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COUNTRY REPORT
CLIMATE RISK MANAGEMENT IN MALDIVES

Regional Integrated Multi-Hazard Early Warning System for Africa and Asia (RIMES)
January, 2013

United Nations Development Programme

CRISIS PREVENTION AND RECOVERY

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LIST OF ABBREVIATIONS AND ACRONYMS

AEC	Atoll Ecosystem Conservation
BCPR	Bureau for Crisis Prevention and Recovery
BDP/EEG	Bureau for Development Policy Energy and Environment Group
CCA	Coastal Community Adaptation
CCAC	Climate Change Advisory Council
CRM	Climate Risk Management
CRM TASP	Climate Risk Management Technical Assistance Support Project
DIRAM	Detailed Island Risk Assessment in Maldives
DNP	Department of National Planning
DRR	Disaster Risk Reduction
ENSO	El Niño Southern Oscillation
EPA	Environment Protection Agency
EWS	Early Warning System
GCM	Global Climate Model or General Circulation Model
GDP	Gross Domestic Products
GFDL	Geophysical Fluid Dynamics Lab
GIS	Geographic Information System
HadCM3	Hadley Centre Coupled Model, Version 3, United Kingdom
HIES	Household Income and Expenditure Survey
INCOIS	Indian National Centre for Ocean Information Services
IPRC	International Pacific Research Center
ITCZ	Inter Tropical Convergence Zone
LTTD	Low Temperature Thermal Desalination
MACI	Maldives Association of Construction Industry
MHA	Ministry of Home Affairs
MHTE	Ministry of Housing Transportation and Energy
MJJASO	May June July August September October
MMS	Maldives Meteorological Service
MNDF	Maldives National Defence force
MOES	Ministry of Earth Sciences
MRC	Marine Research Centre
MRF	Maldivian Rufia
NAPA	National Adaptation Programme of Action
NDMC	National Disaster Management Centre
NDP	National Development Plan
NE	North East
NGO	Non-Government Organization
NIOT	Institute of Ocean Technology

PFZ	Potential fishing zones
PPP	Public Private Partnerships
RCM	Regional Climate Model
RegCM	Regional Climate Model
RIMES	Regional Integrated Multi-hazard Early Warning System for Africa and Asia
SAP	Strategic Action Plan
SD	Standard Deviation
SNAP	Strategic National Action Plan
SSH	Sea Surface Height
SST	Sea Surface Temperature
SW	South West
UNDP	United Nations Development Program
UNDP CO	United Nations Development Program Country Office
VCR	Video Cassette Recorded
WDC	Women's Development Committees
WMO	World Meteorological Organization

FOREWORD

Climate change has the potential to exacerbate conflict, cause humanitarian crises, displace people, destroy livelihoods and set-back development and the fight against poverty for millions of people across the globe.

For example, it is estimated that over 20 million people in the Mekong Delta and 20 million in Bangladesh could be forced to move as their homes are affected by saltwater incursion from rising sea levels. Entire populations of some low lying island states, such as Nauru or the Maldives may have to be relocated. In countries like Honduras, where more than half the population relies on agriculture, climate induced risks, such as hurricane Mitch in 1998, which caused over USD 2 billion in agricultural losses, will continue to pose a staggering potential for damage. Similarly, climate risk assessments in Nicaragua show that changes in rainfall patterns, floods and drought could put human health at risk by increasing the prevalence of respiratory and water borne diseases and malnutrition.

Long-term incremental changes will mean that people everywhere must learn to adapt to weather or rainfall patterns changing, or to shifts in ecosystems that humans depend upon for food. Perhaps more worrying however, is that climate variability and change will also bring unpredictable weather patterns that will in turn result in more extreme weather events. Heat waves, droughts, floods, and violent storms could be much more common in the decades to come. Climate change is "loading the dice" and making extreme weather events more likely. These disasters will undermine the sustainability of development and render some practices, such as certain types of agriculture, unsustainable; some places uninhabitable; and some lives unliveable.

As climate change creates new risks, better analysis is needed to understand a new level of uncertainty. In order to plan for disasters, we need to understand how climate change will impact on economies, livelihoods and development. We need to understand how likely changes in temperature, precipitation, as well as the frequency and magnitude of future extreme weather will affect any sector, including agriculture, water-use, human and animal health and the biodiversity of wetlands.

This report is a product of the *Climate Risk Management – Technical Assistance Support Project*, which is supported by UNDP's Bureau for Crisis Prevention and Recovery, and Bureau for Development Policy. This is one in a series of reports that examine high-risk countries and focus on a specific socio-economic sector in each country. The series illustrates how people in different communities and across a range of socio-economic sectors may have to make adaptations to the way they generate income and cultivate livelihoods in the face of a changing climate. These reports present an evidence base for understanding how climatic risks are likely to unfold. They will help governments, development agencies and even the communities themselves to identify underlying risks, including inappropriately designed policies and plans and crucial capacity gaps.

This series is part of a growing body of climate change adaptation resources being developed by UNDP. The Climate Risk Management – Technical Assistance Support Project has formulated a range of climate risk management assessments and strategies that bring together disaster risk reduction and climate change adaptation practices. The project is designing a common framework to assist countries in developing the necessary capacity to manage climate-induced risks to respond to this emerging threat. The climate risk assessments discussed in this report and others in the series will feed into a set of country-level projects and regional initiatives that will inform the practice of climate risk management for decades to come.

Addressing climate change is one of UNDP's strategic priorities. There is strong demand for more information. People at all levels, including small communities want to understand the potential impact of climate change and learn how they can develop strategies to reduce their own vulnerability. UNDP is addressing this demand and enabling communities and nations to devise informed risk management solutions. UNDP recognises that climate change is a crucial challenge to sustainable development and the goal of building resilient nations.

As the full effect of climate change becomes apparent, it is assessments such as these that will become the lynchpin of national responses and adaptation strategies for many years to come. Like the threat from many disasters, there is still time to prepare for the worst impacts of climate change in developing countries if we expand our understanding now.

This knowledge must be combined with real preparedness and action at all levels. Only then will we be able to stave off the worst impacts of climate change in the most vulnerable and high risk countries of our world.

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The Project, its methodology and analytical framework was conceptualized by Maxx Dilley, Disaster Partnerships Advisor and Alain Lambert, Senior Policy Advisor, Disaster Risk Reduction and Recovery Team (DRRT), BCPR with key inputs from Kamal Kishore, Senior Programme Advisor, DRRT, BCPR and in consultation with Ms. Bo Lim, Special CC Advisor, Environment and Energy Group (EEG), BDP.

Within BCPR, the Project implementation process has been supervised by Alain Lambert and Rajeev Issar who provided regular inputs to ensure in-depth climate risk assessments and identification of tangible risk reduction and adaptation options. From BDP, Ms. Mihoko Kumamoto and Ms. Jennifer Baumwoll provided their inputs and comments to refine the assessment and recommendations. The climate risk assessment has also benefitted immensely from the strategic guidance provided by Jo Scheuer, Global Coordinator, DRRT, BCPR and by Ms. Veerle Vandeweerd, Director, EEG, BDP.

The Project team would like to acknowledge and give special thanks to the main authors of the Report from RIMES.

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The climate risk assessments under the CRM-TASP project have been undertaken with the funding support of the Government of Sweden.

EXECUTIVE SUMMARY

Maldives is an island nation in the middle of the Indian Ocean. It is the smallest Asian country in both population and land area. With an average ground level of 1.5 meters (4 ft 11 in) above sea level, it is also the world's lowest country.

Its 1192 islands cover an area of around 90,000 sq. km. with a coastline of over 800 kms. Only 1 percent of its land area is suitable for human occupation. It has a total population of around 300,000 people. It is one of the world's most geographically dispersed countries, with 3 islands having land area of around 500 hectares including the national capital Male, inhabiting 120,000 people, and two-thirds of the remaining population spread over 203 islands. All islands with land area of 50 hectares are fully occupied. 949 islands with less than 25 hectares have some available space. The density of population is as high as 45,900 persons per sq. km in Male. In most other islands, the population density is between 50 to 100 persons per sq. km.

Maldives is an upper middle income country with its economic structure dominated by the tourism and fisheries sectors. These two sectors contribute directly and indirectly to more than 80 percent of its GDP. They also support 70 percent of the work force, contribute to 90 percent of government revenue and 90 percent of the national foreign exchange earnings.

The economy of Maldives has grown very rapidly in the last decade -- at the rate of 6.5 percent GDP. The development process of Maldives entailed huge pressure on natural resources that supports the critical sectors of tourism and fisheries. From 1970s onwards, the population of Maldives has increased four-fold from 70,000 to 350,000 people and the economy has expanded 10 times from less than US$ 200 million to almost US$ 2 billion in GDP (2012). Population and development have exerted pressure on its scarce land resources in Maldives that constitute 1 percent of its total area. Maldives underwent a land modification process in the last two decades, which involved change in land use systems, and addition of land through land reclamation. The land modification process largely disregarded the fragile coral based environment, ecosystems and climate risk features. This resulted in poor design of critical infrastructure for water, sanitation, drainage, settlements, waste disposal, communication and health.

This development pattern particularly in the small islands (with less than 0.5 sq km), weakened the first line natural defences like coral reefs, mangroves and coastal vegetation. It thus exposed existing and new critical infrastructures like roads, airports, harbours, coastal protection structures, tourist facilities, hospitals and schools to climate risks. The value of new assets exposed to climate risks is around US$ 2 billion.

In recognition of these challenges, the Government of Maldives (GoM) has proposed to build an environment friendly and diversified economy as part of its Seventh Development Plan and policy documents. It strives for a sustaining growth rate of 6 percent to meet the needs of its growing population and the demands of their living standards. However, it is expected that development aspirations of growing population might increase the countries' initial dependence on tourism and fisheries before alternate economic diversification in the short and medium term is undertaken.

For instance, within the tourism sector, in addition to the existing 87 island resorts there are plans to develop 30 additional islands increasing the current bed capacity from 21,000 to 35,000 to attract around 1 million tourists. The fisheries sector is also under tremendous stress as capital investment is rapidly increasing with privatization, and making the sector and local community vulnerable. Last two decades of development induced vulnerabilities and the future development processes will expose more critical infrastructure, economic systems and production to risk. Climate change is projected to further aggravate this risk.

Considering the GoM's current and near term socio-economic development priorities, the resources available for development and environment management are very limited. Currently, almost 80 percent of the government's expenditure is dedicated to financing recurring expenditures and 20 percent for development expenditure.

There is little consensus on prioritising hard engineering or soft climate adaptation options. The hard engineering options are estimated to be around US$ 2 billion and hence capital intensive. The soft options require recurrent operational and maintenance expenditure. A cost benefit analysis of adaptation options, including technical capacities and civil service management systems, indicates that costs of hard and some soft engineering options far outweigh the benefits, with the exception of favourable benefit in investing in high frequency low impact hazards that have high cumulative impact. Considering its narrow economic base, the GoM has expressed constraint in resources to implement the costly adaptation options recommended by various studies and surveys.

Considering the development context, especially the relationship between economic and environmental sectors and the institutional and technical capacities of the Maldivian climate sensitive stakeholders, the CRM TASP analysis recommends the following way forward:

1. Prioratize **strategic entry level adaptation options** that could be integrated into current development planning process and environment practices of Maldives. For example, the focus should be initially on high frequency and low impact climate related hazard management options to address accumulated risks, build resilience, further environmental preservation and conservation processes, identify the manifesting climate change risks and allow time for adaptation learning processes. Initial adaptation options should be convincing to communities and GoM at first and then expand the scope and or scale up initiatives.

2. Develop a **clear and well-resourced institutional framework for CRM** to identify, formulate and implement policies and programmes in Maldives. The framework should be built around the MoEE's Climate Change Division and its capacities in terms of adequate financial and qualified technical personnel must be built to help coordinate and implement the new CRM programmes and policies.

3. **Develop capacities of stakeholder institutions** within the government and beyond that are mandated, responsible and sensitive to climate risks. This primarily includes the MMS.

4. **Commercialization of selected weather and climate services by the MMS** on a cost recovery basis in the short and medium term. The revenue generated could be used to strengthen the MMS's financial muscle for implementing climate risk reduction functions and building its long term capacities.

5. **Capitalise on CRM resources of government and voluntary organisations** to bridge the gap between the MMS resources and the needs of the WMO Global Framework for Climate Services. Resources may be mobilized essentially in the areas of data acquisition and provision of climate information for agriculture and DRR. Preference should be given to local bodies that are likely to be sustainable and connected to communities at risk.

6. **Strengthen climate information systems** by incorporating weather and climate forecasts and climate risk information in a dynamic manner, so that risks are identified on different time scales and communicated effectively to different user groups.

7. **Strengthen climate risk assessment capacities using** different thresholds specific to critical infrastructure and other economic considerations so that risk is both accounted for and provides a basis for evolving ongoing assessment systems. It should also have an integrated approach including data from all climate-sensitive departments, including the MMS.

8. **Propose small and acceptable climate adaptation options** with low operational and maintenance cost for resorts and island communities. For example, the adaptation options recommended by the DIRAM survey could be presented to stakeholder groups to get their feedback and acceptance.

9. Once the climate risk information process is established **sector-specific climate risk information processes** should be developed for priority sectors like tourism, fisheries and agriculture. It should be a multi-stakeholder process involving and addressing all local actors timely.

10. **Develop a common CRM alert protocol** by assisting the MMS and other climate risk sensitive sectors to help speedy dissemination of climate risk information, remove distorted signals from different actors in times of impending climate related hazards and facilitate easy dissemination to all at risk populations using available communication technologies.

11. **Comprehensive risk-based EWS for islands** should be developed to help each island manage weather related risks to critical infrastructure and production processes. It could serve as an entry-point to constantly assess the risks, upgrade vulnerability status and design adaptation options for climate change. For example, the Indian National Center for Ocean Information Services (INCOIS) ocean state forecast information on wave heights and directions could be downscaled to each island by the MMS in collaboration with regional technical institutions on EWS, to make navigation safer.

12. **Explore the potential role of information and communication technology (ICT) in sharing climate risk data and information**. For example, mobile telecommunications for data and information transmission, through weekly agro-meteorology bulletins and real-time data sharing between the MMS/NDMC and local data collection/information dissemination partners. This will address issues of climate data scarcity; improve climate risk modeling and improve climate information.

13. **Biodiversity and environmental management** will be a cost-effective way of securing the production processes in the sectors of tourism, fisheries and agriculture. At the national level institutional and policy changes can be made and at the local level capacity of both the information providers and users should be strengthened for better management of natural resources such as coral reefs and water resources that support the above critical sectors.

14. **Better understanding of water scarcity issues and its management options** to address scarcity of water for drinking and household purposes. For example, a contingency plan with drought related EWS could be developed to manage drinking water system effectively and maintain the existing water storage capacity by private and community storage facilities, innovative technologies like the Low Temperature Thermal Desalination (LTTD) for most critical islands etc.

15. **Strengthen and replicate Seasonal (Monsoon) Forums** in different islands, sectors and departments in Maldives. The successful pilot of this forum in the Fuvahmulak island was appreciated by the participating departments of tourism, education, environment, the MNDF, and Atoll Council among others.

INTRODUCTION

BACKGROUND

Climate risk management (CRM) is an inter-disciplinary, multi-stakeholder process that involves analysis of climate-related risks leading to consensus-based identification and prioritization of risk management actions to anticipate and manage both existing and emerging climate risks.

Climate change can further alter the observed climate mean, cause changes in the nature of extremes (severity, frequency, spread, duration and timing) and other possible surprises. The resultant climate risks could resemble current climate variability patterns, but with higher amplitude variations. CRM suggests that patterns of risks could be anticipated and the experiences of present systems in dealing with these risks could be drawn upon towards building resilience to long-term climate change. Past climate patterns may not provide any clue on how future climate would unfold and manifest, however human experiences in dealing with extreme climate events may provide guidance for dealing with uncertainties associated with climate change-related risks. Thus from a policy point of view, building the capacities of institutions and systems around managing current climate extremes and thereby a resilient development, could also assist with addressing climate "surprises."

A CRM framework has been formulated to assist countries to develop capacities to manage risks associated with climate variability and change. It is developed by the United Nations Development Programme (UNDP), through its Bureau for Crisis Prevention and Recovery (BCPR), responsible for assisting countries to develop capacity to better manage disaster risks, and Bureau for Development Policy Energy and Environment Group (BDP/EEG), responsible to assist countries to develop capacity to adapt to climate change. The Climate Risk Management -- Technical Assistance Support Project (CRM-TASP) was developed to operationalize the CRM framework by integrating CCA and DRR efforts. The Regional Integrated Multi-hazard Early Warning System for Africa and Asia (RIMES) in collaboration with Asian Disaster Preparedness Center was tasked with implementing the CRM-TASP framework in assessing risk management priorities and capacity needs into development planning in six countries in Asia, including Maldives.

APPROACH AND METHODS

The CRM TASP was initiated through a regional inception meeting in Pondicherry, India in July 2010, with participation of United Nations Development Programme (UNDP) focal points and key government representatives from the six project countries. In Maldives, the project involved the Maldives Meteorological Service (MMS), the Ministry of Energy and Environment (MoEE) and the UNDP country office (CO). The implementation process involved the following steps and activities (Table 1.1).

TABLE 1.1: PROJECT STEPS AND METHODS

PROJECT STEP & PURPOSE		SPECIFIC ACTIVITIES IN MALDIVES
1. Initiation	Introduce CRM-TASP: country engagement in Maldives facilitated by UNDP Maldives	• Inception meeting and discussions with key stakeholders • Key areas of focus under the project prioritized through discussions with stakeholders. Facilitated by the MoEE and UNDP CO
2. Institutional Mapping	Identify stakeholder needs to integrate CRM into sectoral planning and practices	• MoEE expressed need for tools and information that could assist in updating regulations on EIA, coastal development and adaptation planning.
3. Climate Risk Information generation	Generate atoll-specific information to meet requirements of sectors and planning processes	• Atoll-specific downscaling of climate projections for 2030s, 2050s and 2080s was undertaken with support from MoEE and UNDP. Outputs were shared with stakeholders.
4. Integration of CRM into government systems	Integrate CRM into the government's development planning processes	• Results fed into the next MoEE initative for climate resilient planning. It involved developing guidelines for coastal zone management with the support of UNDP.
5. Development of tools for capacity building	Address stakeholders' needs to integrate CRM into development	• Tool to integrate downscaling result, and available development data and observations data, developed and handed over. • Stakeholders in the downscaling process and in utilizing information for integration into development planning trained • Engagement of MMS with user departments facilitated through user forums where a seasonal outlook (for monsoon 2012) was shared for the first time in Maldives
6. Documentation & Report writing	Document the CRM-TASP report	• Report drafted and submitted to the UNDP CO

Stakeholders in Maldives proposed key priorities for the CRM-TASP at the regional inception workshop in July 2010 and during subsequent discussions in Male. These involved the UNDP, MMS, MoEE, Marine Research Centre, Environment Protection Agency, Ministry of Tourism and National Disaster Management Centre. Tourism, fisheries and agriculture were identified as priority sectors, given their contribution to the national economy and support to livelihoods of a majority of the Maldivian population.

UNDP CO facilitated discussions with all stakeholders, especially the MMS (given its strategic role) to support and expedite project implementation and subsequent follow-up.

REPORT STRUCTURE

Chapter 1 captures the process, steps and methods adopted by the study. Chapter 2 focuses on the development context and trends in Maldives and the rationale for prioritization of climate sensitive issues. Chapter 3 focuses on geo-physical environment and climate risk features of Maldives - past, current and future. The assessment of climate threats to development in the context of past climate risks and anticipated climate change projections are covered in Chapter 4. Current Climate Risk Management processes, policy and institutional systems to address climate risks are discussed in Chapter 5, while Chapter 6 focuses on recommendations for strengthening institutional frameworks, developing practices and exploring innovative options for CRM in Maldives.

DEVELOPMENT PROFILE

Vulnerability and exposure of a society to climate risks are closely linked to the current status and future vision of its development paradigm. This chapter examines Maldives' current development conditions, past trends and future as envisaged through the vision and strategies of national planning documents. Focus is on the 'most significant' sectors –tourism, fisheries and agriculture– from the perspective of climate sensitivity and the extent of sustenance provided by it in light of emerging climate risks.

CURRENT DEVELOPMENT CONDITIONS, TRENDS AND CHALLENGES

The Republic of Maldives is an archipelago comprising of over 1192 islands spread over 26 atolls and covering an area of 90,000 sq. km. Physically, it is one of the lowest-lying nations in the world with an average height of less than 1.7 m above mean sea level. It is also one of the smallest independent nations in the world *(MHE, 2010)*[1].

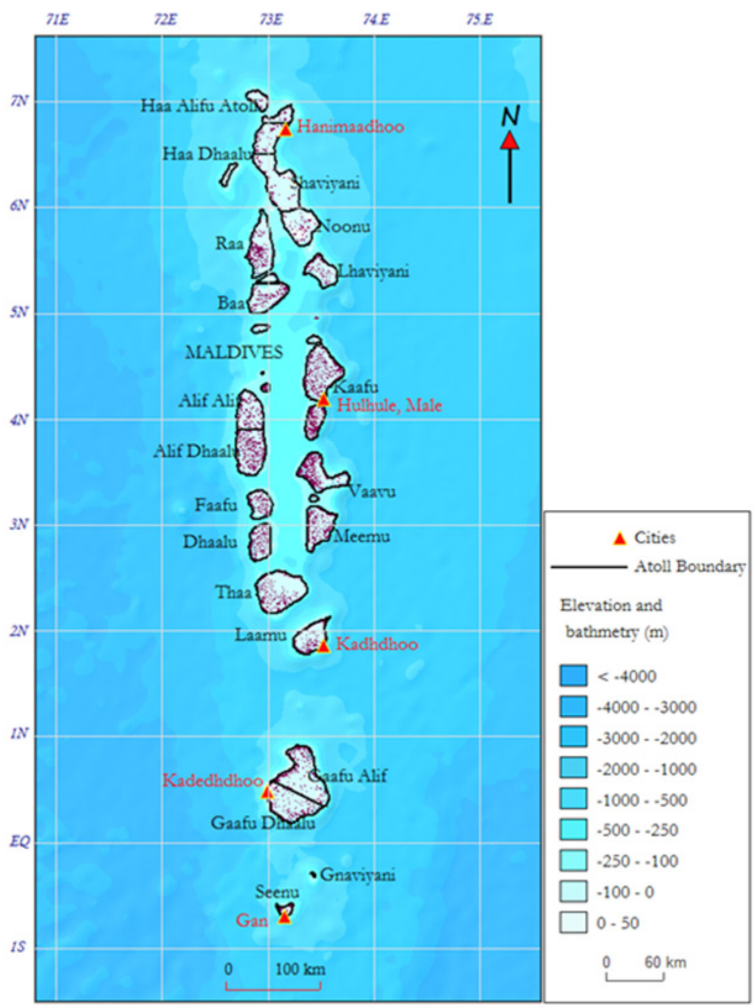


Figure 2.1 Atoll Map of Maldives

Administratively, the islands are grouped into 20 atolls and seven provinces. 194 islands are inhabited by a population of about 298,968 (Maldives Census, 2006) and are currently estimated at 319,740 *(MEE, 2011)*[2]. A distinct feature of Maldives is the use of different islands for different purposes, for example, resorts, infrastructure (fuel storage, garbage dump etc.), agriculture, fishing and recreation (picnic) among others. There are now 98 existing resort islands, which attracted 791,917 tourists in 2010 (DNP, 2011)[3]

The population in Maldives has grown rapidly and in two distinct phases. The growth in the first half of the century was slow, taking over 60 years for the population to double from 72,237 in 1911 to 142,832 in 1977. The second phase witnessed rapid increase in population taking less than 30 years for the population to double to 298,968 in 2006. More than one-third of the population or 110,897 people live in the capital city of Malé, which has an area less than 2 square km, making it the one of the densest cities in the world. The next largest island (in terms of population) is Hithadhoo with 10,123 people. The average population of the inhabited islands (excluding the capital of Male) is 1082 people.

Poverty and Human Development

Maldives' per capita income is highest in the region at US$ 5,750, making it an upper middle income country (World Bank, 2012)[4]. The Household Income and Expenditure Survey (2009-2010) (HIES), notes that poverty in Maldives has largely declined at the national and atoll levels. At the national level less than 8 percent of the population was below the international poverty line of US$ 1.25 per day, in 2010, compared to 9 percent in 2003. 24 percent of the population in 2010 fell under the poverty line of US$ 2 per day compared to 31 percent in 2003. (Refer to Table 2.1 information on Atolls and Male)

TABLE 2.1 POVERTY GAP RATIO FOR REPUBLIC, MALE AND ATOLLS-2002/03 AND 2009/10

RELATIVE POVERTY LINES	REPUBLIC (%)		MALE (%)		ATOLLS (%)	
	2003	2010	2003	2010	2003	2010
International poverty line of US $ 1.25 (1$ a day poverty line used in MDGs)	2	2	0	2	3	2
International poverty line of US $2	9	7	2	5	12	7
Rf.44 (median of Atoll expenditure per person per day for HIES 2009/2010)	24	19	10	15	30	20
Rf. 22 (half the Median of Atoll expenditure per person per day for HIES 2009/10)	5	4	1	3	7	4

Note: Poverty lines adjusted for inflation; comparable consumption aggregate based on 2009-10 definition)
Source: DNP. 2012

In Male, the poverty is lower than at the atoll levels, but shows an increasing trend. For example, the US$ 1.25 line shows an increase from 2 percent in 2003 to 7 percent in 2010, and an even steeper increase for the US$ 2 line with 19 percent in 2010 and 9 percent in 2003. *(DNP, 2012)* While poverty gap measure trends in Atolls and Male show a reduction in poverty in the Atolls and an increase in Male from 2003 to 2010, however, the absolute value of the poverty gap still remains higher in the Atolls. *(DNP, 2012)*

Literacy rates in Maldives are the highest compared to the other countries in the South Asia. 98.2 percent of the total population can read and write the local language Dhivehi (Maldives Census, 2006). The rate is higher in Male at 99.1 percent in comparison to the atolls at 97.7 percent. Life expectancy in Maldives was 75 years (WHO, 2011) and Infant Mortality Rate (IMR) was 13.60 in 2010 (World Bank 2012). These two provide an indication of the level and quality of health care available to the population. Total expenditure on health is 6 percent of the GDP (2010) which shows a decreasing trend compared to previous years.

Water supply is restricted to the capital, with the rest of the country depending on rain water and well water. 76 percent of the atolls use rainwater for cooking and 20 percent use well water. Only 7 percent of the atoll population drank purified water (Maldives Census, 2006). While sanitation coverage is high at 95 percent (Maldives Census, 2006), over 50 percent of the households in the country and an even larger proportion in the atolls use toilets with septic tanks. This leads to contamination of well water.

Economy

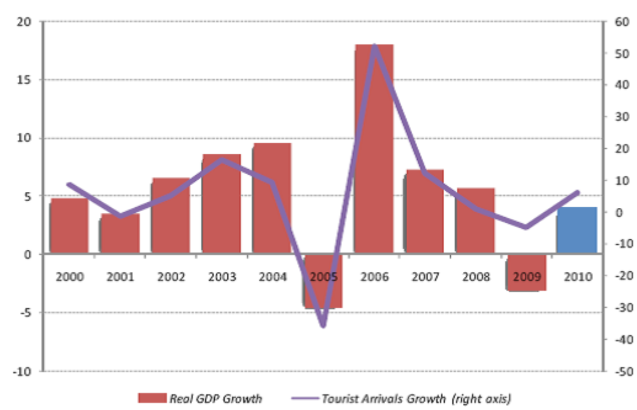
Maldives' Gross Domestic Product for 2010 was 20 billion Rf (15.4 Rf= 1 US$) at 2003 constant prices (MMA, 2012)[5]. Contribution of the primary sector (agriculture, mining and fisheries) was 3 percent, secondary sector was 14.7 percent and the tertiary sector was the largest contributor accounting for 83 percent of the GDP. Among tertiary sector activities, tourism is the largest contributor providing almost 36 percent of the national GDP, followed by transport and communications at 13.9 percent. Tourism and fisheries are also key drivers of economic activities like transport, communications, distribution, construction and real estate (Table 2.2).

TABLE 2.2 GROSS DOMESTIC PRODUCT AT CONSTANT PRICES (2003) BY INDUSTRIAL ORIGIN (MILLION RF)

(MILLION RUFIYAA)	2004	2005	2008	2009	2010	2011
Nominal GDP	13,768	12,704	24,213	24,858	26,566	29,936
Real GDP (2003 constant prices)	13,676	12,489	18,526	17,648	18,659	20,051
Primary Sector	742	786	698	647	602	596
Agriculture and mining	328	300	345	337	352	365
Fisheries	415	486	354	310	251	231
Secondary Sector	2,203	2,431	3,597	2,656	2,793	2,957
Construction	1,088	1,298	2,078	1,303	1,424	1,497
Tertiary Sector	10,994	9,477	14,446	14,519	15,430	16,660
Tourism	4,488	2,972	4,870	4,608	5,335	6,061
Real GDP growth	12.50%	-8.70%	12.20%	-4.70%	5.70%	7.50%

Source: MMA, 2012

The high dependence on these key sectors has not held back the growth of the Maldivian economy. It has grown at an impressive rate of over 5 percent each year for the past decade, except for 2 years. In 2005, the Indian Ocean Tsunami resulted in a negative real GDP growth of -8.7 percent, and in 2009, the global economic downturn led to a fall of 4.7 percent in real GDP. On both occasions, decreased tourism revenue led to fall in GDP (Figure 2.2), illustrating the high sensitivity of the nation's GDP to this sector. The decrease in GDP in 2009 was also due to slowdown in the construction sector.



Source: Maldives Monetary Authority, cited from World Bank, 2010[6]

Figure 2.2 Maldives GDP and Tourist Arrivals Growth

Fiscal deficit is a concern in Maldives, and almost the entire deficit in the annual budget is met from external borrowings, continuing to add to the deficit. Public debts have doubled from 55 percent in 2004 to 97 percent in 2010, and the IMF has classified Maldives as at high risk of debt distress (MEE, 2011). Inflation is also on the rise with food, transportation and housing prices contributing most to it *(ibid)*. These factors combined with the global recession led to the gross reserve of only US$ 386.1 million in 2009, which was equivalent to 4.3 months of import *(ibid*). The gross international reserves amount to US$ 356.4 million, or about 2.8 months of import (MMA, 2012).

Despite its meagre contribution to the economy, the agriculture sector provides employment to 11.5 percent of population employed in Maldives (2009), next to industrial sector employing about 24.3 percent of employed population (UN, 2010)[7], and tourism which accounts for about 58 percent of all jobs. *(Emerton et al, 2009)*[8]

Environment

Land and beaches are a critical component of Maldives environment and land scarcity and its over-utilisation is a key environmental issue. The actual land area is estimated to be smaller than 235 sq. km. than the official figure of 298 sq. km. (Shaig A)[9]. Of the total of 1190 islands, since only 375 islands are used, the usual perception is that expansion can spill over to remaining islands. However, it does not recognise that the currently inhabited 200 islands cover almost 60 percent of the total land, and the rest cover only 15 percent. Thus 75 percent of total available land is already utilised, and the rest is spread across very small islands leaving no land for future expansion. *(ibid).*

There is increasing pressure on land due to increasing population. 24 islands have no land for future housing and an additional 38 are expected to reach their maximum capacity. This has led to over-crowding, deforestation, encroachment of beaches, removal of crucial coastal vegetation, improper waste disposal in coastal areas, ground water contamination due to improper sewerage systems and disposal methods, ground water degradation due to over extraction, marine water contamination, air and noise pollution and coral reef degradation *(ibid)*

Land reclamation has been undertaken in over 150 islands adding 9 to 11 km of land. This has increased environmental pressure on the islands resulting in increased floods and vegetation denudation. Coral mining and reclamation are also affecting the ability of corals reefs to adapt to sea level rise and in assisting with island stability. Increasing extraction of ground water is deteriorating fresh water availability.

Removal of coastal vegetation and inability to strictly implement a 100 feet set back rule for all constructions has increased pressure on beaches *(ibid).* Almost all inhabited islands (97 percent) are reported to face beach erosion with 64 percent with high severity. This includes resort islands. The natural capital of Maldives- biodiversity is being eroded with declines of several harvested marine species (sharks, lobsters, sea cucumbers and reef fish), pollution and damage to reefs from construction.

Biodiversity degradation and loss is not just an environmental issue in Maldives, but poses economic and development problems as most sectors of the economy depend on biodiversity goods and services. *(IUCN)*[10]

NATIONAL DEVELOPMENT VISION, OBJECTIVES AND PRIORITIES

The Strategic Action Plan (SAP) outlines Maldives's development vision for the period of 2009-2013. It follows the Seventh National Development Plan (SNDP) 2006-2010 that was framed to make the goals expressed in Vision 2020 a reality, the primary goal being transforming Maldives into a top-ranking middle-income country by 2020.

The SAP is expected to (i) guide the development processes in the country, (ii) be an instrument for allocation of budgetary and fiscal responsibilities to various sectors and government ministries, and (iii) serve as a mechanism of accountability to the citizens of the country towards achievements of promised development benefits, and enhanced access to goods and services.

The SAP revolves around three key themes of good governance, social justice and economic development. Economic development focuses on diversification of the economy; increasing the role of the private sector to achieve sustainable economic growth, and facilitating transition of Maldives from a Least Developed Country to a middle-income country status.

In the tourism sector, the plan focuses on increasing efficiency and effectiveness of the regulatory framework to allow for sustainable investment, support infrastructure, increase training and employment opportunities for locals and the environmental sustainability of all tourism related ventures.

In the fisheries sector, the government's focus is on sustainable development of fisheries, promotion of exports and trade, enhancement of infrastructure and financial services to support sector development and promotion of research, training and techniques in the sector.

In the agriculture sector its focus is on reducing dependence on imports, improving national food security, strengthening organized farming and subsistence farming systems, applying appropriate technologies and developing the required market infrastructure.

Promotion of small and medium enterprises, enabling legal, regulatory and business environment to enhance trade and investment opportunities, enhancing market access opportunities to create a competitive fair trading business environment, and providing employment and supporting human resource development are among its other priorities.

The plan considers natural environment as the key to socio-economic development, and aims to ensure sustainable adaptation measures by strengthening democracy in the country – a pre-requisite to good governance and therefore successful climate change adaptation (CCA).

The plan notes that the government focus is ensuring that Maldives is resilient to disasters, to preparing the population and creating the institutional framework for disaster risk reduction (DRR) and climate change adaptation (CCA).

In 2010 as part of the SAP, the GoM identified the following 5 priority areas (World Bank, 2010):

i **Macroeconomic reform** to support private sector-led economic growth. It entails reducing the role of the state in the economy –a core component of the SAP– and facilitating conditions for growth in tourism and fisheries;

ii **Public-sector reform,** a key pillar of the structural adjustment program. The public sector is streamlined to make it more efficient and effective in delivering quality government services;

iii **Good governance,** entails strengthening democratic institutions and processes as a priority to ensure that the new democracy is entrenched;

iv **Social development,** focuses on developing the human resources of Maldives in order to effectively deliver on all social development pledges, and;

v **Climate change and adaptation,** is recognised as an existential threat to Maldives. The government proposes a series of mitigation and adaptation measures requiring substantial funding.

CONDITIONS AND TRENDS IN THE PRIORITY SECTORS

Tourism: The tourism sector in Maldives has grown significantly from its humble beginnings in the 1970s. Maldives has emerged as a much-sought after destination, attracting over 800,000 tourists each year. It revolves around the *'one-island one-resort'* concept, where an entire island is leased to the resort developer/owner. All infrastructure on the island is built and maintained by the resort, in adherence to the environmental guidelines of the government. 119 islands are leased to existing resorts, while 72 new resorts are coming up on additional islands (MOTAC, 2012)[11]. Hotels and guesthouses are very few in comparison, 15 and 26 respectively.

Tourism is an important part of the national economy generating 34 percent of all public revenue, 70 percent of all foreign exchange, and contributing to capital investment of 29 percent (or Rf 1.9 billion). Its total contribution (direct and indirect) to the GDP is estimated at 67 percent each year (or Rf 9.74 billion).

Tourism in Maldives depends on the rich biodiversity of its oceans, with most island resorts promoting diving and related activities. Increasing sea levels and rising sea surface temperatures could threaten the ocean wealth drawing these tourists. Disasters like the 2004 tsunami and severe weather events damage the tourism infrastructure and hamper tourist arrivals, directly impacting livelihoods of the people and the national economy.

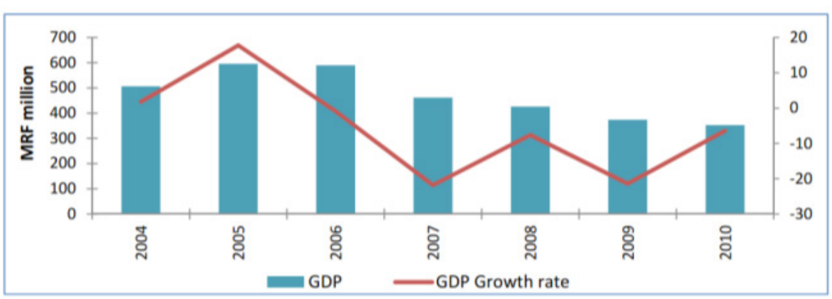
The tourism sector priorities identified in the SAP and the Third Tourism Master Plan are to:

- **i** Facilitate sustainable growth and increase investment in the industry, while enhancing public share of economic benefits from tourism;
- **ii** Increase employment opportunities and, open up opportunities for gainful public and community participation in tourism;
- **iii** Develop and maintain supporting infrastructure required for the growth of the industry;
- **iv** Ensure environmental sustainability in development and operation of all tourism products, and strive for global excellence in environmentally-responsible tourism;
- **v** Continue to brand Maldives as a unique destination with innovative products, and retain Maldives positioning as a top ranking destination in traditional and emerging source markets;
- **vi** Introduce a fair tourism tax regime and continue to strengthen the legal and regulatory framework and the institutional capacity of the Ministry of Tourism.

Fisheries: The fisheries sector is an important part of the Maldivian economy, next only to tourism. In 2009, the fishing fleet comprised over 962 mechanised boats, 54 sailing/rowing boats and 16 Exclusive Economic Zone (EEZ) vessels. Close to 200,000 fishing trips were undertaken, yielding a catch of 116,900 metric tons. Mechanised vessels accounted for 93 percent of the catch in 2010. Tuna (Skipjack and Yellowfin) together formed 76 percent of the fish catch.

Fishing contributes significantly in terms of the foreign exchange earnings, and fish and its products account for almost 98 percent of the total domestic exports. Atleast 15 percent of the employed population depend on fishing either directly or indirectly (MEE, 2012).

The fishing sector continues to face the slump that commenced in 2006. Its contribution to GDP too has declined over the same period (MEE, 2012). The decreasing fish catch is attributed to several environmental and economic factors. The large fishing vessels are no longer economical on single day trips as is custom in Maldives due to rising fuel costs. Increased exploitation in the Indian Ocean's depleting fishing stock, and warmer sea surface is believed to have pushed fish deeper than can be caught using the current pole and line catching systems. *(MEE, 2012)*



Source: MEE, 2012

Figure 2.3 Fisheries sector contribution to GDP (2004:2010)

The Fishery Law (1985) which guides and regulates all fishing activities, methods and zones and the priorities identified in the SAP are:

- **i** Expand the scope of the fisheries sector in the economy and diversify fish and marine products in a sustainable manner;
- **ii** Regulate the market to ensure that changes in the buying price of fish in international markets are passed through to local fishermen;
- **iii** Facilitate business development, trade and export promotion in fisheries;
- **iv** Provide training and capacity building opportunities in the sector;
- **v** Promote research in fisheries and introduce fish breeding and productivity;
- **vi** Establish modern fisheries infrastructure in different regions of the country;
- **vii** Enhance the regulatory framework to ensure sustainable fishery development and management.

Agriculture: The agriculture sector's contribution to the GDP is less than 1.9 percent (2011 estimate). Nevertheless, it is an important source of livelihood for people in the islands. Agriculture contribution to economic production figures is underestimated, since they essentially reflect the landings in Male', and direct trade (sale to resorts). Its contribution within and among islands is not accounted for *(MEE, 2012)*.

Currently people in 76 inhabited islands are involved in agriculture, along with the 600 uninhabited islands leased for agriculture. Most of the 7500 registered farmers in the inhabited islands are marginal farmers with less than 1 ha of land *(MEE, 2012)*. In 2001 an FAO survey estimated total cultivable land of 2,670 ha, of which 1770 ha are on inhabited islands and 900 ha on uninhabited islands. The proportion of local agriculture production to agriculture imports is gradually increasing from less than 25 percent in 2008 to 35 percent in 2010. The imports however still continue to be three times the local production.

Major cultivation season is during the Southwest Monsoon (May to September) and the minor season during the Northeast monsoon (November to March). Cultivation depends on ground water and rain water. It includes home gardening, bush-fallow system of shifting cultivation, and settled year-round cultivation. While agriculture is largely subsistence, commercial agriculture is also carried out on larger islands, including leased agricultural islands and larger inhabited islands. In islands leased for agriculture, all activities and infrastructure including access, accommodation and clearance of land is undertaken by the lessee. Increasing demand from large centres like Male' provide an opportunity for increasing commercialisation of agriculture. However, is limited by lack of transport facilities and marketing infrastructure *(ADB, 2005)*[12]

The agriculture sector priorities identified in the SAP are:

- **i** Strengthen commercial agriculture to reduce reliance on imported food and attain food security;
- **ii** Facilitate the availability of agricultural inputs and accessibility to appropriate and environment friendly technology in all regions to promote sustainable agriculture farming systems;
- **iii** Develop systems, networks and physical infrastructure for strengthening marketing and trade of agriculture produce and to encourage commercial agriculture;
- **iv** Expand the use of technology in the agriculture sector to help develop and diversify the sector and ensure gender disparities are not created due to these technologies;
- **v** Strengthen the institutional capacity to support the growth of the agricultural sector;
- **vi** Strengthen legal framework to regulate the use of natural resources for agriculture and develop services related to agriculture development;
- **vii** Strengthen agricultural statistics for results-based planning.

KEY MESSAGES ON DEVELOPMENT PROFILE OF MALDIVES:

- Maldives is an archipelago of over 1192 islands, is one of the lowest-lying nations in the world with an average height of less than 1.7 m above mean sea level and one of the smallest independent nations in the world.

- It has a narrow based economy with the tourism and fisheries sectors contributing a significant 70 percent to the overall GDP.

- Although the agriculture sector's contribution to the GDP is less than 1.9 percent, it is an important source of livelihood and has the potential for reducing reliance on food imports and future food security.

- In the last two decades, development practices have weakened the fragile coastal and marine ecosystems in Maldives.

- Development associated assets and production systems are becoming more vulnerable to climate risks.

- In the recent years, the economy of Maldives has experienced external shocks –2004 tsunami and the 2009 global economic depression– that have undermined its developmental gains.

- Maldives's development vision is outlined in its Strategic Action Plan (SAP) 2009-2013 and the Seventh National Development Plan (SNDP) 2006-2010. Its primary goal being transforming Maldives into a top-ranking middle-income country by 2020. Its priority is to insulate the economy from external shocks through diversification, regulatory frameworks and sustainable environment management.

- Climate change and its risks are recognised as an existential threat to Maldives and thus the government recognises the need for mitigation and adaptation measures requiring substantial funding.

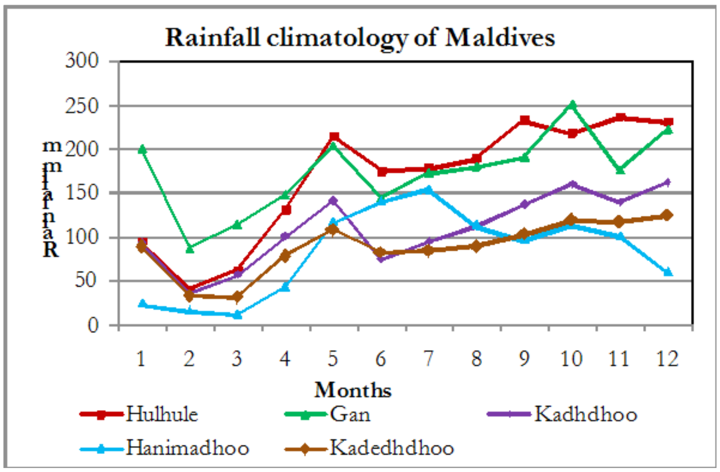
CLIMATE PROFILE

This Chapter provides baseline information on the current and future climate and related trends at the national level.

NATIONAL WEATHER AND CLIMATE CONTEXT

The Maldives archipelago is located in the Indian Ocean and stretches 860km from latitude 7°6'35"N, crossing the Equator to 0°42'24"S, and lays between 72°33'19"E and 73°46'13"E longitude. The islands are low-lying, with more than 80 percent of islands with an elevation of less than 1m above mean sea level, and none exceeding an elevation of 4m (MHAHE, 1999).

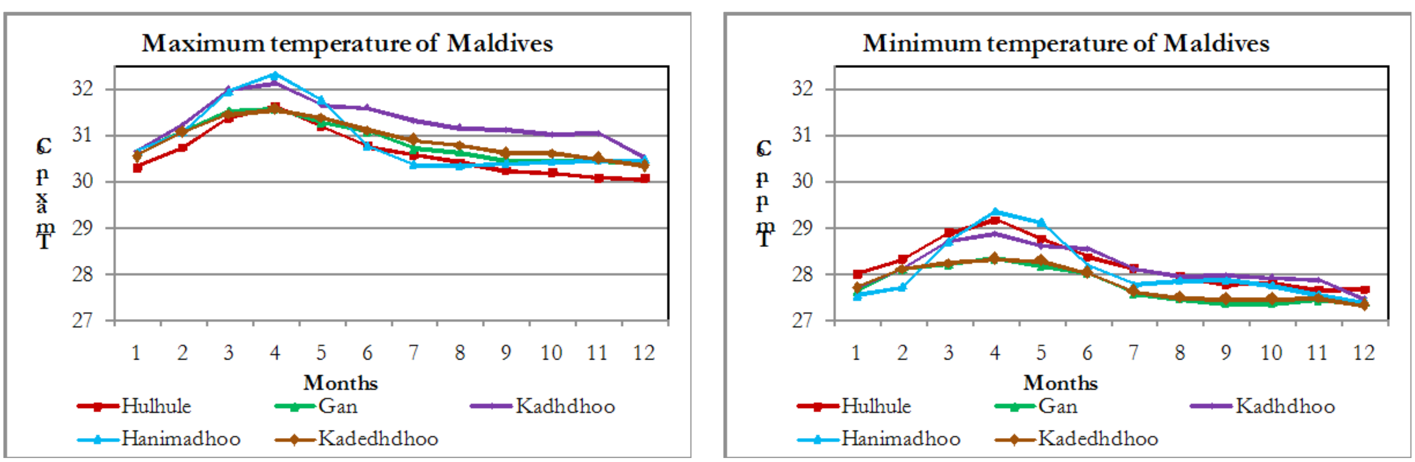
Maldives has a warm and humid tropical climate, dominated by two monsoon periods: the Southwest (SW) monsoon, a wet period, from May to October/November; and the Northeast (NE) monsoon from November/December to March (MMS, 2006[13]; Ramiz, 2007[14]). Annual average rainfall is 2,124 mm. The southern atolls receive, on average, 2,277mm of rainfall annually, while the relatively drier northern atolls receive 1,786mm (MMS, 2006). The monthly rainfall climatology (refer to Figure-3.1) identify May and November as monthly peaks. Other than the Hanimadhoo station (Northern Maldives), all stations have a similar rainfall pattern.



Source: RIMES

Figure-3.1 Rainfall Climatology of Maldives

Maximum temperature fluctuates between 30.1°C to 32.3°C and minimum temperature fluctuates between 27.3°C to 29.4°C. Unlike rainfall, all zones in Maldives have similar temperature patterns. Maximum temperatures are noted in the months of March, April and May, constituting a relatively hot season for Maldives. Minimum temperature is noted from September through January. Refer to Figure 3.2.



Source: RIMES

Figure-3.2 Maximum and Minimum temperature climatology of Maldives

CURRENT CLIMATE VARIABILITY AND CLIMATE EXTREMES

Climate drivers

Since Maldives is a low lying island, its orography's influence on climate is very low. The SW monsoon system is controlled by continental scale circulations. The local geography of Maldives does not influence the climatology significantly. The Inter-tropical Convergence Zone (ITCZ) influences Maldives' climate to an extent. During the summer monsoon, (May to November), moisture is transported from the Arabian Sea and transported out to the Bay of Bengal. The transport of moisture is reversed for the rest of the year, with low activity in all segments between February and May. This produces a slightly longer rainfall season over southern Maldives. Study of various meteorological parameters shows a good relationship with the 'El Niño–Southern Oscillation' (ENSO). (Shrestha & Quadir, 2001)[15]

Rainfall variability

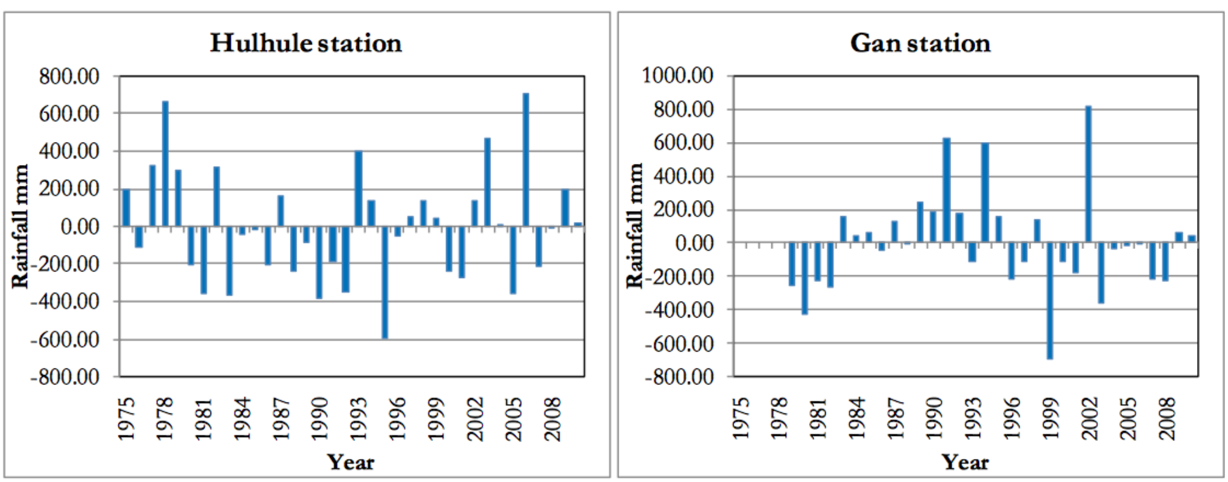
There are two rainfall seasons in Maldives, SW monsoon period (May to November) and NE monsoon season (December to February). The seasonal rainfall distribution is presented in Table-3.1

TABLE 3.1: SEASONAL DISTRIBUTION OF RAINFALL IN MALDIVES

STATION NAME	SW MONSOON NORMAL RF	NE MONSOON NORMAL RF (MM)
Hanimadhoo (North)	834.3	83.9
Hulhule (Central)	1443.6	325.0
Kadhdhoo (Central)	855.7	253.9
Kadedhdhoo (Southern)	702.0	212.7
Gan (Southern most)	1312.9	420.1

Source: Rimes

The annual rainfall anomaly from 1975 to 2010 highlights that central regions have larger variations compared to the southern zones. Variation ranges from -600 to 600mm in central and -650 to 800mm in southern zones. Refer to Figure-3.3. Monthly rainfall variability is high in Maldives ranging from - 100 to 350 percent in the central Hulhule station and - 100 to -200 percent in the southern Gan station.

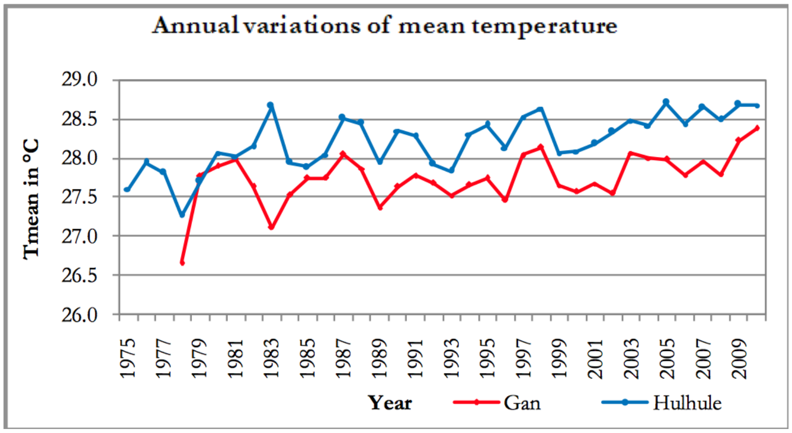


Source: RIMES

Figure 3.3 Annual rainfall anomalies from 1975 to 2010

Temperature

Annual mean temperature for both the stations Hulhule and Gan fluctuates between 27 to 29°C. Year to year variability is less in both the stations (Figure 3.4)

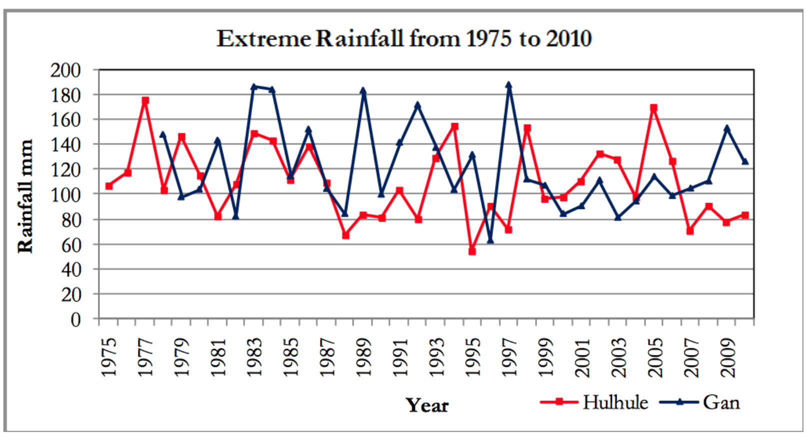


Source: RIMES

Figure 3.4 Annual variation of mean temperature in Maldives

Extremes

From 1975 to 2010, several extreme rainfall events were recorded. This includes events in Hulhule with175.9mm/day, Gan with188.3 mm/day, Kadhdhoo with 178.2 mm/day, Hanimadhoo with 146.9 and Kadedhdhoo with 219.8 mm/day. The maximum 24 hours rainfall in a year from 1975 to 2010 is presented in Figure 3.5



Source: RIMES

Figure 3.5 Extreme rainfall events from 1975 to 2010

Climate hazards

Maldives is exposed to several climate hazards such as heavy rainfall, wave swells, storm surge caused by cyclones in the South Indian Ocean, floods, droughts, and strong winds (RMSI, UNDP & GoM, 2009)[16].

a. Wave swells: There are three major types of wave swells in Maldives. Udha is a gravity wave phenomenon caused by a combination of high tides and strong wind waves. It occurs annually in the month of May-June in southern Maldives during the onset of the SW monsoon season. It usually impacts the western coastline of the southern islands more (UNDP, 2007).

Swell waves are unusual tidal waves with stronger energy triggered by synoptic systems or other factors. Tsunami waves are low frequency hazard that originates from the Sumatra region and could cause devastation like the 2004 tsunami. All these can cause damage to coastal vegetation, salt water intrusion to wetland and island water lens, contamination of groundwater, damage to crops, loss of soil productivity, damage to coral reefs and geomorphologic changes in the shoreline and lagoon.

b. **Cyclonic Storms:** Maldives is less prone to tropical cyclones because of its location within the equatorial region of the Indian Ocean. Only 11 cyclones crossed the islands in the span of 128 years (1877-2004) and were formed between October and January except one, which was formed in the month of April. The northern islands are occasionally affected by weak cyclones that are formed in the southern part of the Bay of Bengal and the Arabian Sea.

c. Local Thunder Storms: Maldives is frequently affected by local thunder storms and thunder squalls. Sometimes, storms accompanied with rainfall and high waves affect the southern parts of islands during April and December, which is the interim period between the NE and SW monsoons. Hazards associated with thunderstorms are strong winds (often exceeding 100kmph), heavy rainfall, lightning and hail. Maldives' close proximity to the equator makes thunderstorms quite frequent but less violent. Strong winds generated by severe local storms generate larger wind driven waves, which are hazardous to lives and infrastructure along the coast.

d. Rainfall flood and droughts: Heavy rainfall occurs during the monsoon season and during storms. Failure of monsoon leads to drought like conditions, since rainwater is the major source of drinking water for many islands.

Historical data shows the 219 mm rainfall a day is the highest recorded in Kadedhdhoo and the country. 175 mm/day and 188.3 mm/day were extreme events recorded in Hulhule and Gan respectively. The (limited) rainfall data in Maldives suggests a standard deviation (SD) of about 16 percent. Using that criterion, the number of excess, normal and deficient years for key stations in Maldives are presented in Table 3.2. Data indicate that southern Maldives is less prone to drought and floods compared to northern Maldives, although frequency of flood and drought years is small (about 15 to 16 percent of the years).

TABLE 3.2: FLOOD AND DROUGHT YEARS IN MALDIVES

STATION NAME	NUMBER OF DROUGHT YEARS	EXTREME DROUGHT YEARS	NUMBER OF FLOOD YEARS	EXTREME FLOOD YEARS
Hanimaadhoo (1992 to 2004)	2	2002 (-26.0)	2	1993 (23.2)
Hulhule (1975 to 2004)	5	1995 (-29.4)	6	1978 (34.1)
Gan (1978 to 2004)	3	1999 (-32.6)	4	1978 (38.5)

Source: RMSI, UNDP & GoM, 2009

OBSERVABLE CHANGES IN CLIMATE VARIABLES AND HAZARD

Rainfall and Temperature:

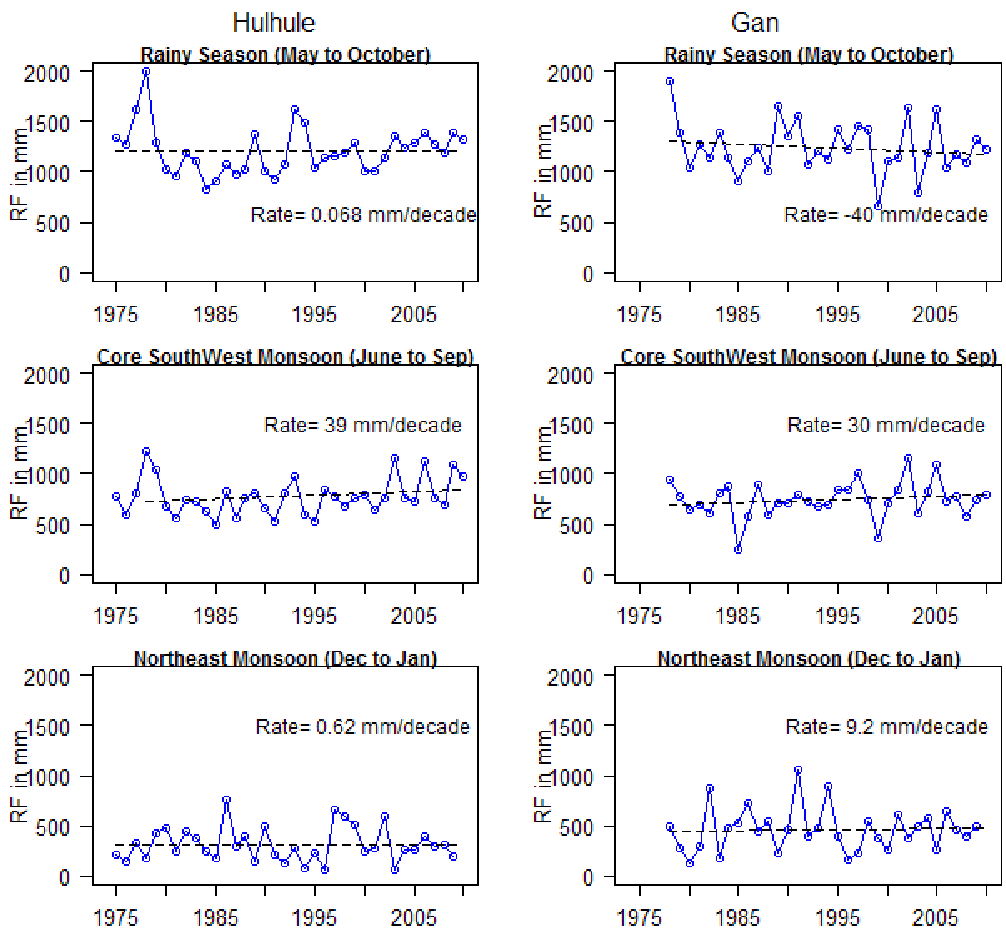
Observable climate trends suggest that both the Hulhule (representing Central zone) and Gan (representing southern zone) stations exhibit increasing rainfall trend during the SW monsoon and NE monsoon season. This is based on the analysis of climate data for the period 1975 to 2010. Refer to Table-3.3 for summary of seasonal trend.

TABLE 3.3 RAINFALL TREND IN MM/YEAR FOR MALE AND GAN LOCATION IN MALDIVES

SEASON	MALE STATION MM/YEAR	GAN STATION MM/YEAR
Pre-monsoon	-3.60 ▼	-3.10 ▼
Southwest monsoon	3.90 ▲	3.00 ▲
Post-monsoon	0.90 ▼	2.20 ▼
Winter	0.29 ▲	0.02 ▲

Trends: ▲ Increasing trend ▼ Decreasing trend . Source: RIMES, 2012

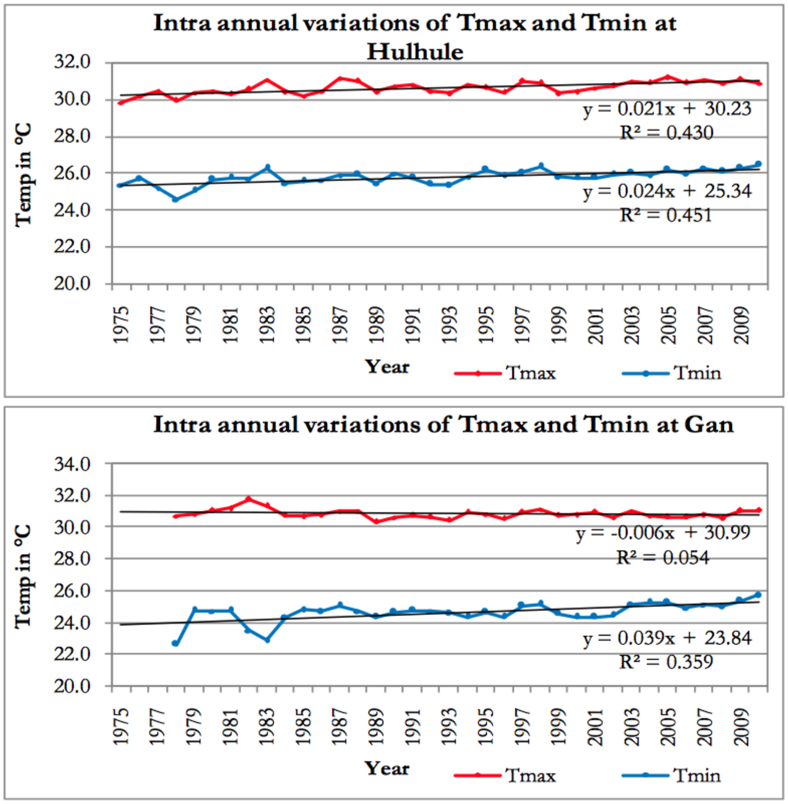
Inter annual variation of rainfall in Gan station varies from +38.5 percent in 1978 to –32.6 percent in 1999. In Hulhule it varies from +34.1 percent in 1978 to –29.4 percent in 1995 and in Hanimaadhoo, +23.2 percent in 1993 to -26 percent in 2002 (RMSI, UNDP & GoM, 2009).



Source: RIMES, 2012

Figure 3.6: Rainfall trends over various season in Maldives (1975 to 2010)

Maximum and minimum temperature analysis for Hulhule and Gan station (Figure 3.7) for the period 1975 to 2010 shows that maximum temperature is increasing for both the stations, which indicates a warming trend over Maldives region from North to South.



Source: RIMES, 2012

Figure 3.7 Intra annual variations in mean maximum and minimum temperature for Hulhule and Gan (1975 to 2010)

Extreme climate events:

The daily maximum rainfall fluctuates between 54mm to 176mm in Hulhule and 63mm to 188mm in Gan station. Number of days with rainfall more than 50mm fluctuates between 2 to 12 days in Hulhule and 2 to 19 days in Gan. Rainfall fluctuation is high in both the stations for the longest available period from 1975 to 2010. Although there is an increasing trend in seasonal rainfall amounts, the daily rainfall amounts or its extremes do not show increasing trends. However analysis of past daily rainfall data reveals that 176mm of rainfall in a day is a relatively rare event in Hulhule. (Table 3.4)

TABLE 3.4 TRENDS OF EXTREME EVENTS IN MALDIVES (1975 TO 2010) SOURCE: RIMES 2012

ANALYSIS	HULHULE	GAN
Cool nights: Percentage of days when TN<10th percentile – Unit in days/year	-1.56 ▼	-1.77 ▼
Cool days: Percentage of days when TX<10th percentile – Unit in days/year	-0.91 ▼	0.97 ▲
Warm nights: Percentage of days when TN>90th percentile – Unit in days/year	-0.32 ▼	0.99 ▲
Warm days: Percentage of days when TX>90th percentile - Unit in days/year	-1.27 ▼	0.86 ▲
Max daily rainfall: Max 1-day rainfall amount in a year/year	-0.08 ▼	-0.54 ▼
No .of days receives rainfall >30mm in a day (no. of days/year)	0.03 ▲	0.01 ▲
No .of days receives rainfall >50mm in a day (no. of days/year)	0.33 ▲	0.51 ▲

Trends: ▲ Increasing trend / ▼- Decreasing trend

PROJECTED CLIMATE TRENDS:

Rainfall and Temperatures: Global Climate Models (GCM) including the Geophysical Fluid Dynamics Laboratory[17] (GFDL) and Hadley Centre Coupled Model, Version 3's (HadCM3)[18] climate projections for three scenarios A1B, A2 and B1 are tabulated in Table-3.5 representing three time slices.

TABLE 3.5: CLIMATE PROJECTIONS FOR MALDIVES

MODEL	TIME SLICE	ANNUAL MEAN SURFACE AIR TEMPERATURE CHANGE IN °C			ANNUAL PRECIPITATION CHANGE IN %		
		A1B	A2	B1	A1B	A2	B1
GFDL	2030	1.0	1.4	2.2	-39.2	-9.1	1.7
	2050	1.0	1.5	2.4	-0.2	-4.1	-8.8
	2080	1.6	1.6	1.9	3.7	7.6	1.8
HadCM3	2030	1.1	1.7	2.7	161.4	38.8	56.9
	2050	1.1	1.7	3.0	12.9	30.8	67.1
	2080	1.0	1.3	1.9	10.3	28.0	35.7

For 2020 temperature increase of 0.9 to 1.3°C is predicted for most of Maldives. Annual precipitation will be reduced by around 0.3 percent to -14 percent. By 2050, warming will reach 1.82 to 2.7°C, and expected annual precipitation to reduce by 8.2 to 24.0 percent. By the 2080s warming could reach 2.1 to 4.2°C, and rainfall could decrease by 19.4 to 21.1 percent. The GFDL GCM projects a decrease in rainfall during the 2030s and 2050s. However, the Regional Climate Models (RCM)[19] predict an increase in rainfall for northern zones compared to the southern zones. Figure 3.8 shows the simulated rainfall changes through SRES A1B scenarios from 20C3M for the months MJJASO (May-June-July-August-September-October). It is clear from the IPRC RegCM that the decrease in rainfall is confined only to a few degrees in the equator for the time slice of 2021-2050. While the time slice of 2082-2100 shows increase in overall rainfall. A greater increase in the rainfall from the north to south during MJJASO is observed encompassing zones 1, 2 and 3. [Source: Rimes, 2012]

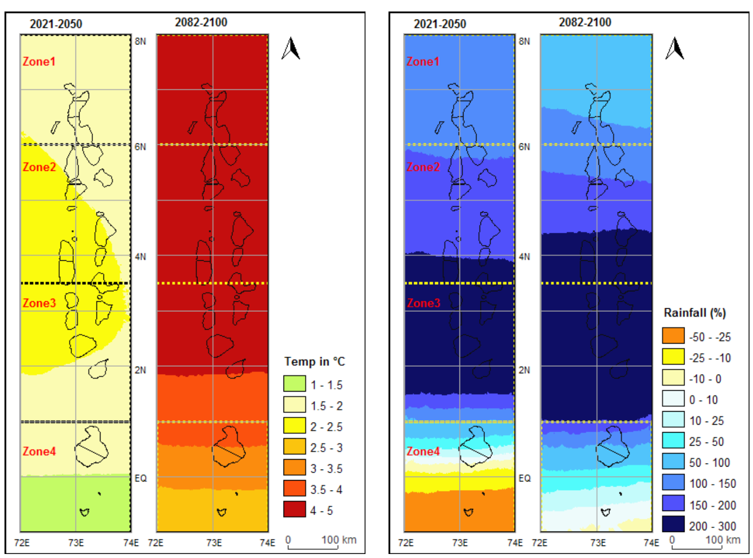


Figure 3.8 Temperature and rainfall changes over Maldives domain from IPRC Reg Climate Model scenario time slices (2021-2050) and (2082-2100) from baseline (1980-2000)

Unit – Temperature change in °C and Rainfall change for MJJASO are in percent.

Sea Surface Temperature (SST) is a very important parameter for Maldives' unique geographical context considering its implications on fisheries, tourism and biodiversity of the lagoons. The projected changes for surface air temperature and sea surface temperature are similar, as the oceanic influence dominates the atoll climatology. Figure 3.9 shows the projected change in sea surface temperature in Maldives for different scenarios, based on different models. The range sea surface temperature change for 3 time slices is 0.76°C to 1.33°C for 2030s, 1.01°C to 1.93°C for 2050s and 1.27°C to 3.40°C for 2080s.

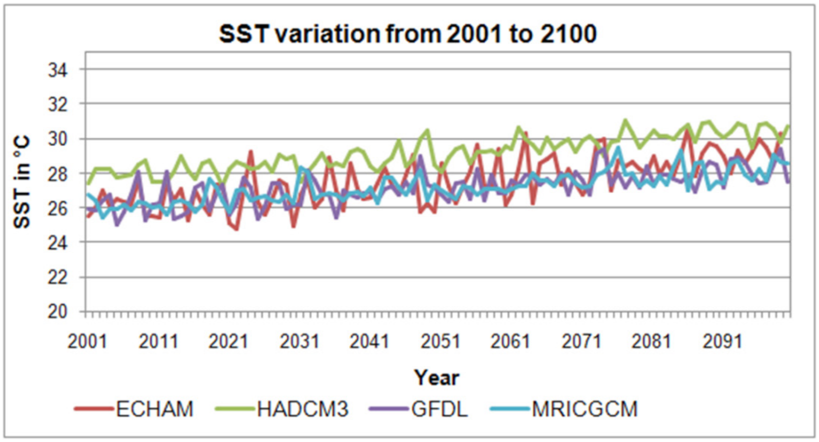
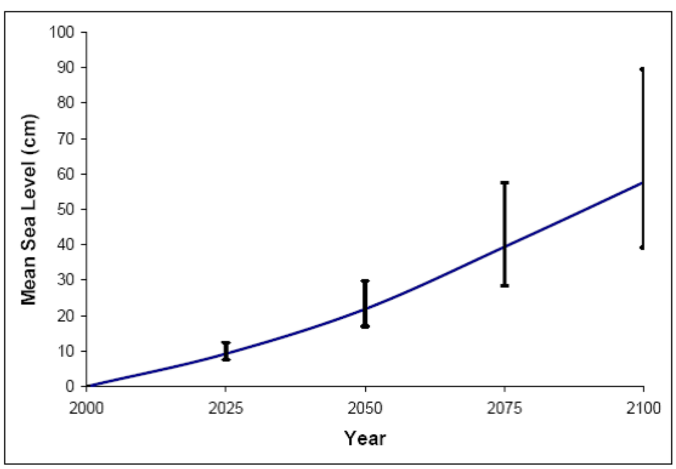


Figure 3.9 Annual Sea Surface Temperatures from 2001 to 2100

Extreme Events Extreme events, especially maximum rainfall in a day or consecutive five days over different zones in Maldives is expected to increase in the projected scenarios. The baseline maximum daily rainfall 55 mm is predicted to increase to 100 mm in 2021-2050 and 112 mm in 2082-2100. Similarly, baseline consecutive maximum five day rainfall of 217 mm over Maldives region reaches 318mm in 2021-2050 and 382mm in 2082-2100. Rainy days with more than 30mm show an increasing trend in both the time slices when compared to the baseline period. The maximum number of consecutive wet days in a year also shows an increasing trend (RIMES, 2012).

Sea level rise (SLR): The Hay report (2006) indicates the estimates of future sea-level rise based on an average of the estimates using a multi model and emission scenario ensemble. Figure 3.10 presents the sea level rise from 2000 to its projected increase in the year 2100 along with the band of extreme uncertainty. It considers the maximum and minimum estimates provided by all possible combinations of the global climate models and emission scenarios.



Source: Hay, 2006

Figure 3.10 Best estimate of projected increase in sea level for Hulhulé

RIMES (2012) maximum sea surface heights projections, represents the worst case scenarios, based on three realizations. The GCM indicates an increase ranging from 8.2 to 9.5 cm across the various atolls for 2080s. 2030s and 2050s time slices are ignored because of the uncertainties and model inconsistency performance. Inundation analysis for the projected SSH (2080s) shows that likely inundated area during mean tide level is 0.04 to 1.8 percent, whereas during extreme high tide (0.65m) is 0.8 to 11.6 percent of lands over different atolls in Maldives. One of the long term risks for Maldives is sea surface height (SSH) rise combined with high tides, which occur for a day or two at times.

STATUS OF CLIMATE AND HAZARD INFORMATION AT NATIONAL AND REGIONAL LEVELS

The National Metrological Centre (NMC) is the central metrological station in Male. It provides daily weather, aviation and marine forecasts and weather warnings. The Maldives Weather Observation Network's medium term weather forecast application for generating location user specific information is however limited. While the Maldives Metrological Service (MMS), is investing in innovative mechanisms like the monsoon forums and other emerging technology to issue hazard warnings including cell broadcast, SMS, email and websites, its capacity is limited in meeting the needs of the existing and emerging climate risks in the country. For example the MMS has Doppler weather surveillance radar but it does not have trained personnel to manage its operations and its maintenance.

At the regional level partnerships like, the sea-level data network in collaboration with Hawaii Sea Level Centre help provide data through the 3 tide gauges situated at 3 different locations in the Maldives. Other partnerships include the Meteorological Network with Regional Telecommunication Hub (RTH) in New Delhi, India and RTH Melbourne, Australia to exchange meteorological data and tsunami information; receive and process downlinks from Chinese Meteorological satellite to monitor satellite imagery for weather predictions, especially cyclone paths etc.

Climate projections however, mostly rely on global circulation models (GCM) and are thus always associated with uncertainties. Various GCMs depict different climatologies over the region. Hence, the dependability of GCM is questionable. Regional models at higher resolution were generated with RIMES and IPRC. However the projections of extreme events have not been carried out since the GCM face uncertainties in projecting the climatological cycle.

KEY MESSAGES ON CLIMATE PROFILE OF MALDIVES

- Climate of Maldives exhibit high spatial variability with rainfall gradually increasing from the north to south and cyclonic systems having reduced impact from north to south Maldives.
- Temporal variability is very high on intra-seasonal and inter-annual scale and so are extreme rainfall events.
- South India based lows' cause swell waves once in a decade, whereas *Udha* waves are very common.
- Climate change associated sea surface temperatures, sea level rise and monsoon system based risks could aggravate current climate risks in Maldives.
- The MMSs has some technology but limited observation system and data processing capacities to monitor and disseminate existing and emerging climate risk in Maldives.
- Overall there are limited national capacities, reliance on regional partnerships and dependence on uncertain global circulation models for climate projections has limited the understanding of climate risks in the current and emerging time.

CLIMATE IMPACTS AND RISKS

PAST CLIMATE IMPACTS

Due to limited past climate impact datasets, synoptic systems and their characteristics and impacts on Maldives are compiled from climate reports of the Maldives Meteorological Services (MMS) for the period 2002 -2007. Selected synoptic system from 2002 and 2007 presented in Table 4.1, reveal that almost every month from May to January severe weather caused significantly damaging impacts in Maldives.

TABLE 4.1: SELECTED SYNOPTIC SYSTEM FOR YEAR 2002 AND 2007 IN MALDIVES

SYNOPTIC SYSTEM	DATE	EVENT CHARACTERISTICS	IMPACTS
Severe disturbance began on July 5 in the form of a low-level circulation in the west of Kaadedhdhoo and moved across the country on July 10. This system was mostly concentrated on central and southern part of the country	July 5, 2002	• Widespread rain and thundershowers over the country • 219.8mm rainfall in 24 hrs at the Kaadedhdhoo on 09th of July 2002. • Continuous thunderstorm was reported for over-night at Gan on 08th of July. • Maximum gust wind speed of 79 Km/h at Kaadedhdhoo	• Many islands flooded • Electronic equipment such as radios, VCRs, refrigerators and hi-fi sets were destroyed. Damages exceeds more than MRF 10,000.00. G.Dh. • Thinadhoo island flooded. • Landslides in some islands of Huvadhu atoll.
Second phase of monsoon began in late September	Last week of Sep, 2002	• Fairly wide spread rain and showers over the country. • Highest rainfall of 70.7mm in 24 hrs. recorded at Gan on 24th September 2002. • Maximum wind speed of 70 Km/h at Kaadedhdhoo on 23 & 24 Sep. • Fuvamulah island received 140mm of rain in 24 hrs.	• Fuvamulah island flooded and some household property damaged • Educational Center closed for one day. • Many trees destroyed and uprooted in Fuvamulah.
Low level circulation, formed in southwest Bay of Bengal	Early Nov, 2002	• Widespread rain and isolated thundershowers over the country. • Highest rainfall of 51.4mm in 24 hrs was recorded at Gan station. • Maximum wind gust speed of 92 Km/h was recoded at Kadhdhoo on 12th of November 2002.	• Flooding in southern most islands of Maldives. • In some areas of. Kanduhuludhoo Island, water level reached more than 2 feet and in other areas up to1 foot on 12th November. • Flooding damaged electrical equipment and furniture in Kanduhuludhoo Island
Trough of low pressure formed over Maldives	May 26, 2007	• Widespread rain and squally showers over the country. • Squally showers experienced in Male'. Wind Gust speed of 54 mph • Heavy rainfall of 84 mm recorded in Kudahuvadhoo, 73 mm in Mulakatholu Muli and 50 mm in Hanimaadhoo.	• The rain continued for 3 days flooding many islands in central and northern atolls. Several plants and homes in many islands badly affected.

TABLE 4.1 CONTINUED

SYNOPTIC SYSTEM	DATE	EVENT CHARACTERISTICS	IMPACTS
Low pressure trough and active southwest monsoon	June 10, 2007	• Widespread rain and isolated squally showers over the country. • Rains, squally showers and thunderstorms in central and northern areas for a few days. • Gan recorded 60mm on 13 June 2007	• Bad weather and sustained strong winds resulted in tidal waves that swamped more than 50 islands. Significant damages reported in some islands on 19 June. • Tidal waves hit few islands in northern most atolls on June 20.
Low level circulation formed in the west of Maldives	Early Sep, 2007	• Heavy showers on Sept 4. 112 mm recorded over Kadhdhoo, 98 mm in Fuvanmulah, 95 mm in Kaadehdhoo and 62 mm in Veymandoo. • Strong surface wind speed of 26 mph sustained for few hours over central Maldives.	• Severe flooding reported in Dhaalu Meedhoo.
Trough of low pressure formed over Maldives.	Early Oct, 2007	• Heavy rainfall of 61 mm recorded in Thaa Veymandoo and 55 mm in Dhaalu Kudahuvadhoo on Oct 2. • Heavy downpours of 114 mm in Kaadehdhoo Oct 3.	• Some islands in south Huvadhu atoll flooded and household goods were damaged.
Very intense convective clouds associated with the trough over Maldives	Dec 6, 2007	• Very heavy rain in southern atolls. Kaadehdhoo recorded199 mm in 24 hours on 6 December 2007	• Some islands in South Huvadu atoll and Fuvahmulah flooded • Several people severely affected by widespread flood.

Source: MMS, 2002 and 2007

Apart from tsunamis, most disasters in Maldives are high frequency including rainfall flooding, swell wave flooding and cyclonic storm. They pose severe threats to infrastructure and production systems, which in turn impact the economy.

a. Rainfall Flooding:

Sudden downpour of heavy rain in a short span of time causes water logging and flooding in many islands. This is more common because of huge variability of monsoon rainfall and intensities. At the **national level** several heavy rainfall events were noted in Maldives (Refer to Table 4.2 for events and Box 1 for some case descriptions).

TABLE 4.2: EXTREME EVENTS IN MALDIVES IN FIVE WEATHER STATIONS

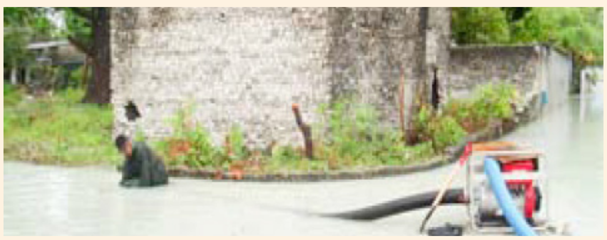
STATIONS	MAX 24 HRS RAINFALL IN MM AND DATE	
Hulhule	175.9	23/12/1977
Gan	188.3	27/6/1997
Hanimaadhoo	146.9	26/5/2008
Kahdhoo	178.2	7/10/1990
Kaadedhdhoo	219.8	9/7/2002

BOX 1: HEAVY RAINFALL FLOODING CASES IN MALDIVES

Flood in July 2002

The heaviest-ever recorded rainfall within 24 hours in Maldives was registered at 219.8mm in Kaadedhdhoo on July 9, 2002. The system affected central and southern Maldives and flooded several islands. Electronic equipment such as radios, VCRs, refrigerators and hi-fi sets were destroyed. According to some reports, the cost of damages exceeded more than MRF 10,000.00. (MMS, 2002[20])

Flood in December 2008



Intense convective clouds associated with the trough over Maldives caused very heavy rain in southern atolls. Kaadehdhoo in the south registered 199 mm in 24 hours on December 6, 2008. Two days later Fuvahmulah, also in the south recorded 158 mm. Due to heavy rain, some islands in the south Huvadu atoll and Fuvahmulah were flooded and causing severe and widespread damage. (MMS, 2008)

Flood in November 2011

Unusually high rainfall of 92mm was recorded in 2 hours on November 21, 2011 in Hulhule. Rain clouds formed over the northern region, moved very slowly due to the low wind speed causing heavy rains in the area. It completely flooded Ameenee Magu, Medhuziyaaraiy Magu and parts of Majeedee Magu. Water entered into shops and some houses damaging goods and belongings. (Haveeru, 2011[21])

Source: Haveeru, 2011; MMS, 2002 & MMS, 2008

The frequency and impact of rainfall flooding due to extreme rainfall and its impacts on islands of Kulhudufushi, Thulusdhoo Kuda-huva, L.Gan and Hithadhoo are presented in Table 4.3.

TABLE 4.3: FLOODING CAUSED BY HEAVY RAINFALL AND ITS IMPACTS IN SELECTED ISLANDS IN MALDIVES

ISLAND NAME	DATES OF THE RECORDED EVENTS	IMPACTS
Kulhudufushi	Once in few years	Flooding caused by heavy rainfall is limited to a few topographic low points on the island. Heavy rainfalls flood houses in these low topographic areas and inconvenience people who are unable to cook in their kitchens. The rain floods reach approximately 0.5m in these topographic low areas.
Thulusdhoo	Frequent events commonly occurring during the SW monsoon season	Flooding limited to the topographic low area in the centre of the island.
Kudahuva	Frequent events commonly occurring during SW monsoon.	Flooding limited to a few topographic low areas on the island. The magnitudes and impacts of these floods are small with water levels barely exceeding 0.3m. However, disruptions to socio-economic activities, result in schools and shops being closed for over 24 hours.
L.Gan	Events commonly occur during the SW monsoon.	Areas in 3 settlements –Thundi, Mathimaradhoo and Mukurimagu– are prone to rainfall flooding. All these settlements have wetland areas in close proximity to the settlement. As settlements expand to the low areas exposure to flooding becomes imminent. Impacts are usually minor with damage to household goods and disruption to daily activities such as businesses and schools.
Hithadhoo	May 6-7, 1978 October 12, 1981 October 14,1985 October 3 - 8, 2005	Rainfall related flooding is mainly limited to the eastern side of the island and around reclaimed wetland areas. Flooding on the eastern side has exacerbated since the construction of the link road between Gan and Hithadhoo. Flooding incidents have caused damage to houses, personal belongings and blockage of sewerage networks.

Source: UNDP, 2007[22]

Based on the historical data, return periods and intensity of extreme rainfall events for Hulhule and Gan station is presented in Table 4.4 (UNDP, 2007)

TABLE 4.4: PROBABLE MAXIMUM PRECIPITATION FOR VARIOUS RETURN PERIODS IN HULHULE AND GAN

ISLANDS	STATION DATA USED	RETURN PERIOD			
		50 YEAR	100 YEAR	200 YEAR	500 YEAR
Kulhudufushi, Thulusdhoo and L.Gan	Hulhule	187.4	203.6	219.8	241.1
Hithadhoo, Kudahuvadhoo	Gan	218.1	238.1	258.1	284.4

Source: UNDP, 2007

b. High Tides/Wave swells/*Udha:*

High tides are caused due to cyclonic activities, astronomical tide diurnally or local wind waves (*udha*) generated during the onset of the SW monsoon season. Historically they have caused significant flooding and wind damage along the coast. (Table 4.5)

TABLE 4.5: HISTORICAL IMPACTS OF HIGH WAVES IN MALDIVES

DATE	REMARKS
April 10-12, 1987	High waves caused by abnormal rise in sea level resulting in widespread flooding. It damaged a number of islands in the central part of the nation. Harbors, buildings and structures and coastal areas in Male were destroyed and damage was also noted in Hulhule.
June, July and September 1988	High waves due to an abnormal rise in sea level damaged houses, structures and coastal areas. Widespread flooding was reported in some islands in the southern atolls.
May 2007	Unusual high tides originated 5630km far from Addu Atoll reached western and southern atolls in Maldives with full energy causing extensive damage to the islands. (More details in Box-1)

Source: ADRC, 2005[23] & MMS, 2007

Swell surge have also affected coastal Maldives, with unrecorded reports as far back as the1950s Their broad impacts in selected island is noted in Table 4.6 and detailed impacts of the May 2007 wave swell is presented in Box 2.

TABLE 4.6: FLOODING CAUSED BY SWELL SURGES AND ITS IMPACTS IN SELECTED ISLANDS IN MALDIVES

ISLAND NAME	DATES OF THE RECORDED EVENTS	IMPACTS
Kulhudufushi	Late 1950s June 18-20, 2007	No established records in the 1950s however geomorphic evidence of severe surges in the coastal zone. Elderly report occasional tide surges although no dates could be determined. One such event was traced to 1955 in the most northern islands (Bodu Vissaara) . Nationwide swell flood of June 2007 destroyed parts of the harbor quay wall and flooded houses within 40m of the coastline.
Thulusdhoo	Late 1950's March 1987 Once in every few years on the eastern shoreline.	There have been 2 major flooding events but only one of them is directly linked to wave surges. Waves surge usually occur from the east (oceanward) side of the island. Flood waters reached up to 200 m inland from the eastern shoreline. Damages to backyard crops and temporary salinisation of groundwater in the flooded areas. Regular floods caused by Udha limited to 10's of meters inland from the eastern shoreline
Kudahuva	Annually (monsoonal wind waves or Udha)	Impact limited to 10 m from shoreline. Low intensity and rarely effects property or people.
L.Gan	1950's (exact date unknown) July 5, 1966	A major flooding event reported for Gan, which is dated back to 1950's. Exact date is not known, but residents say there were reports of fish near the northern wetland area, which is located 400m inland. No substantial damage to the settlements reported.
Hithadhoo	October 14,1984 June 3,1987 September 9-10, 1987 May 15, 2007	No official reports of wave surge flooding on the island, except in 2007. However historical documents show 3 major events. Impacts were moderate to severe on property, crops and personal belongings.

BOX 2: CASE STUDY OF HIGH TIDE/WAVE SWELLS IN 2007

Maldives had a series of wave surges from May 15 to 17 2007. The unusual tidal waves originated from the extra-tropical system in the southern hemisphere, approximately 5630km southwest of Addu atoll. It travelled to the northeast and across equatorial waters without losing the energy acquired from its strong wind source. It approached Maldives from the southwest and severely hit the islands located in the west and southern coast of the atolls (MMS, 2007). Varying magnitude of waves hit approximately 88 islands across 18 atolls, with some surges reaching as far as 600m inland. Wavelength of 350-433 meters in sea and in some cases two times the height at the coast in the southern atolls was noted. The waves started on May 15th and intermittently reoccurred 2 days after resulting in flooding and the following impacts.

- **Geography:** 35 islands in 13 atolls across the country were affected. Southern atolls Seenu and Gaafu Dhaalu were the most affected;
- **Population:** 4 cases of injuries from Th. Omadhoo, L. Kunahandhoo, and Gh. Dh. Madavelli.1,649 people evacuated;
- **Housing:** 475 houses affected due to the frequent flood surges. 217 additional housing units damaged (extent not known). Damage includes collapse of walls, exposed house foundation due to erosion, cracked walls, and collapsed boundary walls;
- **Infrastructure:** A number of harbors and jetties partially damaged. A school boundary wall damaged in one island. Seawalls and island office damaged in some islands. Coastlines and beaches eroded in number of islands;
- **Livelihoods:** Extensive damage to private gardens. Different crops affected to varying degrees. Fish processing facilities of different households affected. Some households lost fishery products such as dried sea cucumber resources which fetches high prices in the South Asian markets. A taro (similar to cassava) field, a major source of income to families, affected. Around 15 sea vessels damaged including family fishing vessels;
- **Water and Sanitation:** Wells and groundwater table contaminated due to salt water intrusion, resulting shortage of drinking water on some islands. Septic tanks damaged. Some landfills swamped by the tides and scattered trash throughout the affected area, raising sanitation concerns. Sewage sludge was observed along with debris in certain areas.

Source: MMS, 2007[24] & UNHRC, 2007[25]

c. Cyclonic Storms

Cyclonic storms positioned in the south Indian Ocean cross north Maldives, causing strong winds, high tides and storm surges. The worst storm surge (up to 2.3m) affected most of the northern islands. Historical storm events and their impacts are presented in Table 4.7.

TABLE 4.7: HISTORICAL STORMS AND THEIR IMPACTS

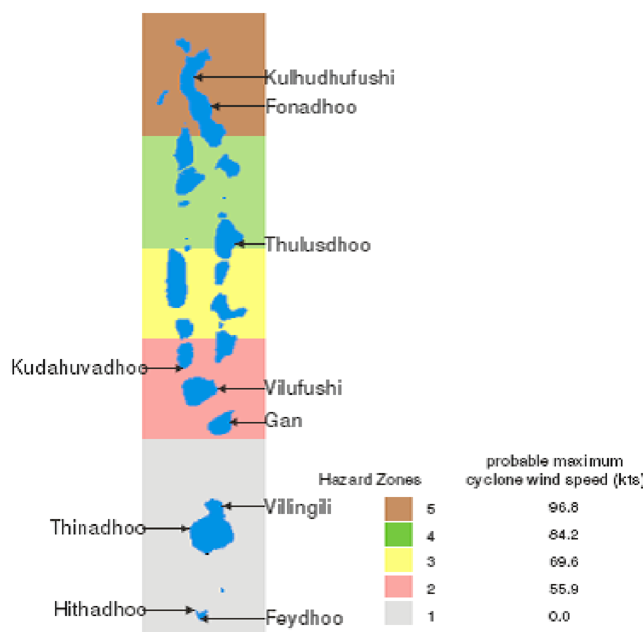
DATE	REMARKS
Before 1733	Several islands in northern Maldives were affected by cyclone-driven storms. About 18 islands in the northern atolls were abandoned after being devastated by storms (Maniku, 1990).
October 1733	Cyclone flooded and devastated many islands, particularly the northern atolls, with great loss of life and property (Bell, 1940).
1742	Storms struck Male from the west and more than 110 coconut trees were toppled (Bell, 1940).
June 7, 1752	Male was affected by a severe storm that blew from the southwest.
May 7, 1812	Storm devastated a number of islands in northern Maldives and affected the south as far as Kuredhoo.
October 9, 1819	Male was affected by a storm that blew from the west.

TABLE 4.7 CONTINUED

DATE	REMARKS
1819	Storm burst upon Male from the west. Many trees were blown down. In the Palace enclosure, 12 buildings fell (Bell, 1940).
December 29, 1819	Storm affected islands south of Maalhoosmadulu.
1820	Tornado struck Maldives. Amny islands of the Tiladummati and Miladhummadulu atolls and one or two islands of Maalhoosmadulu atoll were devastated. More than 30 odifahuru were wrecked and many people drowned. More than 30 islands were temporarily uninhabitable.
December 8, 1821	Storm affected many islands south of Miladhummadulu.
1898	Thulhaadhoo was affected by a storm during the southwest monsoon.
December 25, 1923	"Vodu Vissara" struck Male. Strong winds blew overnight from a south westerly direction, resuting in heavy rains. Winds whipped up with the arrival of another storm from the northwest. Several houses and trees fell and large areas of Male were flooded. Four vessels in the Male harbor were lost.
January 9, 1955	Storm laid waste in many islands from the southern point of Miladhummadulu.
November 3, 1978	The strongest gust of 62 knots was recorded in Hulhule.
June 23 to June 25 1987	Localised storms occurred in a few islands and spread to a large number of islands (24 islands in 9 atolls) (Maniku, 1990).
May 30 1991	Cyclone-driven storm struck the southern atolls. Atmospheric pressure fell to 997 hPa and the maximum squally winds reached 90 knots (DoM, 2001; WMO, 1993). Most parts of the country affected, 4081 houses in 13 atolls damaged (SAAC, 1992).
2000	The resort island of Bolifushi was hit by a storm, lasting for about 1e 4.2) 2 hours and causing significant damage.

Source: ADRC, 2005

Cyclonic hazard zonation map has been developed based on past records in Maldives (Figure 4.1) and threshold levels for various wind speeds and its impact on Maldives has also been developed (Table-4.8) on the basis of interviews with locals and available meteorological data for islands of Kulhudufushi , Thulusdhoo, Kudahuva, L.Gan and Hithadhoo.



Source: UNDP (2006)

Figure 4.1 Cyclone hazard zones in Maldives

TABLE 4.8: THRESHOLD LEVELS FOR WIND DAMAGE RELATED TO CYCLONES IN MALDIVES

WIND SPEEDS	IMPACTS
1-10 knots	No Damage
11 – 16 knots	No Damage
17 – 21 knots	Light damage to trees and crops
22 – 28 knots	Breaking branches and minor damage to open crops, some weak roofs damaged
28 – 33 knots	Minor damage to open crops and vegetation
34 – 40 knots	Minor to Moderate to major damage to houses, crops and trees
40+ knots	Moderate to Major damage to houses, trees falling, crops damaged

Source: UNDP, 2007

Past cyclone related windstorms and their impacts in selected island are noted in Table 4.9

TABLE 4.9: WINDSTORMS AND THEIR IMPACTS IN MALDIVES (SELECTED ISLANDS)

ISLAND NAME	DATES OF THE RECORDED EVENTS	IMPACTS
Kulhudufushi	July 9, 19731 June 17, 1975 May 24, 2005	A single event was reported by the island office that caused severe damage to few houses included blown off roofs, fallen large trees and destruction of backyard crops. The elders report numerous reports of windstorms that had minor impacts on infrastructure in the island. No dates could be determined.
Thulusdhoo	No specific records but reported as frequent	The effect of strong winds was not limited to a particular area of the island, however it was greatest on the western side as these events were mainly caused by the winds during SW monsoon.
Kudahuva	24 June 1987 Dec 18-20, 1992 5 other major events since 1980's (dates unknown).	Windstorms were common and spread along the entire island, affecting housing structures, vegetation and crops. The island is generally protected from thick coastal vegetation, but even before the settlements expanded, there were reports of windstorm related damages.
L.Gan	July 11,1966 May 5, 1977 May 12, 1978 Sept 28,1984	No major recent events reported. Written records suggest some damage to vegetation, crops and property.
Hithadhoo	January 15, 1970 April 29-3, 1971 May 6-7, 1978 October 12, 1981 October 14,1985 March 29, 1989 July 20, 2003	The island reports frequent windstorms. The 1989 event brought winds of 90miles/hr severely impacting the mango plants that are a major source of income for some families on the island. Over 1000 mango trees were affected, 400 breadfruit trees and 4200 banana plants were destroyed and 50 houses had their roofs blown off. It caused road blockages for a couple of days, schools were closed for a week and the cleanup operation took a week.

Source: UNDP, 2007

d. Strong winds:

Strong wind is a phenomenon that occurs during monsoon season, mainly due to depression and cyclonic activity in the region. This strong wind causes high tides which leads to surge in coastal areas and these winds affect transportation and damage boats and vessels.

In 2003, the maximum wind gust speeds were observed at 77 km/hr for Male', 78 km/hr for Hanimaadhoo, 75 km/h for Kadhdhoo and 72 km/h for Kaadedhdhoo. The strong winds lasted for 48 hours and flooded many islands with sea water, including the Male International Airport in Hullhulle. Local sea transportation was also adversely affected (MMS, 2003). Other events include the 2008 strong winds -- refer to Box 3.

BOX 3: THE JULY 2008 STRONG WINDS IN MALDIVES

Characteristics

On July 21, surface winds were 15-25 miles per hour in central atolls and 10-20 miles per hour over the rest of the country. Wind speeds of 30-39 miles per hour sustained in central atolls for about 5 hours starting at 1330 hours. Maximum wind gust speed of 62 miles per hour was registered at the National Meteorological Center followed by 59 miles per hour at the same station. 56, 51 and 45 miles per hour winds were recorded at meteorological offices in Hanimaadhoo, Kadhdhoo and Kaadedhdhoo respectively. The unusually bad weather lasted for 4 days across the country.

Impacts: Male' was severely affected by the strong winds and heavy rains from July 21 to 23. It caused a wall to topple over, destroyed property, blew off roofs of homes and left one person injured. Strong winds and rough seas caused 3 Indonesian fishing vessels to crash onto the Hulhule Island breakwaters on the night of July 21st. Strong winds across the country damaged many islands. A foreigner was seriously injured in Baa atoll Kendhoo when a tree fell was uprooted due to the strong winds. Eydhafushi, the capital island of Baa atoll reported serious damages to roofs of homes and uprooted breadfruit trees. Northern atolls also reported severe damages including uprooted trees and damages to public property.

Source: MMS, 2008 [26]

e. Drought

90 percent of the atoll's population depend on rain water as a principal source of drinking and cooking water. It is often collected in household water tanks. Drought in Maldives is caused due to poor distribution of rainfall over the region and reduced rainfall during the dry season (January-June). It has increased in frequency in recent decades threatening water security. Severe annual water crisis is noted in the summer season. The case of the 2009 drought is detailed in Box 4. In the dry seasons of 2009 and 2010, the Maldivian government supplied desalinated water to over 90 islands at a cost of Rf10 million (US$640,000). The average cost of this service is expected to rise with fuel prices.

BOX 4: THE 2009 DROUGHT IN MALDIVES

The National Disaster Management Centre (NDMC) noted that 55 islands in Maldives faced severe water shortage during the 2009 drought. This includes the entire Addu Atoll and some islands of Raa and Baa Atoll. The water crisis was a result of the prolonged drought in many islands, because of poor rainfall during the 2008 monsoon and post monsoon season. Refer to Figure 4.2 for rainfall distribution from May 2008 to April 2009 in Male and Gan stations. People suffered shortages starting February 2009.

Situation during water scarcity

Rainwater storage capacity is limited to 2500 liters in an average household in Maldives. Due to the changing weather patterns and prolonged dry periods, people experienced severe shortage of drinking water, prompting calls for emergency water supply.

MNDF started refilling public water tanks, including those in schools and mosques. Nearly 10 tonnes of water was supplied to the islands daily. 35 tonnes of water was collected from the Felivaru fish processing plant and carried to the islands of Baa and Raa atoll on a Finnish vessel.

NDMC spent US$60,000 to supply water to 12 islands. People collected water from the public tanks, which also ran out soon. They then resorted to purchasing bottled water. An affected person with a 12-member family spent US$22 a day to buy bottled water for drinking and cooking; while their daily income was only US$26.

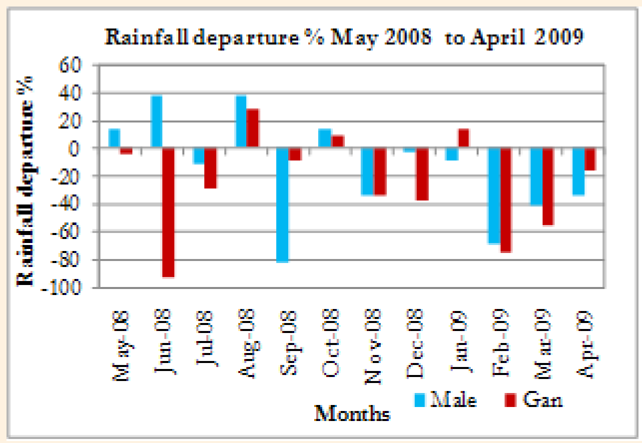


Figure 4.2 Rainfall departures May 2008- April2009

Source: Haveeru, 2012[27] and Minivan, 2012[28] and Minivan News, 2009

FUTURE PROJECTED CLIMATE IMPACTS

A multi-stakeholder study has highlighted future climate projections and its likely impacts on key sectors of the Maldivian economy as detailed in Table 4.10

TABLE 4.10 CLIMATE PARAMETER AND ITS LIKELY IMPACT IN MALDIVES

PRIORITY NUMBER	CLIMATE PARAMETER	SECTORS LIKELY TO GET AFFECTED	LIKELY IMPACTS
1	Sea-surface temperatures	Livelihood and Fisheries	Rise in sea surface temperature will affect coral health and availability of fish in the region.
2	Rainfall (distribution)	Tourism, Water resources, Transportation and Agriculture	Increase in rainfall will help rainwater harvesting and agriculture, however it will challenge tourism and water transportation
3	Sea-surface heights or sea-level (in the long-term)	Disaster Management, Transportation and Infrastructure	Increasing sea level will threaten lives, infrastructure, and the existence of few low lying islands.
4	Temperature	Health	Increase in temperature may lead to disease outbreaks like malaria and dengue, although they have been eradicated in Maldives.

Source: RIMES, 2012

a. Sea Level Rise

Maldives is vulnerable to sea level rise because of its low elevation. Higher the sea level the more frequently these small islands will be washed over by storms. SLR would also cause coastal erosion and landmass submergence in the next 30 years. Additionally, salt water intrusion of the island aquifers may render the islands uninhabitable in the future (Viner & Agnew, 1999[29]). Sea level rise is particularly important for Maldives for risks from inundation. One of the long term risks for Maldives is SLR rise combined with high tides, which occurs occasionally for one or two days. However a +0.65m high tide is considered as extreme case as per historical records in Maldives. Inundation scenarios have been computed and presented for Sea Surface Height (SSH) in Table 4.11.

TABLE 4.11: PROJECTED PERCENTAGE OF INUNDATION FOR SSH RISE IN 2080 DURING HIGH TIDE CONDITIONS

ATOLL NAMES	PROJECTED PERCENTAGE OF INUNDATION FOR SSH RAISE IN 2080		
	MAXMIN_SSH	MAXMEAN_SSH	MAXMAX_SSH
Haa Alifu	3.04	3.20	3.33
Haa Dhaalu	2.67	2.76	2.91
Shaviyani	3.65	3.78	3.95
Raa	4.79	4.95	5.11
Noonu	3.51	3.69	3.82
Lhaviyani	8.92	9.07	9.33
Baa	4.65	4.72	4.86
Kaafu (North and South)	11.09	11.25	11.57
Alifu Alifu	6.52	6.66	6.76
Alifu Dhaalu	5.22	5.36	5.44

ATOLL NAMES	PROJECTED PERCENTAGE OF INUNDATION FOR SSH RAISE IN 2080		
	MAXMIN_SSH	MAXMEAN_SSH	MAXMAX_SSH
Vaavu	6.85	6.91	7.10
Faafu	3.26	3.39	3.45
Meemu	10.64	10.70	10.81
Dhaalu	4.68	4.84	4.92
Thaa	5.09	5.23	5.32
Laamu	3.13	3.23	3.33
Gaafu Alifu	5.13	5.29	5.48
Gaafu Dhaalu	6.07	6.26	6.45
Gnaviyani	0.81	0.86	0.90
Seenu	6.53	6.76	7.00

Source: RIMES, 2012

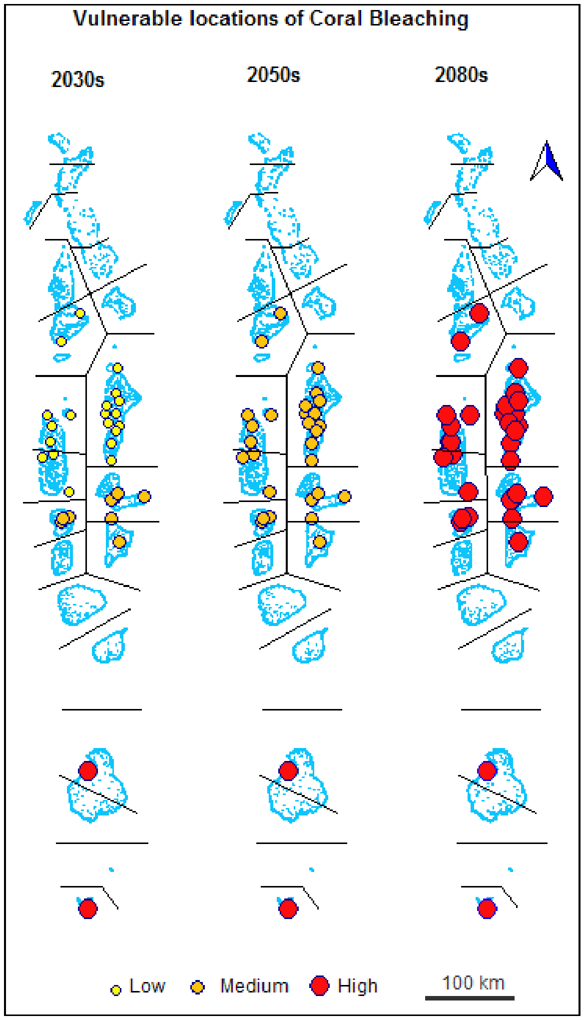
b. Sea Surface Temperature (SST)

SST rise will have a direct impact on coral health, induce storm surges, and swell related flooding. Future impacts of SST on the DIRAM pilot islands are presented in Table 4.12. (UNDP, 2007)

TABLE 4.12: FUTURE IMPACTS ON SST FOR SELECTED ISLAND

ISLAND NAME	PREDICTED RATE OF CHANGE	POSSIBLE IMPACTS
Kulhudufushi Thulusdhoo	1.1°C / decade	Increase in storm surges and swell wave related flooding, coral bleaching and reduction in coral defenses.
Kudahuva L.Gan Hithadhoo	0.3°C /decade	Increase in storm surges and swell wave related flooding, coral bleaching and reduction in coral defenses.

Increase in SST causes coral bleaching and affects fish catch. Projected SST changes and its likely or indicative damage to coral health based on historical impacts is illustrated in Figure 4.3. These impacts are based on general indicators and will have to be interpreted carefully for specific locations (RIMES, 2012).



Source: RIMES, 2012

Figure 4.3 Vulnerable spots for coral bleaching based on historical data and SST projection

c. Heavy rainfall

The increase in heavy rainfall days will have positive and negative impacts for different sectors. While, tourism may be adversely affected, agriculture and water resource may benefit with the additional water supply (RIMES, 2012). Overall, increase in extreme events may result in rainfall flooding and threats to coral reef growth in Maldives (UNDP, 2007). (Table 4.13)

TABLE 4.13: FUTURE IMPACTS OF HEAVY RAINFALL ON MALDIVES

ISLAND NAME	PREDICTED RATE OF CHANGE	POSSIBLE IMPACTS
Kulhudufushi Thulusdhoo	+0.14% / yr (or +28mm/yr)	Increased flooding, could affect coral reef growth
Kudahuva L.Gan Hithadhoo	+0.14% / yr (or +32mm/yr)	

Source: UNDP, 2007

CLIMATE SENSITIVITY AND THREATS TO DEVELOPMENT

The sectors of tourism, agriculture, water resource and fisheries support 71 percent of the population, account for 89 percent GDP, 91 percent of government revenue and 90 percent of foreign exchange earnings (MHTE, undated[30]). However, they are highly sensitive to climatic conditions and their sensitivity could result in the following socio-economic development impacts in Maldives.

a. **Tourism sector** is the most important economic sector, contributing 30 percent of GDP, 90 percent of government revenue, 70 percent of foreign exchange earnings and one third of employment in Maldives. The evolution of resorts since 1970s indicates that, tourism is based on the natural habitat features of Maldives, particularly its natural reef and ecosystems. Most of these tourist resorts are small islands, which are increasingly exposed to climate risks. Their basic infrastructure such as power structure, water systems, drainage systems, waste disposal systems are within 50m from shorelines. The first line of defence of shoreline is degraded, leaving little or no buffer against waves, storm surges and coastal flooding. 50 percent of resorts have faced rainfall based flooding, occasional swells and storm surges in the past. Climate risk especially sea level rise could not only threaten tourism but the very existence of very small island based resort destinations. There is a need to protect the islands by building climate sensitivity features and ensuring the health of their habitat. This is critical given that they are the backbone of Maldivian economy (DNP, 2011[31]).

b. **Fisheries** is the next most important economic sector in Maldives. Fisheries, particularly tuna supports employment of around 15,000 people directly and 5000 people indirectly through processing industries. These industries are linked to resorts and other sectors of the economy. The rise in SST leads to coral bleaching, which results in migration of tuna to eastern waters. The Somali basin of the North Arabian Sea is protective and offers abundance of resources to fish during the strong SW monsoon, resulting in migration of tuna to the area. Also over exploitation of tuna in parts of the Indian Ocean affects the catch in Maldives.

   There is a need to better understand the link between tuna population and its catch related to the health of coral reef in Maldives. For example, the fishing method in Maldives is dependent on pole and line methods on live baits. The live bait is extracted from corals. The reef fishery biology is thus dependent on coral reefs, which are affected by climate variability and change. The increasing SST causes coral bleaching which in turn affects reef fish catch as evident in 1998 (Adam, 2006[32] & MEEW, 2006[33]).

c. **Agriculture** has limited contribution to the national economy, however supports employment of around 15000 people. The GoM's approach is to diversify its narrow economic base from tourism and fisheries to agriculture and other sectors. It is noted that small scale vegetable base systems and gardens benefit from heavy rains and flooding, Thus, it is critical to understand the climate change implications on agriculture production in Maldives to favourably exploit its benefits and minimize the losses in other sectors (DNP, 2011).

d. **Water resource** as a bio-physical system is extremely sensitive to climate conditions. Traditionally the Maldivian society depended on rain water harvesting and shallow wells for fresh water. The shallow wells and fresh water aquifers lay within 1.3m and are being threatened due to land degradation and salinization, especially in low rainfall areas. Low rainfall occurs once in 5 years during El Nino and may be further aggravated due to climate variations. In the year 2009, 2010 and 2012, summer months noted water scarcity in 60 islands, impacting 30000 people. It is estimated that in the coming years 25 to 30 thousand people particularly in northern and central islands could face water scarcity in low rainfall years. The NDMC estimates a recurrent expenditure of 1 million USD for providing drinking water supply to the islands making it critical to understand and address the climate impact on water resources in Maldives (DNP, 2011 & Minivan News).

e. **Critical Infrastructure** includes harbor, hospitals, power stations, communication systems, waste disposal systems and schools in Maldives which are exposed to swells, strong winds and rainwater flooding. Almost all waste disposal facilities are located and 75 percent of communication infrastructure is sited within 100m of the coastline. 42 percent of islands and 47 percent of their infrastructure is exposed to climate risk in these zones. These high frequency and low impact hazards are a serious threat to critical infrastructure in Maldives. Thus, there is a need to understand the economic costs, and identify temporary and long term solutions to manage these recurrent risks and their impacts. (MEEW, 2006)

f. Biodiversity System: Before the 1970s, there was limited human interference with natural habitats and biodiversity systems in Maldives. However, rapid population growth, development of resorts and other critical infrastructure are undermining these systems currently. Since 70 percent of the economy particularly the tourism, agriculture and fisheries sectors, are supported by the natural habitat of Maldives, the economic value of its upkeep needs to be appreciated. Moreover the cost of replacing the degraded natural resources would be much higher than investing in naturally maintaining it. Sustained biodiversity and natural habitats act as defense against climate hazards such as storm surge and coastal flooding and their intrinsic value must be accounted for in understanding the impact of climate related risks and the measures for addressing them (MHTE, undated).

Since the Maldivian economy has a narrow base both in terms of domestic and foreign exchange revenues, any extreme shock to these sectors could undermine the ability to provide basic services and social welfare interventions like poverty reduction to the people. This sensitivity was exposed during the 2004 tsunami and the 2009 economic crisis. Also, the recent population explosion and socio economic development has increased people's exposure to climate related hazards. The value chains of sectors such as tourism, fisheries and agriculture could be severely affected by extreme weather events once in 20 years. This could undermine the very economic base of Maldives, which depends on imports, tourism arrival and export of fish to the external markets.

ADAPTIVE CAPACITIES FOR CLIMATE RISK REDUCTION

Maldives' adaptive capacity to climate variability is very low at the national, atoll, island and community level. Before the early 1970s, the Maldivian economy was predominantly based on primary sectors like fisheries and agriculture. With a small disbursed population of around 70,000 people, and natural barriers like coral reefs and the natural ecosystems, people and socio-economic systems had limited exposure to natural hazards like storm surges and heavy rains. However after the 1970s, a large transformation of the Maldives economy rendered communities, infrastructure and production systems more vulnerable to natural hazards. The impact of development on natural ecosystem and expansion of economy to other sectors such as communication, infrastructure, power, sewage and water management systems have also increased the economy's exposure to climate hazards.

The Maldivian economy is narrow based predominantly on the tourism and fisheries sector. Any shocks to these sectors could impact the government's ability to support the country during disaster events such as swells, storm surges, heavy rains, cyclonic storms and also low rainfall conditions leading to drought , especially drinking water scarcity. The tourism sector experienced two shocks recently –the 2004 tsunami and the 2009 global economy crisis– leading to poor tourism and negative GDP growth. These shocks revealed the government's structural weakness and limited capacity to respond to both climate and global economic shocks and unearthed the need to build resilience in anticipation of the emerging climate and economic risk trends.

Maldives has some sectoral adaptive and coping strategies to address climate risks. Table 4.14 indicates some adaptive strategies adopted by the tourism sector. However, overall the national government has low adaptive capacity to deal with climate events and to reduce vulnerability through development interventions. Technical and institutional capacities are still nascent in Maldives. The institutional systems at the atoll and island level are weak and decentralization is still in transition. The local government entirely depends on national systems which also have limited capacities in dealing with these risks.

As a result, communities struggle to withstand high frequency and low impact hazards such as heavy rainfall flooding, drought like conditions and swells. They largely depend on external assistance for moderate to severe hazard such as cyclonic storms, storm surges and others. Biodiversity based barriers are getting weaker, because of human interventions in the recent decades. Coral reefs are very sensitive to climate conditions, for example, during 1997-98 El Nino conditions, coral bleaching led to fall and migration of fish stock in Maldives. Thus the need to revitalize natural barriers is often expressed.

TABLE 4.14: SOME COPING AND ADAPTIVE STRATEGIES OF THE TOURISM SECTOR IN THE MALDIVES TO REDUCE THE ADVERSE CONSEQUENCES OF PRESENT DAY WEATHER AND CLIMATE EXTREMES AND VARIABILITY

CLIMATE RISK EVENTS	CONSEQUENCES OR SIGNIFICANCE TO TOURISM	CURRENT COPING STRATEGIES PRACTICED BY THE TOURISM INDUSTRY
Elevated sea level, including high wave incidents	Coastal erosion, land loss, flooding, inundation	Moveable groynes, coastal re-vegetation, open-structured, jetties, beach nourishment, wave-breakers, seawalls, elevated structures
Changed ocean currents and/or wind patterns	Coastal erosion, land loss, changed surfing conditions, dangerous swimming conditions	Most of above, plus strengthened early warning, awareness and safety programmes
Elevated ocean and lagoon temperatures	Coral bleaching, algal blooms, fish morbidity	Coral gardens, beach and lagoon clean-up campaigns; changed marketing strategies
Elevated air temperatures	Heat stress for humans, plants and animals, vector-borne diseases	Activity options, education and awareness raising, shade plants and structures, deep ocean water cooling systems, upgraded health-care facilities, mosquito fogging, vegetation and water body management
Increased rainfall variability and greater extremes	Drought, flooding	Water conservation, storage and reuse, rainwater harvesting, improved storm-water management
Extreme high winds	Outside activities curtailed, structural damage	Early warning, strengthened safety programmes, alterative activity options, building design

Source: Hay et. al 2009[34]

KEY MESSAGES - CLIMATE IMPACTS AND RISKS

- Contrary to common perception, the high exposure of lives and livelihoods in the small island nation of Maldives makes it vulnerable to both low and high intensity and frequent climate hazards.
- Low intensity and high frequency natural hazards like rainfall flooding, swell wave flooding and cyclonic storm can have higher impact due to accumulated risks.
- Climate risks pose serious threats to infrastructure and production systems and thus the economic development of Maldives, since most sectors of the economy are highly exposed to climate risks and dependent on the natural environment and resources.
- Natural barriers that cushion the impact of natural hazards are getting weaker, exposing Maldivian people and its economy to increasing risks in recent decades.
- The key sectors of Maldives' economy such as tourism, fisheries and agriculture support livelihoods of 90 percent Maldivians and are highly susceptible to multiple external shocks, especially climate risks.
- Other sectors of development that have high climate sensitivity are water resources, critical infrastructure and biodiversity systems.
- As the Maldivian economy is narrow-based, it has low adaptive capacity to climate risks. Despite decentralised systems both national and local governments have low adaptive capacity to deal with climate risks. Communities largely depend on external assistance for climate related hazards.
- The tourism sector has employed some adaptive strategies for climate risks such high waves, high winds, ocean currents, elevated ocean/sea levels, elevated lagoon and air temperatures, increased rainfall variability and extremes.
- Some adaptive capacities to climate risks include moveable groynes, coastal re-vegetation, jetties, beach nourishment, wave-breakers, seawalls, altered building designs like elevated structures, strengthened early warning, awareness and safety programmes etc.
- Although useful these adaptive capacities are not adequate. Greater investment is needed in revitalising natural barriers, understanding the impact of climate risks on the socio-economic development of the country and developing informed risk reduction and adaptive capacities.

CURRENT CLIMATE RISK MANAGEMENT

INSTITUTIONAL AND POLICY ARRANGEMENTS FOR CRM IN MALDIVES

In Maldives, three distinct frameworks address climate risks and climate risk management (CRM) processes. These include frameworks for development planning, disaster management, and climate change adaptation.

Development Planning Framework

The Department of National Planning (DNP) under the Ministry of Finance and Treasury (MoFT) leads the national development planning process in Maldives. It is responsible for formulating National Development Plans (NDP) and ensuring conformity of Sectoral Master Plans to the NDP. DNP also formulates policies on socio-economic development; identifies development indicators; and formulates and implement development consolidation strategies. The Seventh National Development Plan (SNDP) covering the period of 2006 to 2010 was followed by the Strategic Action Plan (SAP), 2009-2013 prepared by the government elected in 2009.

The SAP (2009-2013) guides development planning in Maldives and is built around five pledges of the government. These include focus on nationwide transport system, ensuring affordable living costs, provision of affordable housing, providing quality healthcare, prevention of narcotics abuse and trafficking. The SAP identified key themes of good governance, social justice and economic development under which sectoral plans were proposed. Climate change is one of the five priority development areas identified by the government (the others are macro-economic reform, public sector reform, social development and governance).

The National Sustainable Development Strategy (2009) provides guidance on sustainable development in Maldives. It sets seven carbon-neutral goals as the basis for policy targets including i) adapt to climate change, ii) protect coral reefs; iii) achieve carbon neutrality in energy; iv) ensure food security; v) establish a carbon neutral transport system; vi) protect public health; and, vii) achieve full employment and ensure social security.

A National Planning Council was constituted in 2009 to ensure coordination of planning functions of different sectors, to determine national priorities, to provide advice on long term development policies and strategies, to ensure sustainable development of the nation and to ensure balanced and equitable development at the provincial level. Its key mandate was to provide strategic direction and policy guidance on national development. This body is currently undergoing reform, and the MoFT is acting as the lead ministry for development planning.

Disaster Risk Management Framework

a. *Institutions:* The National Disaster Management Centre (NDMC) is the lead agency for disaster management in Maldives. It was established after the Indian Ocean tsunami of 2004 and has since been involved largely in improving response capacities and preparedness, especially among schools, with the participation of the Ministry of Education (MoE).

A National Disaster Management Council is proposed under the Disaster Management Bill. The council would be chaired by the President of Maldives, have the NDMC as the Chief Coordinator, a representative of the Supreme Council for Islamic Affairs as Vice Chair. Members would include the Cabinet Ministers who carry relevant portfolios to help with immediate response, a representative from key associations representing the major industries in the private sector and a representative of a national, non-government humanitarian agency. A National Disaster Management Plan and National Emergency Operations Plan are proposed under the council. Its functions would be to guide, advise and approve critical decisions relating to disaster management.

A National Disaster Management Authority is also proposed to undertake all operational activities relating to disaster risk management in Maldives. Atoll and Island Disaster Management authorities are also proposed to prepare disaster management and emergency operation plans. A National Disaster Management Fund is proposed to support financial requirements of impending disasters.

b. Policies, strategies, programmes: A bill on disaster management has been formulated by the NDMC to aid in speedy relief and response and provide legal backing for risk management. It is pending approval from the Parliament.

The Strategic National Action Plan (SNAP) for Disaster Risk Reduction (DRR) and Climate Change Adaptation (CCA) for the period of 2010 to 2020 was formulated taking into cognizance the existing plans and key documents of the government. It consulted with a wide variety of stakeholders at the national level. It integrates DRR and CCA and identifies four strategic areas and ten areas for strategic actions as below:

I. Enabling Environment Towards Good Governance;

1. Institutional framework, institutional alignment and decision-making;
2. Capacity building for disaster preparedness and recovery at all levels: institutions, local authorities and communities;

II. Empowered and Capable Communities;

3. End-to-end early warning system;
4. Community-based disaster risk management;

III. Resilient Communities with Access to Technology, Knowledge and Other Resources;

5. Knowledge management capacity building;
6. Awareness raising;
7. Connecting island communities to technology, knowledge and resources;

IV. Risk-sensitive regional and local development;

8. Regional development focussed on vulnerable communities;
9. Risk-sensitive policy and regulations in construction and industry;
10. Disaster-resilient community housing and infrastructure.

Among sectors, DRR has been considered and integrated into operations by the Tourism and Education sectors through the Disaster Management Strategy and Plan for the Tourism Sector prepared in collaboration with the Ministry of Tourism in 2005 and the School Emergency Operation Plan prepared with involvement of Ministry of Education in 2009 respectively.

Climate Change Framework

a. Institutions: The Ministry of Energy and Environment (MoEE) is the lead line ministry in Maldives for climate change functions. A Climate Change Advisory Council (CCAC) was recently established to provide inputs on all climate change related projects, and is expected to facilitate integration of climate change into development. It is however not fully operational. *(MHE, 2010)*

The Climate Change and Energy Department is the key department in MoEE to coordinate climate change functions and activities, in collaboration with several relevant sectoral ministries such as Ministry of Transport and Communication, Ministry of Housing, and Ministry of Finance and Treasury.

b. Policies, strategies, programmes: The National Adaptation Programme of Action (NAPA) was formulated in 2007 and is the key document guiding climate change actions in Maldives. It outlines priority adaptation needs and strategies focussing on relevant areas and sectors like lands, beaches and human settlements, critical infrastructure, tourism, fisheries, human health, water resources, agriculture, food security and coral reef biodiversity. 30 priority adaptation strategies are identified in NAPA. The top 10 strategies are:

i Build capacity for coastal protection, coastal zone management and flood control;

ii Consolidate population and development;

iii Introduce new technologies to increase local food production;

iv Acquire support for the speedy and efficient implementation of Safer Island Strategy;

v Develop coastal protection for airports and development focus islands;

vi Integrate climate change adaptation into national disaster management framework;

vii Strengthen tourism institutions to coordinate climate response in the tourism sector;

viii Improve building designs to increase resilience and strengthen enforcement of building code;

ix Acquire appropriate sewage treatment and disposal technologies to protect water resources;

x Incorporate climate change adaptation measures in upcoming resorts.

The Climate Change Policy in Maldives has the overall goal of ensuring survival and sustainability of Maldives. Its specific objectives are to i) ensure Maldives is a major influence in driving forward international agreements and international actions on climate change, ii) show leadership in mitigation actions in Maldives to reduce national greenhouse gas emissions and demonstrate commitment to stopping climate change, and, iii) prioritise and implement adaptation actions in Maldives related to the impacts of climate change.(MOFA, 2009)[35]

A Climate Change Trust Fund was set up in 2010 with support from the World Bank, EU and the AusAid, to support the development and implementation of a climate change strategy for Maldives. The fund was intended by the GoM to strengthen knowledge and leadership in the government, build adaptive capacity through pilot programmes, develop renewable energy through low-carbon options and Public Private Partnerships (PPPs) and, improve policy and institutional capacities in both public and private sectors to deal with adaptation and mitigation of climate change. The trust fund will also be used to strengthen coastal protection, biodiversity conservation, tourism, fisheries industry, solid waste management and energy solution. *(Minivan News, 2010)*[36]

Currently the three domains –disaster risk management, development, and climate change adaptation– are under development in Maldives and the process of integrating CRM within and across them is underway.

MAJOR ONGOING AND UPCOMING ACTIVITIES TOWARDS CLIMATE RISK MANAGEMENT

Despite the emerging nature of climate risk management in Maldives, there are several climate change and risk management initiatives that are on-going or in the pipeline. Refer to table 5.1 for details (MHE, 2010)

TABLE 5.1 PROGRAMS AND PROJECTS RELATED TO CLIMATE CHANGE AND RISK MANAGEMENT

FINANCIAL INSTRUMENT/ TYPE	PURPOSE OF FINANCING	PROJECT VALUE	PRIORITY SECTOR OR INTERVENTION
LDC fund for Adaptation, UN Grant	Integrating Climate Change into Resilient Island Planning in the Maldives, concept based on NAPA	USD 9,336,212	Resilient Islands
UNDP, UNESCAP Grant	Early Warning Dissemination and response		Disaster Risk Reduction
UNICEF, Veolia Water Force France, International Red Cross	Desalination plants and water tanks		Water security
Government funded Subsidy	Provide water tanks to all houses in 45 islands		Water security
World Bank	Development of GIS maps		Increasing evidence base
French bilateral fund Grant	Maldives Climate Mapping	USD 1,855,200	Increasing evidence base
EU Trust Fund, managed by the World Bank Grant	Mangrove and wetland restoration for climate change adaptation	USD 123,680	Mangrove and wetland

Source: MHE, 2010

CAPACITY ASSESSMENT FOR CLIMATE RISK MANAGEMENT (CRM)

An assessment of CRM capacities and gaps undertaken using the World Resources Institute's National Adaptive Capacity framework (WRI, 2009) revealed the following:

a. Assessment function: The Detailed Island Risk Assessment in Maldives (DIRAM) project was undertaken in 9 inhabited islands of Maldives and provided an estimate of possible areas and assets likely to be affected by climate risks, considering the extent of impact varying with distance from the coast. It does not integrate specific past weather and socio-economic information, except for tsunamis where the 2004 tsunami event was used as a precedent. It also lacks event-based assessment, connecting meteorological data with socio-economic data, based on past occurrences, particularly for minor (less severe) but frequent events such as coastal flooding, or droughts. These limitations have challenged the use of the assessment for mitigation measures.

For climate risk assessments, weather and climate information is a key prerequisite. However, even within the Maldives Meteorological Service (MMS), the quality of outputs with respect to annual assessment leading to Climate Reports has gone down since 2009, indicating resource crunch, lack of continuity of human resources and leadership. Assessment capacities within the government system remain weak, despite the variety and quantity of risk assessments undertaken in the recent past, including the disaster risk profile and the climate profile of Maldives.

b. Prioritization function: In the absence of practical yet robust assessment capacities, prioritization of risks is challenged. Swells, rainfall flooding, storms, droughts, *Udha* and tsunamis are key hazards in Maldives. Of these *Udha* is the most frequent, followed by droughts, floods, storms, swells and tsunami. However, even a hazard as frequent as the *Udha* is not prioritised and measured to prepare for and mitigate its impacts.

Prioratization discussions have centered on the need for 'hard' or 'soft' adaptation options to meet the challenges posed by climate change. Hard options are found impractical due to the excessive costs, despite being most favoured by most inhabited islands. Soft options on the other hand, are not welcomed by communities. While this debate continues, early warning system for the most frequent hazards, including *Udha* could be prioritised as it is both economical and acceptable to most stakeholders.

Rainfall flooding is a common occurrence in several islands, with water-logging in low-lying areas affecting normal life. Although this issue is acknowledged by all stakeholders at the local and national level, resources are still not prioritised for installing pumps that could drain excess water out of the flood mitigation canals into the seas. Fuvahmulak atoll (island) in Southern Maldives is an example.

Bio-diversity is a key resource for Maldives, especially its most rewarding economic activities of tourism and fishing. Despite being such a valuable asset and its protection being mostly non-structural, primarily non-interference, its protection has not been prioritised by either coastal infrastructure development projects or land reclamation.

There are number of surveys and studies providing a portfolio of hard engineering options and soft options. The GoM is not in a position to allocate resources for either hard or soft options, since they have high deficits and low allocations for development expenditures. The proportion of development and non-developmental expenditure indicates the ratio of 20 to 80. Within the development expenditure allocation for environment management, disaster risk management, water resource management and agriculture management is 0.1 percent. Hence the GoM is resource constraint in providing resources for costly adaptation options.

c. Coordination function: Coordination capacities are weak in the development activities of Maldives,. Environmental management experiences over the past decade itself shows lack of capacities and collaboration among various institutions. For example, changes in functions and priorities of the environment portfolio, have been noted across several ministries from Environment and Energy, Housing, Transport and Environment, Housing and Environment and now again Environment and Energy. Several other changes among ministries, departments and functions, including the NDMC have only aggravated the situation. Adding the dimension of climate risks would most likely add to the complexities in the system.

d. Information management function: Climate observation, monitoring and processing capacities are weak in Maldives. MMS, the agency responsible for weather, climate, ,geo-physical and oceanic hazards is under-funded and under-resourced. Observation systems are not as dense as required considering the remoteness and small sizes of most inhabited islands. Insufficient budgets challenge monitoring functionality and undertaking regular maintenance operations. While this issue is well-recognised, interventions planned would not substantially alter the situation. For example, while the Integrating Climate Change Risks into Resilient Island Planning (ICCRIP) initiative aims to build a climate information system which would collate available climate data (weather, oceanic etc.) on a GIS platform, for stakeholders to use for planning and operations; it is essentially a static system. Risks and the dynamic climate information is not factored in the forecasts, and integrated within the MMS.

e. Climate risk reduction function: Detailed exercises were undertaken under the DIRAM project (UNDP 2007) to identify adaptation options and their cost-benefits. In most cases, except highly populated islands, the costs far outweigh the benefits. (Table 5.2)

TABLE 5.2 SUMMARY OF COSTS AND BENEFITS OF ADAPTATION OPTIONS

ISLAND	MITIGATION COST (RF MILLION)	BENEFITS (RF MILLION)	NET BENEFIT (RF MILLION)
Kulhudhuffushi	183	149	-33
Funadhoo	156	109	-47
Thulusdhoo	116	56	-60
Kudahuvadhoo	163	95	-67
Gan	354	248	-73
Viligilli (after reclamation and coastal protection)	166	124	-43
Thinadhoo	215	169	-46
Feydhoo	172	178	6
Hithadhoo	357	389	32

Table 5.3 captures the frequency and damage potential of key hazards in Maldives. Considering the frequency of low impact climate related hazards in Maldives, their cumulative losses will be more than a low frequency and high impact hazard like a tsunami in the long term.

TABLE 5.3 HAZARDS, FREQUENCY AND DAMAGE POTENTIAL IN MALDIVES

HAZARD	TSUNAMI	SWELL WAVES OR STORM SURGES	RAINFALL FLOODING	STRONG WIND
Frequency	Once in 200 years	Once in 10 years	Once in 1 year	Several times a year
Damage Potential	Very High	High	Moderate	Low
	Infrastructure: Port, island harbour, power house, roads, regional hospital, waste management site, sewerage system, schools, communications facilities, emergency services and public administration buildings. Private investments: Fishing vessels, fuel supply, warehouses, retail shops, cafés, boat yard, households, back yard crops and fish processing. Sectors: Fishing, rope making, boat building, wholesale and retail, tourism, transport, public administration, workshops and agriculture.	Infrastructure: Port, island harbour, power house, regional hospital, roads, waste management site, sewerage system, communications facilities, schools & emergency services. Private investments: fuel supply, warehouses, retail shops, cafés, boat yard, households and fish processing. Sectors: Fishing, rope making, boat building, wholesale & retail, transport, tourism, back yard crops, public administration, workshops and agriculture.	Infrastructure: Power house, road maintenance services, roads, communication facilities and schools. Private investments: Warehouses, retail shops, cafés, households and fish processing. Sectors: Rope making, wholesale and retail, transport and agriculture.	Infrastructure: All infrastructure except port and island harbour. i.e., power house, regional hospital, roads, waste management site, sewerage system, communications facilities, schools & emergency services. Mostly secondary risks from falling trees. Private investments: All land based investments, i.e., fuel supply, warehouses, retail shops, cafés, boat yard, households, back yard crops and fish processing. Sectors: Boat building, wholesale & retail, workshops, transport and agriculture.

Adapted from DIRAM UNDP 2009

With efficient Early Warning System (EWS), the losses could be substantially minimized. Hence, EWS seem to be the most suited risk reduction measure and a first step, for which technical and institutional capacities need to be enhanced. Also, if EWS could be developed for the whole country and cover all hazards, the benefits could far outweigh the costs. It could also be expanded to include coral and other natural resource parameters. A detailed study could bring compelling evidence in favor of this option.

KEY MESSAGES (CURRENT CLIMATE RISK MANAGEMENT)

- Currently, there is no harmonised institutional system to anticipate and manage climate risk holistically in Maldives.
- Climate risk assessment processes are dispersed among different departments and not fully operational.
- The GoM is on a learning process to evolve and integrate climate change adaptation options by appropriate prioritization. It has earmarked very limited resources for climate change adaptation in its budgets.
- The cost benefit analysis shows there is a favourable benefit in investing in CRM when cumulative losses due to high frequency low impact hazards like rainfall flooding, wind storms, swells etc. are reviewed against low frequency, high impact hazards like tsunamis.

RECOMMENDATIONS FOR CLIMATE RISK MANAGEMENT

In light of the economic and environmental linkages, the existing national capacities and needs and the emerging trends in climate and its extremes, the following recommendations are proposed to address and manage climate risks in the Maldives:

1. PRIORATIZE STRATEGIC ENTRY LEVEL CLIMATE CHANGE ADAPTATION OPTIONS:

These options could be integrated into current development planning process and environment practices of Maldives. For example, the focus should be initially on high frequency and low impact climate related hazard management options for droughts, swells, wind storms etc. This would help address accumulated risks which are costlier in the long run, build resilience, further environmental preservation and conservation processes, help identify the manifesting climate change risks and allow time for adaptation learning processes. The adaptation options should include those that are convincing to communities and GoM at first and then expand the scope and or scale up initiatives. This would also help address the mindset of high cost and low benefits of investing in adaptation measures.

2. DEVELOP A CRM INSTITUTIONAL FRAMEWORK:

The current institutional systems for CRM in Maldives lacks clarity and has limited capacity to manage the existing and future climate variability associated risks in a holistic and comprehensive manner. At present, the Ministry of Energy and Environment's (MoEE) Climate Change Division coordinates all climate change activities, the Department of National Planning provides support for development programmes and the President's Office through the Climate Change advisor provides secretariat support for policy making process. There are a large number of ministries which are concerned with CRM issues but not integrated into the system both in terms of policies and programmes.

Thus a clear and well-resourced institutional framework to identify, formulate and implement policies and programmes for CRM needs to be developed in Maldives. The framework should be built around the MoEE's Climate Change Division and its capacities in terms of adequate financial and qualified technical personnel must be built to help coordinate and implement the new CRM programmes and policies.

3. CAPACITY DEVELOPMENT OF CRM RELEVANT INSTITUTIONS ESPECIALLY THE MMS:

Overall, the technical capacity of CRM relevant institutions is weak in managing both short-term initiatives and long-term climate variability related implications. For example, although the MMS is mandated to provide climate data for managing climate risks of all time-scales, its capacities for even short-term weather-related risks, is very limited. A concerted capacity development effort is required for strengthening the MMS, especially in increasing observation, data communication and processing systems to enable MMS to generate actionable information for both short and long-term CRM.

4. COMMERCIALIZATION OF SOME WEATHER AND CLIMATE SERVICES:

The MMS could partner with other agencies to offer selected weather and climate services on a cost recovery basis in the short and medium term. The revenue generated could be used to strengthen the MMS's financial muscle for implementing CRM functions and building its long term capacities. For example, cost recovery revenue could be obtained from the aviation sector, which is lucrative given the relatively high air traffic in Maldives. The World Meteorological Organization (WMO) and International Civil Aviation Organizations (ICAO) already have comprehensive technical guidelines through the WMO Commission for Aeronautical Meteorology which may be used to provide tailored services to tourist resorts and the marine transport sector in Maldives. Such an arrangement would however require the MMS to transform its governing statues and develop a commercial services division.

5. CAPITALISE ON CRM RESOURCES OF GOVERNMENT AND VOLUNTARY ORGANISATIONS:

The MMS has limited resources for implementing the WMO Global Framework for Climate Services, essentially in the areas of data acquisition and provision of climate information for agriculture and DRR. To counter this limitation it could enlist the services of local government institutions and volunteer organizations that can provide climate data and serve as information focal points for communities. Preference should be given to local bodies that are likely to be sustainable and connected to communities at risk.

6. STRENGTHEN CLIMATE INFORMATION SYSTEMS:

Although a UNDP initiative for developing a climate risk information system is in place in Maldives, it is limited in capturing only historical climate data. It could be strengthened by incorporating weather and climate forecasts and climate risk information in a dynamic manner, so that risks are identified on different time scales and communicated effectively to different user groups. It should involve the following:

a) *Assessment of users' requirements and tailoring the climate information* in response to users requirements. Within the same group of users, information requirements are guided by the planning horizon, which could vary from 20-25 years at the organizational/ministerial level to 5 years and below at the directorate level. Thus forecast resolutions, spatial scale and lead time for climate projections should be tailored for different user groups.

b) *Characterizing and packaging uncertainties associated with climate information of different timescales.* Uncertainties inherent in longer-lead climate information should be communicated to prevent untrained and non-technical users from immediately perceiving and attributing climate variability-related phenomena to global warming.

c) *Interpretation and translation of climate information* in terms of sector-specific thresholds that are jointly determined by institutional users and communities.

d) *Application in a risk management framework* in planning and decision-making, cognizant of the risks due to uncertainties in the information.

e) *Demonstration of the economic and social benefits in using climate information and adopting the CRM framework.* It should clarify that investment in an end-to-end CRM system, in terms of time, human resources, and finances would help adoption of the CRM framework and institutionalization of the CRM system.

7. STRENGTHEN CLIMATE RISK ASSESSMENT CAPACITIES:

Climate risk assessment capacities in Maldives are very weak. The country faces a severe weather event on a monthly or annual basis. Each month at least one severe weather event could impact anywhere from 30 to 60 percent of islands due to its small aerial extent, concentrated population and infrastructure in a few islands. Thus different thresholds need to be constructed specific to critical infrastructure and other economic considerations. And, based on these thresholds, the infrastructure and economic activities need to be designed and used such that the risk is both accounted for and provides a basis for evolving ongoing assessment systems. Climate risk assessments should also have an integrated approach including data from all climate-sensitive departments, including the MMS.

8. PROPOSE SMALL AND ACCEPTABLE CLIMATE ADAPTATION OPTIONS:

Considering the cost of heavy engineering adaptation options and community reluctance to accept soft options, there is a need to develop a portfolio of adaptation options with low operational and maintenance cost for resorts and island communities. For example the adaptation options recommended by the DIRAM survey (refer to Table 6.1). These options could be presented to stakeholder groups to get their feedback and acceptance.

TABLE: 6.1 SUMMARY OF ADAPTATION OPTIONS PROPOSED FOR DIRAM SURVEY ISLANDS

MITIGATION OPTIONS	ISLAND CODES*									
	KF	FU	TU	KU	GA	VI	TH	FE	HI	VI
Diversifying and strengthening the economic base	√	√	√	√	√	√	√	√	√	√
Adopting the safe island mitigation measures										
Coastal protection			√	√	√	√	√	√		
Environment protection zone	√	√	√	√	√	√	√	√	√	
Resilient harbour	√	√	√	√		√	√		√	
Evacuation facilities		√	√			√	√	√		√
Flood proofing the hospital	√			√		√	√		√	
Flood proofing regional port facilities	√								√	
Flood proofing warehouses and stock	√		√	√	√	√	√	√	√	√
Protecting the fuel storage and supply	√		√	√		√	√		√	√
Flood proofing the power house	√	√		√	√		√		√	√
Retrofitting to reduce flood risks in high risk houses and buildings	√	√	√	√	√	√	√	√	√	
Flood proofing communications infrastructure	√	√	√		√	√	√	√		
Earthquake resilient public buildings								√	√	
Constructing artificial drainage systems in low lying areas and main roads	√				√	√	√		√	√
Flood proofing waste management sites	√	√	√	√	√	√	√	√		
Creating disaster risk awareness among businesses	√	√	√	√	√	√	√	√	√	√
Adjusting the existing land use plan to										
relocate key business establishments away	√			√	√		√		√	
from high risk zones.										
Reviewing the new land use plans to										
relocate key business establishments away	√		√		√		√			√
from high risk zones										
Creating insurance awareness among high risk investments	√	√	√	√	√	√	√	√	√	√
Create awareness among the population to use banking facilities to store cash	√	√	√	√	√	√	√	√	√	√
Mitigating the economic down turn following a disaster										

MITIGATION OPTIONS	ISLAND CODES*									
	KF	FU	TU	KU	GA	VI	TH	FE	HI	VI
Income support to severely affected population	√	√	√	√	√	√	√	√	√	√
Financing the replacement of key assets and tools of most affected businesses	√	√	√	√	√	√	√	√	√	√
Marketing campaigns to restore consumer and investor confidence	√	√	√	√	√	√	√	√	√	√
Full integration of natural hazard risk assessment in Environment Impact Assessment (EIA) of development projects and mandatory inclusion of mitigation measures.										
Addressing external factors – addressing mitigation requirements for national infrastructure and key industries										
Changing the building code to address housing vulnerabilities in high risk zones										

***Island codes and its names** KF- Kulhudhuffushi; FU – Funadhoo; TU –Thulusdhoo; KU –Kudahuvadhoo; GA – Gan; VI – Viligilli; TH- Thinadhoo; FE-Feydhoo; HI-Hithadhoo ; VF-Vilufushi*

9. SECTOR-SPECIFIC CLIMATE RISK INFORMATION PROCESSES:

Once the climate risk information process is established, it should be strengthened to communicate climate risks in the following priority sector and possibly islands:

i. *Tourism sector* is most critical for the national economy and is affected by climate risk both directly and indirectly. CRM planning in the sector needs to involve the stakeholders of hotels, resorts, safari boats etc. Advances in forecasting technologies, makes it is possible to provide island-specific weather information upto 3 to 5 days ahead. This information could be used by tourism resorts and operators to plan itineraries or stays in islands such that tourists face minimal disruptions due to unfavourable weather conditions, like rainfall, visibility under water based on ocean currents etc.

ii. *Fisheries:* The fisheries sector is directly sensitive to climate risks due to El Nino and La Nina influences, for example trends in tuna migration. Climate information could be used to better manage direct fishing activities and indirect processing activities. Climate related risk patterns for the supply chain of fisheries sector could help design suitable mitigation measures. The information could also be used to advance fishing in the country. For example, advances in use of satellite-based information of ocean conditions for generating potential fishing zones (PFZ) currently produced by Indian National Centre for Ocean Information Services (INCOIS) for India could be extended to cover Maldives based on a request from the government. This will facilitate the fishermen undertaking single-day fishing trips to focus on areas likely to have better fish density, save fuel costs and improve their catch. MMS could be capacitated to generate this information, and a dissemination system built to share it with fishing islands.

iii. *Agriculture:* Although agriculture is a minor sector in Maldives, it has potential to meet the diversification and food security goals of the country. Currently, there is no climate risk information system to enable farmers to plant and manage harvest of crops. Such a system could be integrated with market systems to provide farmers both climate and market information for managing climate risks in crop cultivation in various islands. There is also a need for capacity building of MMS to provide need-based information and the agriculture department to communicate this information to help farmers take appropriate actions.

10. DEVELOP A COMMON CRM ALERT PROTOCOL:

There is a need to assist the MMS and other climate risk sensitive sectors to develop a common alert protocol. The protocol should help speedy dissemination of climate risk information, remove distorted signals from different actors in times of impending climate related hazards and facilitate easy dissemination to all at risk populations using available communication technologies.

11. COMPREHENSIVE RISK-BASED EARLY WARNING SYSTEM (EWS) FOR ISLANDS:

This would help each island manage weather related risks to critical infrastructure and production processes. It could serve as an entry-point to constantly assess the risks, upgrade the vulnerability status and design adaptation options to mitigate the impacts of climate change in the long term.

MMS has identified ocean state forecast information as a critical need for all islands considering that sea transport is the main means of travel across islands. The Indian National Center for Ocean Information Services (INCOIS) ocean state forecast information on wave heights and directions could be downscaled to each island by the MMS in collaboration with regional technical institutions on EWS. Such risk information products would help make navigation safer.

12. EXPLORE THE POTENTIAL ROLE OF INFORMATION AND COMMUNICATION TECHNOLOGY (ICT) IN SHARING CLIMATE RISK DATA AND INFORMATION:

The rapidly growing ICT sector especially mobile telecommunications can be used for data and information transmission, through for example dissemination of weekly agro-meteorology bulletins. Data could also be shared between the MMS/NDMC and local data collection/information dissemination partners in the atolls in real time. This will partially solve issues relating to scarcity of climate data; improve climate risk modeling results (since greater data will be available at shorter spatial intervals) and the dissemination of climate information.

13. BIODIVERSITY AND ENVIRONMENTAL MANAGEMENT:

The three sectors of tourism, fisheries and agriculture heavily depend on the health of the eco-system and the environment. Encouraging natural conservation processes will be a cost-effective way of securing the production processes of these sectors at the island level. It could be encouraged through proper environment management systems that are sensitive to climate risk information. At the national level institutional and policy changes can be made to support ecosystem conservation. Refer to Box 4 for some recommendations at the atoll level in Maldives. There is also a need for strengthening the capacity of both the information providers and users for better management of natural resources such as coral reefs and water resources that support the above critical sectors.

BOX 4: ATOLL ECOSYSTEM CONSERVATION (AEC) STUDY RECOMMENDATIONS

- Biodiversity should be accorded a high priority in economic policies and planning, in line with its immense value to national development;
- Awareness of the economic importance of biodiversity conservation should be raised in all sectors and among the general public;
- A national policy for atoll ecosystem conservation is needed that recognizes the importance of safeguarding biodiversity as a major asset of the Maldives, underpinning economic growth and social development;
- Existing sectoral laws, regulations and incentives should be aligned with this national policy;
- Appropriate institutional and financial arrangements should be provided to safeguard and sustainably manage the biodiversity of atoll ecosystems.

Source: MHTE[37]

14. BETTER UNDERSTANDING OF WATER SCARCITY ISSUES AND ITS MANAGEMENT OPTIONS:

Scarcity of water for drinking and household purposes has emerged as a rising issue in the last decade. Departure of rainfall in critical months has resulted in upto 200 percent less rain than normal. There is need to better understand the impact of low-rainfall on agriculture and water harvesting systems, in order to design climate risk-based water harvesting systems and agricultural practices and to manage freshwater resources in the long-run.

Based on the risk pattern, a contingency plan with drought related EWS could be developed to manage drinking water system effectively and maintain the existing water storage capacity by private storage facilities of 91.2 million liters and community storage facilities of 14.6 million liters. In addition, innovative technologies like the Low Temperature Thermal Desalination (LTTD) developed and tested by the National Institute of Ocean Technology (NIOT) at the Ministry of Earth Sciences (MOES) should be considered for most critical islands. LTTD has been successfully commissioned as a cost-effective technology over the last 5 years in Lakshadweep islands of India, which shares similar geo-physical features of Maldives.

15. STRENGTHEN AND REPLICATE SEASONAL (MONSOON) FORUMS IN DIFFERENT ISLANDS SECTORS AND DEPARTMENTS IN MALDIVES:

Sectoral departments have sighted limited access to and understanding of MMS information products as a constraint in using them. A recent initiative of MMS created a Seasonal (Monsoon) Forum to facilitate sharing of monsoon season outlook and its interpretation for sectoral agencies including the NDMC, as a pilot in the Fuvahmulak island. This was appreciated by the participating departments of tourism, education, environment, the MNDF, and Atoll Council among others. A feedback system is included in the next forum to identify the accuracy, relevance and constraints in using the outlook. This initiative could be further strengthened to cover other vulnerable islands, sectors and departments involved in CRM. These may include the following stakeholders (refer to Table 6.2 for details).

TABLE 6.2: STAKEHOLDERS AND THEIR CLIMATE RELATED FUNCTIONS

STAKEHOLDERS	FUNCTION
Maldives Meteorological Services, MHTE	Providing meteorological information at different time scales.
Climate Change Division, Department of Climate change, Sustainable Development and Energy, MHTE	Developing climate change policy, adaptation strategies and plans and implementing NAPA priorities
Landuse planning Section, Housing Division, MHTE	Develop land use planning policies and regulations
Environment Protection Agency (EPA), MHTE	Formulate and implement laws and regulations to conserve the environment
MHTE: Programmes and Projects Dept., MHTE	Design and monitoring of coastal infrastructure projects such as harbour, reclamation and breakwaters.
National Disaster Management Centre (NDMC), MHTE	Coordinate activities related to natural disaster events by formulating policies and conducting programmes to increase preparedness of community
Ministry of Home Affairs (MHA)	Monitor and Deals with administrative issues of all province, atoll and island offices.
Atoll and Island Authorities (including civil servants and elected officials, i.e, Island and Atoll Coucillors)	Elected bodies that will make development planning decisions and subsequent planning and implementation.

TABLE 6.2 CONTINUED

STAKEHOLDERS	FUNCTION
Community Representatives (Women's Development Committees (WDC)/Youth NGOs/National NGOs	Raise awareness on climate change in WDCs and NGOS and build their capacity to advocate for and support climate change adaptation planning
Climate Change Council under the President's Office	Advises the President of Maldives on matters related to climate change adaptation and mitigation
Privatization Committee under the President's Office	To implement privatization programme. Also to advertise and promote investment oppurtunities and encourage public private parternship
Department of National Planning, Ministry of Finance	Formulation of policies on socio economic development and forumation and implementation of development coordination strategies
National Planning Council, Ministry of Finance and Treasury	To ensure coordination of planning functions of different sectors and to determine national development priorities. Also on long term development policies and strategies to ensure sustainable development of the nation
Ministry of Tourism, Arts and Culture	Responsible for development and implementation of tourism development policy in the country
Ministry of Fisheries and Agriculture	Responsible for formulating and implementing policy on sustainable use and development of marine resources, agriculture and forestry in the country
Maldives Association of Construction Industry (MACI)	Introducing new guidelines on coastal infrastructure to member private companies
The college of Higher Education	Curiculum development on climate change risk adaptation relevant for Maldives
Marine Research Centre	Undertake research to provide information needed for management of fisheries and the marine environment

Source: UNDP, 2009[38]

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