimates (WHO, 2014a). While there are no studies done in Maldives, numerous studies from various regions have examined the impact of degrading air quality on human health in developing cities where a significant proportion of deaths occur when air pollution levels are high and growing. Previous reports on State of Environment have also used respiratory diseases as an indicator of air pollution (MEE, 2012a). As seen in Figure 3-10, an increasing trend is observed in Acute Respiratory Infection (ARI) cases in Maldives.

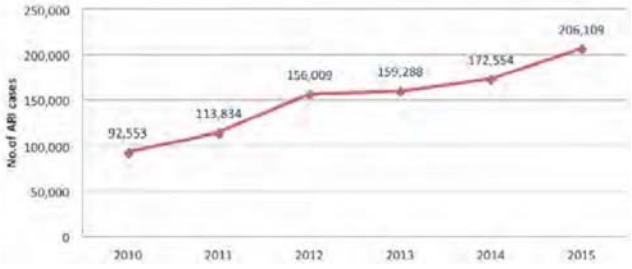


Figure 3-10: Number of cases of Acute Respiratory Infection (ARI) from 2010 to 2015 (Data provided by Health Protection Agency, 2015).

3.1.6. Government responses

Maldives does not have a national air quality policy or a national ambient air quality standard. The main legislations and programmes relevant to air pollution include Environmental Protection and Preservation Act (4/93), National Solid Waste Management Bill, Waste Incineration Guideline, Concrete Batch Plant Guideline and the Vehicular Emission Standard.

While strong policy framework for environmental protection exists, legal framework needs to be strengthened with respect to air pollution. There is poor monitoring and enforcement due to lack of institutional and human resource capacity. At present the air quality monitoring stations established for local air quality monitoring do not function due to lack of trained personnel.

At present, mechanisms for emission regulation from industries do not exist. The Environmental Protection Agency (EPA) has a strong Environmental Impact Assessment (EIA) regulation where environmental impacts are assessed for any developmental or industrial activity and pollution prevention is given great emphasis. Ministry of Environment and Energy is implementing an investment plan to achieve low carbon development in the energy sector (Details provided in Section 4.2). To reduce emission from the transport sector, there is an import ban on use of cars older than five years and motorcycles with engine capacity less than 150 cubic centimeters. There is also an age limit of vehicles on the road, where taxi cars should not be more than 25 years. There is no import duty on electric vehicles, while petrol and diesel vehicles face 200% mark up. In addition, as a means to promote public transport, bus service in Hulhumale' and Addu City are ongoing since 2006.

The Government of Maldives is committed to be a leading voice in global environmental issues, including air quality among others. Maldives is signatory to the following international and regional conventions relating to air pollution control (Refer to Chapter 5 for details).

Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal

Male' Declaration on Control and Prevention of Air Pollution and its Likely Transboundary Effect for South Asia

Stockholm Convention on Persistent Organic Pollutants

Rotterdam Covention

Climate and Clean Air Coalition (CCAC)

Vienna Convention and Montreal Protocol

3.2. Coastal and marine environment

Maldives has a range of coastal ecosystems including coral reefs, seagrass beds, lagoons, beaches, and areas of mangroves. The total area of the atolls, including lagoons is 21,372km^2 (Naseer & Hatcher, 2004). The total reef area of Maldives is 4,515.14km^2, of which include 2,041 distinct coral reef structures (larger than 0.01 km^2) with an area of 4,493.85km^2 and small areas of coral substratum covering another 19.29 km^2 (Naseer & Hatcher, 2004). The coral reef systems of the Maldives has two of the largest natural atolls in the world, Thiladhummathi Atoll, with an area of 3,789 km^2 and Huvadhu Atoll, with an area of 3,278km^2 (Naseer & Hatcher, 2004). Total area of wetlands and mangroves in Maldives is approximately 7.39km^2 (MEE, 2015a).

In addition to their global significance, the coastal and marine ecosystems and their resources form the bedrock of the country's economy. Our two major industries, tourism and fisheries heavily depend on a healthy and diverse marine and coastal ecosystem. These ecosystems also play key roles in providing employment, income, food security and recreation. Furthermore, coral reefs, wetlands and mangrove systems protect the shorelines from wave action and maintain the balance of the environment.

However, over-extraction of coral and sand, habitat destruction and modification, pollution and unsustainable development have led to degradation of these ecosystems. Beach erosion is among the most serious environmental issues facing the islands of Maldives. Climate change and sea level rise aggravate the erosion process. In addition, El-Nino induced bleaching is a significant threat to the coral reefs, which provide important protection function for beaches.

3.2.1. Status of coastal and marine environment

Coral reefs

The unique and rich diversity of coral reefs of Maldives makes them globally significant. Covering a total reef area of 4,500km^2 (Naseer & Hatcher, 2004) the coral reefs of Maldives are the seventh largest reef system in the world and represents about 3.14% of the global reef area (Spalding, Ravilious, & Green, 2001). Thiladhummathi Atoll with approximately 500km^2 has the largest reef area (Table 3-2). Of the 2,041 distinct coral reefs in the Maldives, 529 are found on the rims of the 16 complex atolls. Five reefs make up oceanic faros and four are oceanic platform reefs. The rest are found as patch reefs within the lagoons of the complex atolls. Figure 3-11 shows a map of the major reef structures in the Maldives

Table 3-2: Reef Area Statistics of Maldives. Adapted from (Naseer & Hatcher, 2004)

Major Coral Reef Structures	Total Surface Area (km^2)	Number of Reefs	Reef Area (km^2)	Reef Island Area (km^2)
Complex Atolls			119.50	
Ihavandhippolhu	289.81	30	500.70	5.70
Thiladhunmathi	3,788.71	164	223.50	68.70
North Maalhosmadulu	1,184.31	155	262.90	12.90
South Maalhosmadulu	1,126.95	105	158.00	5.50
Faadhippolhu	701.42	84	349.00	7.20
North Male'	1,568.18	189	175.60	9.40
South Male'	536.33	112	489.40	2.00
Ari	2,271.75	268	151.30	8.30
North Nilandhe	597.15	86	179.40	2.20
South Nilandhe	736.46	98	251.10	4.40
Felidhe	1,090.97	203	197.30	0.92
Mulaku	983.92	111	243.30	4.20
Kolhumadulu	1,695.79	154	203.70	9.30
Hadhdhunmathi	884.63	56	437.90	23.10
Huvadhoo	3,278.59	210	70.32	34.30
Addu	157.22	7		15.00
Oceanic Faros (5)			142.48	
Makunudhoo	142.48	1	112.61	0.96
Goidhoo	112.61	1	88.05	2.20
Gaafaru	88.05	1	61.84	0.19
Rasdhoo	61.84	1	46.72	0.62
Vattaru	46.72	1		0.01
Oceanic Platform Reefs (4)			4.38	
Alifushi	4.38	1	9.54	0.71
Kaashidhoo	9.54	1	4.75	2.89
Thoddoo	4.75	1	10.18	1.62
Fuvahmulah	10.18	1	4,493.85	5.13
TOTAL	21,372.72	2,041		227.45

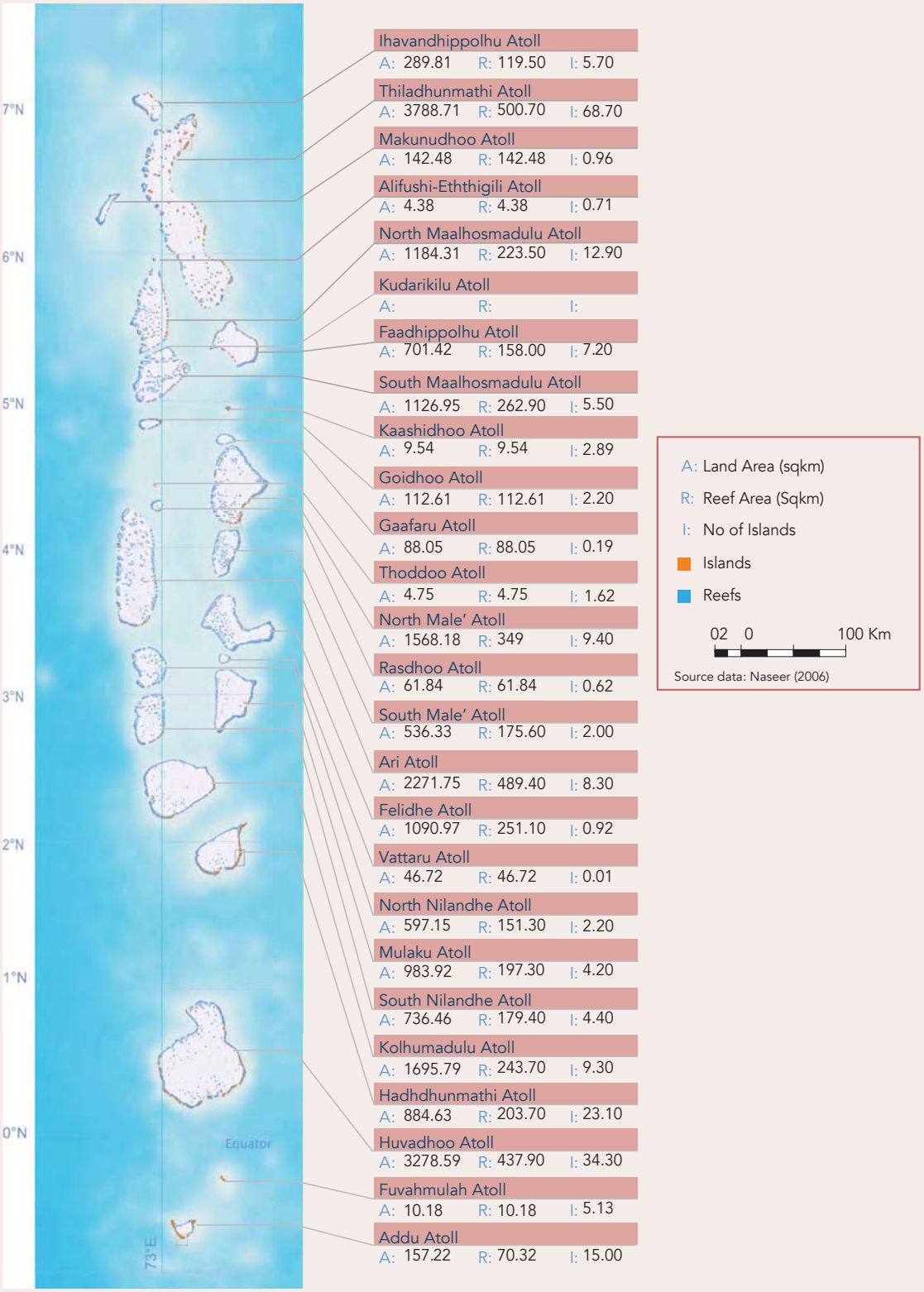


Figure 3-11: Reef Area Statistics of Maldives. Adapted from (Naseer & Hatcher, 2004)

Marine environment Himithi House Reef

Coast and beaches

Land is the scarcest resource in the Maldives and makes up only about 1% of the total area. Due to the small size of the islands, the whole land area is considered as a coastal zone. Over 80% of the total land area of the Maldives is less than one meter above mean sea level (MEEW, 2007).

The small size of the islands forces the people to live next to the sea. Given the close proximity of the settlements to the sea and low elevation of islands, homes of people are at significant risk from inundation due to high sea levels.

Beaches represent approximately 5% of the total land area (Shaig, 2006). They are particularly dynamic with substantial to seasonal change. Additionally, human interventions including poor waste management practices, coastal modification and unsustainable extraction of resources places further pressures on coastal areas.

Erosion is one of the most significant challenge and concern the island communities face in Maldives, with over 80% islands facing erosion issues. It is a dynamic, natural process brought by changes in wind direction and ocean currents due to monsoon shifts. However, human interventions such as sand mining and removal of vegetation, and coastal developments such as harbour construction and land reclamation interfere with sediment movement around the islands, which alter the balance of natural processes along the coastline. In 2014, a total of 116 inhabited islands reported erosion to Ministry of Environment and Energy and Environmental Protection Agency (EPA). Figure 3-12 shows the erosion status of reported islands based on surveys conducted by the EPA in 2014.

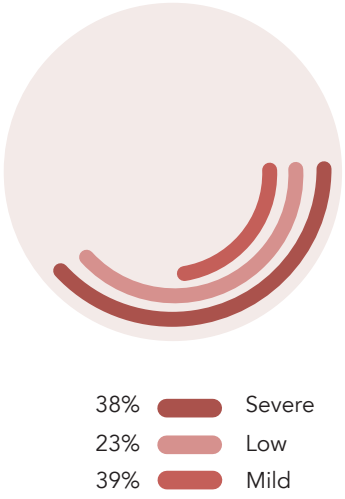


Figure 3-12: Erosion status of surveyed islands in 2014 (n=116)
(Data provided by: Environmental Protection Agency, 2014)

Wetlands

Wetlands are highly productive ecosystems, providing several goods and socio-ecological services. In Maldives there are about 74 islands with wetlands or mangroves. The wetland or mangrove areas cover a total area of approximately 7.39km^2 (MEE, 2015a). Figure 3-13 shows the total wetland area found in the atolls of Maldives. Wetlands are more extensive in the northern islands, while some of the southern islands are characterized by large areas of wetlands. Fuvahmulah (Gnyaviyani atoll) has the largest wetland with an area of 1.41km^2.

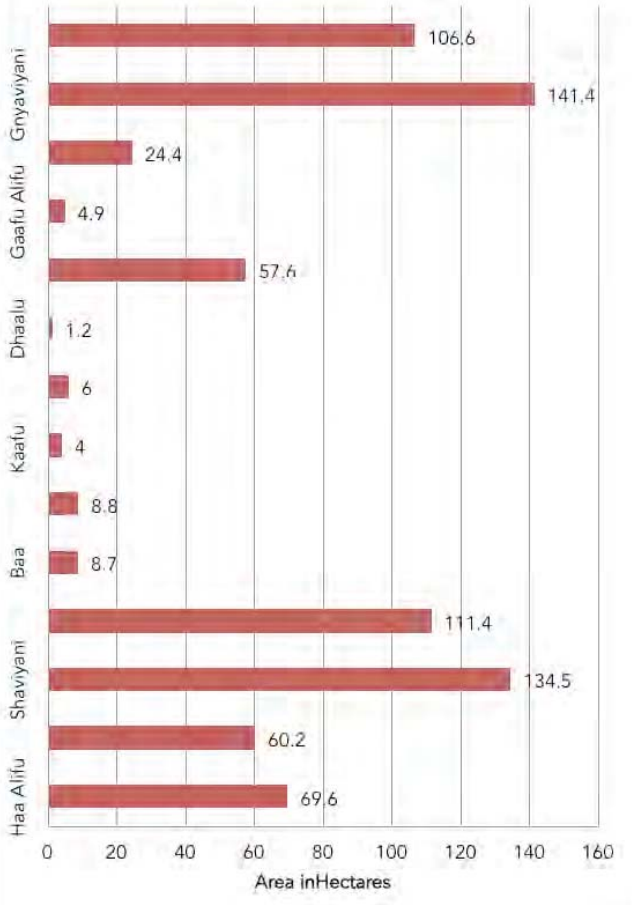
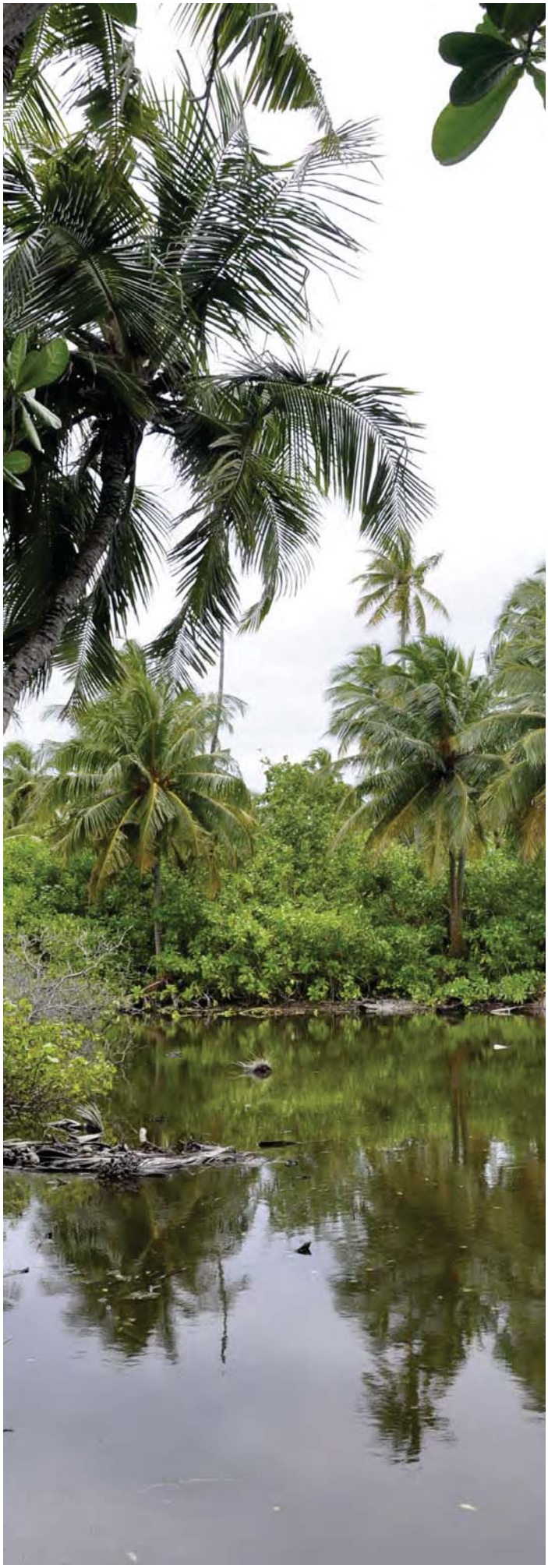


Figure 3-13: Distribution of wetland areas in Maldives. Data source (MEE, 2015a).



Seagrasses

In Maldives seagrass is not extensively developed. However, extended and developed seagrass around some islands, particularly those which are densely populated and are associated with high nutrient influx. Ecologically, seagrasses are important as they provide breeding and nursery grounds for many reef organisms, and they also provide nutrient for the reef system. However, seagrass beds on tourist resorts are considered aesthetically unpleasant. Resorts make extensive efforts, such as dredging techniques, manual removal and use of chemicals to control adverse growth of seagrass beds (Ali, 2004).

3.2.2. Threats to coastal and environment

Increase in sea surface temperature

Warming of ocean's temperature due to climate change is a key factor impacting corals and altering coral reef communities. High SST is known to cause mass coral bleaching. The trend in SST in the central region of Maldives (from 1951 to 2010) shows an increase of 0.11 to 0.15°C (Refer to Section 4.1.1 of this report). Future projections for SST shows an increase of 0.76 to 1.33°C for 2030, 1.01 to 1.93°C for 2050 and 1.2 to 3.4°C by 2080 (MEE, 2016a). In Maldives, mean monthly SST is generally lowest in December and January, while highest in April and May. During the 1998 El Nino, monthly mean SST was 1.2+/-4°C SD above the 1950-1999 average, with the highest anomaly of +2.1°C (Edwards, et al., 2010). The most recent global El Nino occurred in 2016, with high SST over 32°C recorded from Maldives during late April through to mid-May (Ibrahim, et al., 2016). Mass spawning and recruitment in the reef ecosystems depends on environmental conditions. Therefore, coral reef biodiversity is particularly vulnerable to rise in SST.

Pollution

Coastal and marine pollution can arise from land-based sources such as solid waste and untreated sewage disposal, or sea-based sources such as oil pollution and ballast water. The short distance from land to sea in Maldives increases the severity from both these sources. While pollution from land and sea-based sources are known to impact the onshore coastal environment, the quality of the marine environment and the health of marine organisms, information on pollution, including marine and coastal pollution are extremely limited.

The growing amount of waste generated and the lack of sufficient capacity for sound management of waste on the islands have raised waste management as one of the most challenging environmental issues in Maldives. Hence, poor waste management practices are common in the islands. Most inhabited islands either dump or burn their waste, usually at the island periphery in designated waste management centres or on the beach. Majority of islands dump food waste to the sea (Refer to Section 4.3 for further details). Food waste is known to contribute to nutrient influx in the marine waters, leading to algal blooms. In addition, open burning of waste results in vegetation die-off and exacerbates coastal erosion.

Furthermore, trash and other solid material washed away from landfills, beaches or thrown off from safaris and boats affects the reef habitats and threatens marine life.

Random disposal of waste and littering is common in most islands. Figure 3-14 shows the results of a waste audit of the East Beach in Villimale' over seven days. East Beach is the most commonly used beach locals for picnics in Villimale'. Over one week a total of 37.9Kg of litter was collected from an area of 24,900 square feet. Significant amount of plastic (approximately 15%) was present in the litter.

Discharge of untreated sewage, which contains a wide array of polluting agents including pathogens, organic substances, heavy metals and trace elements, and wastewater directly to the reefs presents direct or indirect risks to the ecosystem and the organisms. Population increase and rapid development in the islands intensifies the impacts from land-based contamination on the marine ecosystems (Ali, 2004) Municipal and industrial waste is known to increase the Biological Oxygen Demand (BOD) of marine waters.

In addition to local pollution, transboundary pollution is of growing concern to the coastal environment of the Maldives. Threats that have transboundary effects and those of special concern to the Maldives include persistent organic and heavy metal pollutants to the marine and coastal resources, accidental or deliberate oil spill along the tanker route in the region, continuous discharge and runoffs of pesticides and other harmful agricultural chemicals, risk of alien invasive species that may enter the territorial waters, poaching and other destructive fishing methods in the EEZ, and straddling and migratory fish stock management (Ali, 2004). Drifting fishing nets and long lines is often picked up by fisherman, indicating transboundary movement of such gears based on seasonal wind drifts.

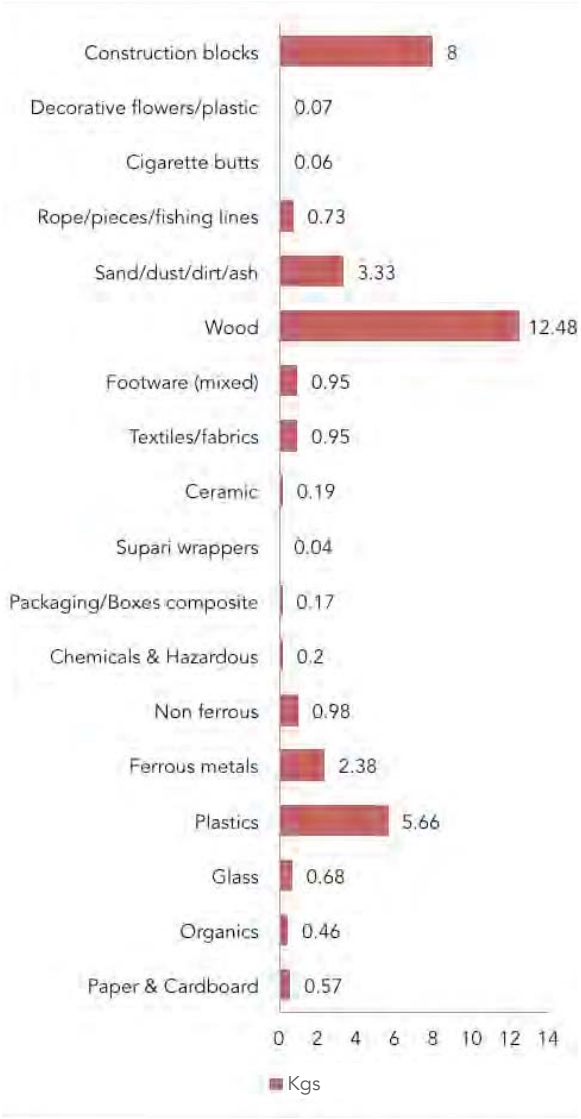
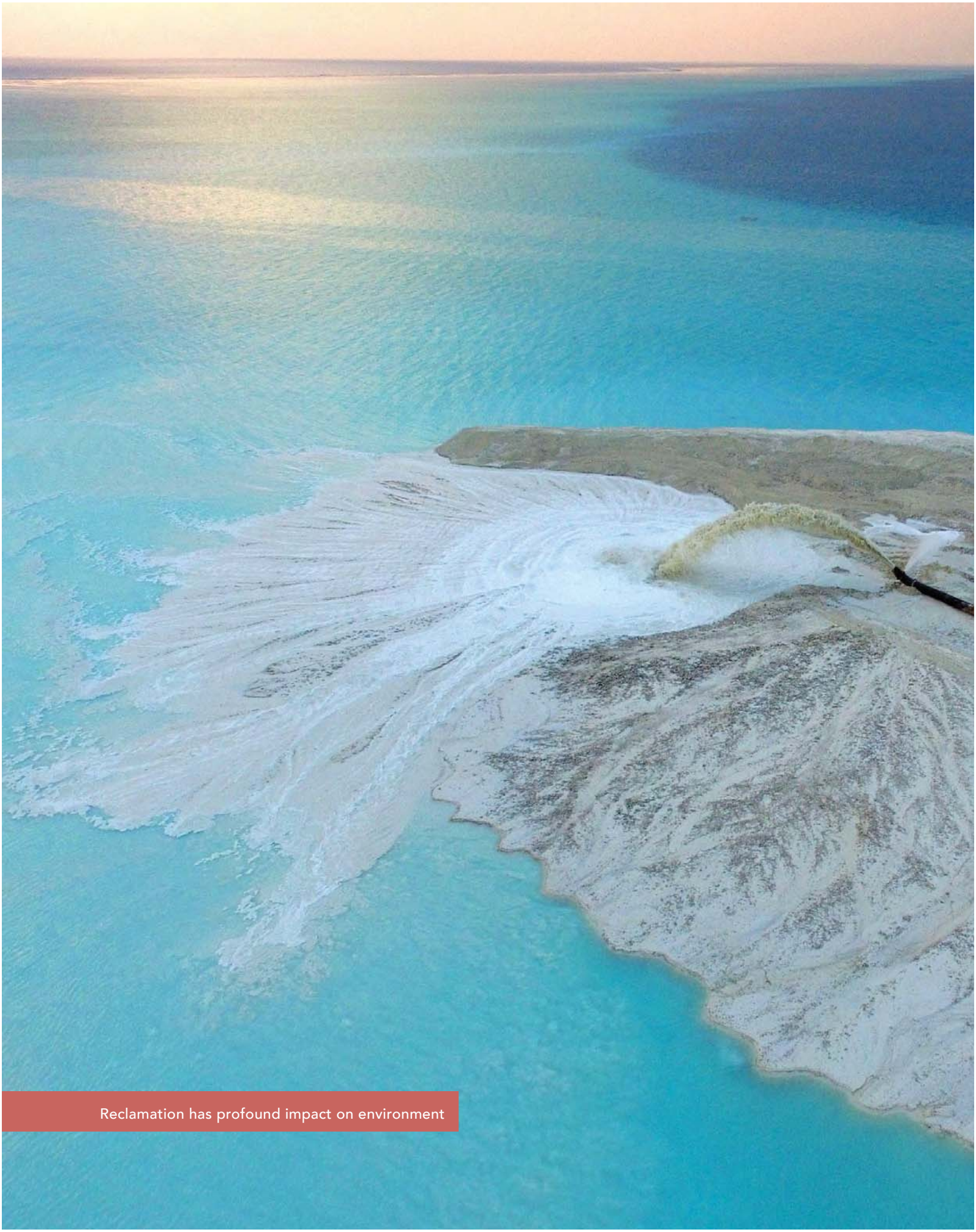


Figure 3-14: Type of waste accumulated on the East Beach in Villimale' over a week in March 2016 (Data provided by: Save the Beach, 2016).



Reclamation has profound impact on environment

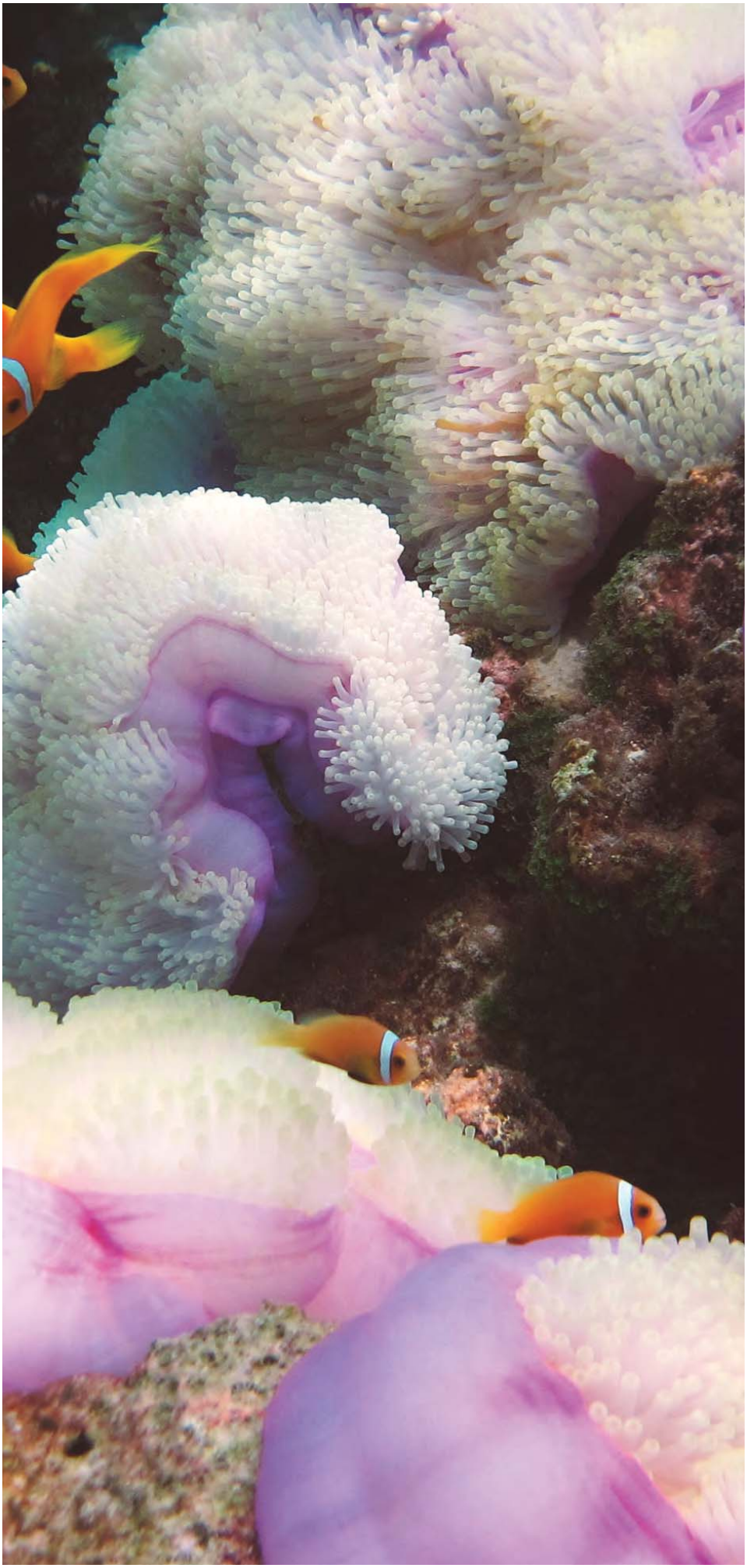
Coastal modification

Coastal modification including sand mining, cutting channels, reclamation and harbour development are identified as significant threats to the marine and coastal environment. Major modifications such as construction of jetties and gryones, breakwaters and other offshore structures, and channel blasting are known to have significant long term impacts on the morpho-dynamics of the islands. While these changes are important for coastal development, they result in emphatic consequences in the long term (Ali, 2004).

The limited land area in islands requires reclamation to provide land for human settlement. In addition to reefs and lagoons, several islands have reclaimed mangrove and inter-tidal marshy areas. Reclamation statistics from the Ministry of Housing Infrastructure (MHI) estimates that over 1,300 hectares of reef or lagoon area has been reclaimed from some 98 inhabited islands (MEE, 2015a). The largest land reclamation project was the Hulhumale' reclamation project, in which approximately 430 hectares were reclaimed to reduce population pressure on Male' (Table 3-3). There is also an emerging trend to reclaim reefs for tourist resort development. Harbour dredging affects the island stability and threatens coastal resources. In addition, poor design of harbours and other coastal protection structures often restrict through flow, thus resulting in stagnation of the water body within.

Table 3-3: Major reclamation activities in inhabited islands. Adapted from (MEE, 2015a).

Atoll	Island	Area reclaimed (ha)
Haa Alif	Dhidhdhoo	35.4
Haa Dhaalu	Kulhudhuffushi	44.2
Noonu	Velidhoo	17.9
Baa	Dharavandhoo	15.3
Baa	Eydhafushi	29.4
Baa	Thulhaadhoo	28.2
Lhaviyani	Hinnavaru	40.5
Lhaviyani	Naifaru	34.4
Kaafu	Hulhumale'	200.9
Kaafu	Hulhumale' Phase 2	226.95
Kaafu	Male'	94.7
Kaafu	Hulhule	76
Alif Dhaalu	Maamigili	73.8
Dhaalu	Meedhoo	20.0
Dhaalu	Kudahuvadhoo	69.7
Thaa	Vilufushi	40.2
Thaa	Thimarafushi	26.5
Gaafu Alif	Villingili	55
Gaafu Alif	Dhaandhoo	13.8
Gaafu Dhaal	Gadhdhoo	14.9
Gaafu Dhaal	Thinadhoo	71.4
Gaafu Dhaal	Fares-Maathoda	19.2
Seenu	Hithadhoo	53
Seenu	Meedhoo	11.5
Seenu	Gan	32.5



3.2.3. Impacts

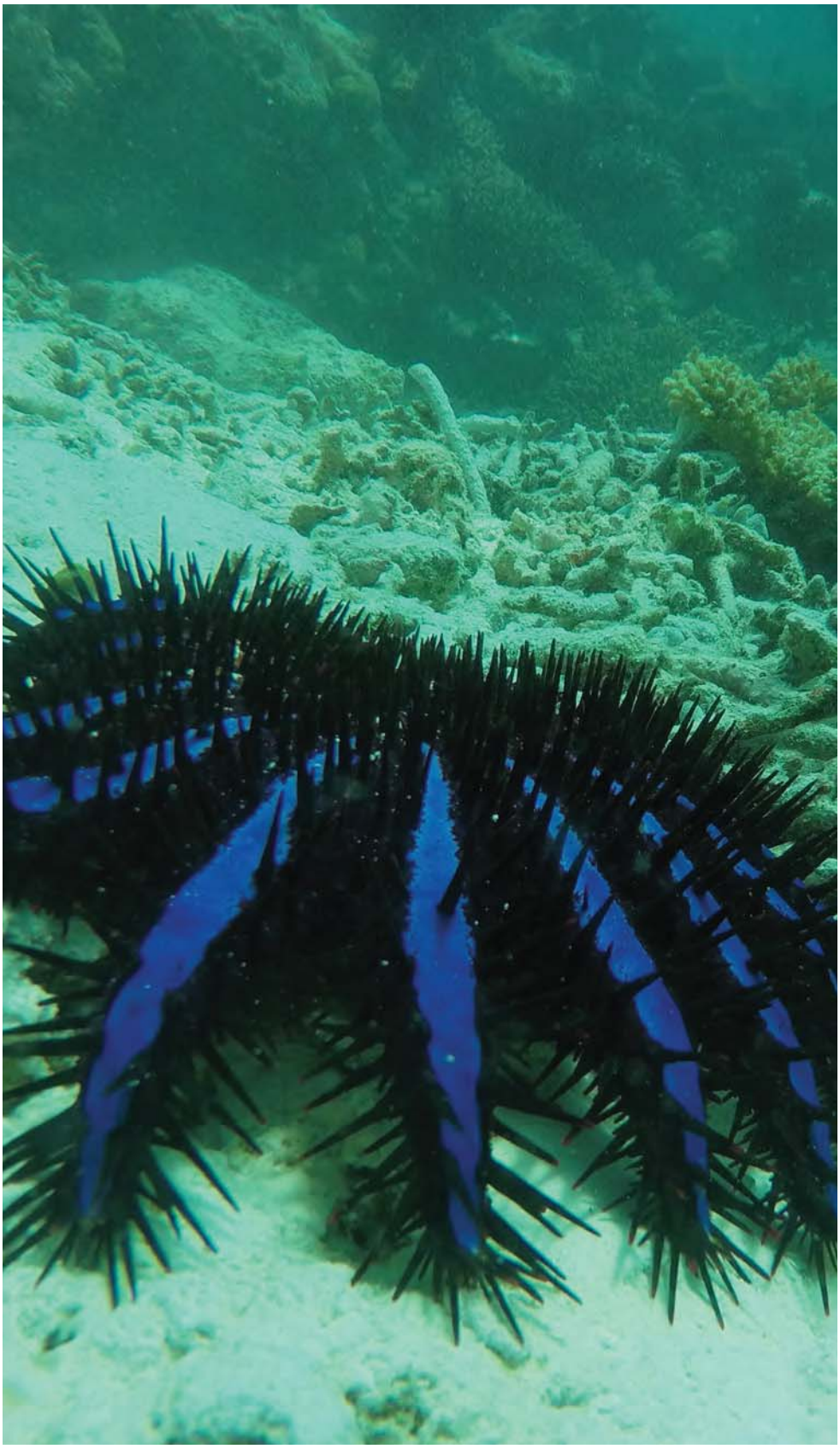
Coral bleaching

Since 1977, episodes of coral bleaching have been reported from Maldives (MEEW, 2007). The first recorded disastrous episode of bleaching occurred in 1998, during which the consistent high temperature of the sea caused the live coral cover to plummet to less than 3%, from a pre-bleaching level of 40-60% (Zahir, 2000). Subsequent surveys since 1998 showed significant recovery in live coral cover. While moderate bleaching episodes were also experienced during 2010, the 2016 El Nino and associated mass bleaching event was the largest bleaching episode recorded since 1998 (Ibrahim, et al., 2016). A comprehensive survey of a total 71 sites across 11 atolls conducted by MRC in collaboration with local and international partners reported approximately 75% average bleaching; indicating a severe episode (Ibrahim, et al., 2016).

Crown of Thorns starfish outbreaks

The Crown of Thorns starfish (CoTS), *Acanthaster planci* feed on live coral and is recognized as a major cause of coral reef degradation throughout much

of the Indo-Pacific region. Observing more than 15 CoTs per hectare (or 2 CoTs in a 2 minute swim) is considered an outbreak according to the Great Barrier Reef Marine Park Authority of Australia (GBRMPA, 2014). The first recorded outbreak of CoTs in Maldives occurred in the 1970s (Linden, 2016). While the second recorded outbreak which occurred in the early 1990s was more widespread, the most recent outbreak which began in 2013 is the largest ever recorded in Maldives (Linden, 2016). In June 2014, localized outbreaks were reported from Ari Atoll. An average density of 120±51 CoTS per transect, with a maximum of 222, was recorded around Mama Ghiri (Saponri, Montano, Seveso, & Galli, 2014). Furthermore, coral mortality of approximately 70% including complete or partial death of nearly 100% of tabular *Acropora* was estimated in this area. By 2015, large numbers of CoTS were reported from Ari Atoll, Baa Atoll, Lhaviyani Atoll and South Male' Atoll (Linden, 2016).



Impact on marine water quality

Eutrophication is one of the major effects from pollution affecting the water quality of

the marine environment. Large quantities of nutrients released into the coastal water through the sewage wastewaters increases the nutrient enrichment, stimulating algal growth. This is evident from the growth of seagrass beds in the vicinity of islands following inhabitation or increased population in the islands (BOBLME, 2010). Comparison of aerial photos from the 1960s and more recently in the 2000s, show that along with inhabitation and population increase, seagrass beds have been established along the coasts of many inhabited islands over time (Figure 3-15). This could be an indication of the alleviated nutrient input from the discharge of untreated sewage or food waste. In recent years, 'Red tides' in the lagoons and beaches of some resorts have also been reported, which could be attributed to algal blooms, such as *trichodesmium*.

Mass fish kill events, which have been reported from Maldives in the recent years, are often linked to poor water quality. The 2007 and 2008 mass fish mortalities was the most severe fish kill episodes that have been documented in Maldives. The fish kill events could be related to changes in physical and chemical conditions in the marine environment, algal blooms, viral or bacterial infections, or a combination of these factors (Naeem & Sattar, 2007). Similar events were also reported in 2012, when large numbers of dead fish were found washed ashore on resorts in Noonu and Haa Atoll. The dead fish include red-tooth trigger fish and several other reef fish including *Acanthurids* (surgeon fish) and *Serranids*.

Figure 3-15: Increase in the extent of seagrass with inhabitation and increase in population in B.Goidhoo (left) and K.Maafushi (right). Adapted from (BOBLME, 2010).

3.2.4. Government responses

Maldives became a member of the International Maritime Organization (IMO) on the 31 May 1967 (BOBLME, 2010). Under IMO several conventions were adopted, including the International Convention for the Control and Management of Ships Ballast Water and Sediments (BMW Convention). In addition, a maritime regulation for vessels entering and trading in the territorial waters of Maldives came into effect on the 1st of January 2000. This regulation requires for all vessels trading within Maldives to undergo annual inspection and certification. In addition, the Maldives is party to several international conventions and instruments on protecting the marine and coastal environment (Table 3-4).

Table 3-4: Major conventions and programs relating to protection of coastal and marine environment

Instrument	Status	Date
Stockholm Convention on Persistent Organic Pollutants, 22 May 2001	Ratified	17 October 2006
London Conventions 1972 and its 1996 Protocol	Ratified	08 October 1997
MARPOL (International Convention for the Prevention of Pollution) from ships, 1973 and the Protocol of 1978)- 20 May 2005	Accession	20 May 2005
UNCLOS (United Nations Convention on the Law of the Sea), 1982	Ratified	07 September 2000
Convention on the International Maritime Organization (MO), 6 March 1948	Acceptance	31 May 1967
International Convention for the Control and Management of Ships Ballast Water and Sediments, 13 February 2004	Ratified	22 June 2005
Basel Convention on the Control of Transboundary Movements of Hazardous Wastes ad their Disposal, 22 ,arch 1989	Accession	28 April 1992
GPA for the Protection of Marine Environment from Land based Activities, 1995	Adopted	1995
Agenda 21 (Chapter 17) of the UN Conference on Environment and Development, 1992	Adopted	
Convention on Biological Diversity, 1992	Ratified	1992

Maldives became signatory to MARPOL on 20th of May 2005, with Ministry of Transport and Communication mandated with the responsibility of implementing the programs under the convention. Three of the six annexes under the convention which have been adopted by the Maldives to date include:

1. Annex I- Regulations for the prevention of pollution by oil
2. Annex II- Regulations for the prevention of pollution by noxious liquid substances in bulk
3. Annex V- Regulations for the prevention of pollution by garbage from ships

Maldives depends on the coastal and marine environment for its economy, livelihood, protection of islands and food security. Therefore, Maldives gives a high importance to protect and conserve the marine and coastal environment. In this regard, key legal instruments for protection and conservation of marine and coastal environment are listed below. Further details of these legislations are considered in Section 5.1 of this report.

The Fisheries Act of Maldives(Law No. 5/87)

Regulation on Cutting, Uprooting, Removing and Transfer of Palms and Trees Between Islands

Environment Protect ion and Preservation Act of Maldives (EPPA)
(Act No. 4/1993)

Maritime Zones of Maldives Act (Law No. 6/96)

Maldives Tourism Act (Act No. 2/99)

Fisheries Regulation (2000)

Act on Coral and Sand Mining (2000)

Regulation on the Protection and Conservation of Environment in the Tourism Industry (2006)

National Wastewater Quality Guidelines (2007)

Regulation for Determination of Penalties and Obtaining Compensation for Damages Caused to the Environment (Regulation No. 2011/R-6)

Environmental Impact Assessment Regulation (EIA)
(Regulation No. 2012/R-27)

Regulation on Dredging and Reclamation of Harbours
(Regulation No. 2013/R-15)

Inter-Agency Task Force on Coral Bleaching

The Inter-Agency Task Force on Coral Bleaching was established in 2016 to address the 2016 mass bleaching event in the Maldives, with the purpose of increasing coordination among stakeholders to monitor predicted coral bleaching across the Maldives. This task force consists of the Marine Research Centre, Ministry of Fisheries and Agriculture, Ministry of Environment and Energy, Environmental Protection Agency (EPA), Ministry of Tourism and the Coast Guard of the Maldives National Defence Force (MNDF).

Coral reef monitoring

The vulnerability of coral reefs to threats such as increased SST has been highlighted in the previous sections of this chapter. Therefore, Conservation and management of these systems should be given high importance. Long term coral reef monitoring has been carried by MRC since 1998. Limitations in technical and financial capacity are barriers for regular monitoring. In addition to the national reef monitoring by MRC, under the Maldives Environment Management Project, a coral reef monitoring project was initiated.

National Coral Reef Monitoring Framework (NCRMF) initiated by Climate Change Trust Fund (CCTF) is aimed to support the national coral reef monitoring program. This framework includes a set of protocols to collect important coral reef health information and a web enabled database named coral database to act as a repository for the archiving and enabling easy access to reef health data collected by MRC, resort marine biologists, EIA consultants, coral reef researchers and others. Under the second phase, Climate Change Adaptation Project (CCAP) implemented by MEE, NCRMF is further developed and revised based on the feedback from the first phase.

A citizen science program was initiated by MRC in June 2015, in collaboration with USAID supported Project, to prepare for the monitoring of predicted bleaching in the Maldives.

Coastal protection projects

The first guideline for coastal protection in Maldives was established in 2014. Under this guideline islands that require most immediate coastal protection measures were identified based on a criteria that addresses rate of erosion, population, potential for population consolidation, economic activity, critical infrastructure, extent of direct impacts to community and mitigation measures undertaken by the community. This guideline was revised and updated on September 2016. Table 3-5 shows the status of coastal protection projects from 2013 to 2016.

Table 3-5: Status of coastal protection projects from 2013 to 2016 (Data provided by: Coastal Protection Unit, Ministry of Environment and Energy, 2016).

#	Meters	Island
COMPLETED		
1	734	Gdh.Fares Maathoda
2	815	N.Holhudhoo
3	890	N. Maduvvari
4	1150	G.Dh Thinadhoo
5	570	M.Naalaafushi
6	720	Hdh.Kulhudufushi
7	155	R. Fainu
8	462	Gdh.Thinadhoo (Baraasil)
9	440	K.Maafushi
10	220	Lh.Kurendhoo
11	280	AA.Ukulhas
12	355	B.Thulhaadhoo
13	510	Sh.Bilehfahi
14	6,000	Hulhumale shore protection (Phase 02)
15	255	k.Villimale
TOTAL	13,556	
ONGOING		
1	1000	S. Hulhudhoo
2	700	Th.Kandoodhoo
3	205	Th.Veymandoo
4	1215	Dh. Maaemboodhoo
5	800	HA.Hoarafushi
6	673	GDh. Gadhdhoo
7	245	N. Velidhoo
8	450	Ha.Dhidhoo
9	454.5	GDh. Madaveli
TOTAL	5,742.5	

3.3. Biodiversity

Biodiversity and ecosystems form an integral part of Maldivians, contributing directly and indirectly to their social and economic wellbeing. These ecosystem services provide the basis for foreign income, employment opportunities, food security, aesthetics and recreation. According to the estimates of economic valuation report on biodiversity by Emerton, Baig and Saleem (2009), biodiversity based sectors contributes to 71% of the nation's employment (78,500 jobs), 49% of public revenue (MVR 2.5 billion), 62% of foreign exchange (US$ 435 million), 98% of exports (MVR 1.7 billion) and 89% of GDP (MVR 135 billion).

Being a coral island nation, the marine environment forms the dominating ecosystems of the Maldives. The coastal and marine ecosystems, particularly the coral reefs are globally significant. They form the seventh largest reef system in the world, and supports extremely rich biodiversity. In addition, the reef system also has internationally threatened species including hawksbill and green turtles. Compared to the rich marine fauna, the terrestrial fauna is considered poor. However, the islands have diverse coastal vegetation, including rich stands of mangroves. In addition swamp, wetlands and seagrass beds also form important habitats for the biodiversity of the Maldives. The statuses of marine and coastal ecosystems are considered in details in Section 3.2 of this report.

Over the past century, biodiversity throughout the globe has been subjected to extreme pressure. Habitat loss, reclamation, invasion by alien species, climate change, over exploitation and pollution pose significant threats to island biodiversity. The ecologically fragile islands of Maldives are more vulnerable to such changes. Reducing the degradation of ecosystems and minimizing the rate at which biodiversity is being lost is a priority issue for the Maldives. The Government of Maldives is highly committed to protect and conserve the biodiversity, and has ratified a number of national legislations and international agreements, including the Convention on Biological Diversity and is working towards the achievement of the Aichi Biodiversity Targets.

3.3.1. Biodiversity Status of Maldives

Terrestrial Diversity

Despite the poor and infertile soils, Maldives support extremely rich coastal vegetation. Vegetation and other ecological features vary between islands from north to south in the country. Furthermore, variations exist between exterior and interior islands in atolls. The characteristics of the foreshore area also influence the ecology and vegetation in these islands.

Regardless of harsh climatic and environmental factors, the abundant growth of trees, some of which may attain heights above 30m indicates the uniqueness of the terrestrial vegetation of Maldives. While tall trees such as *Ficus*, *Casuarina* and Coconut are particularly common in most islands, large stands of mangroves are characteristic of some of the northern islands (FAO, 2016).

Vegetation found in the Maldives can be categorized into 5 groups, namely beach pioneer, littoral hedge, sub littoral thicket, climax forest and mangrove and swamp forests (Adams, 1988). Past

publications on terrestrial diversity revealed that the flora of Maldives comprises of 583 species of vascular plants, of which 323 are cultivated species while 260 are naturalized plants (Adams, 1984) The Catalogue of Plants, 1992, reported 486 species of plants in Maldives (MoFA, 1992). Among these, the highest species diversity exists in the medicinal plants group, while the least species diversity is found in the cereal group (Figure 3-16).

At least 14 species of mangroves belonging to 10 genera (Table 3-6) grow in about 150 islands of Maldives (Saleem & Nileysha, 2003). Mangroves in these islands are found in enclosed or semi-enclosed brackish water locally known as *kulhi* or in muddy areas without standing water (locally known as *chas bin*). If mangrove vegetation is found in these habitats, it is known as *faa* (MEE, 2015a). The large extent of pure mangrove stands is characteristic of the northern islands. Among the dominant species of mangroves are *Luminitzera recemosa, Bruguiera cylindrica and B. gymnorhiza* (FAO, 2016). *Bruguiera cylindrica* is the most common true mangrove in the Maldives, and is found throughout the islands from north to south with mangrove habitats. Figure 3-17 compares the mangrove species diversity of Maldives with other countries of South Asia.

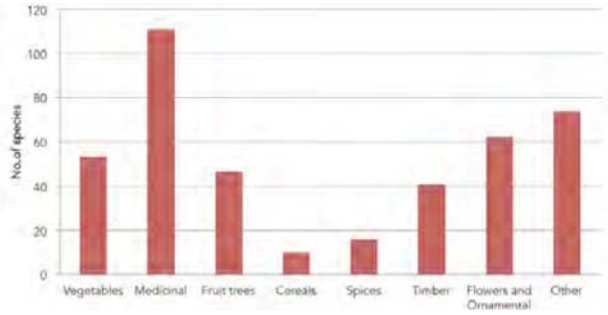


Figure 3-16: Number of species by type of plants in the Maldives. Source: (MoFA, 1992).

Table 3-6: Mangrove species found in Maldives. Information extracted from (FAO, 2016; Saleem & Nileysha, 2003).

#	Common Name	Local Name	Family	Status
1	Gray Mangrove	*Baru*	Avicenniaceae	Very rare, restricted to northern islands
2	Red Mangrove/ Stilted mangrove	*Ran'doo*	Rhizophoraceae	Occasional, found in both northern and southern islands
3	Mangrove Apple	*Kulhlhavah*	Sonneratiaceae	Occasional, found in both northern and southern islands
4	Oriental Mangrove/Large-leaved Orange Mangrove	*Bodaavaki*	Rhizophoraceae	Rare, occurs in some Southern islands
5	Small-leaved orange Mangrove	*Kandoo*	Rhizophoraceae	Common, found in northern and southern islands with mangrove ecosystems
6	Tall-stillt Mangrove	*Thakafathi*	Rhizophoraceae	Rare, a few individuals are found in the northern islands
7	Yellow Mangrove	*Karamana*	Rhizophoraceae	Rare, restricted to some islands
8	Cedar Mangrove/ Cannonball	*Maru*	Meliaceae	Rare, a few individuals are found in the northern islands
9	Black Mangrove	*Burevi*	Combretaceae	Restricted to some islands
10	Looking-glass Mangrove	*Kaharuvah*		A single tree is observed in N. Narudhoo
11	Milky Mangrove/ Blinding Mangrove	*Thela*	Euphorbiaceae	Occurs in some of the northern islands
12	Mangrove Fern	*Maakeha*	Pteridaceae	Fairly common in few northern islands associated with mangroves
13	Mangrove Vine/ Common Derris	*Thelaviyo*	Papillionoideae	Fairly common in some northern islands with mangrove habitats
14	White Burma Mangrove		Rhizophoraceae	Common in the northern and southern islands with mangrove habitats

Compared to the rich marine fauna, the terrestrial fauna is poor in Maldives. A study on fruit bats and birds, insects, arachnids and mollusks revealed that Maldives is particularly rich in species of spiders (Holmes, Huston, & Morris, 1993). In the same study four species of bumblebees, which were very much a feature of the islands, were also collected. In addition, dragon flies are seasonal migratory species recorded in Maldives, of which 98% of those recorded at Male' is *Pantala flavescens* (Anderson, 2009).

Among reptiles, the Maldivian Black Turtle (*Melanochelys trijuga thermalis*) is a species of turtles listed as 'near threatened' on the International Union for Conservation of Nature (IUCN) Red List and is found only in Kaafu Kaashidhoo, Meemu Muli and Haa Dhaalu Kanburudhoo (MEE, 2015a). It is protected under Environmental Protection and Preservation Act (Law No. 4/93). Other reptilian species recorded include two gecko (*Hemidactylus sp*) commonly seen throughout the country (Webb, 1988). In addition, two agamid lizards including the common garden lizard or blood sucker (*Calotes versicolar*), the snake skink, *Riopa albopunkata*; and two species of snakes including the common wolf snake L*ycodon aulicus*, and *Typhlops braminus* are also found (Webb, 1988). Among amphibians, only one species of frog (*Rana breviceps*), and a larger toad (*Bufo melanostictus*) are seen (MEC, 2004).

The only native terrestrial mammals found in Maldives include two sub species of fruit bats. Among these *Pteropus giganteus* ariel is common and widespread within the country, while *Pteropus hypomelanus maris* is rare and has only been recorded from Addu City (Holmes, Huston, & Morris, 1993).

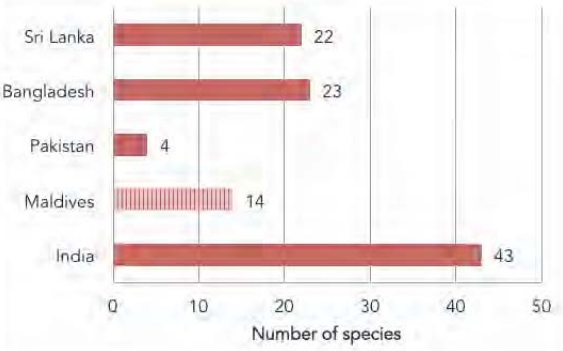


Figure 3-17: Mangrove species diversity compared with countries of South Asia. Data source (FAO, 2007).

Avifauna

Although an extensive study on ornithology of Maldives does not exist, to date some 167 species of birds have been recorded, including breeding residents, seasonal migrants and introduced species (Ash & Shafeeg, 1994). Only five sub species have been identified as endemic (Figure 3-18).

Over 70 species of shorebirds are found in Maldives (Anderson, 1996). While most of the shorebirds are common winter visitors, some are resident and immigrant species (MEE, 2015a). Among the 40-50 species of sea birds found in Maldives include species of terns, namely *Sterna sumatrana*, *S.albifrons, S. anaethetus, S. dauglli, S.bergi, S. bengalensis,* two species of noddies, *Anous stolidus* and *A. tenuirostris* and the white tern *Gygis alba monte*, which is known to breed only in Addu Atoll (MEE, 2015a). Other breeding species found are frigate birds, white-tailored tropic birds, boobies and some shearwaters (Shafeeg, 1993). However, the number of terrestrial birds are very less compared to other tropical islands and most of them are likely to have been introduced (Zuhair, 1997).

Maldivian little heron
Local name: *Dhivehi Raabondhi*
Scientific name: *Butroides striatus albidulus*

Maldivian pond heron
Local name: Huvadhoo *Raabondhi*
Scientific name: *Ardeola graii phillipsi*

Maldivian waterhen
Local name: *Dhivehi kanbili*
Scientific name: *Amouronis phoenicurus maldivus*

Asian koel
Local name: *Dhivehi kanbili*
Scientific name: *Eudynamys scolopacea scolpacea*

Central Maldivian little heron
Local name: *Medhu Raajjetherey Raabondhi*
Scientific name: *Butorides striatus didii phillipsi*

Figure 3-18: Bird sub-species endemic to Maldives. Information source (MHAHE, 2002)

Marine diversity

In contrast to the terrestrial environments of the Maldives, the marine ecosystems have been recognized among the most diverse and richest in the world (Kanvinde, 1999). However, relatively few species have been recorded compared to the high diversity inhabiting the marine ecosystems of the Maldives due to limited documentation.

The marine algal diversity comprise of species belonging to the four different phyla, *Cyanophyceae* (blue-green algae), *Rhodophyceae* (red algae), *Chlorophyceae* (green algae) and *Phaeophyceae* (brown algae), of which the largest number of species belong to *Rhodophyceae*. A total of 21 species of *Cyanophyceae*, 163 *Rhodophyceae*, 83 *Chlorophyceae* and 18 *Phaeophyceae* have been reported from Maldives (Hacket, 1997).

Five species of seagrass, belonging to four genera have been reported from Maldives (MHAHE, 2002). These include S*yringodium isoetifolium*, *Thalassia hemprichii*, *Thallasso dendronciliatum*, *Cymnodoearotundata* and *Cumnodocea sp*. Of these *Thalassiahemprichii* was most dominant, while *Thallasso dendronciliatum* was only reported from Addu City (MHAHE, 2002).

Marine invertebrate diversity comprise of 36 species of sponges (Thomas, Bakus, & Gulko, 1992), over 400 species of molluscs (Coleman, 2000), 350 species of marine crustaceans (Nomura, 1996) and over 80 species of echinoderms (Coleman, 2000). Knowledge on other marine invertebrate groups such as Chaetognatha (arrow worms), Plathelminthes (flat worms), Nematoda (round worms), Annelida (segmented worms), Bryozoa (moss animal), Sipuncula (peanut worms) and Brachiopoda (lamp shells) is mainly based on expeditions 50 to 100 years ago (MHAHE, 2002).

Over 209 species of hermatypic corals belonging to over 62 genera have been recorded in the Maldives (Zahir & Naeem, 1996). Recent review of published literature reported 258 species of hermatypic corals representing 57 genera (Pichon & Benzoni, 2007). The families of hard and soft corals found are presented in Table 3-7.

Table 3-7: Families of hard and soft corals found in the Maldives. Adapted from (MEE, 2015a).

#	Hard Corals	Soft Corals
1	Astrocoeniidae	Elioporidae
2	Pocilloporidae	Elisellidae
3	Acroporidae	Helioporidae
4	Poritidae	Clavuriidae
5	Sidestreidae	Tubiporidae
6	Agaricidae	Alyoniidae
7	Fungidae	Nephtheidae
8	Oculinidae	Nidalidae
9	Pectiniidae	Subbergorgidae
10	Mussidae	Melithaeidae
11	Merulinidae	Acanthogorgiidae
12	Faviidae	Plexauridae
13	Trachyphillidae	
14	Caryphillidae	
15	Dendrophyllidae	

Smith (1906) recorded some 258 species of univalves, 92 species of bivalves, 14 species of cephalopods and few species of chitons. Of the univalves, the most diverse group includes *Muricidae* (murex shells) and *Cypraeidae* (cowry shells). Octopus is popular among seafood and is widely used in restaurants and the tourism sector.

Although the crustacean population of Maldives is rich and highly diverse, documentation on crustacean diversity is extremely limited. Recorded number of species include some 120 copepods (Wolfenden, 1906), 15 amphipods (Walker, 1906), over 145 species of crabs (Alcock, 1906) and 48 species of shrimps (Nomura, 1996). At least 83 species of echinoderms have been recorded from the Maldives, of which *Asteroidea* (sea stars) are the most diverse group (Coleman, 2000).

The baseline study on marine turtles in Maldives done by Frazier, Salas and Didi (1984) reported five of the seven turtle species to occur in Maldives. The species, their status and global significance is shown in Table 3-8.

A more recent analysis on the status of marine turtles in the Maldives was done by Ali and Shimal (2016). The survey conducted through diver observations, reported that hawksbill turtle was the most commonly found foraging turtle (includes 67% of the turtles sighted), while the remaining 33% were green turtles.

To date, a total of 1,200 species of fishes have been recorded from the Maldives, of which gobies are the most diverse group with about 80 species belonging to 30 genera recorded (Kuiter, 2014). Box 3.2 lists the endemic fish species according to Kuiter (2014).

About 40 species of sharks have been recorded in Maldives of which 15 are likely to be seen by divers and snorkelers (Kuiter, 2014). Table 3-9 lists the most common species of reef sharks seen in Maldivian waters. The whale shark (*Rhincodon typus*), which is listed as vulnerable under International Union for Conservation of Nature (IUCN) Red List, is sighted year round by divers in the southern tip of Ari Atoll (MEE, 2015a). Since 2010, all sharks have been declared as protected in Maldives.

About 16 species of rays are known from the Maldives (Kuiter, 2014). They include the largest ray, the Ocean Manta ray (*Manta birostris*) and the reef manta ray (*Manta alfredi*). Among other species recorded are eagle rays, electric rays and guitarfishes (Kuiter, 2014).

Maldives has a rich cetacean diversity. However research on this group of marine fauna is extremly limited. Approximately 23 different species of whales and dolphins have been recorded (Anderson, 2005). Spinner dolphins are the most abundant species seen.

Table 3-8: Status of marine turtles in Maldives and their global significance

English Name	Local Name	Scientific Name	Status in Maldives	Global status according to IUCN Red List
Green turtle	*Velaa*	*Chelonia mydas*	Common	Endangered
Hawksbill turtle	*Kahan'bu*	*Eretmochelys imbricata*	Common	Critically endangered
Loggerhead turtle	*Boa bodu velaa*	*Caretta caretta*	Rare	Vulnerable
Olive-Ridley turtle	*Vaa woshi velaa*	*Lepidochelys olivacea*	Rare	Vulnerable
Leatherback turtle	*Musimbi*	*Dermochelys coriacea*	Rare	Vulnerable

NOTE: Include species in IUCN Red List of Threatened Species 2016-2

Box 3.2. Endemic fish species. Source (Kuiter, 2014)

Maldives Cardinal fish
(Apogon sp.)

Maldivian Grubfish
(Parapercis signata)

Maldives Triplefin
(Helcogramma maldivensis)

Little Combtooth Blenny
(Ecsenius minutus)

Local boys enjoying in the Mangroves

Table 3-9: Eight most common species of reef sharks seen in Maldives (MEE, 2015a).

English Name	Scientific Name	Local Name
Whitetip reef shark	*Triaenodon obesus*	*Faana miyaru*
Blacktip reef shark	*Carcharhinus melanopterus*	*Miyaru*
Grey reef shark	*Carcharhinus amblyrhynchos*	*Thila miyaru*
Scalloped hammerhead shark	*Sphyrna lewini*	*Kaaligandu miyaru*
Silvertip shark	*Carcharhinus albimarginatus*	*Kattafulhi miyaru*
Tawny nurse shark	*Nebrius ferrugineus*	*Nidhan miyaru*
Variegated shark	*Stegostoma fasciatum*	
Whale shark	*Rhincodon typus*	*Fehurihi*

3.3.2. Threats to biodiversity

Loss of habitats

Loss of coastal habitats, including lagoons, reefs, seagrass beds and mangroves in Maldives are particularly associated with dredging of harbours and reclamation (Refer to Section 3.2.2 for further details).

Exploitation of resources

Tuna Fishery

Tuna is the single most important fishery in the Maldives. Fishing for tuna is carried out using pole-and-line and handline and requires baitfish. *Katsuwonus pelamis* (skipjack tuna) and *Thunnus albacares* (yellowfin tuna) are the most important species of fish caught in the Maldives, contributing to 53.25% and 38.16% of the total fish catch respectively. Among other species caught are *Thunnus obsesus* (bigeye tuna), *Auxis thazard* (frigate tuna or frigate mackerel) and *Kawakawa* (little tuna).

Fish catch statistics from 2005 to 2014 indicates a decrease of 31% in the total catch over the duration (Figure 3-20). Over the decade, a significant decline in the skipjack tuna catch is also seen. Contrary to skipjack tuna, yellowfin tuna catch shows an increasing trend over the decade. While only 24,600 MT of yellowfin tuna was caught in 2005, the trend increased over the years, with the highest catch of 49,100 MT being recorded in 2014.

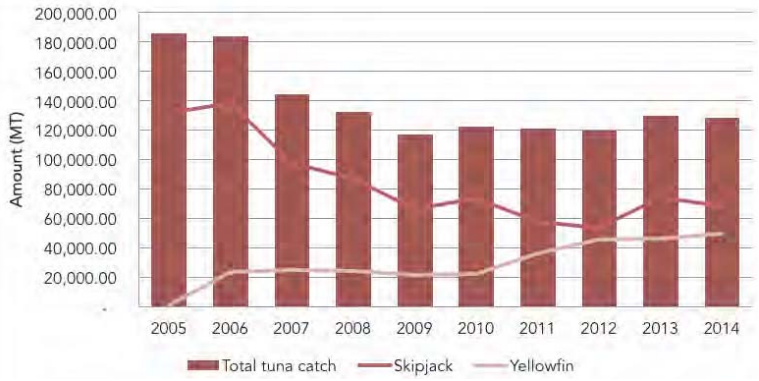


Figure 3-19: Skipjack and yellowfin tuna catch from 2005 to 2014 (Data source provided by: Ministry of Fisheries and Agriculture)

Bait fishery

Live bait fishing is an essential component of tuna pole-and-line fishery. Of the 40 different species of baitfish recorded in the Maldives only few species dominate catches, with silver sprat (*rehi*) being the most popular bait. Table 3-10 presents pelagic and reef associated species of live bait used in the pole-and-line fishery.

Table 3-10: Major species of bait fish used in pole-and-line fishery. Adapted from (Jauharee, Neal, & Miller, 2015).

English Name	Scientific Name	Local Name
Silver sprat	*Spratelloides gracilis*	*Rehi*
Blue sprat	*Spratelloides delicatulus*	*Hondeli*
Anchovy	*Encrasicholina heteroloba*	*Miyaren*
Fusiliers	*Caesionidae*	*Muguraan*
Cardinal fishes	*Apogonidae*	*Boadhi, fathaa*
Chromis	*Chromis sp.*	*Nilamehi*

Sea cucumber fishery

Sea cucumber *(Huifi Landa)* fishery or Beche de mer fishery in Maldives started in 1985, with only one species collected and processed. Figure 3-20 shows the export of sea cucumber from 2006 to 2014. The highest amount was exported in 2011, after which a decreasing trend is observed. In 2014, 80,792 kg of dried sea cucumber were exported from Maldives. Decreasing catches of high value species is a concern in the industry.

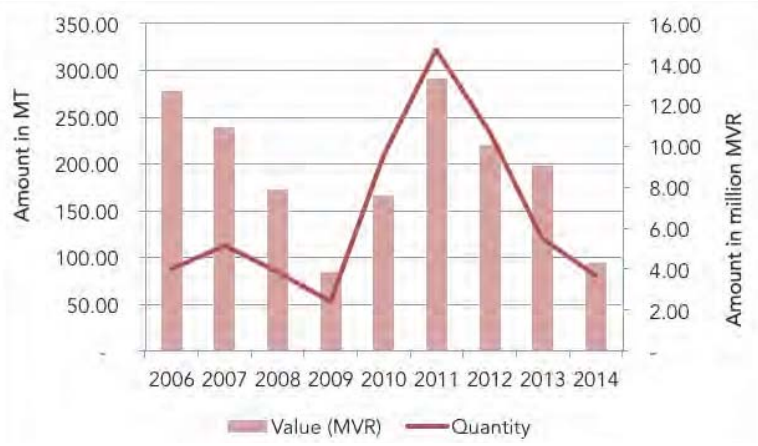


Figure 3- 20: Amount and value of sea cucumber export from 2006 to 2014 (Data provided by: Ministry of Fisheries and Agriculture; and Maldives Customs Service).

Reef Fishery

The demand for reef fish in Maldives has grown due to the expansion of tourism industry, both as a source of food and tourist attraction. According to the most recent reef fishery assessments report, the most commonly caught species include: *Elagatis bipinnulata* (rainbow runner); *Aprion virescens* (green jobfish), *Lutjanus gibbus* (humpback snapper); *Lutjanus bohar* (red snapper); and various species of trevallies (Sattar, Wood, Islam, & Najeeb, 2014). The estimated annual catch of reef fish in the Maldives is in the range between 10,400 MT to 29, 145 MT (Sattar et al., 2014). Anderson, Waheed, Rasheed and Arif (1992) estimated the Maximum Sustainable Yield for reef fish as 30,000 MT. The current estimated maximum value of reef fish catch for Maldives is just few metric tonnes short of the Maximum Sustainable Yield (Sattar et al., 2014).

Grouper fishery

Targeted grouper fishery in the Maldives was first initiated in Vaavu atoll in 1993 (Sattar & Adam, 2005). Due to the high demand from the export market, the grouper fishery expanded over the years. The most commonly caught species in Maldives include *Epinephelus fuscoguttatus (Kas faana), Epinephelus spilotoceps (asdhaanu faana), Plectropomus areolatus (olhu faana), P. laevis (olhu faana), Cephalopholis argus (mas faana), Aethaloperca rogaa (ginimas faana), Anyperodon leucogrammicus (boalhajehi faana)* and *Variola louti (kandu haa)* (Sattar & Adam, 2005). Export figures for live grouper over the decade shows that a high quantity is exported each year (Figure 3-21).

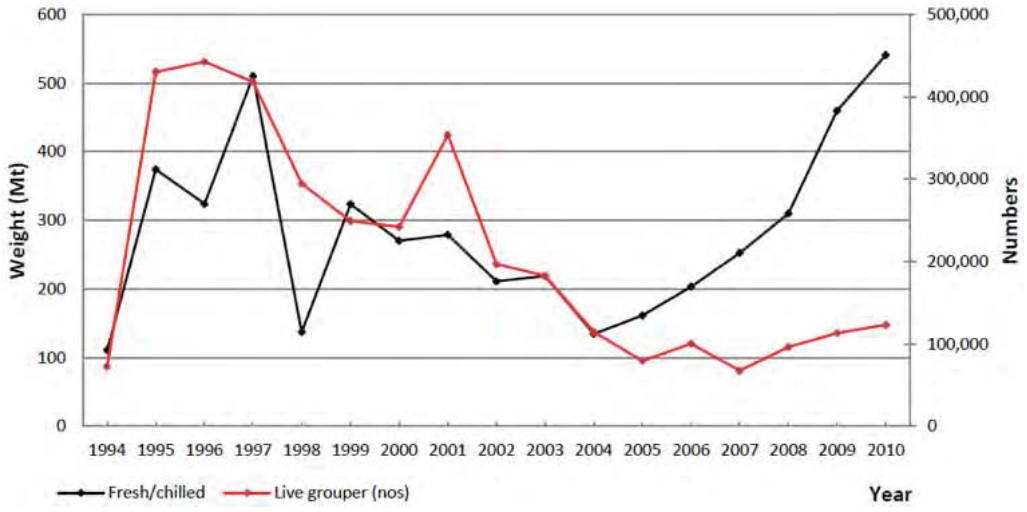


Figure 3-21: Export quantities of fresh/chilled and live groupers (1994-2010). Adapted from (Sattar, Wood, Islam, & Najeeb, 2014).

As seen in the figure, the export of live groupers shows a decreasing trend, while export of fresh chilled groupers are on the increase. Although live groupers are more valuable in the market, the declining trend indicates their decreased availability (Sattar et al., 2014).

Lobster fishery

The lobster fishery widened over the past decades, mainly due to the expansion of the tourism sector. Five species of lobsters are harvested in the Maldives. According to export statistics, in 2013 approximately 373 kg of frozen lobsters were exported from Maldives.

Exotic and invasive alien plants

Exotic species and invasive plants are considered a threat to the continued existence of the native vegetation. More than 60 % of plants in the Maldives are estimated as exotic species and some of these species have become invasive (FAO, 2016). The major invasive plants seen in Maldives, as observed according to FAO (2016) are shown in Figure 3-22. Among already established alien species are *Prosopis juliflora, Lantana camara, Sphagneticola trilobata* and *Bidens pilosa* (Figure 3-23)

Wollastonia biflora

English name: Beach sunflower
Dhivehi name: *Merihi*
Threats: Forms dense stands that compete, outgrow and eliminate crops and native vegetation

Cassytha filiformis

English name: Love vine
Dhivehi name: *Velanbuli*
Threat: The plant smothers native shrubs and trees

Leucaena leucosephala

English names: Lead tree, Leucacena
Dhivehi name: *Ipil ipil*
Threats: Can form dense thickets, eliminating native plants and cover large areas within a short duration. It can affect the biodiversity and disturb the ecological equilibrium

Figure 3-22: Major invasive plants seen in Maldives. Information and image source (FAO, 2016).

Prosopis juliflora

English name: Velvet mesquite
Dhivehi name: *Giulhilaashi*
Threats: Grows aggressively, forming dense thickets affecting growth of native plants

Lantana camara

English names: Sleeper weed, Wildsage
Dhivehi name: *Kashikothan*
Threats: Lantana spreads through seeds and vegetative means. Birds and other small animals consume and pass seeds in their droppings, spreading it far and wide. Poses serious threats to coastal vegetation

Sphagneticola trilobata

English name: Singapore daisy
Dhivehi name: *Valu Mirihi*
Threats: The palnt is listed by Global Invasive Species Database as one among the 100 worst invaders in the world. The plant can spread fast, crowd out and prevent regeneration of native species

Bidens pilosa

English name: Hairy beggarticks
Dhivehi name: *Enbureymaa*
Threats: Forms dense stands that compete, outgrow and eliminate crops and native vegetation

Figure 3-23: Some alien species which are already established in Maldives and is in the spreading phase. Information and image source (FAO, 2016).

Pests and pathogens

The increase in the number of invasive pests and pathogens pose a threat to biodiversity. Due to the absence of a proper monitoring mechanism, reporting and monitoring of plant pests and pathogens in Maldives remains weak. Whitefly was the most common pest in the islands according to the State of Environment Survey (Figure 3-24). In addition, hispid beetle, powdery mildew and giant African snail was also reported (Table 3-11).

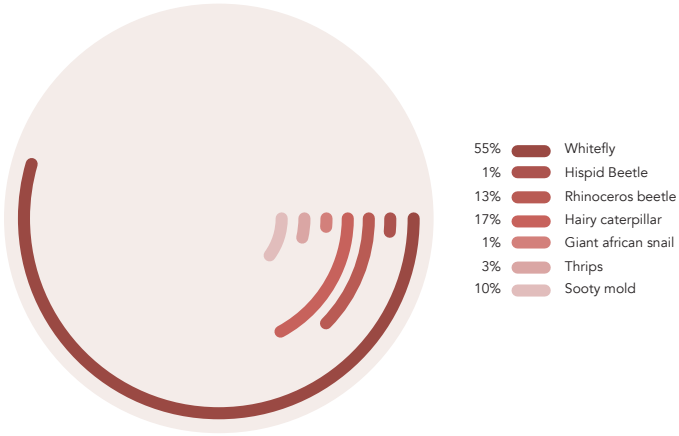


Figure 3-24: Percentage of islands which reported various types of plant pests

Table 3-11: Plant pests and pathogens reported from islands.

Common Name	Local Name	Scientific Name
Whitefly	*Hudhu koodi*	*Aleyrodidae*
Hispid beetle	*Ruku madi*	*Brontispa longissima*
Rhinoceros beetle	*Ruku madi*	*Dynastinae*
Hairy caterpillar	*Huvani*	*Euproctis fraterna*
Sooty mold	*Kalhu koodi*	
Thrips	*Thrips*	*Thysanoptera*
Giant African snail	*Finihaka*	*Achatina fulica*

Climate Change

Climate change impact on biodiversity is widespread. For an island nation depending entirely on its reef and coastal ecosystem for survival, climate change is the most important challenge and one of the greatest national concerns. The increasing Sea Surface Temperature has a direct impact on the distribution and abundance of several species and habitats. Increase in ocean temperature also plays a major role in coral bleaching and ocean acidification. Refer to Sections 3.2.2 and 4.1.3 for details.

3.3.3. Government Responses

National legal instruments and international commitments

The Environment Protection and Preservation Act (Law no. 4/93) provides the legal basis for environmental protection, preservation and conservation in the country. It has provisions for protection and conservation of biodiversity, under which protected areas are classified. Under the EPPA (Law no. 4/93), the government has the authority to protect and preserve all the coastal resources. The regulation on Migratory Birds (2014/R-169) provides for the prohibition of any activity which could harm the seasonal migratory birds, as they play a major role in the natural ecosystems of Maldives. In addition to this, all laws, regulations and coastal and marine environment management plans mentioned in section 3.2.4 of this report also support biodiversity conservation

Some important biodiversity related international agreements to which Maldives is signatory are listed below. Details of these conventions and agreements are considered in section 5.1.

- Convention on Biological Diversity (CBD)
- Cartagena Protocol on Biosafety
- Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES)
- International Plant Protection Convention
- Indian Ocean Tuna Commission (IOTC)

National Biodiversity Strategy and Action Plan (NBSAP)

Under its commitments to the CBD, Maldives has prepared its first National Biodiversity Strategy and Action Plan (NBSAP) in 2002, which served as an instrumental policy and planning document towards protection and conservation of biodiversity. The second NBSAP was developed in 2016, which is a 10 year plan designed to address 6 broad areas of concern (MEE, 2015d). Figure 3-25 shows the strategies under the NBSAP 2016-2025

White Tern - First protected bird under EPPA 4/93

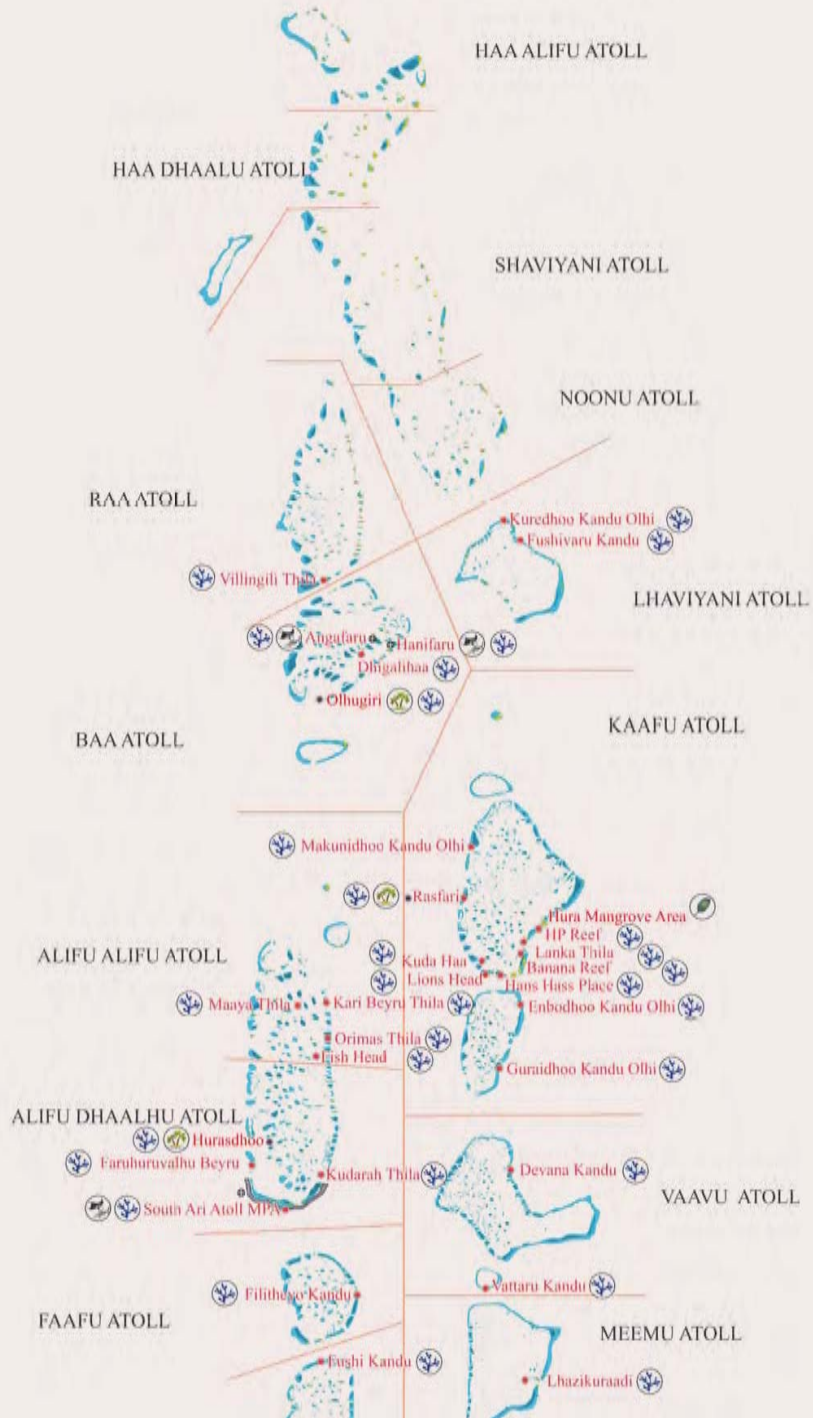
Figure 3-25: Strategies under NBSAP 2016-2025

Protected areas

The first protected areas in the Maldives were designated in 1995, and included 15 Marine Protected Areas (MPAs). MPAs were initially established for tourism purposes (MEE, 2015a). Other reasons for MPA establishment included banning of export of baitfish as aquarium fish, banning fishing from 'house' reefs of tourist resorts and protection of threatened marine species. While some of the terrestrial protected sites including uninhabited islands and wetlands are known for their diverse bird life, other areas serve as rookeries for sea turtles. To date, a total of 42 protected areas (Figure 3-26), totalling more than 24,494 hectares (MEE, 2015a) and one biosphere reserve, consisting of marine, mangrove and terrestrial ecosystems are designated under EPPA 4/93.

Maldives as a UNESCO Biosphere Reserve

In June 2012, the Government of Maldives pledged to nominate the entire Maldives as a biosphere reserve by the end of 2017. The announcement was inspired by the success achieved in designating Baa atoll as the first United Nations Educational Scientific Cultural Organization (UNESCO) Biosphere Reserve in the Maldives (Box 3.3). The Baa Atoll Conservation Program (BACP) is the biodiversity conservation program for the Biosphere Reserve, which encompasses all islands, waters and resources (biological and non-biological) of Baa Atoll with an outer perimeter extending one nautical mile from the outer zone of the atoll (MEE, 2015a).


HAA ALIFU ATOLL
HAA DHAALU ATOLL
SHAVIYANI ATOLL
NOONU ATOLL
RAA ATOLL
Kuredhoo Kandu Olhi
Fushivaru Kandu
Villingili Thila
LHAVIYANI ATOLL
Angafaru
Hanifaru
Dhigalihaa
Olhugiri
BAA ATOLL
KAAFU ATOLL
Makunidhoo Kandu Olhi
Rasfari
Hura Mangrove Area
HP Reef
Lanka Thila
Kuda Haa
Banana Reef
Lions Head
Hans Hass Place
ALIFU ALIFU ATOLL
Maayaa Thila
Kari Beyru Thila
Enbodhoo Kandu Olhi
Orimas Thila
Fish Head
Guraidhoo Kandu Olhi
ALIFU DHAALHU ATOLL
Hurasdhoo
Faruhuruvalhu Beyru
Kudarah Thila
Devana Kandu
VAAVU ATOLL
South Ari Atoll MPA
Vattaru Kandu
Filitheyo Kandu
FAAFU ATOLL
MEEMU ATOLL
Fushi Kandu
Lhazikuraadi

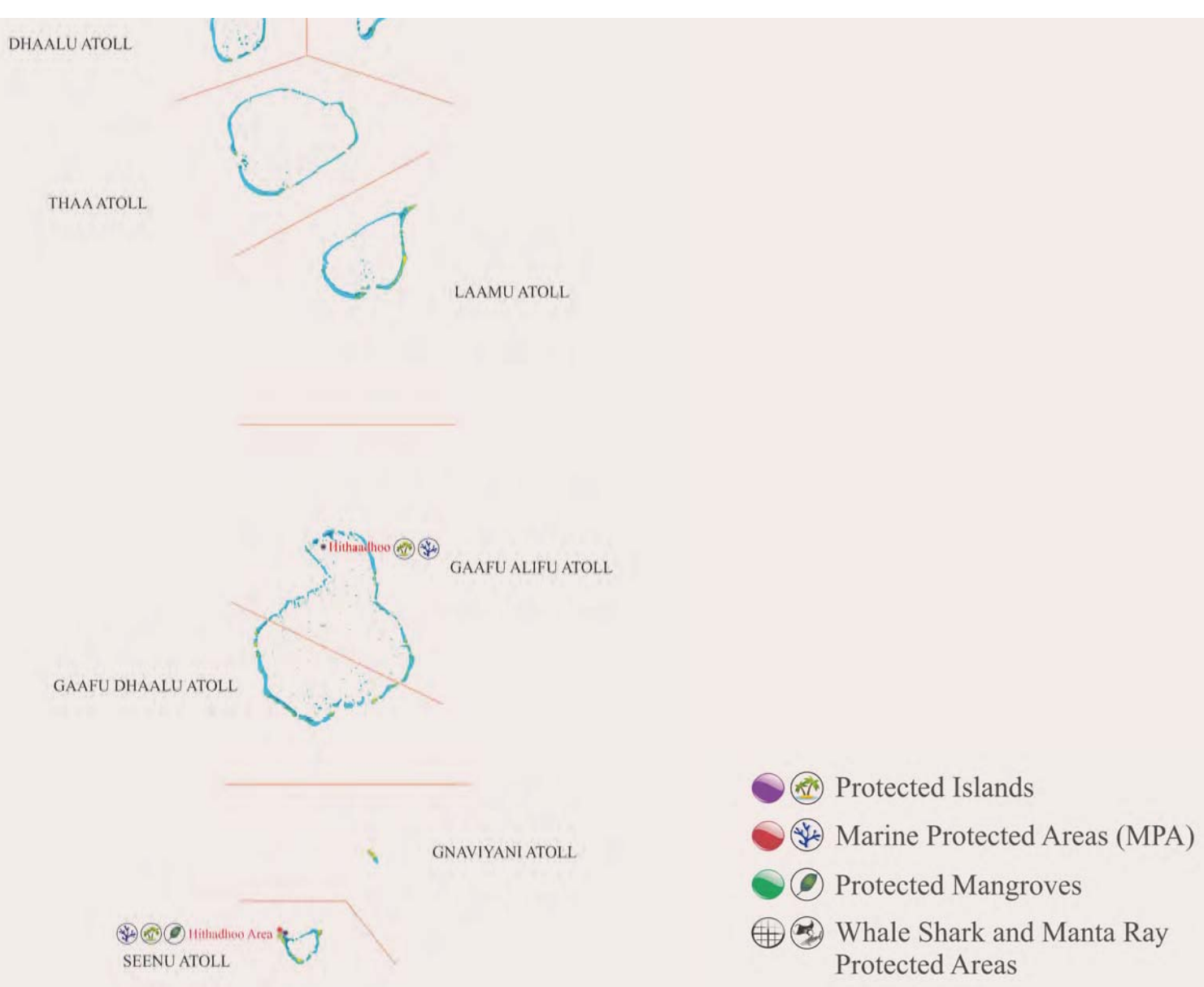


Figure 3-26: Protected areas of Maldives (Provided by: Ahmed Shan)

Box 3.3 Baa Atoll Biosphere Reserve: A success story

Recognizing the significance of biodiversity and the need to conserve the ecosystems and the species, conservation of Baa Atoll was first initiated through the Atoll Ecosystem Conservation Project (AEC Project) in 2004, with the support of United Development Program (UNDP) and the Global Environment Facility (GEF). The purpose of the project was to design and demonstrate an effective management system for atoll ecosystem conservation and sustainable development at Baa atoll, which could then be replicated throughout the Maldives. The project's vision has been "to make Baa Atoll a world class model of atoll ecosystem conservation where sustainable use supports a prosperous economy and good quality of life for all, forever". Baa atoll was declared as a UNESCO Biosphere Reserve on 28 June 2012.

Baa Atoll has a rich biodiversity that includes large mangroves and a unique diversity of fauna. The Baa Atoll Biosphere Reserve consists of nine core protected areas: Mendhoo Region; Dhigali Haa; Hanifaru; Angafaru; Maa huruvalhi; Bathala; Olhugiri; Goidhoo Koaru; and Dhorukandu (Figure 3-27 Hanifaru Bay is considered one of the few places in the world where whale sharks congregate in to mate. The Bay is also home to some of the largest gatherings of Manta rays worldwide. The coral reefs support a high diversity of reef animals, including approximately 250 species of corals (stony and soft corals) and 1,200 reef and reef-associated fish species, a population of marine turtles, manta rays (*Manta birostris*), whale sharks (*Rhincodon typus*) and seabirds (UNESCO, 2016). These also include threatened and endangered species such as the green turtle (*Chelonia mydas*), hawksbill turtle (*Eretmochelys imbricata*), Napoleon wrasses (*Cheilinus undulatus*), and tawny nurse shark (*Nebrius ferrugineus*).

The three key programmes through which the Biosphere Reserve Strategy is adopted include:

Outreach programme: Involves reaching out to all and conveying messages across to facilitate the success of Baa atoll Biosphere Reserve and strengthen participatory approaches.

Conservation programme: The three main tasks of the programme include; supporting implementation of the Biosphere Reserve Zonation System, including monitoring developments, input to EIAs where possible, and the enforcement of regulations in close consultation with Environmental Protection Agency and the Maldives Police Service; promoting implementation of the management plans for core areas, and where necessary enforcement of regulations in close consultation with Environment Protection Agency, Maldives Police Service, Atoll Council and Island Councils; and Implementing, and regularly updating the programme of strategic actions to reduce key threats to biodiversity.

Livelihood and sustainable development programme: The three main tasks of the programme include: support to livelihood development initiatives that are consistent with the objectives of the Biosphere Reserve; working with key sectors (fisheries, tourism, agriculture) to build sustainability as a core principle of development; and promoting measures to address climate change including mitigation and adaptation activities.

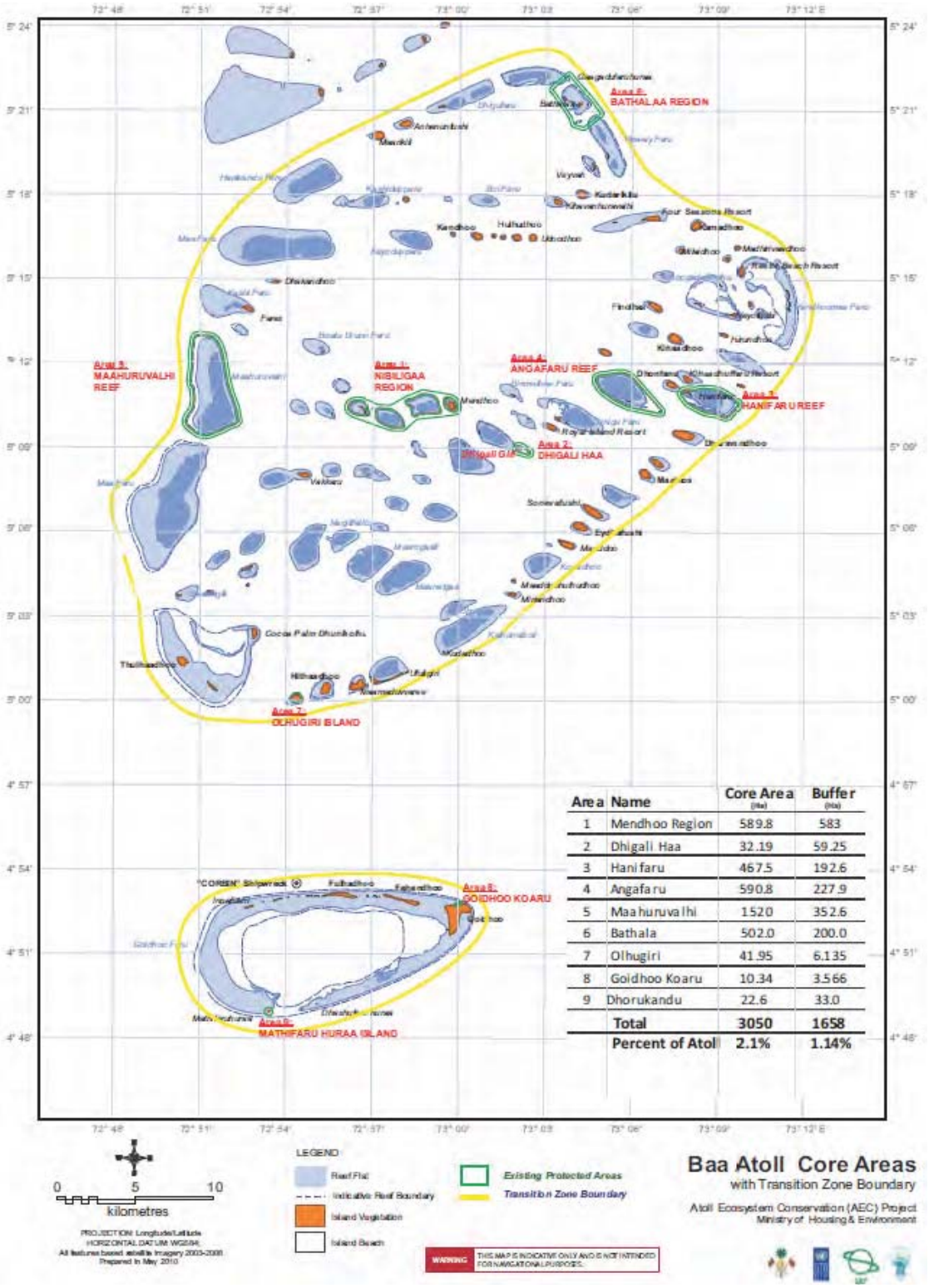


Figure 3-27: Baa atoll core areas, including transition zone boundaries

Protected Species

To date, a total of 103 bird species have been declared protected under the Environmental Protection and Preservation Act (EPPA 4/93). In addition, Table 3-12 presents other species, including 2 marine species and one land species protected under EPPA 4/93. The regulation on Migratory Birds (2014/R-169) provides for the prohibition of any activity which could harm the seasonal migratory birds. Under the Fisheries Act (Law No. 5/87), 9 marine species have been declared as protected (Table 3-13). Table 3-14 lists export prohibited species under the Fisheries Act.

Table 3-12: Marine and land species protected under the Maldives EPPA 4/93

Common Name	Local Name	Date	Directive
All turtles	*Velaa kahanbu*	4 April 2016	(IUL)438-ECAS/438/2016/72
Rays and Skates	*Madi*	9 June 2014	IUL) 438-ECAS/438/2014/81
Black turtle	*Kanzu kahanbu*	22 May 2003	10-ERC/2003/21

Table 3-13: Species protected under the Maldives Fisheries Act, Law No. 5/87

Common Name	Local Name	Date	Directive
Dolphins	*Koamas*	15 May 1993	FA-A1/29/93/14
Napoleon Wrasses	*Maahulhunbu landaa*	24 June 1995	FA-A1/29/95/39
Giant Clams	*Gaahaka*	15 May 1993	FA-A1/29/93/14
Black Coral	*Endheri*	24 June 1995	FA-A1/29/95/39
Whale Shark	*Fehurihi*	24 June 1995	FA-A1/29/95/39
Conch (Triton) Shell	*Sangu*	15 May 1993	FA-A1/29/93/14
Whales	*Bodumas*	15 May 1993	FA-A1/29/93/14
Lobsters (berried female lobsters and those smaller than 25 cm in total length from head to tail)	*Ihi*	15 May 1993	FA-A1/29/93/14
Sharks	*Miyaru*	15March 2010	

Table 3-14: List of export prohibited species and products from the Maldives. (MEE, 2015a)

Species/Products
Bait fish (for pole and line fishing)
Big eye scad (less than six inches)
Black coral
Napoleon wrasse
Turtles
Whale shark
Conch (Triton) Shell
All types of coral
Whales
Giant clams
Dolphins
Eels
Lobsters and lobster meat
Skates and rays
Pear oyster
Parrot fish
Puffer fish

National initiatives for conservation and management of species

Shark conservation

The shark fishery of Maldives widened in the 1980s as a result of export opportunities (MEC, 2004). Due to over-exploitation of reef and near shore pelagic stocks, the first ban on shark fishing was introduced in 1995 (Table 3-15). Further concerns for the survival of shark species led to a total ban on all shark fishing within the Maldives EEZ in 2010, declaring sharks as protected species. The stakeholder consultations for the Fifth National Report on Convention to Biological Diversity identified an increase in the number of sharks seen, particularly during fishing trips (MEE, 2015a).

Table 3-15: Timeline of developments in shark fisheries and management. Source (Sinan, Adam, & Anderson, 2011).

Year	Development in the shark fishery and management
10 Nov 1981	Shark fishing prohibited during daytime in tuna fishing areas (Directive 48/81/34/MF)
19 May 1992	Shark fishing with live bait prohibited in vicinity of tuna schools while other vessels are present and fishing for tunas (Directive 16/92/29FA.A1). This replaced the *Iu'laan* of 10 Nov 1981.
5 June 1995	Declaration of first Marine Protected Areas (15 dive sites, nine of which were well-known for their reef sharks) (Directive E/95/32)
24 June 1995	Ban on fishing for whale sharks (DirectiveFA-A1/29/95/39)
8 Oct 1996	Ban on taking sharks or any type of fishing the might be detrimental to pole and line tuna fishing within 3 miles radius of any fish aggregating device (Directive FA-A1/29/96/39)
28 Nov 1996	Long-lining banned in vicinity of seamount between Hadhdhunmathi and Huvadhoo Atolls (Directive FA-A1/29/96/43)
10 Dec 1997	Long-lining banned in vicinity of seamount south of Addu Atoll (Directive FA-A1/29/96/54)
8 Sept 1998	10-year moratorium on shark fishing within 12 nautical miles of seven (tourism zone) atolls (Directive FA-A1/29/98/39)
1 March 2009	Ban on shark fishing within 12 nautical miles of any atoll (Directive FA-D/29/2009/20)
11 March 2010	Ban on shark fishing throughout Maldives from 15th March 2010 (Directive 30-D2/29/2010/32)

Turtle conservation

The first legislative action towards conservation of marine turtles was taken on 6 February 1978, with the passing of the parliament bill (No. 24/78) which prohibits the capture of Hawksbill turtles less than two feet in carapace length and other turtles less than two and a half feet in carapace length. Since then, several efforts have been made towards conservation of sea turtles and protection of their nesting and foraging habitats. The following table presents a timeline of developments on turtle conservation and management in the Maldives (Table 3-16).

All turtles are protected in Maldives under EPPA 4/93

Table 3-16: Timeline of developments on turtle conservation and management in the Maldives. Information extracted from: (Ali & Shimal, 2016); Ministry of Environment and Energy, 2016.

Year	Legislation
1978	Parliament passed Bill No. 24/78 prohibiting the catching of hawksbill turtles less than 61 cm in carapace length and all other turtles less than 76 cm in carapace length
1979	Parliament passed Bill No. 31/79 prohibiting the export of raw hawksbill turtle shells, however export of items from processed hawksbill turtle shells were permitted
1980	Ministry of Fisheries banned the sale and display of turtles below the size limited specified in Bill 24/78
1995	Under a Presidential Decree, killing, fishing and harvesting of all species of turtles were banned for 10 years. This replaced the Bill No. 31/79 of 1979
1995	Export of all species of turtles were banned by the Ministry of Trade
1995	Ban on importations of turtles and turtle products to the country
1996	Ban on sale of turtle and turtle products in the country
2006	Ministry of Fisheries and Agriculture and Marine Resources renewed the moratorium on turtle killing and harvesting for another ten years
2006, 2007	Egg harvesting was banned from 14 islands identified as nesting site; HA. Mulidhoo, HDh. Muiree, HDh. Vaikaradhoo, R. Furaveri, R. Vandhoo, B. Maamaduvvari, B.Maaddoo, B.Olhugiri, B. Miriyandhoo, Th. Kanimeedhoo, Th.Funaddoo, Th.Kan'doodhoo, L.Gaadhoo, GDh. Gan
2016	Protection of all turtles under EPPA 4/93 (IUL)438-ECAS/438/2016/72)

3.4. Water resources

Except for a few freshwater lakes or wetlands, Maldives do not have surface water resources such as rivers and streams. The conventional freshwater resources available in Maldives mainly are in the form of rain fed shallow groundwater lens, small fresh or brackish water ponds in few islands and rainwater. Those of non-conventional freshwater resources available include desalinated water and bottled drinking water. Groundwater aquifers on islands lie at an average depth of 1-1.5m below the ground surface. However, in many inhabited islands of Maldives, freshwater lens have been depleted as a result of salt water ingress due to extraction of groundwater from shallow aquifers. The quality of groundwater has been further deteriorated due to disposal of untreated wastewater into the ground and unplanned disposal of solid waste on land. In addition, development projects including paved roads decreases the ground surface availability for groundwater recharge. Due to the current status of groundwater, rainwater and desalinated water are the most important sources of drinking water used in the islands and Male' respectively. However, the lack of land for water storage is a major hindrance to achieve water security. While the current storage in Male' is only sufficient for 24 hours, the unavailability of land does not allow for storage expansion.

3.4.1. Status of water resources

Groundwater

The rain fed groundwater aquifers naturally formed in the shape of lenses are the only natural freshwater resource available in Maldives. Groundwater extracted from open wells had been an important source of drinking water in the past. However, due to salt water intrusion and groundwater pollution resulting from poor sanitation systems, the groundwater quality has deteriorated over the years. In addition, changes in the method of water extraction also led to changes in groundwater quality. Furthermore, the growth in the construction industry has led to extensive dewatering with huge volumes of groundwater being pumped into sea. Although groundwater is not commonly used for potable needs at present, it is still the major source used for non-potable needs such as bathing, washing and toilet flushing.

Groundwater quality assessments were carried out in four islands for the Second National Communication (SNC) of Maldives to the United Nations Framework Convention on Climate Change. Samples taken from all four islands indicated significant contamination of groundwater (Table 3-17).

Table 3-17: Indicators of groundwater quality in study islands. Adapted from (MEE, 2016a).

Water quality parameters (averages)	B. Hithaadhoo	Hithadhoo, Addu city	Gn. Fuvahmulah	Ga. Dhekanbaa
pH	8.0	7.5	7.6	8.8
Electrical Conductivity (µS/cm)	1108.3	824.7	687.8	1725.6
Salinity (‰)	0.9	0.5	0.3	12.6
Percentage of samples positive with faecal coliforms (%)	100.0	60.0	100.0	100.0
Faecal Coliform counts (CFU/100ml)	97.0	59	54.0	45.5

Rainwater

The annual average rainfall of the Maldives is 2,218mm over the southern atolls, 1,966mm over the central atolls and 1,799mm over the northern atolls over the period 1978 to 2012 (MEE, 2016a). Regional climate projections show warming likely to be well above the global mean over the South Asian region, which increases the likelihood of intense monsoon precipitation and decreased number of wet days, which increases the likelihood of flash-floods (Christensen, et al., 2007).

Rainwater harvesting in Maldives began in early 20th century, but it was not practiced widely until the cholera and shigella outbreak across the country in late 20th century. Ferro cement and steel tanks of capacity 2500 – 5000 litres were mainly used to store roof top harvested rainwater both at household and community level until the introduction of high density polyethylene (HDPE) tanks in 1994. Between 1995 and 2004 these HDPE rainwater storage tanks of capacity 2500 – 5000 litres were sold by government to households on instalment basis through a revolving fund program (MEEW, 2007).

Rainwater is also affected by atmospheric pollution that occurs in the Indian sub-continent and is considered a threat to Maldives where more than 50% people still depend on roof top harvested rainwater. In H.Dh Kulhudhuffushi (capital of H.Dh Atoll) roof top harvested rainwater was found coloured even after filtration (WHO Maldives News, 31/1/2006). Dark rainfall also has been reported in B.Eydhafushi and V.Keyudhoo in December 2011 (EPA, 2012). Occurrence of dark rainfall over Maldives also has been reported from Dh.Meedhoo (Haveeru Daily, 2013)

Based on the census 2014, the main drinking water supplies used within the country includes rainwater, bottled water and desalinated water (Figure 3-28). At the republic level, the majority of the population use rain water for drinking (54%). The total rainwater storage capacity and the per capita storage in atolls show that more storage is available in the northern and southern atolls (Figure 3-29). However, the type of water used by majority of the population in Male' and atolls are very different (NBS, 2016). In atolls 87% of population use rainwater for drinking, while 7% of the population use desalinated water and 5% use bottled water (NBS, 2016). In administrative islands the share of rainwater is 93%, while that of desalinated and bottled water are 1.9% and 4.3% respectively. Contrary to this, the majority of Male' population use bottled water (68%) and 29% uses desalinated tap water for drinking. The share of population using rainwater in Male' is extremely less at 2% (NBS, 2016). The high dependence of atoll population on rainwater indicates the need to increase the rainwater harvesting potential within the country. The rainwater harvesting capacity and per capita water storage is lower for the central atolls (Figure 3-29). The continuous annual requests for emergency water shipments shows that the amount of rainwater harvested is not sufficient to last the dry season.

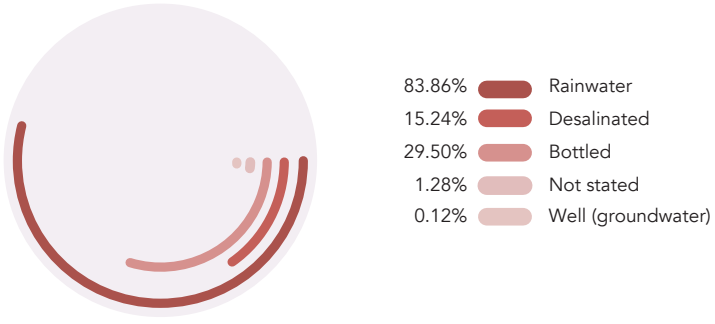


Figure 3-28: Percentage of atoll population using various types of water for drinking. Data source (NBS, 2016).

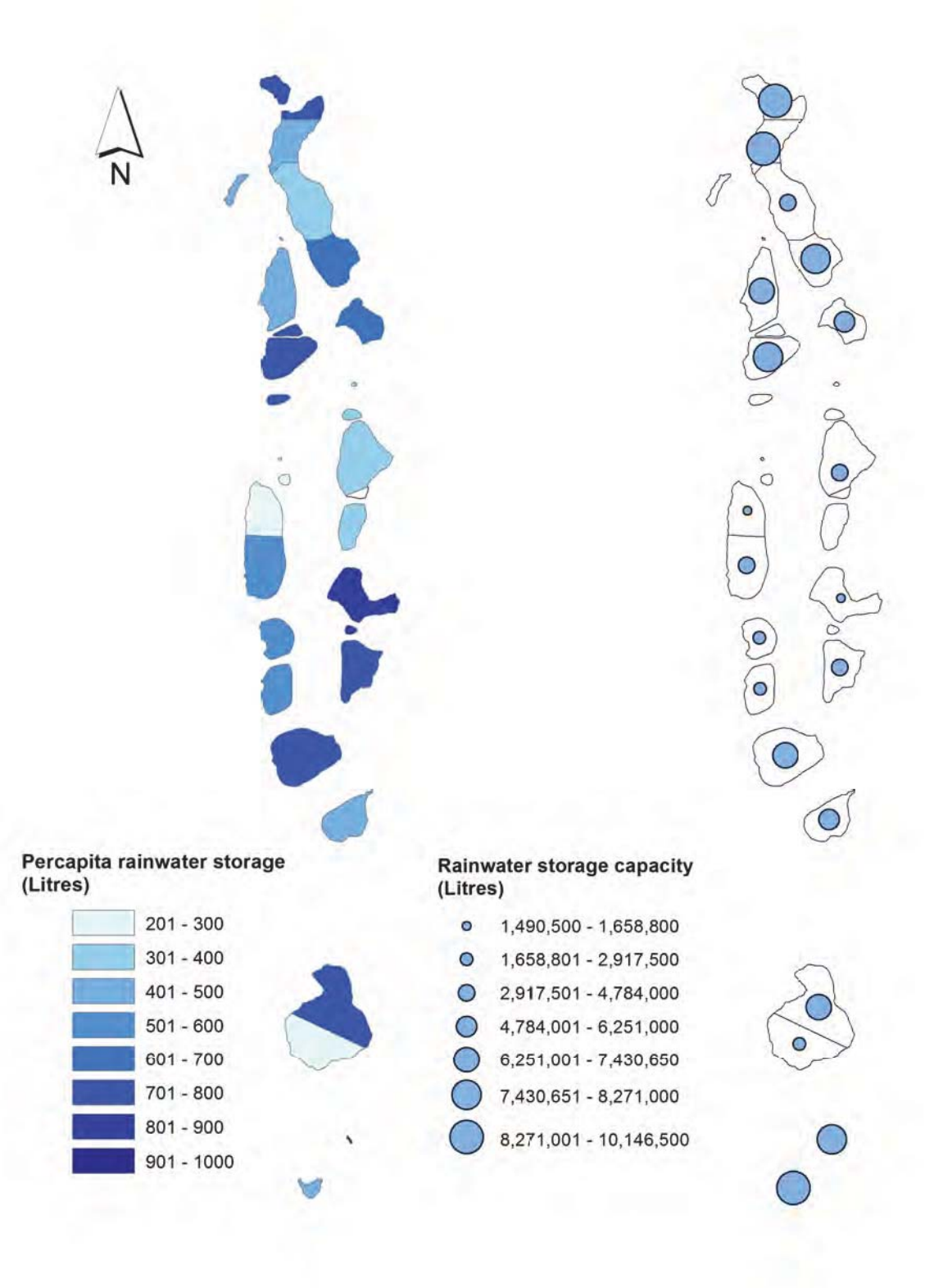


Figure 3-29: Rainwater harvesting capacity in atolls. Adapted from (MEE, 2016a)

Desalinated water supply

Desalination in Maldives for the first time was introduced in the tourism sector in early 1970's and for public use in Male' in 1985 (MCST, 2002). Desalination in Male' began with the installation of a 200m^3/day capacity desalination plant which later expanded into Villingili and Hulhumale (Falkland, 2001). Desalination in outer islands began in 1999 in Raa. Kandholhudhoo with a plant of capacity 50m^3/day (Falkland, 2001). At present 17 islands, excluding Male' have access to a desalination water network. Based on 2014 census, approximately 43% of the total population (including the population in Male') has access to a desalination water network. In addition, 51 islands have reverse osmosis (RO) plants. However, at present RO plants are operational only in 16 islands.

3.4.2. Pressures

Population growth and water demand

Population increase has a profound impact on the already vulnerable status of water security within the country (The World Bank, 2013). Population increase and lifestyle changes increase the demand for water supply. The net water production data from the MWSC shows a steady increase in production from 2010 to 2015, with an increase of 67.63% over the period (Figure 3-30).

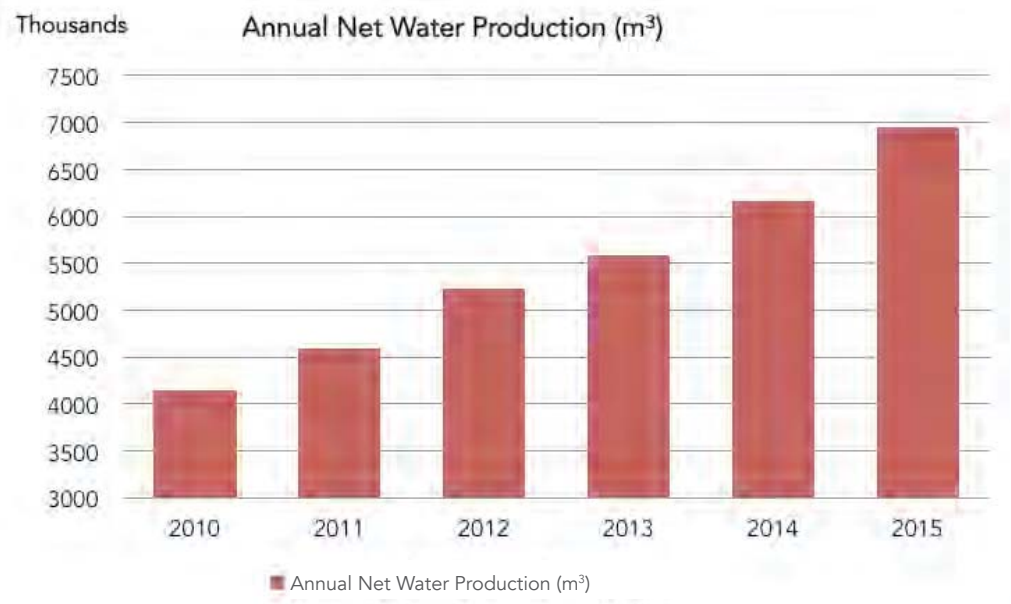


Figure 3-30: The net annual water production by MWSC from 2010 to 2015 (Data provided by: Male' Water and Sewerage Company).

Note: Data includes water production amounts by MWSC desalination plants in Male', Hulhumale', Villimale', Thilafushi, Gulhifalhu, Maafushi and Dhuvaafaru

Pollution from sanitation

Water-based sewerage systems built in several islands across Maldives consist of a toilet flushed by water either from a fixed cistern or by pour-flush manually using a bucket or a traditional *Dhaani*. The toilet is connected to a sewer leading to an on-site septic tank and effluent soak-pit, or to an island wide piped sewerage system. The first water supply and sewerage project in Maldives was launched in 1985 in Male'. In outer islands the first sewerage project was launched in early 1992 in V. Rakeedhoo. At present nearly 57% of total population has access to sewerage networks. Within the outer atolls, the major type of sanitation system in place includes toilets connected to septic tanks. Among others, various types of sewerage technologies in use, as shown in Table 3-18 include small bore sewerage, conventional deep sewer gravity sewerage and vacuum sewerage systems.

Table 3-18: Types of sewerage technologies in use in Maldives. Source (Musthafa, 2016).

Type Sewerage Systems
Simplified sewerage with shallow sewers without septic tanks and effluent discharged into a beach well or near shore lagoon
Septic tanks with effluent draining to on-plot soak-pits generally made from coral rocks.
Small-bore sewerage systems with septic tanks where effluent under gravity draining into lagoon through near-shore outfalls or into beach through beach soakage wells
Sewage consisting of solids and liquids draining through 'simplified' sewerage systems pumped into outfalls at the edge of the island. Some of these systems drain only 'black-water' (i.e. water from toilets) whiles others drain both black-waters and 'grey-water' (i.e. water from other discharge points including bathrooms and kitchens).
Conventional deep sewer gravity sewerage systems draining black-water and grey-water to lift stations + pump stations which pump the 'raw sewage' to the sea (untreated) through a series of outfalls outside the house reef
Conventional deep sewer gravity sewerage systems draining black-water and grey-water to pump stations which pump the 'raw sewage' to sewage treatment plant and effluent is used for irrigation, treated sludge is used as fertilizers
Sewerage draining or pumped to package treatment plants and from there to effluent reuse schemes (e.g. irrigation of plants) and discharge to soak-pits.
Sewerage connected to vacuum valve pit/holding tank (Vacuum Sewerage) + effluent (solid+ liquid) pumped into sea via ocean outfall

Climate change

Section 4.1 of this report highlights that climate change impacts including sea level rise, changes in rainfall patterns and extreme events are likely to increase in the future. Climate change will have severe impacts on water resources and freshwater availability in the Maldives due to inundation of land, saltwater intrusion, change in rainfall patterns, and increase in frequency of extreme events such as the El Nino/ Southern Oscillation (MEEW, 2007). The impact on groundwater from sea level rise is considered as one of the greatest threats facing low, small island nations like Maldives (Falkland, 2001). The possible salt water intrusion from sea level rise may affect the thickness of fresh groundwater aquifers by reducing the volume and quality of groundwater. In addition, the elevation of groundwater salinity could be increased due to storm surges. Groundwater lens in islands also get further deteriorated due to sewage spills from septic tanks during flooding from heavy rainfall. Sudden heavy downpours also increase surface runoff, which reduces the groundwater recharge.

Evidently, climate change and water security are inextricably linked. Over the recent years, Maldives has experienced high frequency, low impact hydro-meteorological disasters leading to storm surges, and often coastal flooding, along with drought conditions. Furthermore, climate induced weather changes in the Indian Ocean has altered the rainfall conditions within the country, causing record rainfall in some parts and prolonged drought in others. Increasing sea water temperatures, ocean acidification and saltwater intrusion to coastal aquifers which are directly relevant to water security are further exacerbated by climate change.

3.4.3. Impacts

Water shortage

The impacts of water shortage are more profound in the outer islands than in the capital island. Although the major source for drinking water in the islands is rainwater, prolonged dry season and inadequate rainwater harvesting capacity has forced the islands to request emergency shipment of water from Male'. Request for emergency water supplies from the National Disaster Management Centre (NDMC) each year indicates that the harvested rainwater is not sufficient in most islands, especially during the dry season (Figure 3-31).

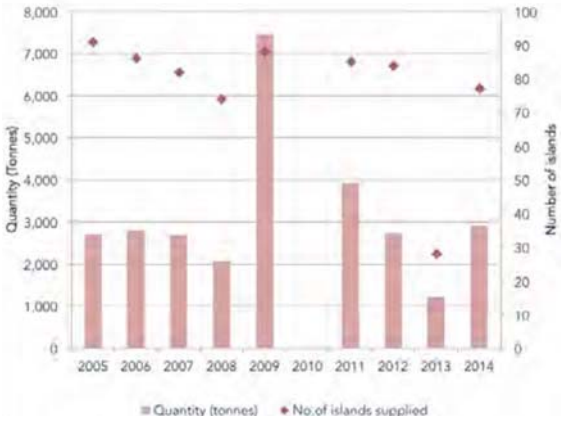


Figure 3-31: Number of islands and quantity of water supplied in emergency from2005 to 2014 (Data provided by: National Disaster Management Centre, 2015)

Box 3.4. Male' Water Crisis 2014

On 4 December 2014, a fire broke inside the Maldives Water and Sewerage Company (MWSC)'s Generator Unit, causing a major breakdown in the functioning of the main desalination plant and disrupting Male' City's water supply. Following the accident, the water supply by MWSC was suspended temporarily. Due to lack of spare parts and technical expertise, the authorities announced that it would take at least a week before the plant starts functioning. With groundwater degraded to unusable quality and air quality too deteriorated for rain water collection, desalinated water and bottled water is the only source of water the Male' population depends on.

A state of emergency was declared by the government and a task force, headed by the Minister of Defence was set up to coordinate and distribute safe drinking water in the island. National Emergency Response Team (NERT) and Emergency Response Team (ERT) volunteers of Maldives Red Crescent Male' branch have been deployed to assist Maldives National Defence Force (MNDF) and Maldives Police.

Following the crisis, governments of India, Sri Lanka, Bangladesh and China responded with air-lifts of drinking water. In addition to this, navy ships with desalination equipments and technical expertise was mobilized. With the outstanding emergency response of the government and immense help provided by foreign governments, international organizations and NGO's, normal water supply resumed.

This incident proves the extent of vulnerability of the Maldivian population in terms of water security.

Water borne diseases

The major diseases classified as water-borne include acute gastro-enteritis (AGE) and typhoid. Chikungunya and dengue are also identified as water related diseases. Although studies on water-borne diseases in Maldives is limited, the study conducted by Saleem (2012) broadly examined a positive correlation between water related diseases and water security issues. Figure 3-32 shows the prevalence of AGE cases from 2005 to 2015 in the Maldives. In Maldives, the number of AGE cases reported annually remained high over the years. In 2015 the incidence of AGE cases showed a 40% increase, compared to the previous year. With frequent flood events, high level of incidence is further expected.

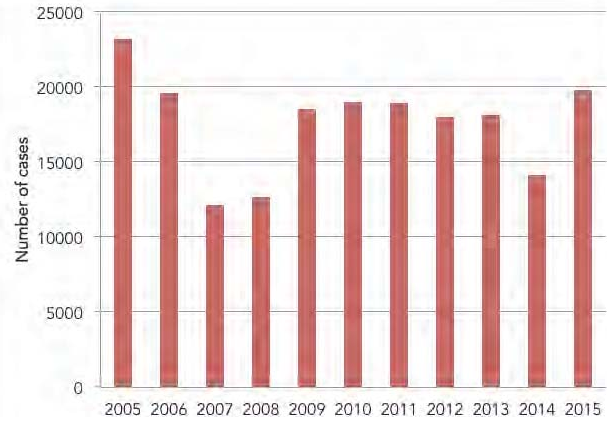


Figure 3-32: Incidence of acute gastro-enteritis cases from 2005 to 2015 in Maldives (Data provided by: Health Protection Agency).

3.4.4. Government responses

The Constitution of the Maldives which came into force in 2008 guarantees every Maldivian the right to clean water supply and access to sanitation. The Water and Sanitation Department (WSD) within the Ministry of Environment and Energy (MEE) is responsible for formulation of policies, regulations and action plans relating to water and sanitation, while Environment Protection Agency deals with water quality monitoring, tariff approval and design of water supply and sewerage systems. MEE is also responsible for construction of water supply and sewerage systems. The Male' Water and Sewerage Company (MWSC) was the first established water and sewerage utility company in Maldives. Together with MWSC, the recently established FENAKA Corporation is responsible for providing utility services to the atolls. In 2015, State Electric Company (STELCO) has also been listed to provide water and sewerage utility services.

Currently, Maldives is moving towards an integrated water resource management (IWRM) approach to address water insecurity in a changing climate. IWRM is an emerging concept which integrates available water resources in the islands such as groundwater, rainwater and supplemented with desalinated water to produce freshwater at affordable cost to the communities.

At present, 18 islands including Male' have access to desalinated water networks and 41 islands have improved sanitation systems. The population with access to clean water supply and improved sewerage system is shown in Figure 3-33.

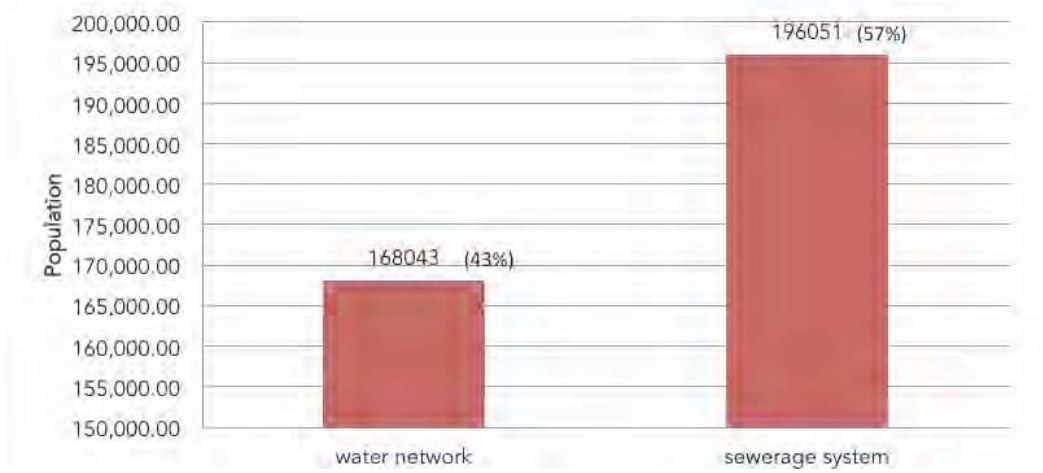


Figure 3-33: Population by number and percentage with access to safe water supply and improved sewerage facility-2016 (Based on census data from NBS, 2016a and information provided by Water and sanitation department of Ministry of Environment and Energy).

CHAPTER 04
KEY ENVIRONMENTAL ISSUES

Chapter 4 Key environmental issues

This section highlights key environmental issues such as climate change, energy security, solid waste management and chemical management.

4.1. Climate change

The vulnerability assessment of the National Adaptation Plan for Action (2007) identified the following areas which are highly vulnerable to climate change impacts: land, beach and human settlements, critical infrastructure, tourism, fisheries, human health, water resources and coral reef biodiversity (MEEW, 2007). The high dependence on natural resources for its social and economic security further increases the vulnerability of Maldives to climate variability.

More sustainable developmental practices need to be adopted in order to minimize the consequences of climate change impacts. Maldives is in the frontline of the international negotiations of climate change. At the national level, current policies and development strategies are considered to gradually incorporate climate change into all sectors of development. In this regard, the first comprehensive Climate Change Policy Framework developed in 2015 is the main guiding policy instrument to address climate change impacts and ensure climate resilience in the Maldives.

4.1.1. Current and future trends

The following section presents the trends in the general climate and future projections for the Maldives. The data from meteorological stations in Hanimaadhoo (northern region), Hulhule/Male' (central region) and Gan (southern region) are used to analyse the current trends. The government of Maldives commissioned the Regional Multi-Hazard Early Warning Systems (RIMES) to produce high-resolution regional climate models (RCMs) for the nation by downscaling global climate models (GCMs) to predict future projections.

Temperature

Each of the last three decades has been successively warmer at the Earth's surface than any preceding decade since 1850 (IPCC, 2014). The globally averaged combined ocean and land surface temperature data shows a warming of 0.85 (0.65°C to 1.06°C respectively) over the period 1880 to 2012 (IPCC, 2014). Figure 4-1 presents the long-term annual mean surface air temperature recorded from the central (Male'), northern (Hanimaadhoo) and the southern (Gan) regions of the Maldives. An increasing trend in the mean annual temperature is seen for Male' (0.267°C/decade) and Gan (0.168°C/decade), whereas a decreasing trend is seen for Hanimaadhoo (0.086°C/decade). It is important to note that this decreasing trend may be due to the high uncertainty of the Hanimaadhoo records, as Hanimaadhoo records are available for a short duration (20 years). The increase in terrestrial temperature over the duration is consistent with the warming of the sea surface temperature (SST) throughout the country, with a general trend of 0.11 to 0.15 °C/decade (Figure 4-2). SST is generally found to be lower in the northern regions, compared to the central and southern atolls (MEE, 2016a).

Mean temperature projections over Maldives for three time slices are shown in Figure 4-3 for the geographic

zones shown in Figure 4-4. An increasing trend is seen from the time slices experiments (2021-2050) and (2082-2100), compared to the baseline (1981-2000). Mean annual temperature during 2021 to 2050 is about 27°C, which is approximately 1.8°C higher than the baseline climate (1981-2000). The temperature projections for time slice 2082-2100 are higher over the northern and central regions when compared to the southern zones (Figure 4-4).

SST projections show an increase in trends in all four geographic zones (0.76°C to 1.37°C for time slices 2030s; 1.01°C to 1.93°C for 2050s; and 1.27°C to 3.07°Cfor 2080s, from the baseline 1961 to 1990 mean annual SST over the four zones (MEE, 2016a).

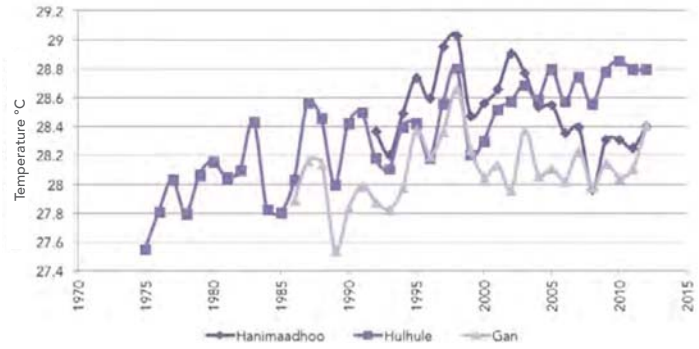


Figure 4-1.Time series of annual mean temperature. Data source: Maldives Meteorological Services.

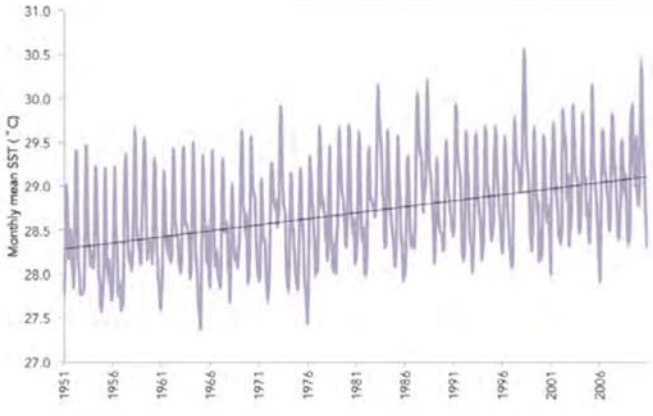


Figure 4-2: Sea surface trend in central Maldives from 1951 to 2010. Adapted from (MEE, 2015b)

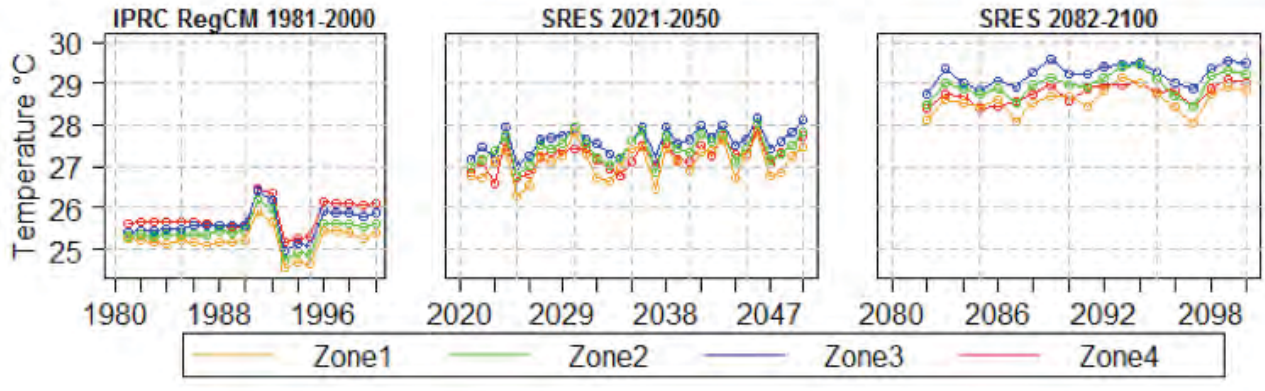


Figure 4-3: IPRC RegCM annual mean temperature projection for Maldives (Zones are given in figure 4-4) Adapted from (MEE, 2015b).

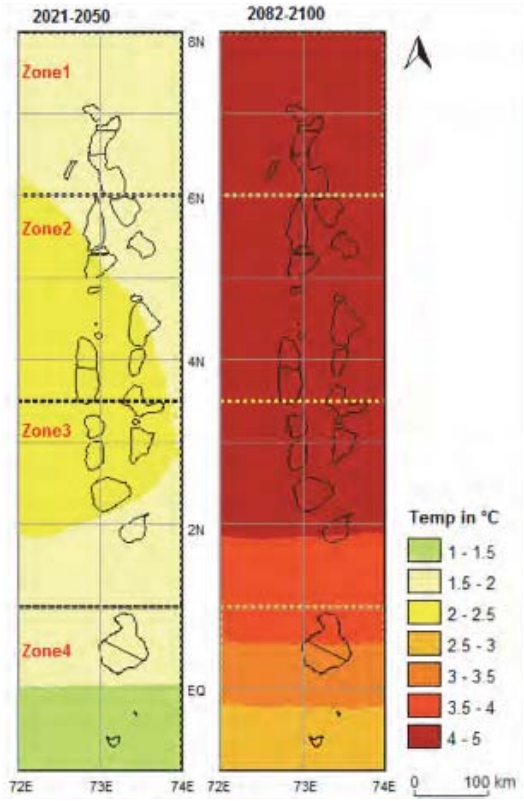


Figure 4-4: Temperature changes over Maldives from IPRC RegCM scenario for time slices (2021-2050) and (2082-2100) from baseline (1980-2000). Adapted from (MEE, 2015b).

Precipitation

Long term total annual rainfall shows a declining trend of 9.5mm, 0.02mm and 2.21mm per year for Hanimaadhoo, Male' and Gan respectively (Figure 4-5). However, high uncertainty is associated with Hanimaadhoo records due to short span of data. Analysis of number of rainfall days (days with at least 1 mm of rainfall) shows a significant decreasing trend (Figure 4-6), indicating a change in the intensity of rainfall. An increase in the number of rain days is seen in the north, compared to the rest of the country (MEE, 2016a).

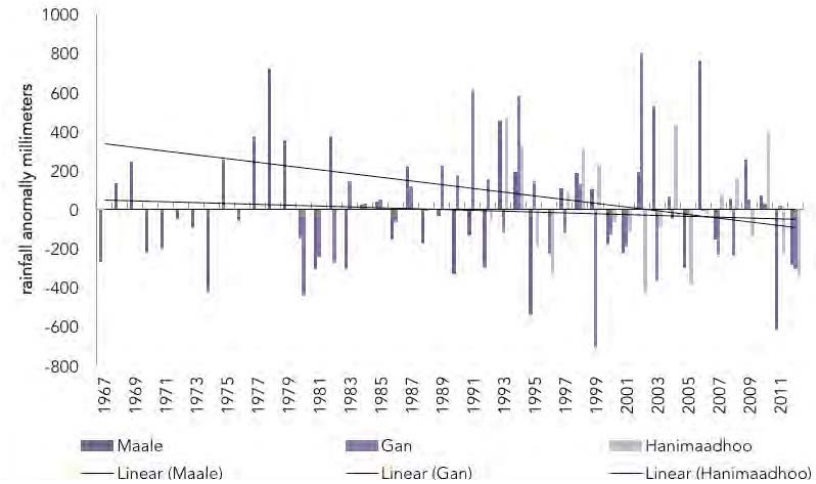


Figure 4-5: Annual rainfall anomaly over the Maldives from 1967 to 2012. Adapted from (MEE, 2016a).

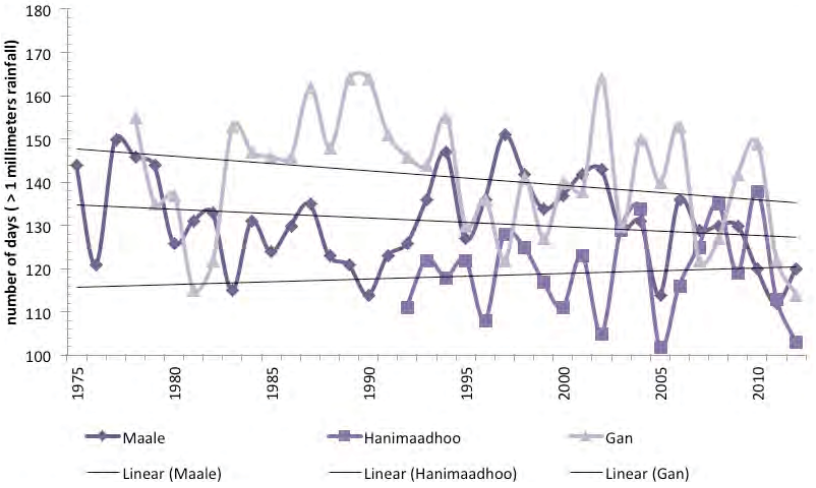


Figure 4-6: Long-term annual number of rain days. Adapted from (MEE, 2016a).

Due to increase in temperature over the South Asian Region, there is very likely to be an increase in intense precipitation events, while wet days are likely to decrease (Christensen, et al., 2007). Downscaled future projections done by MEE (2015b), as seen in Figure 4-7 show an increase in precipitation over northern and central regions, while a decrease in precipitation in the southern regions for the years 2021-2050. However, this pattern is different to the current trends observed from the meteorological data. For the years 2082-2100 an overall increase in precipitation is seen

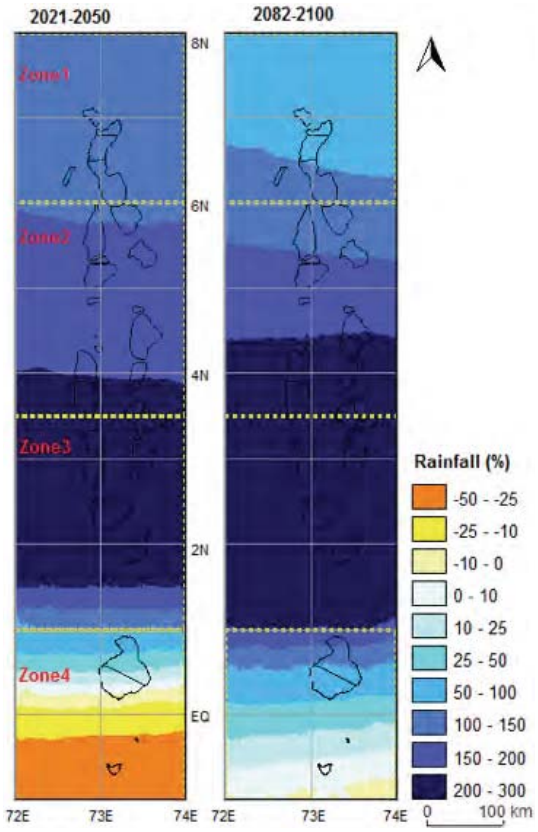


Figure 4-7: Rainfall changes over Maldives from IPRC RegCM scenario for time slices (2021-2050) and (2082-2100) from baseline (1980-2000) (MEE, 2015b).

Sea level rise

Sea level rise poses one of the most widely recognized climate change threats to low-lying coastal areas. Long term annual sea level data for the past 20 years shows a rise of 3.753 and 2.933mm per year in Malé and Gan respectively (Figure 4-8).

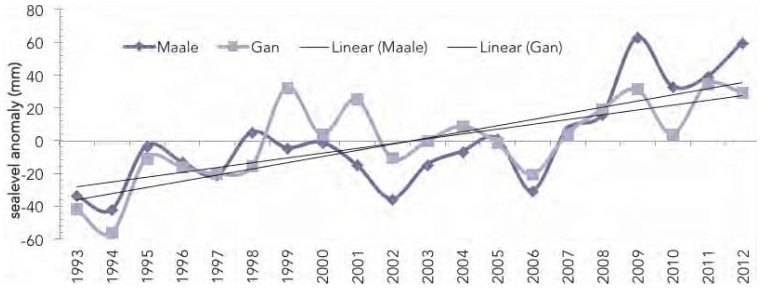


Figure 4-8: Sea level anomaly for Male' and Gan from 1991 to 2012. Adapted from (MEE, 2016a).

Figure 4-9 shows the annual sea surface height projections for central and southern regions of Maldives. Sea level projections are not available for Maldives due to lack of sufficient data. Therefore, changes in sea surface height are predicted based on sea surface height projections from the global models. Maximum sea surface height is projected to vary between 0.40m to 0.48m from 2001 to 2100 (MEE, 2015b). Global projections for sea level rise indicate a change of 0.2m to 0.5m in sea level by the end of 21st century.

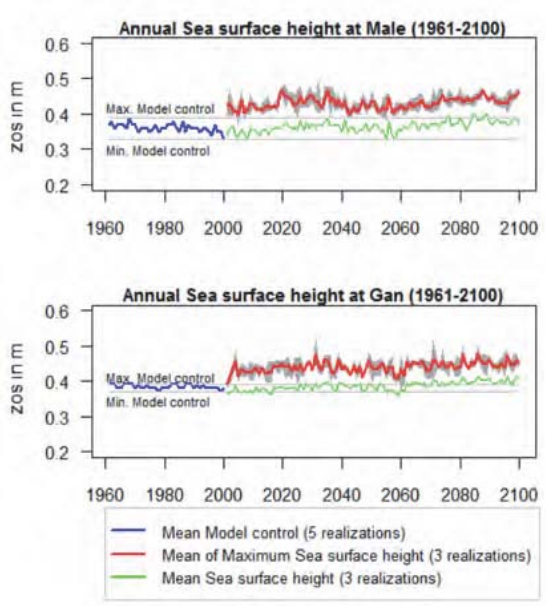


Figure 4-9: Annual mean sea surface height projections with respect to mean sea level. Grey shades indicate the range of uncertainty of maximum sea level. Adapted from (MEE, 2015b).

4.1.2. Climate change impacts

Similar to other Small Island Developing States (SIDS), the Maldives has already existing environmental and socio-economic challenges, which are further aggravated due to climate change. Among others, these challenges include extremely high population density, geographic dispersion of islands which challenges communication and transport, and a small island economy that is physically isolated from the world markets but highly susceptible to global influences (MEE, 2015c). The limited economic and technological capacities within the country present huge challenges to tackle climate change and mitigate the associated impacts.

Likely impacts of sea level rise scenarios

Sea level rise is recognized as the greatest threat to Maldives as this increases the possibility of land inundation. The small size and low elevation of the islands increases the vulnerability to coastal hazards. The coastal vulnerability criteria determined by MEE (2016a) shows high vulnerability where

human settlement remains less than 50m from the shoreline in a five-year period. Coastal vulnerability is moderate where human settlement remains 50 to 100m from the shoreline in a five-year period, whereas low vulnerability is indicated where human settlement remains more than 100m from the shoreline in a five-year period. Given the small size of the islands, almost all islands are high to moderately vulnerable to coastal hazards. Only one island (HDh. Nolhivaranfaru) has all its settlements 100m away from the coastline (MEEW, 2007). Box 4.1 presents an inundation analysis of B. Hithaadhoo islands.

Box 4.1. Inundation analysis of B. Hithaadhoo Island. Source: (MEE, 2016a)

An inundation analysis of B.Hithaadhoo island, as seen in Figure 4-10 shows that under the best case scenario (B1 Low Scenario) a rise of 0.18 m in the sea level is projected. This increases the risk of flooding in the lower elevation area of the island which would result in significant threat to critical infrastructures such as the hospital. Under worst case scenario (A2 High scenario) a rise of 0.38 m in sea level is projected, which would result in further inundation, damage to infrastructure and significant land loss.

Administrative atoll: B. Atoll
Land area: 0.392km^2
Population (2014): 669

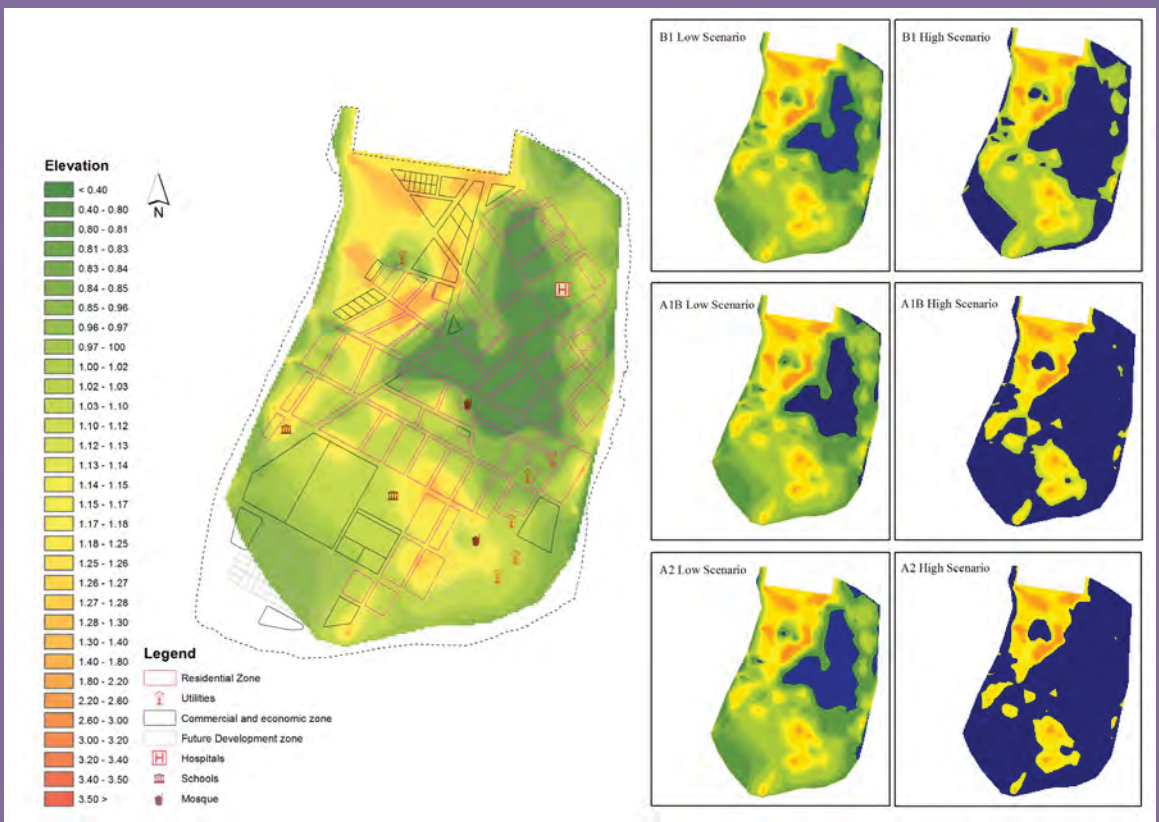


Figure 4-10: Inundation analysis of B.Hithaadhoo Island. Adapted from (MEE, 2016a)

Natural disasters and extreme weather events

Prevalence of extreme weather events and natural disasters in recent years serve as forewarning of the climate change impacts that are likely to occur in the future. Extreme events have become frequent over the past decades, while some events had led to significant economic losses. The natural disasters which are risky to the Maldives, as identified by the Disaster Risk Profile of Maldives done in 2006 include earthquakes and tsunamis, cyclones/thunderstorms, floods (due to rain), drought; storm surges, and strong winds and tornadoes (UNDP, 2006). Table 4-1 presents major natural disasters and extreme events which occurred during the recent years.

Table 4-1: Major natural disasters that hit Maldives in recent years

Disaster Event	Details
Indian Ocean Tsunami (December 2004)	This was one of the most apocalyptical natural disasters experienced in the Maldivian history. The tsunami waves which initiated off the coast of Sumatra hit Maldives, causing massive destructions. It was reported that 82 people were dead, 26 were missing and more than 2000 homes got destroyed. Significant damages occurred to the infrastructure and property. The total economic losses were approximately 470 million USD (ADRC, 2005).
Storm surges (15-17 May 2007	A series of swells between 10 to 15 feet hit the islands of Maldives on 15-17 May 2007. An estimated 68 islands in 16 atolls were affected, causing inundation of up to 600 m from the coastline. Over 24 islands of Gaafu Dhaalu, Dhaalu, Thaa and Laamu. Although no human fatalities were reported, 1649 people were evacuated from their homes. While flooding caused damage to 579 housing units, 33 islands reported salt water intrusions. Significant damage was caused to agricultural farms and home gardens, disrupting food supplies and livelihood of many people (ADRC, 2015).
Cyclone Nilam (October-November 2012)	A tropical cyclone that originated from the Bay of Bengal hit Maldives late October and continued until the first few days of November, flooding over 51 islands. Severe flooding was reported in 28 islands and critical damages reported from 4 islands. The cyclone affected over 33 islands, 826 people and caused an estimated damage of USD 133, 090 (ADRC, 2015).
Cyclone Madi (6-13 December 2013)	Very severe cyclonic storm caused extensive damage in several regions of the country due to high wind and flooding following torrential rain.
Addu City Flood Crisis (24-25 November 2015)	Addu Atoll in the south of the Maldives was severely flooded after several hours of torrential rainfall, causing damage to over 297 homes and other infrastructure. The city received 228.4 mm rainfall between 8am Tuesday and 8am Wednesday and was the highest rainfall within 24 hours recorded in the country. The islands of Feydhoo, Maradhoofeydhoo and Maradhoo were severely affected. A loss of USD 0.3 million was estimated (ADRC, 2015).

4.1.3. Vulnerabilities to climate change

Land, beach and human settlements

The impacts of water shortage are more profound in the outer islands than in the capital island. Although the major source for drinking water in the islands is rainwater, prolonged dry season and inadequate rainwater harvesting capacity has forced the islands to request emergency shipment of water from Male'. Request for emergency water supplies from the National Disaster Management Centre (NDMC) each year indicates that the harvested rainwater is not sufficient in most islands, especially during the dry season (Figure 3-32).

Table 4-2: Areas and associated vulnerability to impacts of climate change

Disaster Event	Details
Land, beach and human settlements	• With islands on average 1.5 m above mean sea level, the islands are highly vulnerable to sea level rise, high wave incidents and increased erosion. • Very high risk of inundation.
Critical infrastructure	• Due to the small size of islands, infrastructure including airports, harbours, telecommunication infrastructures and tourism infrastructures are located close to the coastlinex. • The high vulnerability of critical infrastructure was reflected by the sea swells of 1987, which caused damage of approximately USD 4.5 million to the Male' International Airport (MEE, 2012a). • As can be seen in Table 4-1, recent extreme weather events and natural disasters have caused various extents of damage to human settlement and other infrastructure.
Coral reef	• Corals are highly sensitive to changes in temperature and some species of corals live at or near their thermal limits. • The historical bleaching and mortality events reflect the effects of warming of oceans in coral reefs of the Maldives. • Past bleaching episodes in Maldives occurred in 1977, 1983, 1987, 1991, 1995, 1997 and 1998 due to El-Nino events (Mimura, et al., 2007). • During the 1998 bleaching event, which was the most damaging episode recorded in global history, average live cover reduced from about 42% to 2% in some areas (Zahir, 2000). • Localized warming episodes with bleaching were observed during 2005 and 2010 (NOAA, 2016). • The 2016 El-Nino associated mass bleaching was the largest episode recorded since the 1998 event, with approximately 75% average bleaching recorded from the surveyed sites (Ibrahim, et al., 2016). •Figure 4-11 illustrates vulnerable spots for coral bleaching, based on

historical bleaching events and future SST projections.

Water resources	• Inundation of land and associated saltwater intrusion due to predicted sea level rise would further reduce the size of the freshwater lenses of the islands. • Decrease in the number of annual rainfall days. • Prolonged dry periods. • Increased intensity of rainfall, with rainfall occurring as short outbursts, leading to increased flooding incidents.
Agriculture and food security	• According to the National Adaptation Plan for Action to climate change, limited agricultural production, heavy import dependency, limited food storage and ad hoc distribution are factors which impact food security status of the country (MEEW, 2007). • Rising temperatures, prolonged drought, intense rainfall and flooding, soil erosion, salt water intrusions and wind gusts have destroyed farming activities in the country. • In the recent years, various levels of damage to agriculture and farming have been reported from the islands (Figure 4-12). As seen in the figure, the most number of cases were reported in 2012 due to Cyclone Nilam.
Tourism	• Change and unpredictability in seasons, increase in cooling costs, heat stress for tourists, infectious disease increases. • Risk for tourism facilities, increased insurance costs/loss of insurability, business interruption costs. • Coastal erosion, loss of beach area, higher costs to protect and maintain beaches. • Increased number of bleaching episodes and increased bleaching severity; and marine resource and aesthetics degradation in dive and snorkel destinations. • Loss of natural marine attractions and biodiversity.
Fisheries	• Changes in ocean temperature can affect the distribution, migration patterns of species. • Skipjack tuna abundance is affected by El-Nino events.
Human health	• Direct health impacts include exposure to heat/drought and extreme weather events. • Survey of selected island communities reported climate-related health concerns including dehydration, skin irritation, Urinary Tract Infections, eye irritation, respiratory diseases, increase in dust accumulation and skin diseases (MEE, 2016a). • Indirect health impacts of climate change include increase of mortality and morbidity of diseases. • The main climate-induced disease categories of significance include vector-borne diseases, water-borne diseases and respiratory diseases. • Warm and moist climatic conditions are known to increases the incidence of vector-borne diseases (Dengue, chikungunya and scrub typhus are the

main vector-borne diseases reported to HPA).

• Dengue outbreaks have been recorded in 1988, 1998, 1999, 2006, 2007, 2011 and 2015 (MEE, 2016a).

• The first case of chikungunya was reported from Maldives in 2006 and reached epidemic levels in 2008 and 2009 (Figure 4-13). Since 2010, the number of chikungunya cases started reducing drastically, with the most recent cases reported in 2012.

• Scrub typhus is another re-emerged vector-borne disease which is highest reported during the monsoon (Figure 4-14). Acute gastroenteritis is the most commonly occurring food and water-borne disease in Maldives

• HPA reported a total 19,786 acute gastroenteritis cases in 2015, showing an increase of approximately 40% of from the previous year.

• In Maldives, the high risk of climate change related food and water-borne disease epidemics is evident from the 50% increase in the number of flooding related gastroenteritis cases in 2005 following the Tsunami (MEEW, 2007).

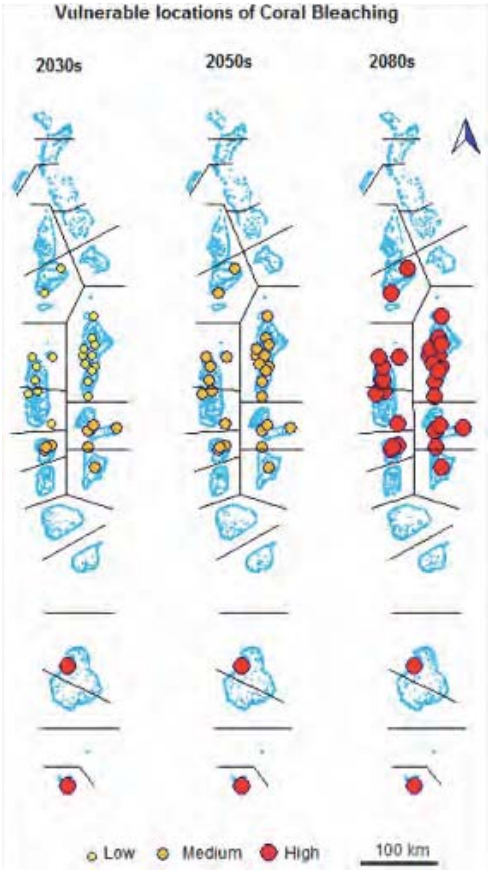


Figure 4-11: Vulnerable spots for future coral bleaching based on historical coral bleaching locations and SST projection, Adapted from (MEE, 2015b).

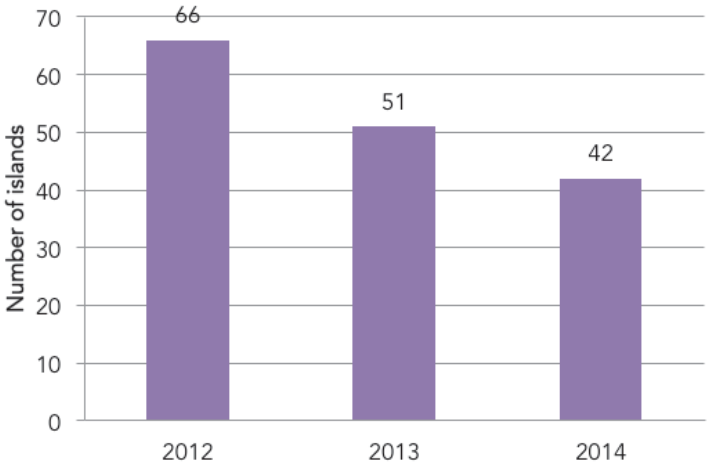


Figure 4-12: Number of islands which reported agricultural damages (Data source: Ministry of Fisheries and Agriculture, 2015)

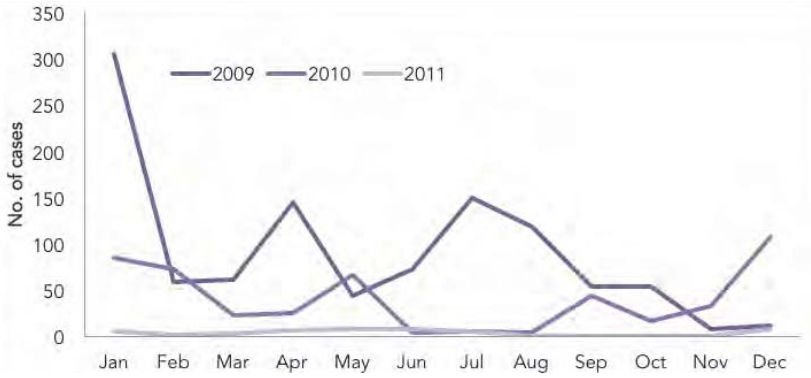


Figure 4-13: Chickungunya cases reported in 2009-2010. Adapted from (MEE, 2016a).

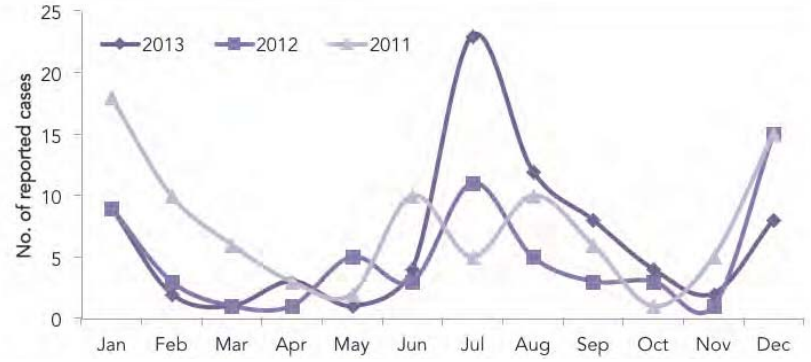
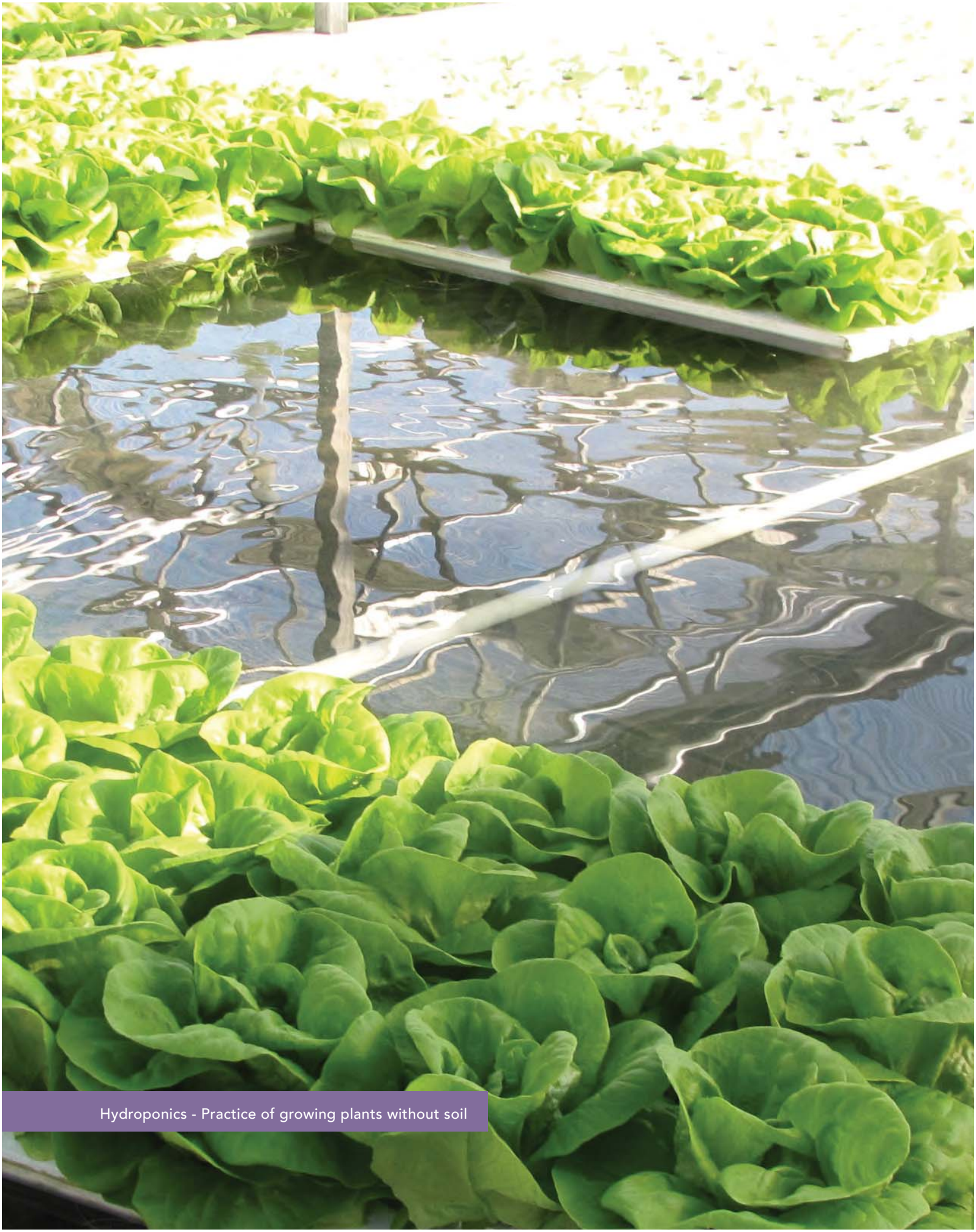


Figure 4-14: Scrub Typhus cases reported monthly to HPA from 2011 to 2013. Adapted from (MEE, 2016a).

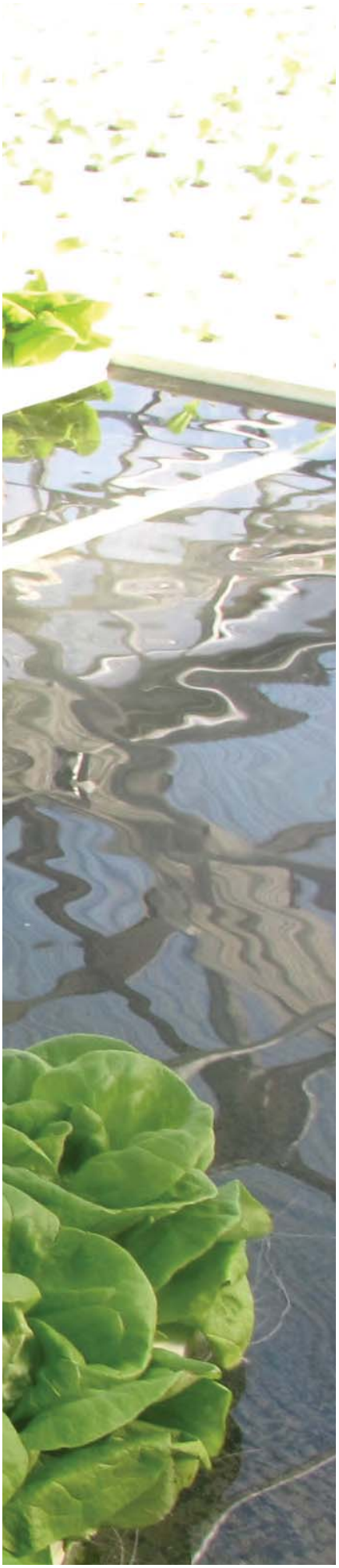
4.1.4. Government responses

Climate change adaptation and mitigation measures

Maldives has incorporated climate change adaptation and mitigation into sectoral planning and development and the Climate Change Policy Framework (MCCPF) is the key policy document (refer to Section 5.1 for details). Maldives aims to undertake adaptation actions and opportunities and build climate resilient infrastructure to address the current and future impacts of climate change. In its Nationally Determined Contribution (NDC) to the Paris Agreement, the Maldives committed to reduce its GHG emission by 10% unconditionally, and by 24% conditionally with international support by 2030. The conditional reduction will be achieved through sustainable development, supported and enabled through financial resources, capacity building and technology transfer. Box 4.2 summarises the main mitigation strategies in the two key emitting sectors (energy and waste sector as identified by GHG Inventory). Table 4-3 summarises the main adaptation measures in climate vulnerable sectors.



Hydroponics - Practice of growing plants without soil



Box 4.2. Key mitigation strategies. Information extracted from (MEE, 2016a).

Energy Sector

• Mitigation from electricity generation through promotion of renewable energy and enhancing energy efficiency (Refer to Section 4.2 for details).

• Mitigation from the transport sector: Due to the limited feasible mitigation options available for air and sea transport, focus is given for traffic management and enhancing efficiency of vessels. In this regard, air traffic control and operation at Velana International Airport provide the shortest and most direct routes for aviation within the Maldivian air space. Similarly, well coordinated routes exist for the integrated ferry transport system for the Male' urban region. In addition, efforts are being made by the largest ferry operator, the Maldives Transport and Contracting Company (MTCC) to maximise the distance travelled per litre of diesel in their vessels. To improve the land transport system, the government has undertaken several initiatives for improving road conditions, safety, reduce congestion and introduce public transport systems. The Transport Authority has also introduced import bans on use of cars older than five years and motorcycles with engine capacity less than 150 cubic centimeters. There is also an age limit of vehicles on the road, where taxi cars should not be more than 25 years. There is no import duty on electric vehicles, while petrol and diesel vehicles face 200% mark up.

Waste Sector

• The Maldives is moving towards an Integrated Waste Management approach. This involves establishment of community level waste management system at the islands and regional waste management systems. The first regional waste management facility is established in R. Vandhoo, under the Maldives Environment Management Project (MEMP) with assistance from the World Bank. This facility will manage waste from the four atolls N, R, B and Lh in the north.

Table 4-3: Climate change adaptation measures and actions. Information source (MEE, 2016a)

Area	Adaptation measures
Land, beach and human settlements	• Facilitate and continue to invest in coastal protection of inhabited islands and resorts • Include land elevation, shore protection and reclamation as adaptation measures to increase resilience of vulnerable islands • The first guideline for coastal protection was established in 2014, which outlines the standards for selection, design, implementation and maintenance of the relevant coastal protection measures
Critical infrastructure	• The Velana International Airport is planned for expansion. Coastal protection measures would be carried out to protect the shoreline of Hulhule as well as other air and sea ports • Male' Commercial Port which handles more than 90 percent of the imported cargo will be relocated to Thilafushi as a means to reduce the impacts of high winds and seas to the operation of the port • Increase resilience and climate proofing of all critical infrastructures across the country including utility services, healthcare facilities, and telecommunications • Establish a national building code to provide guidance to the planners, architects and engineers to integrate climate and weather factors into the designs of buildings and facilities. • Establish National Development Act to facilitate integration of climate change into development planning
Coral reef and biodiversity	• MRC has been conducting reef monitoring at 15 locations after the 1998 coral bleaching event • A National Coral Reef Monitoring Framework has been established to support the national coral reef monitoring program. • Under the framework includes a set of protocols to collect important coral reef health information and a web enabled database named coral database have been developed to act as a repository for the archiving and enabling easy access to reef health data collected • Remote sensing tools have been developed, including the Coral Reef Watch Satellite Monitoring and Bleaching Risk Assessment Tool (BRAT)
Water resource	• Maldives is moving towards an Integrated Water Resource Management (IWRM) approach.
Agriculture and Food Security	• Enhance local food production through introduction of new technologies such as hydroponics and autopot systems. Hydroponics projects have been implemented at land scarce islands including AA. Ukulhas, Lh. Kurendhoo and Th.Buruni. Under an integrated farming project, greenhouse auto-pot systems were introduced in different islands including H.A. Baarah, H.A. Filladhoo, G.A. Kondey and Addu City. • Poultry farms have been established in H.A. Baarah, B. Veymandoo, HDh. Hanimaadhoo and Th.Veymandoo
Tourism	• Tourism sector have incorporated climate change adaptations into policies and plans in all service areas including critical infrastructure, waste, water and food. • Climate proof infrastructure is being developed.

Fisheries	• Fisheries Master Plan (MASPLAN) is being developed which recognises impact of climate change on fisheries sector. • Identification of Potential Fishery Zones using satellite data • Efforts are underway to develop a multi-species hatchery to establish mariculture • The MoFA and MRC has prepared a 'Maldives livebait fishery management plan" which focuses on sustainability of bait and reduce over exploitation of live bait species • MRC is conducting research on aquaculture of live bait species • An integrated reef fish management plan is included in the MASPLAN
Human health	• The Searo Integrated Data Analysis System (SIDAS) established in 2006 records and monitors the communicable diseases from all atolls of the country. • The 'Mosquito Control Regulation 2007 aims to reduce mosquito breeding grounds, promote application of insecticides to larval stage and promote public awareness

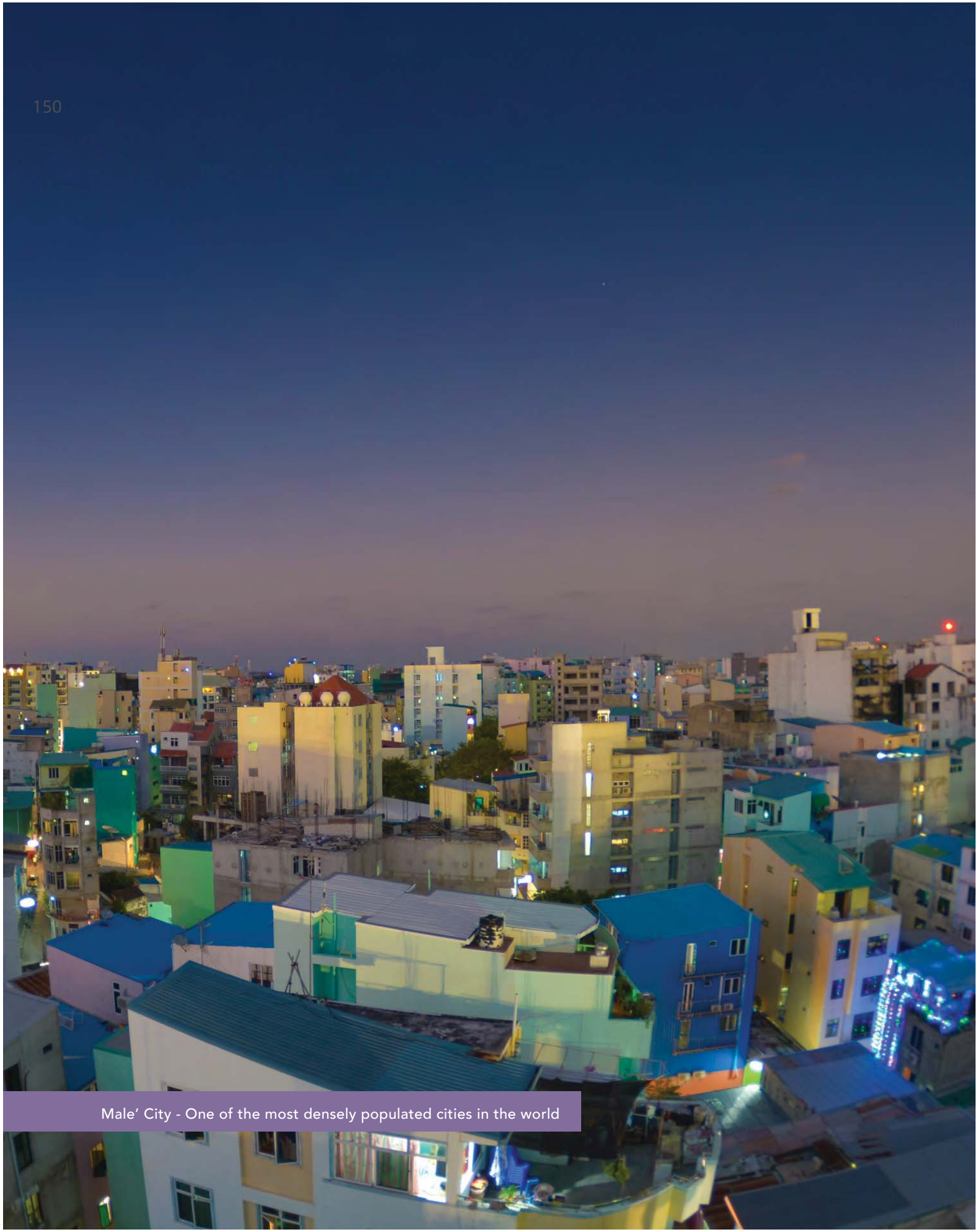
Alliance of Small Island States

In 1987, the Maldives pioneered climate change advocacy on behalf of small island states. Since then, Maldives has been actively involved in major climate change deliberations. The Maldives hosted the first conference of Small Island States on Sea Level Rise in 1989. Following this conference and its succeeding action group meetings, the Alliance of Small Island States (AOSIS) was established in 1990. AOSIS is a lobby group at the UN which advocates on behalf of small island states. At present, AOSIS has 44 member countries and Maldives is the chair for the current period.

United Nations Framework Convention on Climate Change

The Maldives played an important role in the negotiations that led to the United Nations Framework Convention on Climate Change (UNFCCC). In 2001, the Maldives implemented its first GHG Inventory and subsequently submitted the First National Communication (FNC) to the UNFCCC. The Maldives has submitted the Second National Communication (SNC) in November 2016. The key objective of National Communications is to prepare a comprehensive report on the progress towards achieving the objectives of UNFCCC. Furthermore, it provides the national GHG Inventory and presents the mitigation strategies. In addition it describes the vulnerabilities, adaptation efforts and outlines the barriers to address the vulnerabilities.

The Paris Agreement under UNFCCC has the key aim to strengthen the global response to the threat of climate change by keeping a global temperature rise this century below 2°C above pre-industrial levels, and to pursue efforts to limit the temperature increase even further to 1.5°C. On 5 November 2016, the Paris Agreement entered into force after reaching its double trigger thresholds. The Maldives was among the first to ratify the Paris Agreement in April 2016.



Male' City - One of the most densely populated cities in the world

4.2. Energy Security

The uninterrupted availability of energy products at affordable prices at all times significantly determines the energy security of a country. Maldives do not have conventional energy resources such as coal, oil or natural gas. Hence, all its energy demands are met through imported petroleum products. This dependency has grown over the years, mainly driven by the surge in demand for electricity and transport due to population growth, urbanization and development of the tourism sector.

The high reliance on petroleum imports leaves Maldives highly vulnerable to global fuel price fluctuations. This was evident during the global oil price surge in 2008, during which Maldives experienced significant deficit in the balance of payments due to the increased fuel prices.

The limited capacity for fuel storage is a further challenge for the energy sector of the Maldives. The current nation-wide fuel storage capacity is approximately 27.9MT (MEE, 2016b). The State Trading Organisation (STO) receives 2 to 3 shipments each month, hence, the current capacity is sufficient to last about 10 days, even if delay of one shipment occurs (personal communication, STO, 2016). However, the dependency on maritime shipping routes for fuel product imports is a challenge for supply security, particularly with the current storage limitations. Maldives has experienced low fuel stock levels due to rough weather conditions in the past. In addition, the limited storage does not allow importing large quantities when market fuel prices are low.

The government recognizes the importance of promoting conservation and energy security through diversification of the energy sector and developing renewable. To this end, the government has formulated policies, strategies and action plans to enhance the energy security of Maldives. Significant efforts are ongoing to introduce renewable energy technologies, as well as promoting energy conservation and energy efficiency programs within the Maldives.

4.2.1. Energy supply

Fossil fuel

Imported petroleum fuel is the main source of energy in the country. Diesel (marine gas) is the main fuel used for electricity generation and sea transport, while petrol and aviation gas is used for land transport and aviation respectively. LPG is the main fuel used for cooking. The cost of fuel import accounts for a high proportion of the annual GDP each year. In 2014, approximately 667,011 MT of petroleum fuel was imported, accounting for approximately 553 million USD (based on fuel import data from Maldives Customs Service and nominal GDP value from National Bureau of Statistics, 2015). This amount contributed to roughly 18% of GDP. Diesel comprises the bulk of the fossil fuels imported, accounting for 58% of the total fuel imported in 2014 (Figure 4-15).

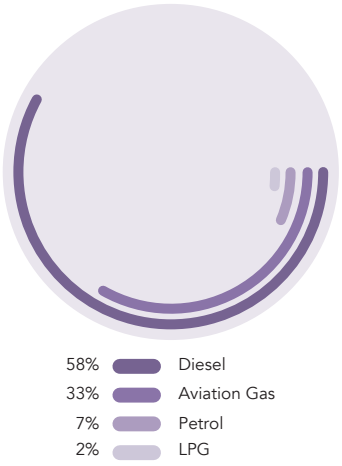


Figure 4-15: Quantity of fuel import-2014 (data source: Statistics Division, Maldives Customs Service, 2015)

Sola PVs

Renewable energy

Solar energy

Lying across the equator, Maldives receives an abundance of sunshine throughout the year. Solar energy is the most commonly used source of renewable energy in the Maldives at present. The first solar photovoltaic (PV) was installed in Maldives in 1995 by Dhiraagu. Solar heating is mostly used in resorts to generate electricity and water heating. Figure 4-16 shows the growth of solar PVs from 2006 to 2014. As can be seen from Figure 4-16, installation of solar PVs has been increasing in the Maldives over the years. The total capacity installed has increased from 52.1kWp in 2006 to 4,064.91kWp in 2014. Of the total capacity installed, 45% accounts for government installations (Figure 4-17). The percentage share of installed capacity shows that out of the total capacity installed, 70% accounts for solar PVs in the outer islands, while 30% accounts for installations in Male' (Figure 4-18).

Solar PVs - Hiriya School Male' City

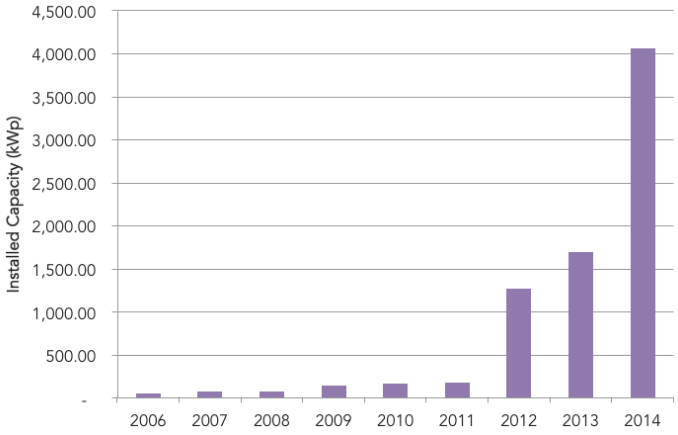


Figure 4-16: Growth of solar PV in the Maldives (Data source: Energy Department, Ministry of Environment and Energy, 2016)

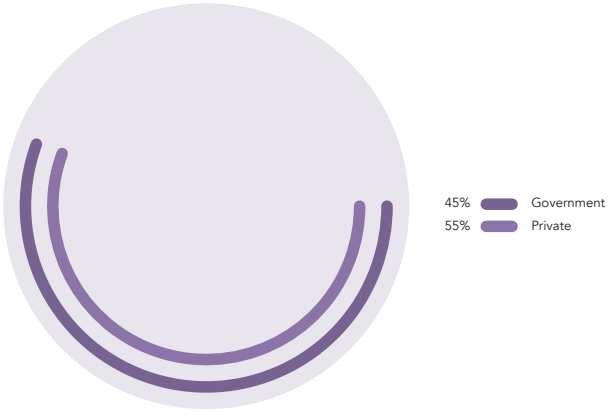


Figure 4-17: Percentage share of installed solar PV system (Data source: Energy Department, Ministry of Environment and Energy, 2016)

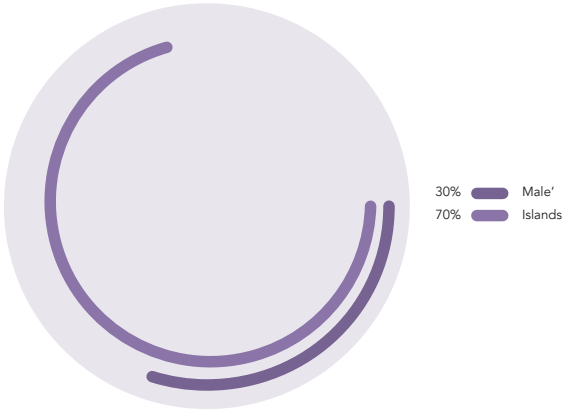


Figure 4-18: Percentage distribution of installed PV systems (Data source: Energy Department, Ministry of Environment and Energy, 2016)

Wind energy

In 2003, an assessment on wind energy potential was carried by the US National Renewable Energy Laboratory (NREL). Figure 4-19 shows the wind resource map for Maldives generated by this assessment. It was found that North Maalhosmadulu, South Maalhosmadulu, North Miladhunmadulu, South Miladhunmadulu and Faadhippolhu Atoll had the highest wind resource potential. The level of resource was estimated to be good for only small-scale wind applications, whereas moderate for large-scale applications. Although, the atolls lying north and south to the high potential zones, including Male' atoll showed slightly lower wind resource, they are still considered good for small-scale and moderate for large-scale applications. A gradual decrease in wind energy was found towards the southern atolls.

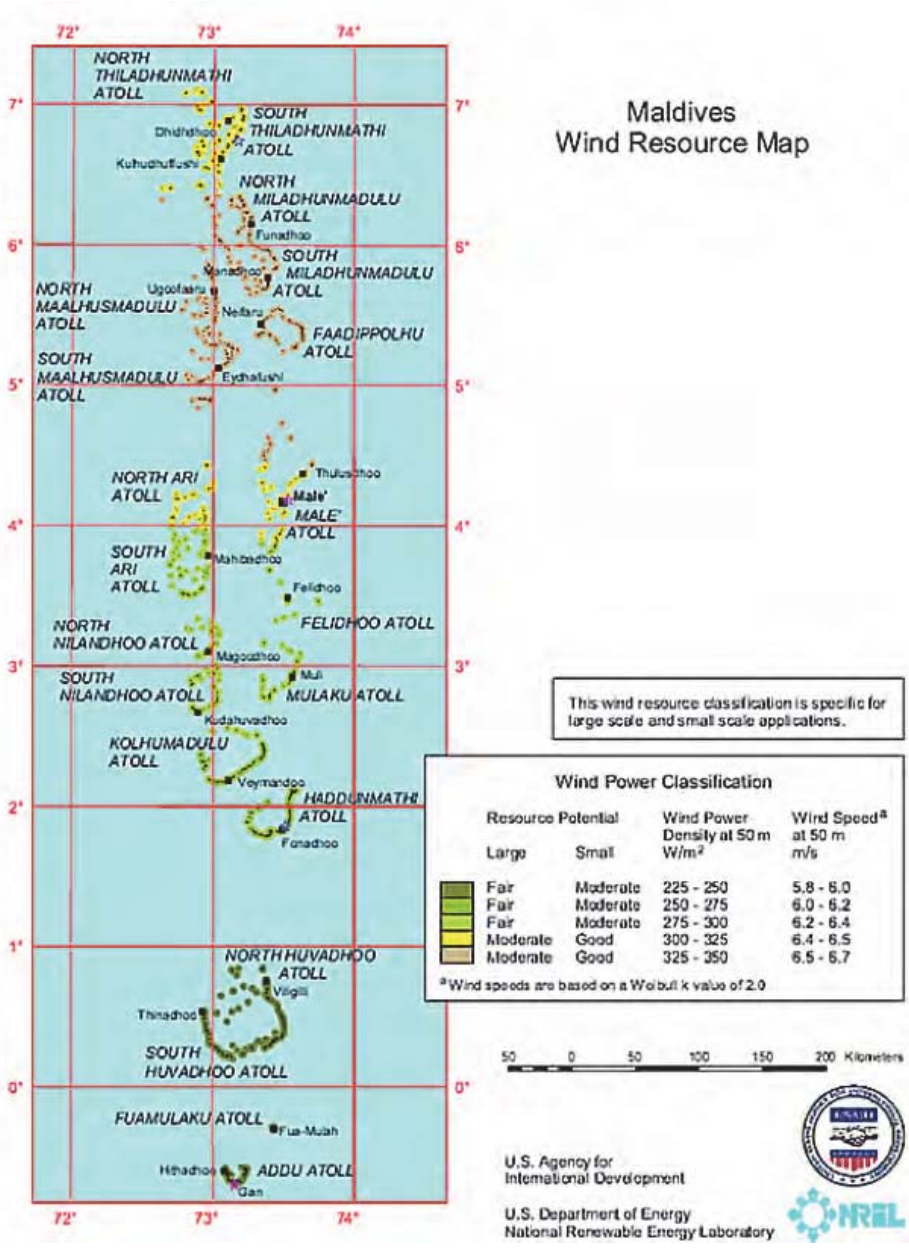


Figure 4-19: Wind resource map for Maldives. Adapted from (NREL, 2003).

4.2.2. Electricity generation

Maldives achieved universal access to electricity in 2008. More than 44% of diesel imported to Maldives is utilized for electricity generation (MEE, 2012b). The dispersed nature of the islands and the absence of a national grid require installation of individually operated powerhouses in each island. Therefore, a high cost is associated with initial setup and subsequent operation of powerhouses in the islands. There are a

total of 191 powerhouses in inhabited islands, and are mainly operated by three utility companies namely, State Electric Company (STELCO), FENAKA Corporation Ltd. (FENAKA) and Male' Water and Sewerage Company Pvt. Ltd (MWSC). To date, a total of 299 MW capacity for electricity generation has been installed (Figure 4-20). The percentage distribution of installed capacity as seen in Figure 4-21 shows that the inhabited islands accounts for the largest installed capacity (55%). With 37%, resorts also accounts for a significant proportion of the nation-wide energy generated.

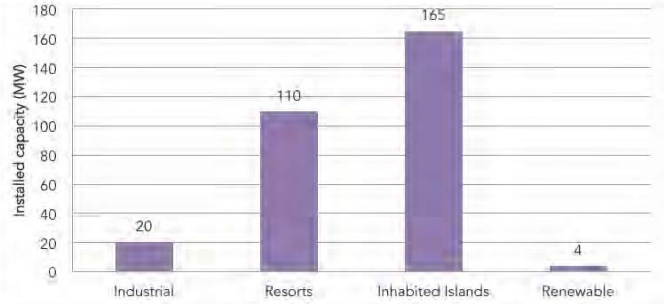


Figure 4-20: Total installed capacity for electricity generation until 2015 (Data source: Energy Department, Ministry of Environment and Energy, 2016)

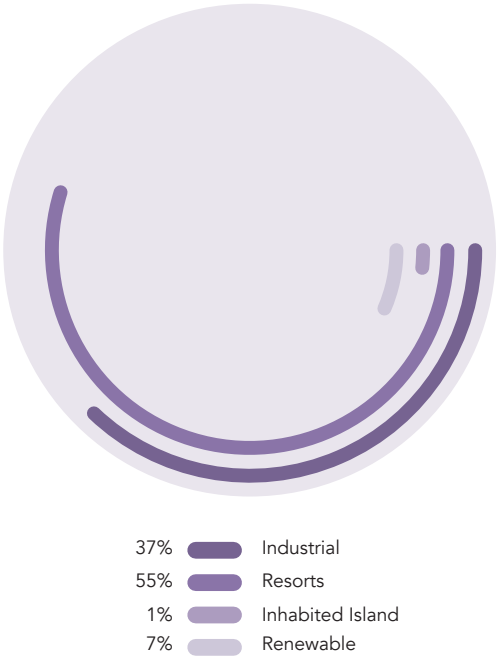


Figure 4-21: Percentage distribution of installed capacity for electricity generation (Data source: Energy Department, Ministry of Environment and Energy, 2016).

4.2.3. Electricity demand and consumption

Population increase and industrial sector growth has resulted an increase in electricity consumption. Electricity utilization data from STELCO and FENAKA shows that a total of 442.75GWh of electricity was consumed by the inhabited islands for the year 2014. The greater Male' region, with a total consumption of 271.39GWh of electricity, accounts for 61% of the total electricity consumed in inhabited islands (Figure 4-22). With an accompanying increase in the maximum power demand, the energy sector of the Male' city has witnessed significant growth over the last 9 years. The energy consumption in Male' shows an average increase of 7.5% per annum (Figure 4-23).

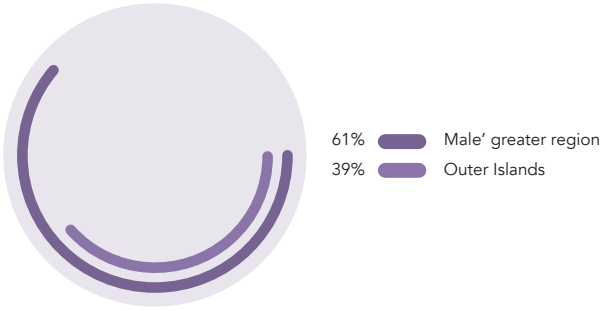


Figure 4-22: Percentage share of electricity consumed by greater Male' region and outer islands in 2014 (Data source: Maldives Energy Authority, 2016).

Figure 4-23: Electricity consumption for Male' city from 2005 to 2014. Data source (NBS, 2015a).

4.2.4. Challenges to energy sector in Maldives

High dependence on imported petroleum fuel

In Maldives, the net oil imports have increased from 227,063.6MT in 2005 to 667,011MT in 2014 (Figure 4-24). This is an increase of 164.9% over the decade, with the total oil import reaching a peak in 2014. Since 2011, significant increase in import of aviation gas is also seen. Based on the current trend, a further increase of 19.5% in fuel import is expected by 2020.

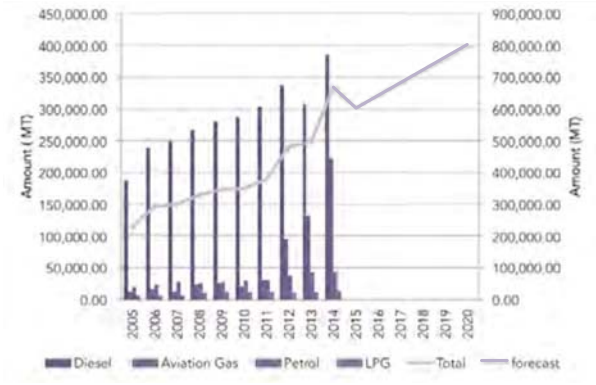


Figure 4-24: Amount of fuel imported (in metric tons) from 2005 to 2014 and forecasts based on the current trend (data provided by: Maldives Customs Service, 2015).

Escalating market price of fuel

Being completely dependent on imported fossil fuel for electricity generation and transport, Maldives is highly vulnerable to the surging fuel prices in the global market. Figure 4-25 shows the change in market price of diesel in Maldives from 2002 to 2014. Increase in global fuel price affects the market price of fuel in Maldives. The peak represents the rapid increase in oil price during the global financial and oil crisis.

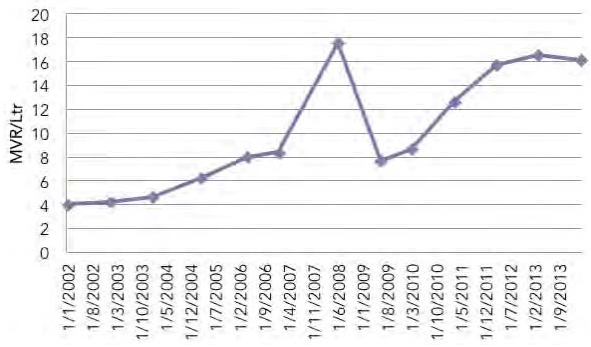
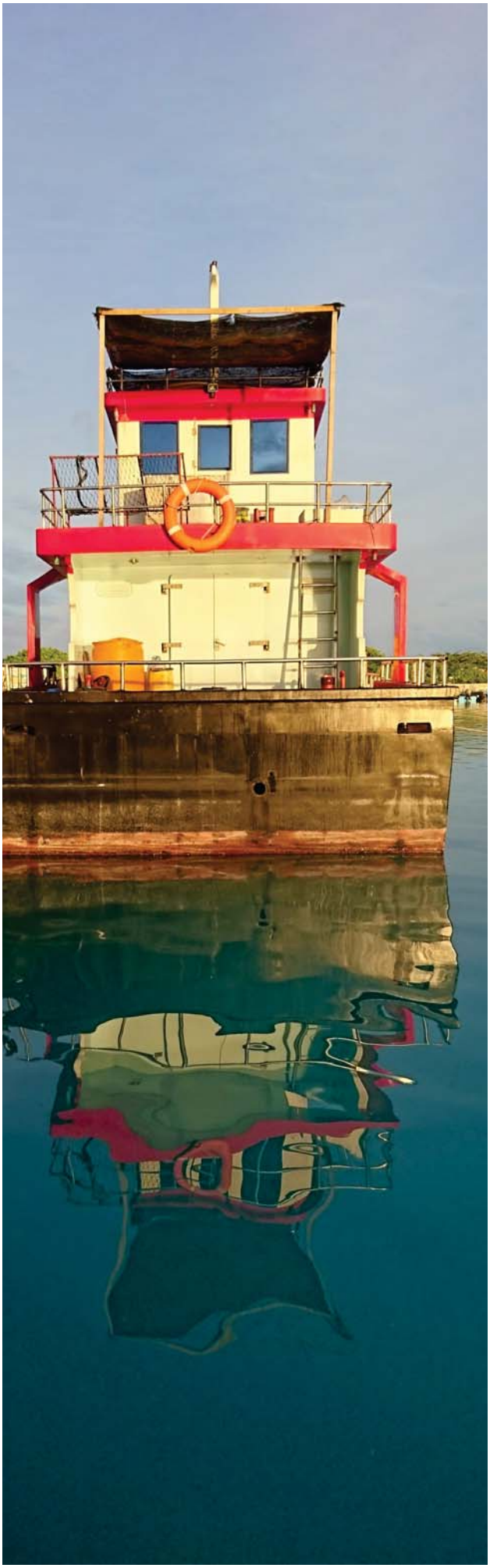


Figure 4-25: Changes in open market price of diesel in Maldives from 2002 to 2014 (Data source: Statistical Yearbooks 2004-2015, National Bureau of Statistics)



High expenditure on fuel import

The complete reliance on petroleum fuels to generate electricity places significant economic burden on the national economy. Compared to 2013, expenditure on fuel rose by 13.47% in 2014. The import of petroleum fuel in 2014 accounted for 28 percent of total imports. Figure 4-26 presents the expenditure on fuel imports from 2005 to 2014.

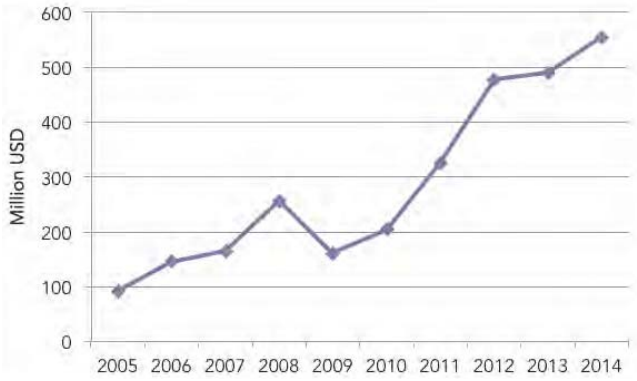


Figure 4-26: Expenditure on fuel import from 2005 to 2014 (Data provided by: Maldives Customs Service).

4.2.5. Government responses

Energy Department within the Ministry of Environment and Energy is responsible for making sector related policies, planning and seek resources to develop the sector. The Maldives Energy Authority is a regulatory authority within the Ministry of Environment and Energy and has the mandate to regulate the energy sector through the implementation of relevant regulations.

The National Energy Policy and Strategy document include policies, to provide all citizens with access to reliable and sustainable energy services at lowest possible cost, enhancing energy security, promoting energy efficiency and conservation, and moving towards the target of renewable energy based electricity supply. Table 4-4 includes a summary of current achievements and planned measures under the policy to date.

Table 4-4: Achievements and planned measures (Information provided by Energy Department, Ministry of Environment and Energy, 2016).

Policy	Completed and ongoing actions	Planned measures
Strengthen the institutional and regulatory framework of the energy sector	The government intends to develop guidelines, design requirements and establish certification norms for achieving energy efficiency in buildings A medium-term investment plan was initiated in 2012 to scale up renewable energy investments to increase energy security. The government has set import duties for renewable energy related imports to zero	Policies and regulations are being formulated for renewable energy integration Research on feasible alternative energy sources is to be undertaken
Promote energy conservation and efficiency	The government has undertaken investments to replace generator sets in a few outer islands	
Promote renewable energy technologies	Under Scaling up Renewable Energy Program (SREP), a five year investment plan was prepared to support renewable energy development Renewable energy feasibility studies were conducted in different regions In 2014, A road map (Table 4-5) on transition to renewable energy was prepared	
Improve the reliability and sustainability of electricity service		The government plans to upgrade power infrastructure on the islands to improve performance while reducing the costs to industry
Increase national energy security	Identified measure, including timely supplies of required petroleum projects at identified regional centres across the country and opening up the fuel market for investors Renewable energy projects are being scaled up	With the assistance of The World Bank and Asian Development Bank, Maldives Energy Authority is developing a regulatory framework for the sector

Transformation of energy sector

To enhance energy security and to achieve a low carbon development economy, the Maldives has initiated an investment plan, the Scaling-up Renewable Energy Program (SREP). The initiation of SREP was one of the most significant steps taken by the government in the transformation of the energy sector, from being completely fossil based to a low carbon energy sector. This transition will scale up renewable energy from the current 4 MW to 21 MW. In 2014, a roadmap for transition to renewable energy was prepared with the following targets (Table 4-5). Furthermore, initiatives including net metering regulation and Bank of Maldives Green Fund were introduced to strengthen private sector involvement in renewable energy.

Table 4-5: The targets of the roadmap for energy sector transition (Information provided by Energy Department, Ministry of Environment and Energy, 2016).

	Target	Target year
Impact: More sustainable energy sector based on renewable resources	Increase contribution of renewable energy in the supply mix of the Maldives to 25% from less than 1% in 2009	2022
	All islands initiate electricity sector de-carbonization and the reduction of CO_2 emissions to 0.6 kg of CO_2/kWh from 2009 baseline of 0.9Kg of CO_2/kWh	2022
Outcome: Shift towards clean and cost-effective energy sources	Gradual reduction in diesel consumption to 0.1-0.3 l/kWh in outer islands from 0.45-0.70 l/kWh in 2012	2019
	Electricity tariffs on average improve to cover closer to 100% of costs from less than 50% in 2011	2019
	CO2 emissions reduced by 40,000 tons in the power sector from 40,000 tons forecasted for 2019	2019
Output: Renewable energy ready grid systems developed for islands	21MW of solar photovoltaic, 7MWh of energy storage designed and installed; 20MW of diesel generator sets replaced; and the distribution grids upgraded in 160 islands	2019

Feed-in Tariff Mechanism

A Feed-in Tariff Mechanism was introduced in 2011 to promote renewable energy projects in the private sector. Under this mechanism, solar PV systems could be connected to the utility grid, and the electricity produced through PV systems can be sold to the utility under a certain tariff.

Net Metering Regulation

The formulation of the Net Metering Regulation in December 2015 was one of the most significant accomplishments in the transformation to a renewable energy sector. The "Net Metering Regulation" for connecting renewable energy systems to utility's power grids was ratified in December 2015, in order to facilitate the production of renewable energy by individual and private parties from a national level. This is a step taken to encourage the public in utilizing the clean energy sources available in the Maldives and to reduce dependence on imported fuels.

Bank of Maldives Green Loan

As part of Bank of Maldives' plan to encourage investment in environment-friendly green technologies, the Bank launched the 'BML Green Loan' in February 2016. The Green Loan will be available for individuals and businesses seeking to finance environmentally friendly green technologies such as solar panels for power generation, photovoltaic panels and systems, or energy efficient equipment and appliances.

Promoting energy efficiency

Utility energy efficiency programs provide significant energy and economic benefit to the utility system and ratepayers. Table 4-6 shows the supply side and demand side energy efficiency programs adopted in the Maldives.

Table 4-6: Energy efficiency programs in Maldives (Information provided by Energy Department, Ministry of Environment and Energy, 2016).

Supply side energy efficiency programs	Demand side energy efficiency programs
Power system rehabilitation: Aims: 1. Reduce consumption of diesel by increasing the efficiency of power generation. 2. Enable mechanisms to incorporate large amounts of electricity generated from intermittent renewable energy sources into the grid	**Energy Efficiency (EE) standards and labeling-** a project implemented by MEE with the assistance from Global Environment Facility. **Energy Efficiency and Energy Conservation (EE & EC) awareness campaigns-** implemented by MEEE The campaigns are: "It's cool at 25" campaign, which aims to promote the correct setting of tem perature in air conditioners to feel com fortable as well as to save energy "LED Saves" campaign, aiming to promote the use of energy efficient equipment **Distribution of LED lights-** MEE distributed 267,750 LED tube lights from 2013 to 2015. Distribution of additional 210,000 LED lights is currently going on. These lights are used to replace the old inefficient lights in households, buildings and streets.

Electricity subsidies

In Maldives there was a long history of subsidizing electricity consumption motivated by high cost of energy due to reliance on imports and lack of diversification in energy resources.

Subsidy for electricity had increased tenfold from 2010 to 2014. In 2014, government had spent US$58 million for electricity subsidies. On March 2015, the government has discontinued fuel subsidy for business meters. In January 2016, the government took the initiative to discontinue subsidy for domestic customers. Realisation of the true cost of electricity to customers would be an incentive to reduce electricity consumption and adopt more energy efficient ways.

Waste Management - A huge environmental challenge

4.3. Solid Waste Management

Maldives is a small island developing state with existing geographical and environmental challenges and a small island economy based on tourism and fishery. Hence, solid waste management is widely recognized as a pressing environmental concern in Maldives. Over the recent decades, waste management problems have increased significantly, mainly driven by rapid population growth, changing consumption patterns, barriers in transportation and rapid growth of the tourism sector.

While the total quantity of waste generated in the country is not reported, the per capita waste generation per day in Male', outer islands and resorts are estimated as 1.7Kg, 0.8Kg and 3.5Kg respectively (MEE, 2015d). With an estimated increase of 4% per annum, the current pattern in the magnitude of waste generation in Maldives is similar to most developed countries. Biodegradable waste constitutes a large proportion of the total waste generated in the Maldives. In addition, chemical waste or hazardous waste and electronic waste (e-waste) generation is of growing concern at present. However, due to poor record keeping and lack of a systematic monitoring mechanism, data on the magnitude of waste generated is currently unavailable.

The Male' region is responsible for a significant proportion of waste generated within the country. Organic waste constitutes the bulk of the municipal waste. Waste is generally not segregated at household levels and only few islands practice composting. Waste from the Male' region and most resorts are transported to Thilafushi, the landfill island, where they are stockpiled. Open burning is frequently carried out at Thilafushi, which contributes significantly to air pollution. The main methods of waste disposal in the islands include open burning, burying or dumping into the sea. Such unsafe practices of waste disposal are increasingly resulting in pollution of the environment and generating conditions harmful to public health.

The Government of Maldives gives high importance to improve the existing system and move towards a more sustainable, integrated approach of waste management within the country. In this regard, the National Waste Management Policy was ratified in 2015. Under this policy, a national waste management initiative called 'Saafu Raajje Initiative' was launched in 2015 during the 6th Regional 3R Forum in Asia and the Pacific. In addition, the country's first integrated waste management system, the Vandhoo facility was established in 2016 (Box 4.3).

Box 4.3. Integrated Regional Solid Waste Management Facility- R.Vandhoo

The Regional Solid Waste Management Facility (RSWMF) is built with an advanced incineration system and a fully engineered landfill in the Maldives that established an integrated waste management system first ever known to the Country. This facility will cater 44 islands and 22 resorts in Noonu, Raa, Baa and Lhaviyani atolls. A total of 15ha is designated for the RSWMF, with a landfill site of 27,000m^3.

4.3.1. Current state

Waste generation

The rate of solid waste generation depends on the socio-economic situation, level of industrialization, types of industries, climate and land use (MHTE, 2010). Data on the total amount of waste generated in the country is currently unavailable. The urban regions, particularly the Male' region is estimated to generate more than half of the total waste generated within the country (Figure 4-27). The island communities accounts for 28% of waste generated and the tourist resorts and safaris account for approximately 21% of the total waste generated.

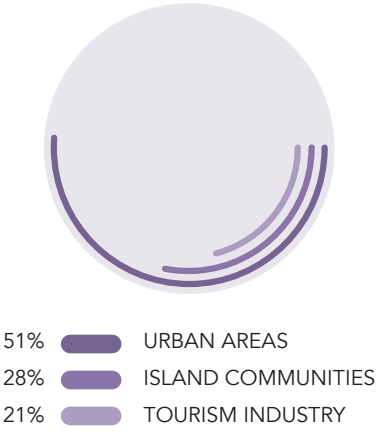


Figure 4-27: Percentage of waste generated per day by the urban areas, island communities and tourist resorts. Based on estimates from (MoT, 2015b).

The growth of waste generated in the urban areas is reflected by the increase in waste generation in the Male' City, which accounts for the majority of municipal waste discarded in the Male' region (Figure 4-28). However, the figures are estimates and may not reflect the true magnitude of waste generated. The waste generation in Male' shows an increasing trend, with an increase of 155% over the decade. In 2014, 255, 826MT of solid waste was generated in Male'.

Municipal waste generation data for the atolls show a steady increase from 2006 to 2015 (Figure 4-29). While 42,628 Mt of waste was generated by the atolls in 2006, the total waste generated increased to 67,096MT in 2015, showing an increase of 57.4% over the decade.

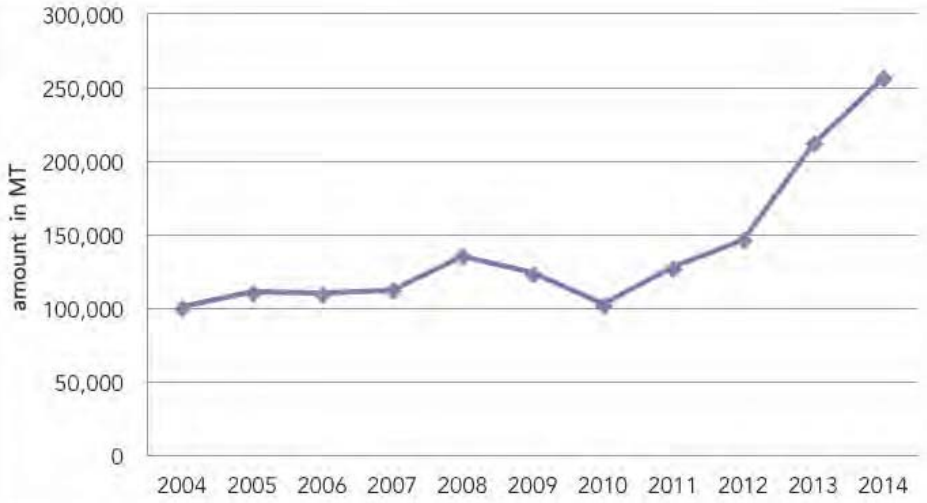


Figure 4-28: Estimated amount of waste generated in Male' from 2004 to 2014. Data source: (NBS, 2015a).

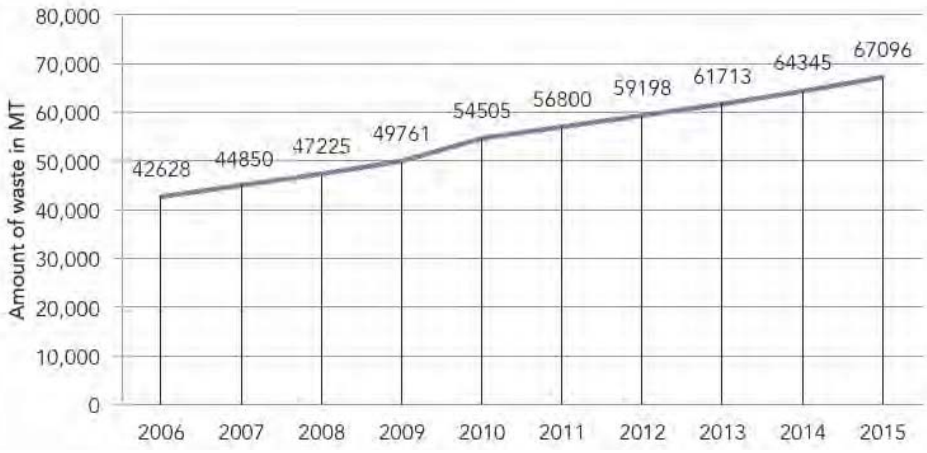


Figure 4-29: The estimated amount of municipal waste generated in atolls (Excluding construction and demolition waste, and waste from resorts) (Data provided by: Waste Management and Pollution Control Department, Ministry of Environment and Energy).

Waste composition

Previous waste audits and assessments on various localized regions have shown that food waste accounts for a significant proportion of solid waste discarded in Maldives (MoT, 2015b). A similar pattern is seen in the waste mix of the Male' region, where organic waste constitutes the bulk of the waste generated (Table 4-7).

Table 4-7: Waste composition in Male' City. Data source (MEE, 2013).

Composition	PERCENTAGE
Total compostable waste	79.45
Yard waste	50.85
Food waste	22.22
Dirt, ash, stone, sand	7.60
Other organic waste	4.64
Steel cans	2.35
Paper	1.87
Plastic film	1.84
Textiles	1.75
Wood	1.74
Cardboard	1.55
Glass	1.37
Rubber & leather	0.77
Other plastics	0.66
Other metals	0.34
Hazardous waste (batteries)	0.17
Aluminium cans	0.15
Pet	0.14

A survey on 46 islands in four atolls by the Maldives Environment Management Project (MEMP) in 2010 showed that the composition of organic wastes, including kitchen waste and green waste accounted for 88% of the total waste generated (Figure 4-30). Kitchen waste included all vegetable peelings and food scrap, while green waste included plant debris such as coconut husks, coconut leaves, tree clippings and leaves. The survey also showed that significant quantities of plastics, bottles and bags, aluminium and steel cans were discarded. It should be noted that organic waste is either compostable or recyclable, therefore presents an opportunity to engage in economic activities related to composting and recycling in Maldives, thus reducing the amount of waste to be disposed.

Due to the absence of proper collection and disposal facilities, segregation of waste at household level is low (MHTE, 2010). A survey of 79 islands carried out by MEE in 2015 showed that only few islands practice waste segregation (25% islands) at household level (Figure 4-31). Partial segregation is practiced in 5% of islands, where segregation is usually limited to combustible and non-combustible waste.

Organic waste, comprising the bulk of the total waste generated, presents huge opportunities for composting, thereby reducing the harmful impact to the environment. However, only relatively few islands practice composting, mainly due to lack of technical expertise at island level (Figure 4-31).

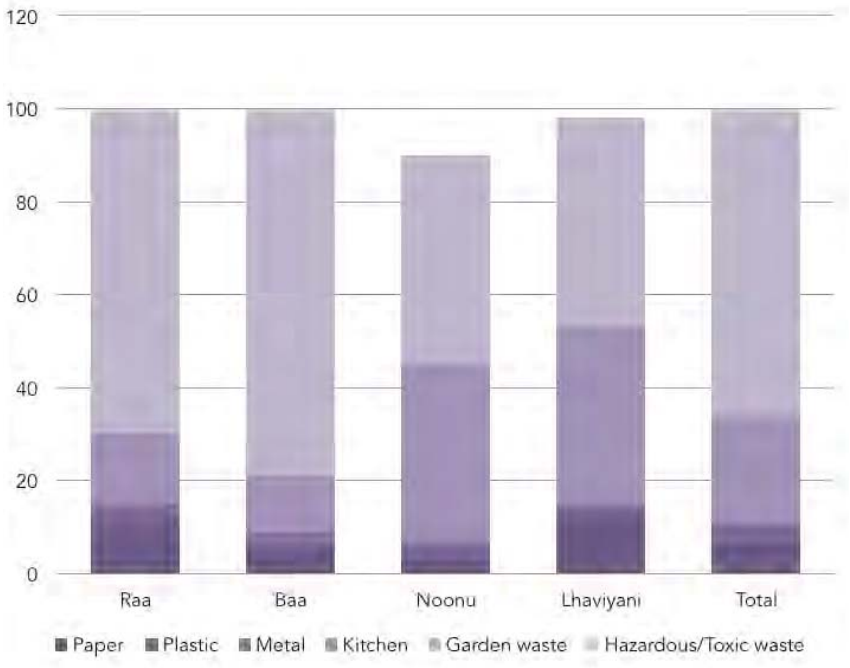


Figure 4-30: Percentage of waste produced at household level in the surveyed islands of Maldives. Source: Adapted from (MHTE, 2010).

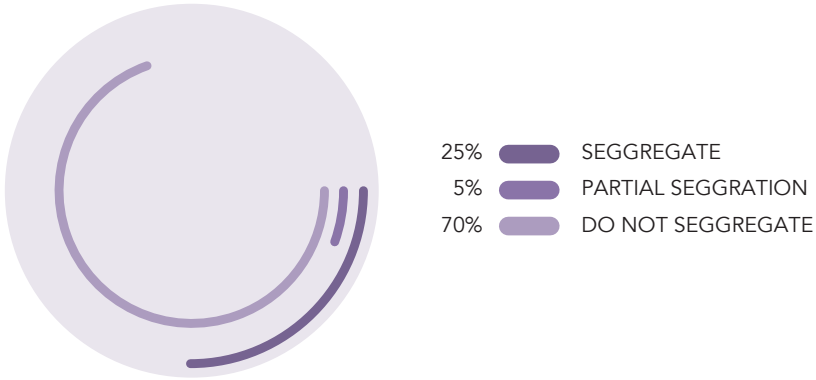


Figure 4-31: Percentage of islands which segregate their waste at household level

Solid waste management practices

The waste generated at Male' is collected daily and transported to Thilafushi for disposal. Household level collection is usually done informally by expatriate workers on their spare time and also unlicensed private small companies for a monthly fee ranging MVR 100 and MVR 500. Waste accumulated in bins at public places and government institutions are collected by Municipal Service Division of the Ministry of Housing and Infrastructure.

Thilafushi is a fully reclaimed island, built from landfill to host waste management and carry out industrial activity. Two barges of 589 tonnes, operate daily between Male' and Thilafushi landfill. In addition, Thilafushi also receives waste from resorts and construction and demolition sites. Thilafushi is not an engineered waste disposal facility and serves as an open dump site. Preliminary recycling activity is carried out in Thilafushi, where manual segregation of glass, plastics, aluminium, sawdust and lead acid batteries are carried out. Waste stockpile at the site is frequently burned, and contributes significantly to air pollution at the Male' region and the nearby islands. Hazardous wastes are also generally treated in the same way as all other wastes, thus causing harm to the environment.

The waste management situations in the atolls are more pronounced than in the urban areas. Until recently, three regional waste management centres were present in three distinct regions; the north regional waste management centre at Hdh. Kulhudhuffushi, the central regional waste management centre at K.Thilafushi and the south regional waste management centre at Hithadhoo of Addu City. However, the north facility is dysfunctional as it has been constructed in an inhabited island. Waste management at the south facility is also considered marginal. These facilities are non-engineered or partly engineered landfills. Under the Maldives Environment Management Project (MEMP), the first integrated regional waste management facility was established at R. Vandhoo (Box 4.3).

The lack of a solid waste management system in the atolls presents huge challenges to the inhabited islands. In general, disposal practices in most islands are inadequate, with random dumping of waste being widespread. In the islands waste collection services are carried out individually or through community or private entities.

Figure 4-32 shows the common methods of waste disposal used at household level in the atolls. While the most common method of disposal by households include dumping into the designated garbage sites (79.13% islands), the next most common methods are dumping into the beach/seaside (7.19%) and throwing into the bushes (7.46%). Burning in backyards was reported by 4.70% households. Other methods of waste disposal include taking waste to reclamation sites, burying in the house compounds and burning using an incinerator.

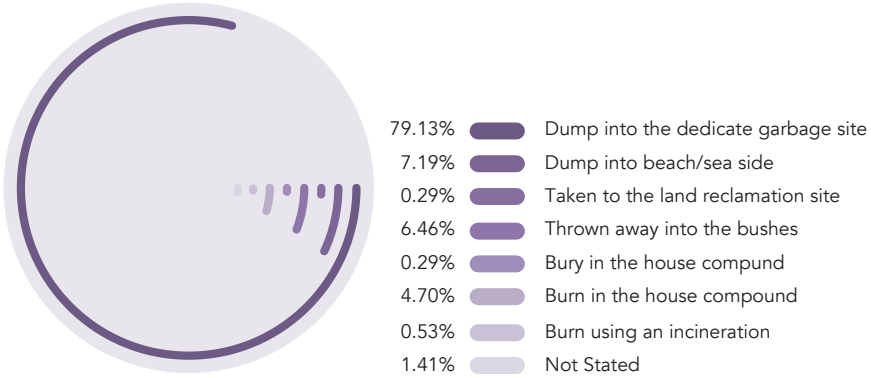


Figure 4-32: Methods of solid waste disposal at household level. (NBS, 2016).

Under the Decentralization Act (7/2010), the island councils are mandated in the management of household solid waste collected at the waste management centres or the designated areas. While just a few islands practice small scale composting and recycling, waste is used by some islands for reclamation purposes. Hard waste and electronic waste are generally stockpiled at disposal sites or at the island periphery. The methods of kitchen waste disposal in the islands were analysed through the State of Environment Survey (Figure 4-33). The most common method was found to be dumping to the sea or beach (63%). A significant amount of islands (17%) bury the kitchen waste. Only 7% of the surveyed islands use open burning to reduce the volume of kitchen waste. While 7% islands practice composting, only 6% islands incinerate kitchen waste.

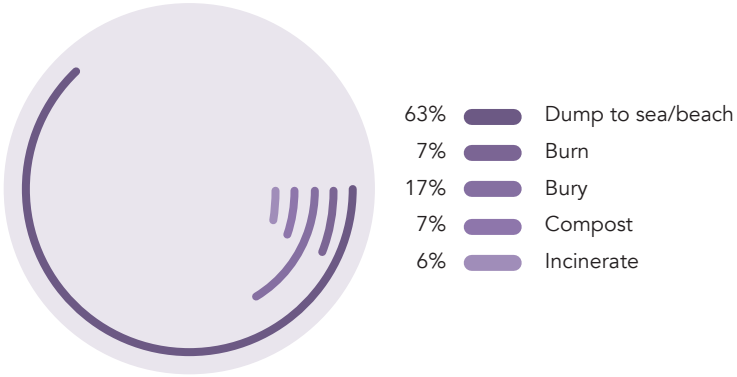


Figure 4-33: Methods of kitchen waste disposal in inhabited islands of the Maldives

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Recycling is not common in the Maldives, particularly due to lack of sufficient financial and technical capacity in the islands. The term recycling in Maldivian perspective is collection and segregation of recyclables and processes them to export. However, considerable recycling activity is carried out in the Thilafushi, where manual segregation of recyclable wastes takes place. Among other recyclable materials, PET and scrap metals are also predominantly found. Most resorts compact metal and plastic discards, which are then either transported to the disposal or recycled. Scavenging rights over all waste received to Thilafushi have been issued to a private company, who periodically crush and export the stockpiled recyclable materials. Statistics from Maldives Customs Service shows that approximately 7,277MT of waste material worth over 50 million MVR was exported in 2014 alone (Figure 4-35). The waste items exported in 2014 included waste oil, parings and scrap of plastics, waste paper, waste and scrap of steel, copper scraps, wastes and scraps of aluminum and battery waste.

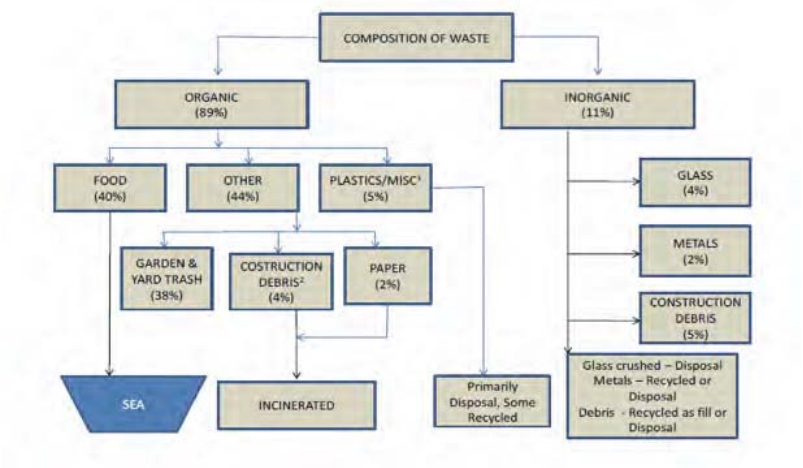

Figure 4-34: Waste composition and management practices at a typical resort. Adapted from (MoT, 2015b).

Note:

1. Miscellaneous includes the organic residues such as textiles, leather and rubber.

Additionally, hazardous waste (1%) was included in this component

2.Organic construction debris includes wood and paper products

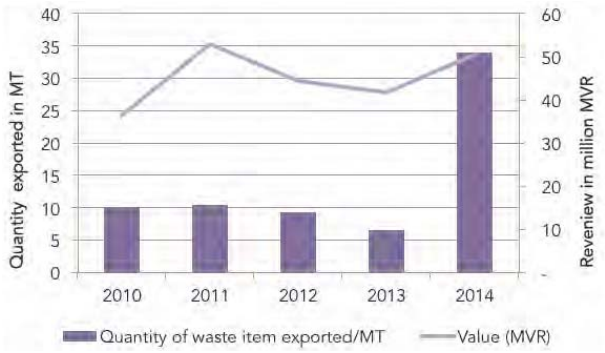

Figure 4-35: Quantity and value of solid waste scrap exported from 2010 to 2014 (Data source: Maldives Customs Service, 2015)

Box 4.4. Recycling Activity: An initiative by Ghiyasuddin International School (GIS)

As part of the Community Service Programme of GIS inaugurated in 22 February 2016, the school is working with a local NGO, Biodiversity Education and Awareness Maldives (BEAM) who is working with communities and school to increase participation to create respect and passion for the living environment. One of their major areas is working towards protecting the oceans. In pursuing this, they have partnered with Parley, a US based NGO working internationally for the Oceans.

Students and staff of the school collected common household plastic which is collected in a bin kept inside the school. Once the bin is full, BEAM collects and sends to the US for recycling. In 2016, a total of 398, 697 items were collected for recycling (Figure 4-36)

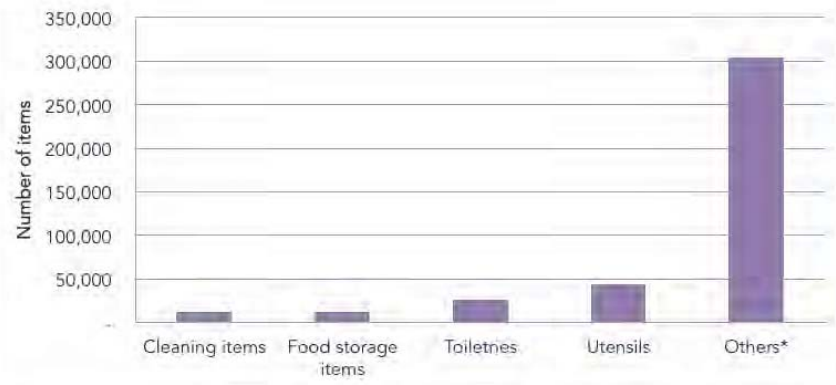

Figure 4-36: Items recycled by GIS in 2016 (Data source: Giyasuddin International School)

*Others include straws, bottle caps, wrappings, shopping bags

Information and image source: (GIS, 2016)

4.3.2. Issues in waste management

Solid waste management is recognized as one of the greatest environmental challenges in the Maldives. The limited availability of land and the dispersion of the islands over a large geographic area are existing natural challenges towards implementing waste management strategies. Over the recent years, the problem of waste management has grown drastically due to a number of reasons, including but not limited to: increase in population, the uneven distribution of this population over a widely dispersed set of islands, limited availability of land, changing life style and consumption patterns and growth of the tourism industry.

Key problems preventing sustainable improvements in solid waste management are: lack of appropriate waste management system, insufficient infrastructure, unavailability of funds which needs to be collected for waste management (such as green tax), absence of appropriate cost recovery mechanisms, inadequate institutional capacity, weak legislative and regulatory framework and limited opportunities for involvement of private sector. In addition, geographic isolation of islands is also a major obstacle.

4.3.3. Impacts on environment and human health

The inappropriate waste management situation in the country is generating significant pollution problems and risks to the environment and human health. In the islands the existing waste disposal sites are often located close to the shoreline. Discharge of leachate from the landfills affects groundwater quality. Litter from the landfills is sometimes carried away by wind into the sea, causing marine pollution. This waste in most cases sinks to the bottom of sea and becomes entangled in the reef, causing harm to the corals and other marine life.

Non-combustible wastes are usually stockpiled in islands due to lack of further management options. The stockpiles contain large amounts of glass, cans and containers which accumulate water, thereby providing suitable breeding grounds for mosquitoes. Furthermore, waste stockpiles attract other vectors including rodents. This increases the risk of spreading vector-borne diseases such as dengue, chickungunya and scrub typhus.

Open burning of waste is practiced in almost all the islands where smoke nuisance, vegetation die off and accelerated coastal erosion problems are experienced. Incomplete combustion of waste is a known source of persistent organic pollutants and particulates. Exposure to air pollutants is linked to a wide range of health problems associated with headache, skin, eye irritations and coughing. Over time it can increase the risk of developing lung and heart diseases. In addition, burning of waste produces large amounts of ash and debris. The ash from the waste may be contaminated with toxic chemicals including dioxins and furans and other potentially harmful carcinogens.

As mentioned before, the most common method of kitchen waste disposal is by dumping in to the sea. Along with sewage, food waste also contributes to the nutrient enrichment in marine waters which causes algal blooms.

4.3.4. Government responses

Recognizing the urgent importance to adopt sustainable waste management practices, substantial efforts are being done to improve the waste management issues in Maldives. Below are the main policy instruments relating to waste management.

Legislative and policy instruments

The EPPA 4/93 is the primary legal instrument for environment management in the Maldives. The following sections of EPPA 4/93 specifically address waste management:

Section 7- Waste disposal, oil and poisonous substances

Section 8- Hazardous/Toxic or nuclear wastes

The National Solid Waste Management Policy (2015) focuses on the following objectives:

- Implement the 3R concept in Maldives in order to reduce waste
- Identify ways to aware people at all levels about proper waste management
- Assign the Ministry of Environment and Energy as the regulatory body that oversees all the works related to waste management and establish waste management systems in all the islands of Maldives
- Establish a plan to manage waste in all the islands and implement the waste management plan
- Establish waste management legal framework and ensure effective implementation of the framework
- Review the regulation regarding management of clinical, infectious and dangerous/hazardous waste and implement this regulation
- Keep a statistical record of waste at island and national level and disseminate this information
- Establish a system to collect fees from waste producers and use this money to fund waste management
- Establish environmentally sound waste management systems in inhabited islands accordingly and provide required resources
- Conduct trainings for best waste management practices and continue to do in a sustainable manner.
- Conduct and update accordingly, the inventory of the waste management systems in inhabited islands
- Establish regional waste management facilities accordingly.
- Establish regional waste management facilities and make necessary arrangements to transfer and manage excess waste from those islands to regional waste management facilities.
- Conduct research on latest waste management technologies
- Encourage industrial islands to develop waste management plans, and monitor its progress.
- Establish a national waste management trust fund.

The Waste Management Regulation (Regulation number 2013/R-58) aims to implement national policies regarding waste management. In this regard this regulation shall implement these policies to conserve the environment by:

• Minimising the direct and indirect negative impact caused to human health and the environment due to waste.
• Compiling the standards to be maintained in relation to waste management.
• Establishing an environmentally friendly, safe and sustainable waste management system through an integrated waste management structure
• Encouraging minimising, reusing, recycling and recovering of waste.
• Implementing polluters pay principle.
• Introducing extended producer responsibility

Section 5 of the regulation developed in response to the Maldives Tourism Act (Law No 2/99), the Regulation on the Protection and Conservation of Environment in the Tourism Industry addresses provisions concerning solid waste management for the tourism sector (MoT, 2015c). Among the requirements of the regulation are:

• Waste collection bins with lids are to be placed for convenient use on leased tourist properties such as resorts.
• The components of discarded wastes (food, glass, metals, toxic or hazardous materials) are to be separately collected
• Waste disposal is to be done in a manner that will have the least impact on the environment.
• All tourist resorts are to have and use incinerators, compactors and bottle crushers
• Waste is to be disposed in the designated area, or in the absence of a designated area, disposed in a manner that is least harmful to the environment
• Food and biodegradable wastes may be dumped in the sea (outside the atoll) in the absence of a designated area for waste disposal in the region.
• Waste burning is only to be done in an incinerator and open burning is prohibited
• Combustibles such as plastics that may produce noxious emissions are not to be burned but rather segregated and transferred to a designated waste management area.

Construction of Island Waste Management Centers

To date, a total of 128 inhabited islands have established waste management centres. Most of the Island Waste Management Centres (IWMCs) were constructed through the post-tsunami rebuilding programs. Substantial efforts are being underway to upgrade the existing IWMCs and establish new waste management centres in further islands (Figure 4-37).

Figure 4-37: Percentage of islands with and without waste management centres and percentage of islands where establishment is ongoing (Data source: Waste Management and Pollution Control Department, Ministry of Environment and Energy, 2015).

Efforts to reduce import of plastic bags

High tariff is charged by the Maldives Customs Services (MCS) on non-biodegradable plastic bags and polyethylene sheets, while zero tariffs are levied on biodegradable plastic bags. The current taxation rates are implemented in order to discourage the import and use of plastic bags which are harmful to the environment. The different tax rates imposed by MCS for the three categories of plastic bags include zero tax rate on biodegradable bags, 15% tax rate on other than biodegradable bags and 400% on non-biodegradable bags. Figure 4-38 presents the amount imported, Cost Insurance Freight (CIF) values and tax charges for the three categories of plastics. Although biodegradable bags have a high CIF value, due to zero taxation rates the import of biodegradable bags is cheaper. Despite the purchase cost of non-biodegradable bags being lower than the other two types, due to the 400% tax rate levied, this becomes the most expensive option.

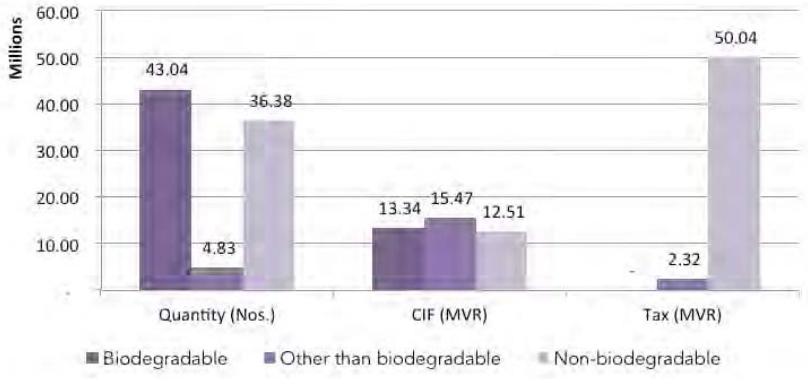

Figure 4-38: The amount imported, CIF values and tax amounts for the three categories of plastic bags imported from January to October 2015 (Data provided by: Maldives Customs Service, 2015)

4.4. Chemical Management

Chemicals play an important role in human life, providing a wide range of economical and societal benefits. However, there is growing awareness that chemicals may pose harmful impacts on the environment and human health. Synthetic chemicals and naturally occurring chemicals used in industrial activities or in consumer products may enter the environment by means of disposal of a used product. Chemicals released into the environment may have a variety of adverse ecological and health effects. Ranging from degradation of soil, groundwater contamination, marine pollution, to affecting fish and other biota, ecological impacts of chemicals can be long-term or short-lived. In addition, a number of health impacts ranging from mild to severe and fatal symptoms are associated with chemicals and their pollutants. Understanding these potential impacts is important for the sound regulation and management of chemicals. However, to date no studies have been conducted to determine the impact of chemicals on the environment or human health in Maldives.

Maldives do not produce any chemicals; hence all its chemical requirements are met through imports. The main pattern of usage of chemicals in Maldives is in the form of consumption of petroleum products in the energy and transport sector, the agricultural industry, construction, boat building, health sector, domestic use and a variety of other uses in the tourism industry. While it is generally known that chemicals use is increasing, the amount of chemical consumption in Maldives is not monitored at present. However, the increase of chemical imports each year reflects the growth in chemical use within the country. From 2010 to 2014, the expenditure on chemical imports has increased by 104.87%, with an average increase of 26.21% per annum.

The high dependence on chemicals and the potential consequences, combined with limited capacity for management of these impacts, makes effective management of chemicals a key cross-cutting issue in the Maldives. Maldives has a cross-sectoral approach in chemical administration, where the Ministry of Defence and National Security (MDNS), Ministry of Health (MoH), Ministry of Environment and Energy (MEE) and Ministry of Fisheries and Agriculture (MoFA) have mandate requirements for chemical administration. However, due to the lack of a specific legislature on chemical management, regulatory mechanism for chemical management remains weak.

Waste burning in Thilafushi

4.4.1. Status and trends

Concurrent with the population growth, urban development and growth in the economic sectors, the increase in chemical imports reflects the growing trend in chemical use within the country (Figure 4-39) In 2014 the gross value of chemical imports exceeded MVR 2 billion, showing an increase of 104.87% from the 2010 baseline. The most widely imported category, as shown in Figure 40-40 is petroleum products, roughly accounting for 41% of the gross value of chemical imports in 2014. Figure 4-41 shows an overview of chemical use in major sectors in Maldives.

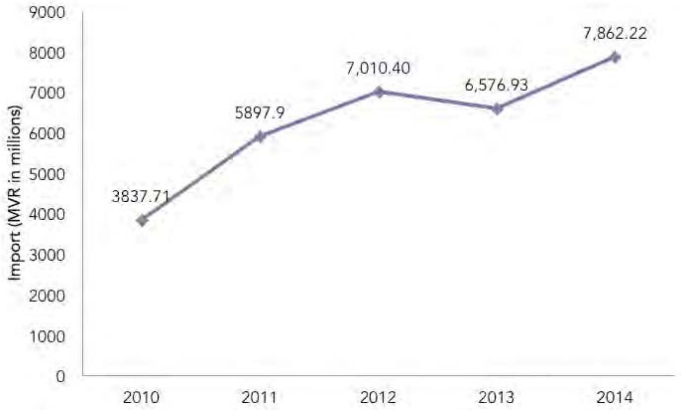

Figure 4-39: Total import value of chemicals into the Maldives from 2010 to 2014 (Data provided by: Maldives Customs Service, 2015)

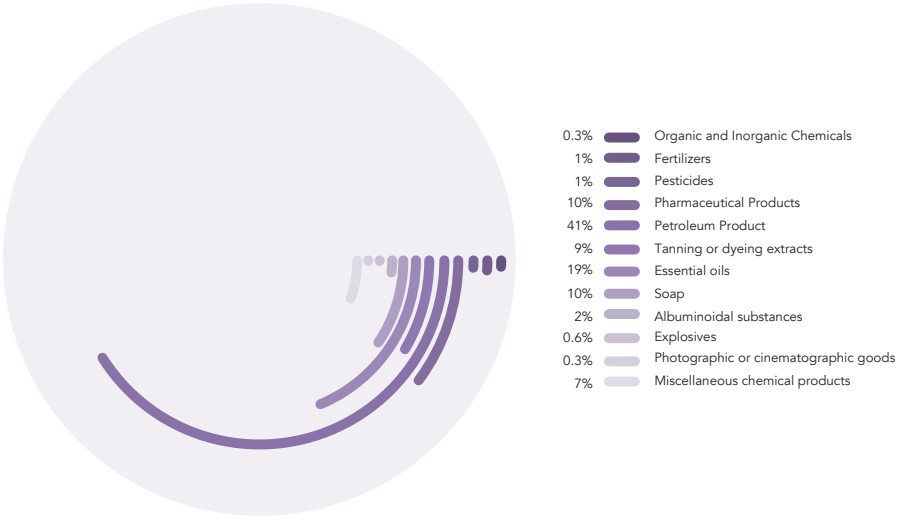

Figure 4-40: Percentage of chemical imports in 2014 by value (Data source: Statistical Division, Maldives Customs Service, 2015)

Figure 4-41: Chemical use in major sectors in Maldives. Information Source (MEE, 2016b)

Imported petroleum products such as diesel, petrol, LPG (cooking gas) and aviation gas are the main source of energy supply within the country, and therefore constitute the bulk of chemicals imported. In 2014 approximately 59,0541MT of petroleum fuel was imported to Maldives. This showed an increase of 19.13% compared to the previous year. The rapid population increase and economic sector growth have led to the increase in fuel import each year (Figure 4-42). Diesel which is the primary fuel imported is used to generate electricity and for sea transport. Petrol is the main transport fuel used for land vehicles, while aviation gas is used for air transport. LPG is used for cooking.

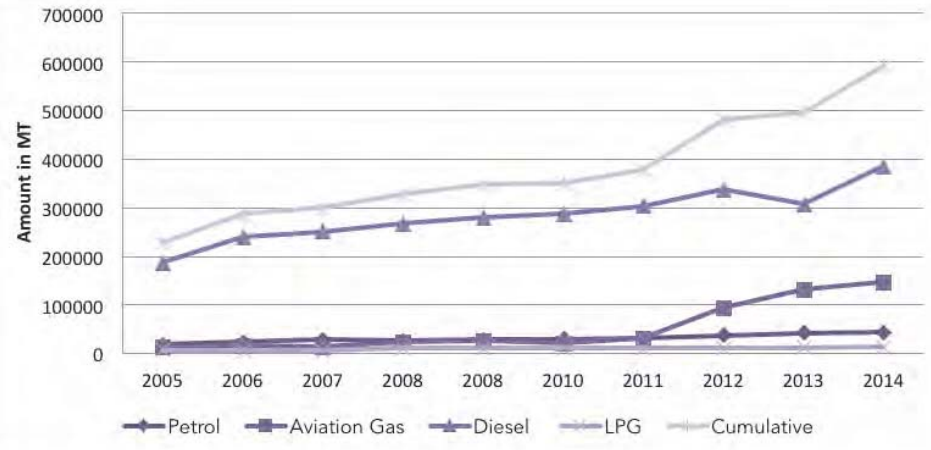

Figure 4-42: Amount of petroleum fuel imported from 2005 to 2014 (Data provided by: Maldives Customs Service, 2015)

The agriculture sector contributes significantly to the food security and livelihood of the atoll population. Although the amount of fertilizers consumed in the islands are not being monitored at present, with recent diversification of the sector, fertilizer use is expected to be high, particularly in agricultural islands. According to MoFA, by the end of 2014, a total of 49 inhabited islands were leased for agricultural purpose. However, the amounts of fertilizers consumed in the islands are not recorded.

In 2013, Maldives imported approximately 1,645MT of chemical fertilizers (Table 4-8). The main products of import were fertilizers containing nitrogen, phosphorous and potassium (N, P, K) compounds. Maldives also imports large amounts of fertilizer such as ammonium sulphate, urea, calcium nitrate, super phosphates, potash and potassium chloride.

Figure 4-43 shows the amounts of pharmaceuticals imported from 2010 to 2014. Over the duration, the largest amounts of pharmaceuticals were imported in 2014. In 2014, approximately 817m^3 and 718MT of pharmaceuticals were imported into Maldives.

Figure 4-44 shows the amount of pesticides imported into Maldives from 2010 to 2014. The MoFA has posed restrictions based on their toxicity. However, there are no controls on placing hazardous pesticides in the local market. In addition, consumer use of pesticides is not recorded.

Table 4-8: Amount of chemical fertilizers imported by the agricultural sector. Adapted from (MEE, 2016b)

Fertilizers by Type		Quantity	
		m^3	Tonnes
Nitrogen fertilizers	Ammonium Sulphate	-	98.85
	Calcium nitrate	1.6	11.97
	Urea	-	112.20
Phosphatic fertilizers	Potassium chloride	-	106
	Potassium oxide	-	5.03
	Superphosphates	-	92.7
	Potash	-	12.416
N, P, K+micro-elements		4.37	1,056.19
Ca, Mg, Na, S fertilizers		0.19	149.59
Total chemical fertilizers		6.17	1,644.92

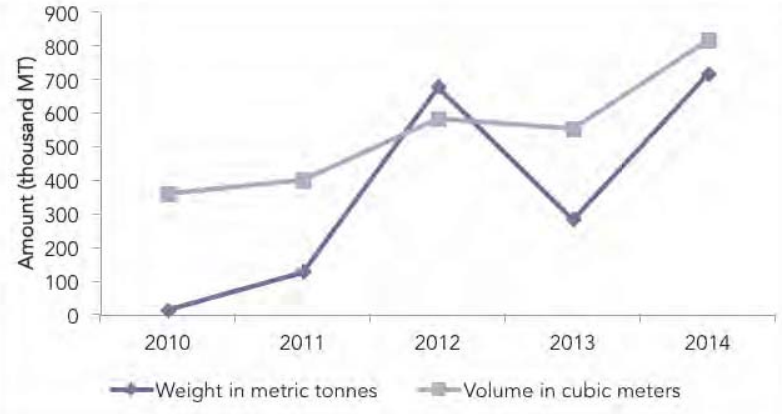

Figure 4-43: Amounts of pharmaceuticals imported into Maldives from 2010 to 2014 (Adapted from MEE, 2016b).

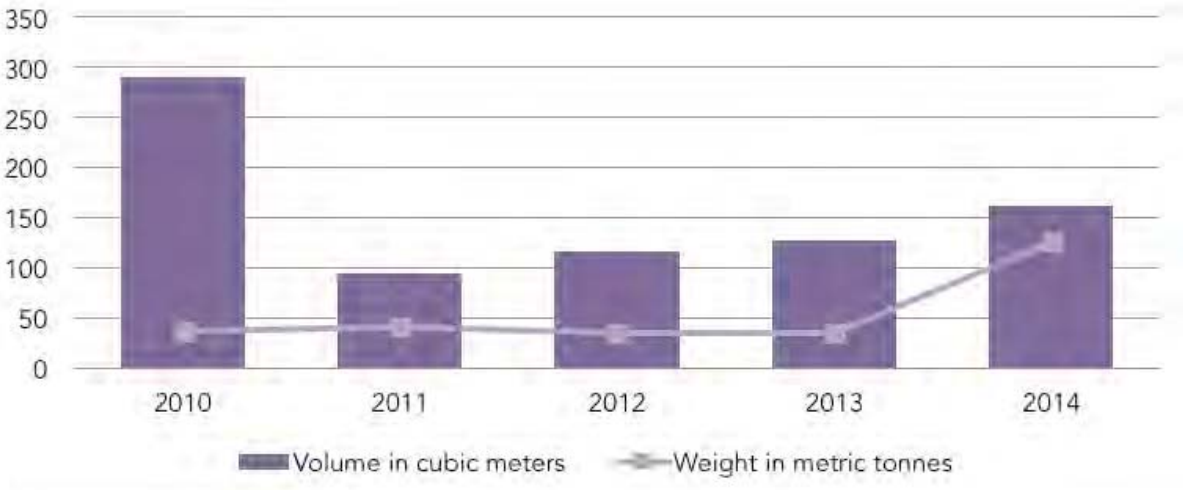

Figure 4-44: Amount of pesticides imported from 2010 to 2014 (Data provided by: Maldives Customs Service, 2015)

4.4.2. Impacts.

Concurrent with the population growth, urban development and growth in the economic sectors, the increase in chemical imports reflects the growing trend in chemical use within the country (Figure 4-39) In 2014 the gross value of chemical imports exceeded MVR 2 billion, showing an increase of 104.87% from the 2010 baseline. The most widely imported category, as shown in Figure 4-40 is petroleum products, roughly accounting for 41% of the gross value of chemical imports in 2014. Figure 4-41 shows an overview of chemical use in major sectors in Maldives.

Impact on environment

The waste dumps including the Thilafushi waste disposal site receives mixed waste from the islands, which are usually disposed without segregation. Waste is disposed by open-air incineration and burying. While burning releases harmful pollutants into the air including GHGs and particulates, toxic chemicals leach through the soil into the waters, polluting the shallow aquifers. Furthermore, oil which is used for burning the rubbish also leak into the surrounding area (MEE, 2015c). Leachate could also enter the sea, leading to marine and coastal pollution.

Persistent organic pollutants (POPs) are toxic chemical compounds that are resistant to biodegradation and therefore remain in the environment for a long period of time. Due to their toxic characteristics, POPs pose adverse effects to human health and the environment. The Preliminary Inventory Report on POPs estimated that burning of mixed waste in landfills emit POPs, including dioxins and furans in the

range of approximately 1,000 micrograms TEQ/ton of material burnt. POPs have been associated with significant environmental impacts in a wide range of species and virtually at all trophic levels (MEE, 2016b). While POPs and their impacts have not been assessed in Maldives previously, studies from other countries have established positive correlation between exposure to POPs and population declines in a number of marine species (Boscher, Gobert, Guignard, Ziebel, & L'Hoste, 2010; Corsolini, Teresa, Ademollo, Greco, & Focardi, 2002; White, Richardson, & Kelsey, 2007).

Burning oil at power houses can produce nitrogen oxides, carbon dioxide, and methane as well as mercury compounds and sulphur dioxide, depending on the sulphur and mercury content in the burned oil.

Agro-chemicals have the potential to pollute the environment. Amount of fertilizers used on agricultural islands are not monitored at present. In addition, information on chemical pollution emissions from the agricultural sector in Maldives is also unavailable. However, farmers are known to use fertilizers without knowing the manufacturer's recommendations, which results in exceeding the required concentrations. Excessive use of fertilizers increases the nutrient levels of nitrogen and phosphorous in the water, causing eutrophication and affecting marine life. Misapplication of fertilizers can also cause degradation of soil and pollute groundwater. Agricultural soils can also release greenhouse gas (GHG) emissions into the environment

Impact on human health

WHO, 2016b estimates that globally 1.3 million lives and 43 million disability-adjusted life-years were lost in 2012 due to exposures to selected chemicals. Although there has not been an assessment done in the Maldives to determine the impacts of chemicals on human health, studies in various regions have examined harmful effects of certain chemicals on human health.

Burning of mixed waste release toxic fumes which cause adverse health effects with symptoms such as headache, nausea, dizziness and breathing difficulty. Pollutant emission from mixed waste are associated with respiratory and heart diseases. POPs are linked to cancer, neurological damage, birth defects, sterility, and defects to immune system (Dalton, et al., 2001; Gilden, Huffling, & Sattler, 2010). Long term exposure to certain agrochemicals including fertilizers pesticides and insecticides may cause adverse impacts to human health through ground water pollution, accumulation in the food chain or direct contact. Agrochemicals can be acutely toxic if present in the food at high levels and may cause health risks with long-term exposure. Many studies have examined the effects of pesticide exposure and links have been found with cancer, problems with fertility and reproduction, respiratory diseases, disruption of hormones, immune systems and nervous systems (Blair, Ritz, Wesseling, & Freeman, 2014; Viel & Richardson, 1993). In Maldives import of pesticides under WHO toxicity classes are banned, except few rhodenticides (MEE, 2016b).

Construction and boat building industry involves exposure to hazardous chemicals including solvent, paints, glues, adhesives, pesticides, uncured resin, hardeners, glass fibre, styrene, asbestos, auxiliary

agents and Fibreglass Reinforced Plastic dust. Exposure to some of these toxic chemicals can cause serious damage to nervous system, kidneys and liver. In addition, formaldehyde which is commonly used in the construction sector and boat building is associated with various health complications such as respiratory disorders. Chronic exposure to formaldehyde has the potential to cause cancer, and therefore is classified as a known carcinogen by the IARC and as a probable human carcinogen by US EPA (MEE, 2016b).

4.4.3. Government responses

The Government of Maldives recognizes the importance of sound management of chemicals and its impacts on the environment and human health. Maldives is signatory to a number of international agreements in relation to chemicals. At the national level, there is no specific legislative means addressing chemicals. The Act no. 4/75 is the main Act concerning chemicals in Maldives, which defines the obligations and rights of MDNS to regulate the importation of chemicals. Chemical administration is divided among four ministries, namely MDNS, MoH, MEE and MFA. Nonetheless, due to the lack of a national chemical Act, fragmentation of responsibilities among different ministries exists. In addition, there is significant gap and lack of adequate regulatory mechanism for managing chemicals due to limited technical and financial capacity within the institutions. However, recent efforts are underway to improve chemical management within the country. In this regards, some significant progress include improvement of waste management situation within the country, and preparation of the National Chemicals Profile (NCP) are some recent efforts towards strengthening the management of chemicals.

Key chemicals-related conventions and agreements to which Maldives is signatory are listed below. Details of the conventions are considered in Section 5.2 of this report.

Stockholm Convention on Persistent Organic Pollutants

Rotterdam Convention on the Prior Informed Consent Procedure

Vienna Convention on the Protection of the Ozone Layer

Montreal Protocol on Substances that Deplete the Ozone Layer

Basel Convention on the Control of Trans boundary Movements of Hazardous Wastes and their Disposal

Convention on the Prohibition of the Development, Production, Stockpiling and Use of Chemical Weapons and on their Destruction (CWC)

Maldives is also a member of, inter alia, the Intergovernmental Forum on Chemical Safety (IFCS) and the Strategic Approach to International Chemicals Management (SAICM).

The key legal instruments relating to chemical management within the Maldives are given in Table 4-9. In addition to these, the Environment Protection and Preservation Act of Maldives (Act no. 4/93), HCFC Regulation (Regulation no. 2010/R-19), the Regulation on the Protection and Conservation of Environment in the Tourism Industry and Waste Management Regulation (Regulation no. 2013/R-58) also contain chemicals related provisions.

Table 4-9: Laws and regulations relating to chemicals and waste management within the country: Information source: (MEE, 2016b).

#	Instrument	Details
1	Substances Prohibited to be Brought into the Maldives (Act no. 4/75)	The object of this Act is to deal with substances that are prohibited to be imported unless for government purposes, or only to be imported with special permission, or materials which are completely prohibited from being imported into the country.
2	Draft Pesticide Bill	Pesticides Bill has been drafted and sent to the Attorney General's Office by MFA. The primary objective of this Bill is to manage pesticides in the country at every stage of its chemical life cycle.
3	Law on Drugs (Act no. 17/2011)	The Law on Drugs makes provisions for the prevention of the use, peddling and trafficking of drugs.
4	Draft Chemical Regulation	This regulation was drafted from rights vested from the Law no. 4/75, under Article no. 5a (3). It was drafted in 2005 and has not yet been enacted. Chemical use categories covered: Different aspects of hazardous chemical management such as its import, sale, use permits, safe handling, storage, and disposal.


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CHAPTER 05
ENVIRONMENTAL GOVERNANCE

Chapter 5 Environmental Governance

The Maldives gives high priority to strengthen environmental governance as to effectively address the current and emerging environmental challenges and integrate sustainable development into the planning process. The Ministry of Environment and Energy (MEE) is the primary government authority with overarching responsibility for protecting and preservation of the environment in Maldives. The MEE coordinates and implement several areas of activities related to environment, climate change, meteorology, energy, water, sanitation, waste and sustainable development goals. The Environmental Protection Agency (EPA) is the regulatory entity, working under the supervision of a governing body under the MEE. The EPA Governing Board is a statutory body, established under the Environment Protection and Preservation Act (4/93). Other regulatory organizations affiliated to the MEE are Maldives Energy Authority (MEA), Maldives Meteorological Services and the Biosphere Reserve of Maalhosmadulu Dhekunuburi (Baa Atoll). Other government ministries and agencies including the Ministry of Fisheries and Agriculture, the Marine Research Centre and Ministry of Tourism play key roles in the management and protection of environment and natural resources. In addition, several Non-Governmental Organizations (NGOs) and international agencies play active roles in promoting awareness, understanding and action towards human and environmental sustainability.

While Maldives has a strong policy and legal framework, weak enforcement and implementation presents challenges for environmental management. EPPA (4/93) which is the main overarching umbrella law concerning environment is over 20 years old. Environmental governance in Maldives involves multiple policies under various organizations. Mandate overlaps often exist between these organizations, acting as barriers for effective governance. In addition, a number of Acts, Regulations and Bills have remained in the draft stage for several years. This section highlights key policy and legal instruments related to environmental management in Maldives. In addition, it also presents the main international and regional conventions ratified by Maldives.

5.1. National laws and policies

Current national environmental policies are based on a sectoral approach to managing of the environment and to work towards the goal of sustainable development. The Environment Protection and Preservation Act (EPPA) of the Maldives, Act No. 4/93 (1993) is the umbrella law for protection and preservation of the environment. In the recent years, significant effort has been made to strengthen the policy context to support environmental protection focusing on wetland conservation, coral reef protection, coastal protection and biodiversity conservation through adopting policies and strategies to support climate change adaptation and mitigation and sustainable environmental management.

5.1.1. National Policies

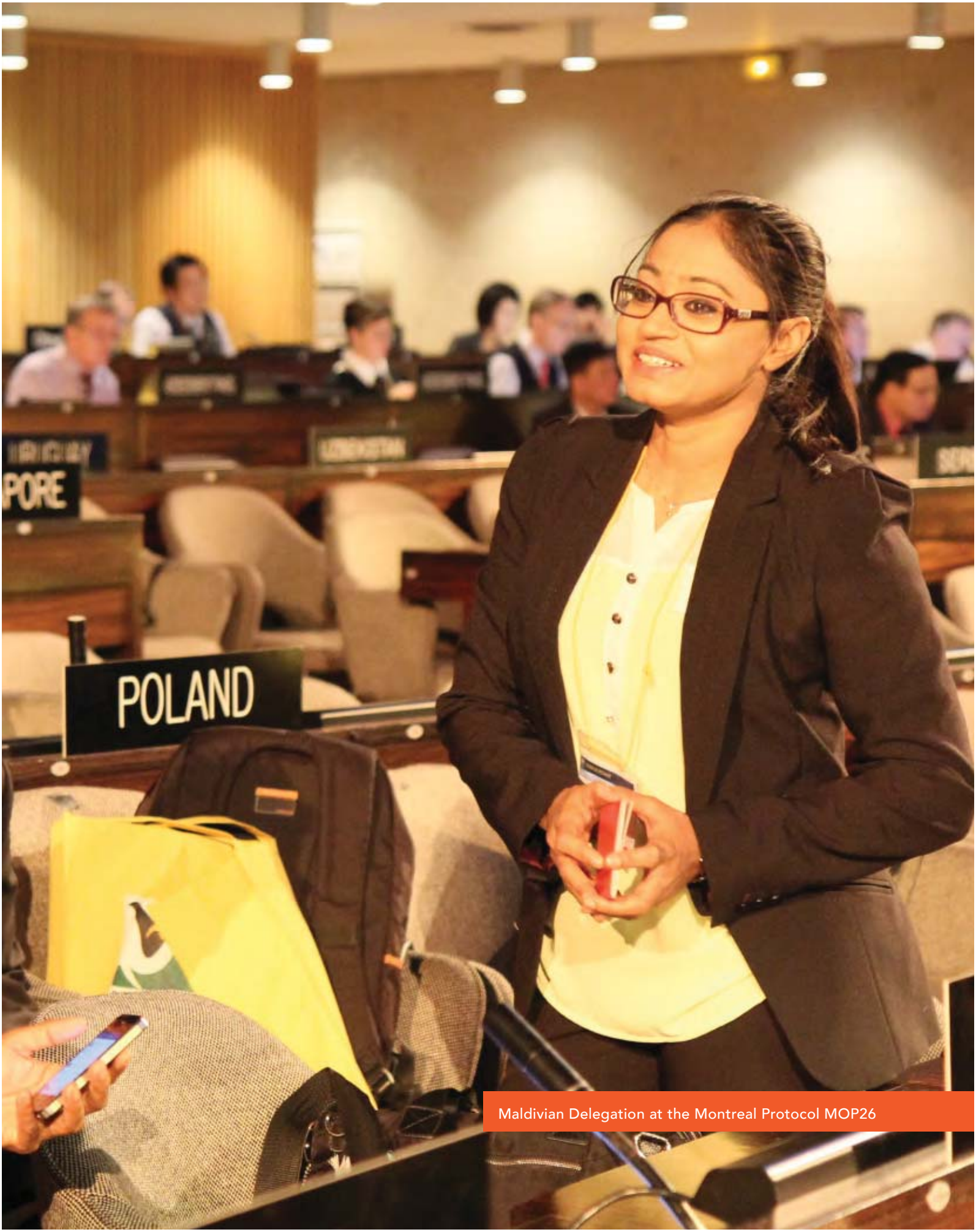
Maldives National Energy Policy and Strategy (2010)

The National Energy Policy and Strategy document include policies, to provide all citizens with access to reliable and sustainable energy services at lowest possible cost, enhancing energy security, promoting energy efficiency and conservation, and moving towards the target of renewable energy based electricity supply.

The Maldives Climate Change Policy Framework (2015)

The Maldives developed and adopted its first comprehensive Climate Change Policy Framework (MCCPF) in August 2015. The MCCPF provides a comprehensive framework for national action and prescribes to the Government strategic policies for responding to climate change impacts from 2015 to 2025. The framework is based around five policy goals:(1) sustainable financing; (2) low emission development and ensuring energy security; (3) adaptation actions or opportunities and building a climate-resilient infrastructure and communities; (4) building local capacity and taking up an advocacy role at international level; and (5) fostering sustainable development (MEE, 2015c).


AMERICA
PINES



Maldivian Delegation at the Montreal Protocol MOP26

National Solid Waste Management Policy (2015)

The Policy focuses on the following objectives:

- Implement the 3R concept in Maldives in order to reduce waste
- Identify ways to aware people at all levels about proper waste management
- Assign the Ministry of Environment and Energy as the regulatory body that oversees all the works related to waste management and establish waste management systems in all the islands of Maldives
- Establish a plan to manage waste in all the islands and implement the waste management plan
- Establish waste management legal framework and ensure effective implementation of the framework
- Review the regulation regarding management of clinical, infectious and dangerous/hazardous waste and implement this regulation
- Keep a statistical record of waste at island and national level and disseminate this information
- Establish a system to collect fees from waste producers and use this money to fund waste management
- Establish environmentally sound waste management systems in inhabited islands accordingly and provide required resources
- Conduct trainings for best waste management practices and continue to do in a sustainable manner.
- Conduct and update accordingly, the inventory of the waste management systems in inhabited islands
- Establish regional waste management facilities accordingly.
- Establish regional waste management facilities and make necessary arrangements to transfer and manage excess waste from those islands to regional waste management facilities.
- Conduct research on latest waste management technologies
- Encourage industrial islands to develop waste management plans, and monitor its progress.
- Establish a national waste management trust fund.

National Biodiversity Strategy and Action Plan (NBSAP)

Under its commitments to the CBD, the Maldives developed its second National Biodiversity Strategy and Action Plan (NBSAP) in 2016, which is the key policy and planning document towards protection and conservation of biodiversity

5.1.2. Acts

Act on Sand Mining (1978)

The Act which requires obtaining permission prior to sand mining from inhabited islands.

The Fisheries Act of Maldives (Law No. 5/87)

The Act relating to fishing , capturing or taking of living resources in the seas of the Exclusive Economic Zones of the Maldives.

Under the Fisheries Act several species have been identified to receive protection against exploitation, trade and/or export.

Environment Protection and Preservation Act of Maldives (EPPA) (Act No. 4/1993)

This law provides the legal basis for environmental protection, preservation and conservation in the country. This law contains provisions for conservation of biological diversity, management of protected areas and natural reserves, environment impact assessment procedures and guidelines, disposal of waste, oil and poisonous substances, and transboundary movement of hazardous, toxic or nuclear waste.

The Maritime Zones of Maldives Act (Law No. 6/96)

This Act makes provision in respect of internal waters, territorial sea and contiguous zone and the Exclusive Economic Zone of the Maldives.

Maldives Tourism Act (Act No. 2/99)

This Act provides for the determination of zones and islands for tourism development, the leasing of islands for development as tourist resorts. It contains provisions for regulations on protection and conservation of environment.

Ozone Protection Act (41/2015)

The aim of this Act is to reduce, control and manage the import and use of ozone depleting substances, alternatives to ozone depleting substances and its equipment to the Maldives

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5.1.3. Regulations

Fisheries Regulation (2000)

This regulation drawn under the Fisheries Law of Maldives and regulates fishing in the lagoons and reefs of inhabited islands and resorts, prohibition of several activities which may harm the ecosystem or the biological diversity, and prohibition of catching of several coral, reef and fish species.

Regulation on Coral and Sand Mining (2000)

Within the Fisheries Act, this regulation regulates coral and sand mining in the Maldives through a system of designated areas which requires prior permission.

The Regulation on Cutting, Uprooting, Removing and Transfer of Palms and Trees between Islands(2006)

The main purpose of this regulation is to minimize the ill effects posed by deforestation of the Nation's environment and to use our land in a sustainable way. Under the regulation, the removal of coastal

vegetation growing around the islands extending to about 15 meters into the islands, all the trees and palms growing in mangrove and wetland spreading to 15 meters of land area and all trees that are in protected areas are prohibited.

The Regulation on the Protection and Conservation of Environment in the Tourism Industry (2006)

This regulation stipulates the standards for the protection and conservation of environment in the tourism industry. Its purpose is to encourage and facilitate sustainable development of tourism as well as protect ing the environment.

National Wastewater Quality Guidelines (2007)

This guideline was developed with the purpose to improve public health through improved sanitation and provide a cleaner and safer environment by regulating the disposal of domestic wastewater.

Regulation for Determination of Penalties and Obtaining Compensation for Damages Caused to the Environment (Regulation No. 2011/R-6)

The purpose of this regulation is to stop violations of EPPA (Law No. 4/93); to prevent the repetition of such violations; to penalize and obtain damages caused to the environment

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Environmental Impact Assessment Regulation (EIA) (Regulation No. 2012/R-27)

The EIA Regulation was established under the EPPA (Law No. 4.93) and provides the basic framework for EIA process in the country. EIA ensures minimization of impacts from development projects.

Regulation on Dredging and Reclamation of Harbours (Regulation No. 2013/R-15)

The aim of this regulation is to fulfill the provisions laid under the Article 3 of the EPPA (Law 4/99) with regards to minimizing any damage caused to the ecosystem due to dredging and reclamation actions

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Waste Management Regulation (Regulation number 2013/R-58)

The purpose of this regulation is to implement national policies regarding waste management. In this regard this regulation shall implement these policies to conserve the environment by:

- Minimising the direct and indirect negative impact caused to human health and the environment due to waste.
- Compiling the standards to be maintained in relation to waste management.
- Establishing an environmentally friendly, safe and sustainable waste management system through an integrated waste management structure
- Encouraging minimising, reusing, recycling and recovering of waste.
- Implementing polluters pay principle.
- Introducing extended producer responsibility.

Minister of Environment and Energy Hon. Thoriq Ibrahim speaking at the Ministerial Roundtable during Montreal Protocol MOP26

5.2. International and regional agreements

The Maldives has continued to work in the wider international context in making commitments to global efforts in environmental protection and sustainable development. Maldives has played key roles in highlighting the special vulnerability of low-lying small islands developing states to the climate change and in getting the attention to this issue in the international forums. Some key international and regional environmental agreements to which Maldives are signatory are mentioned below.

Vienna Convention and Montreal Protocol

The Maldives signed the Vienna Convention for the protection of the ozone layer in 1988 and the Montreal Protocol in 1989. The Montreal Protocol on substances that deplete the ozone layer aims to protect the ozone layer by phasing out the production of numerous substances believed to be responsible for ozone depletion.

United Nations Framework Convention on Climate Change and Kyoto Protocol

The Maldives ratified the UNFCCC in 1992 and was the first to sign the Kyoto Protocol to the UNFCCC in 1998. The UNFCCC promotes actions to reduce greenhouse gas concentrations in the atmosphere.

Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal

The Basel Convention was designed to reduce the movements of hazardous waste between nations, and specifically to prevent transfer of hazardous waste from developed to less developed countries. Under the Convention, Parties have an obligation to ensure that transboundary movements of hazardous wastes are reduced to a minimum. Maldives ratified the Basel Convention on 28 April 1992

Male' Declaration on Control and Prevention of Air Pollution and its Likely Transboundary Effect for South Asia

One of the first major initiatives towards air pollution management has been the Male' Declaration on Control and Prevention of Air Pollution and its Likely Transboundary Effect for South Asia. The Declaration was adopted in 1998 at the seventh meeting of the Governing Council of South Asia Co-operative Environment Programme (SACEP), held in Male', Maldives.

Rotterdam Convention on the Prior Informed Consent Procedure for Certain Hazardous Chemicals and Pesticides in International Trade

The Rotterdam Convention is a multilateral treaty to promote shared responsibilities in relation to import of hazardous chemicals. The convention promotes open exchange of information and calls on exporters of hazardous chemicals to use proper labelling, include directions on safe handling and inform purchasers of any restrictions or bans. Signatory nations can decide whether to allow or ban the import of chemicals listed in the treaty, and exporting countries are obliged to make sure within their jurisdiction to comply with the terms of the convention. Maldives signed the Convention in October 2006.

Stockholm Convention on Persistent Organic Pollutants

The Stockholm Convention on Persistent Organic Pollutants is an international environmental treaty that aims to eliminate or restrict the production and use of persistent organic pollutants (POPs). Parties must develop a National Implementation Plan (article 7) and designate a National Focal Point (article 9). They are to promote and facilitate a wide range of public information, awareness and education measures (article 10) and are required to encourage and undertake research, development, monitoring and cooperation on all aspects of POPs and their alternatives (article 11). Furthermore, parties have obligations to report on the measures they take to implement the Convention, on the effectiveness of measures taken and on data/estimates for the total quantities of POPs traded and lists of states involved (article 15). COP-1 determined that reports have to be submitted every five years. Maldives ratified Stockholm Convention on 17 October 2006.

Climate and Clean Air Coalition (CCAC)

CCAC is a global effort that unites governments, civil society and private sector, committed to improving air quality and protecting the environment in next few decades by reducing short-lived climate pollutants across sectors. CCAC was initiated by the governments of Bangladesh, Canada, Ghana, Mexico, Sweden and the United States, along with the United Nations Environment Program (UNEP). At present CCAC have 51 country partners, 16 IGO Partners and 45 NGO Partners. Maldives joined CCAC in December 2012.

Convention on Biological Diversity (CBD)

Maldives ratified CBD on 29th December 1993. The three main goals of CBD include the conservation of biodiversity; sustainable use of biodiversity components; and sharing the benefits arising from the commercial and other utilization of genetic resources in a fair and equitable way.

At the 10th meeting of the Conference of the Parties, Strategic Plan for Biodiversity 2011- 2020 including

the Aichi Biodiversity Targets 2011- 2020 was adopted. Providing an overarching framework on biodiversity, Parties agreed to revise their National Biodiversity Strategy and Action Plan (NBSAP) according to the Strategic Plan for Biodiversity 2011 – 2020. There are 20 targets under Aichi Biodiversity Targets, supporting four strategic goals. Following the meeting, the existing NBSAP of Maldives was revised and NBSAP 2016-2025 was launched in July 2016.

Cartagena Protocol on Biosafety

On 29 January 2000, the Conference of the Parties to the CBD adopted a supplementary agreement to the Convention known as the Cartagena Protocol on Biosafety. The Protocol seeks to protect biological diversity from the potential risks posed by living modified organisms resulting from modern biotechnology. Maldives ratified Cartagena Protocol on 11 September 2003.

Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES)

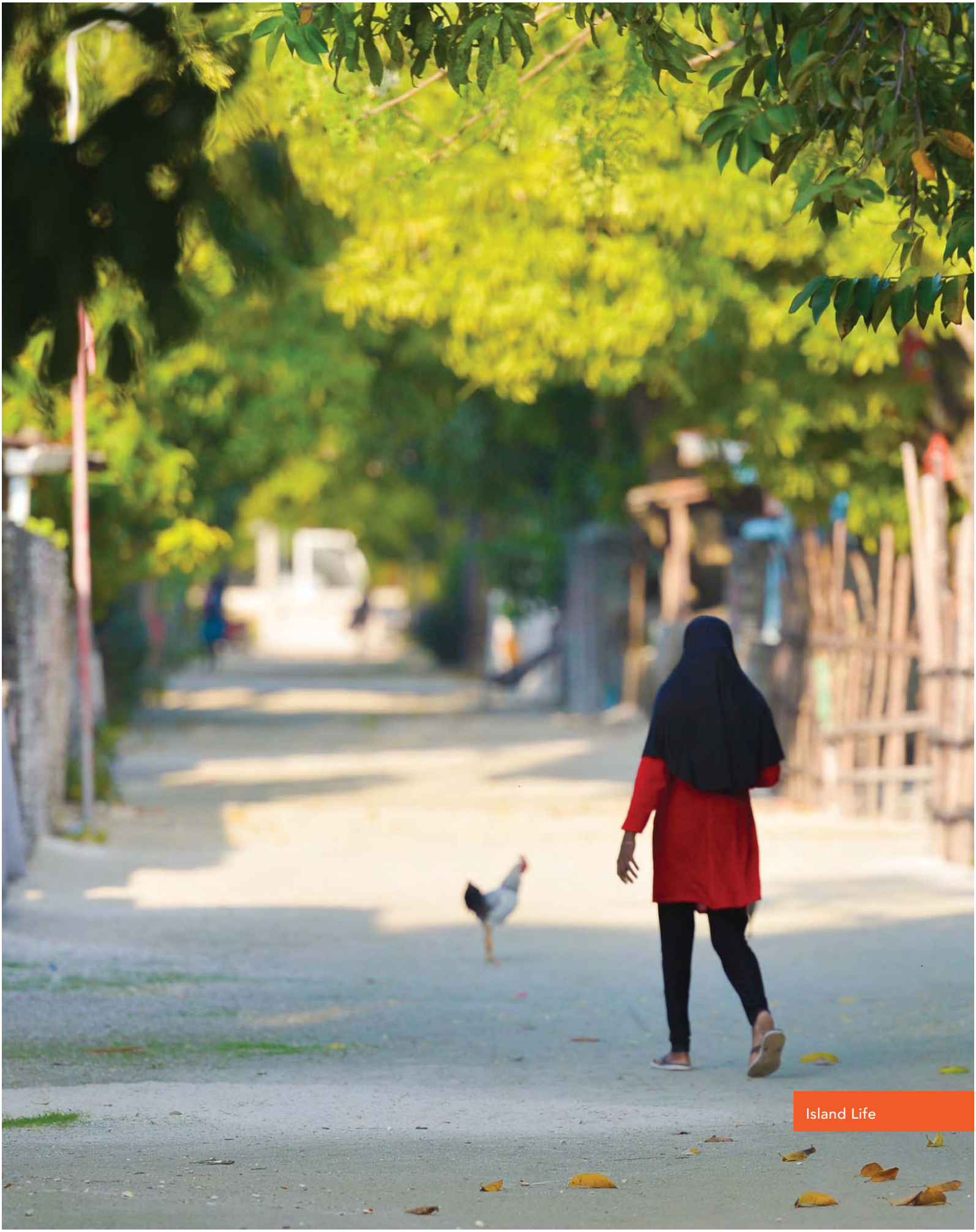
Maldives ratified CITES in March 2013. CITES is aimed towards strengthening effective regulation in trade of CITES listed species, endangered species and alien species in general.

International Plant Protection Convention

The Maldives has become a party to International Plant Protection Convention (IPPC) on 3 October 2006, as a step to protecting native plant species in the Maldives from the risk of diseases introduced by imported plant varieties.

Indian Ocean Tuna Commission (IOTC)

Maldives became a member of the IOTC on 13 July 2011. IOTC is an intergovernmental organization responsible for the management of tuna and tuna-like species in the Indian Ocean through promoting cooperation among its Contracting Parties and Cooperating Non-Contracting Parties to ensure the conservation and appropriate utilization of fish stocks and encouraging the sustainable management of fisheries (Indian Ocean Tuna Comission, 2016).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