National Adaptation to Climate Change

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Introduction

"The planet's warming is unequivocal, its impact is clearly noticeable and it is beyond doubt that human activities are contributing to it... We cannot afford to ignore or underestimate this existential threat. Failure to combat climate change will increase poverty and hardship" UN SG Mr Ban Ki-Moon

The Maldives today is faced with unprecedented challenges unwitnessed by previous generations of Maldivians. One such challenge is the impact of climate change. Climate change threatens the very existence of the low-lying small coral islands which we call home, and poses significant threats to the survival of our society, cultures and traditions which have, since time immemorial, co-existed harmoniously with the fragile island ecosystem. Furthermore, climate change threatens to remove the very lifeblood of our economy; our treasured coral reefs and oceans on which our most important sectors- the tourism and fisheries industries are based on. In this regard, the Maldives is among the most vulnerable and least defensible countries to the projected impacts of climate change and associated sea level rise.

The extraordinary challenge before the present generation, therefore, is to make the Maldives resilient and adaptable to the impacts of climate change. To understand the vulnerability of the Maldives to this challenge, a vulnerability assessment was undertaken in 2001 and was presented in the First National Communication of the Maldives to the UNFCCC. Based on the findings of the First National Communication, at the request of the UNFCCC, the Maldives prepared its National Adaptation Programme of Action.

This paper has been prepared as a background paper to the Third Maldives Partnership Forum in the area of adaptation to climate change. This paper also presents the main findings included in the Maldives NAPA.

Background to National Adaptation Programme of Action (NAPA)

Article 4.9 of the United Nations Framework Convention on Climate Change (UNFCCC) recognizes the specific needs and special situations of the Least Developed Countries (LDC). Decision 5/CP.7 of the 7th Conference of the Parties (COP) also acknowledged the specific situations of LDCs, in that they do not have the means to deal with problems associated with adaptation to climate change, and established an LDC work programme including NAPAs as well as other supporting activities. Decision 28/CP.7 set the guidelines for NAPAs. Also related to the NAPA process, Decision 29/CP.7 set up an LDC Expert Group (LEG) to provide guidance and advice on the preparation and implementation strategy for NAPAs. The focus of NAPA is to identify the urgent and immediate needs of the country to address the impact of the climate change. These are actions which further delay could increase vulnerability or lead to increased costs of adaptation at a later stage. The UNFCCC convention process outlined the process that need to be followed in the preparation of the NAPA.

NAPA of the Maldives

The NAPA was prepared with support from the Global Environment Facility (GEF) with the assistance from United Nations Development Programme (UNDP). Preparation of NAPA began in October 2004 and the process was halted because of the Indian Ocean Tsunami of December 2004. NAPA work recommenced in February 2006. The process was guided by the principles of broad stakeholder engagement, partnership building among focal agencies and ownership by the people of Maldives especially the atoll population. A multidisciplinary National Climate Change Technical Team (CCTT) was established as a first step to foster stakeholder engagement. Community consultations and awareness raising activities were held for representatives from seven atolls of the Maldives and the capital Male'. Targeted awareness raising and activity-based learning was conducted for school children from five secondary schools. Existing climate data for the Maldives was analysed with international expertise culminating in the first Climate Risk Profile for the Maldives.

National experts produced vulnerability and adaptation (V&A) related technical papers for priority sectors identified by the NAPA Working Group. Extensive consultations at regional and national level were undertaken based on a prior agreed methodology to identify vulnerabilities and adaptation activities and to prioritize these activities. The NAPA provides project profiles of 12 projects that need to be urgently implemented so to adapt to climate change in the Maldives.

Vulnerability of Climate Change

The Maldives is vulnerable to the following climatic hazards;

Rise of Sea level Rise

The observed long term trend in relative sea level for Hulhulé is 1.7mm/year. The maximum hourly sea level is increasing by approximately 7mm/year, a rate far in excess of the observed local and global trends in mean sea level. For Hulhulé an hourly sea level of 70cm above mean sea level is currently a 100-year event. It will likely be at least an annual event by 2050.

Decreasing the amount and increasing the intensity of Rainfall

Currently a daily rainfall of at least 160mm is a relatively rare event at Hulhulé, with a return period of 17 years. An extreme daily rainfall of 180mm is currently a 100-year event. It will likely occur twice as often, on average, by 2050. An extreme three-hourly rainfall of 100mm is currently a 25-year event. It will likely become at least twice as common, on average, by around 2050.

Increasing the Minimum and Maximum Temperature

There is relatively high confidence in projections of maximum temperature. The annual maximum daily temperature is projected to increase by around 1.5°C by 2100. A maximum temperature of 33.5°C is currently a 20-year event. It will likely have a return period of three years by 2025.

Increasing the intensity and frequency of the Extreme Events

The predicted return periods for cyclonic activity based on historical records of wind data. Currently an extreme wind gust of 60 knots has a return period of 16 years. It is estimated that this will reduce to 9 years by 2025.

Presently, the maximum storm surge height is reported to be 1.32m with a return period of 500 years in the Maldives. When storm surges coupled with high tide, it could generate a storm tide of 2.30m which is disastrous to islands which have a mean elevation of 1 – 1.5 m above the mean sea level. Increasing the frequency of such storms would put pressure on to the natural balance of the islands and would cause overtopping of the existing coastal structures on the island. The impact of climate change on the islands in-terms flooding increases from north to south (Jameel, 2006).

Impacts of Climate Change

The following key vulnerabilities have been identified as part of the NAPA process.

1. Land, beach, and human settlements

Maldives is the sixth smallest sovereign state in terms of land area, estimated to be approximately 235 sq km. This land is divided over some 1,200 coral islands, of which 96 percent are less than 1 square km in area. Only ten islands are more than 2.5 square km; and the largest island, Laamu Gan, has an area of 6.1 square km.

At present, 44 percent of the settlement footprints of all islands are within 100 m of coastline. This translates to 42 percent of the population and 47 percent of all housing structures being within 100 m of coastline. Over the last six years more than 90 inhabited islands have been flooded at least once, and 37 islands have been flooded regularly or at least once a year (Shaig, 2006).

The beaches of the Maldives, which represent 5 percent of the country's total land area, are of an unconsolidated nature and naturally dynamic and unstable. More than 97 percent of inhabited islands reported beach erosion in 2004, of which 64 percent reported severe beach erosion. More than 45 percent of the country's 87 tourist resorts have also reported severe erosion (Shaig 2006).

The scarcity of land, the smallness of the islands, and their extreme low elevation all make retreat inland or to higher ground impossible. Building setback has limited utility and beach replenishment may only be a temporary remedy for beach loss. Unless expensive coastal protection measures are undertaken, human settlements face the threat of inundation.

2. *Critical infrastructure*

Significant investments have been made to develop the country's infrastructure, which is highly vulnerable to sea level rise and storm conditions. The transport infrastructure, for example, includes three major commercial sea ports, more than 128 island harbours, and five airports, of which two are international. The infrastructure of the two international airports is within 50 m of the coastline. About 30 percent of the infrastructure of Male' International airport lies within this range, and land reclamation towards the ocean-ward side has resulted in parts of the airport being within 15 m of the wave break zone (Shaig 2006).

Other critical infrastructure includes utilities and environmental services. The average width of inhabited islands is 566 m; and on both inhabited islands and resorts 80 percent of the powerhouses and 75 percent of communications infrastructure are located within 100 m of coastline. Also, 90 percent of the islands have their waste disposal sites within 100 m of coastline and on the ocean-ward side of the island (Shaig 2006).

If appropriate adaptation measures are not taken, frequent inundations could virtually obliterate the critical infrastructure, severely damaging the economy and threatening the safety and security of the people. The scale and magnitude of potential damage can be deduced from historical records. The flooding of 1987 caused damages of US$4.5 million to the Male' International Airport alone (MHAHE 2001). During the tsunami of 2004, damage to transport and communications infrastructures was estimated to be US$73 million, with some 4,200 m of quay wall and 15,000 m of harbour/sea walls and breakwaters damaged or destroyed (World Bank 2005; National Recovery and Reconstruction Plan, 2005).

3. *Tourism*

The small island beach environment, rich marine biological diversity, tropical climate, and the world-class hotels are the unique marketable assets of the tourism sector. About 70 percent of tourists visit the Maldives primarily for beach holidays, which would be severely disrupted through loss of beaches. Already 45 percent of tourist resorts have reported varying degrees of beach erosion (MHAHE 2001).

In addition to attracting tourists to its beaches, the Maldives is the "World's Leading Dive Destination" and the "Indian Ocean's Leading Destination" (World Travel Awards 2006). The area's coral reefs thrive in a narrow temperature range and are highly sensitive to changes in temperature. Given the current predictions for an increase in the sea surface

temperature (SST) and the observed relatively more frequent or persistent El Nino episodes, coral bleaching is expected to rise rapidly and significantly (IPCC 2001).

Investments in a resort range from US$10 million for an average tourist resort with 200 beds to over US$40 million for a modern high-end resort (MHAHE 2001). The current total investments in tourist resort infrastructure exceed US$1 billion. Loss, or even under-utilization, of such infrastructure due to climate change will devastate the Maldivian economy.

Additional risks to tourism are in many cases indirect, with the initial impacts being imposed on infrastructure, fisheries, water resources, agriculture, and human health. For example, over 99 percent of tourists arrive to the Maldives by air and Male' International Airport is the only entry point by air, the second international airport will be operational from November 2007. The airport sea defences are barely adequate and any damage to the international airport by climate change and sea level rise will cause extreme loss to the tourism sector.

4. Fisheries

The fisheries industry is highly vulnerable to climate change as tuna is highly attuned to the biophysical conditions of the pelagic environment, particularly El Nino Southern Oscillation and associated changes in SST. During El Nino years in the Maldives, catch rates of skipjack tuna are depressed while catches of yellow fin tuna are elevated, and the effect is reversed in La Nina years (Adam and Anderson 1996).

Tuna movement and abundance in the Indian Ocean is closely linked to the climate driven ocean productivity (Adam 2006). The recent trend of declining winter and spring snow cover over Eurasia is causing a land/ocean thermal gradient that is particularly favourable to stronger southwest monsoons. Such favourable conditions have caused more than a 300 percent increase in phytoplankton biomass in the Somali Basin and the north Arabian Sea (Goes et al. 2005). This could have profound implications for tuna distribution and abundance in the Indian Ocean (Adam 2006).

Dependency on the pole-and-line tuna fishery method using live bait makes the tuna fishery further vulnerable to climate change. For every 7-10 kg of tuna caught, a kilogram of live bait is required (Adam 2006). The bait is taken from small schooling varieties associated with the coral reefs and are highly vulnerable to changes in SST and other climate changes.

A decline in tuna fishery will have direct implications on food security in the Maldives. Fish is the primary source of dietary protein for the Maldivians, and tuna is served daily in every meal (Adam 2006). Local fish consumption exceeds 50,000 metric tons a year (MPND 2006). Reef fish is also a significant item of the tourist resort cuisine, and impacts on reef fishery will affect tourism and communities who depend on reef fishery as a source of income.

5. Human health

The health status of the Maldivian population has improved significantly over the past decades and is in a transition phase from communicable to non-communicable diseases. Communicable diseases such as malaria and vaccine preventable diseases such as polio, neonatal tetanus, whooping caught and diphtheria have been successfully eliminated. While non-communicable disease such as heart diseases, diabetes, hypertension, cancer and renal diseases have emerged as a major health concerns in recent years. Despite improvements in the public health sector, the country still experiences high incidences of climate sensitive diseases that will be enhanced by climate change. The main health outcomes affected by climate change are:

- Heat strokes: heat waves will cause heat stress, increasing strokes and cardiovascular disorders and warmer temperatures and air pollution will add to the number of respiratory disorders such as asthma i.a.;
- Injuries, disability and drowning risk will increase due to more frequent and more intense extreme weather events such as storms and cyclones;
- Mental stress: Sea level rise, forced displacements of population and loss of livelihood will increase psychosocial stress in the affected populations
- Water-borne diseases: Diarrhoeal continues to cause significant morbidity among children and adults, indicating inadequate access to safe water and sanitation. The number of cases of acute gastroenteritis increased by 50 percent, from 15,000 in 2004 to 21,000 in 2005 (Moosa 2006) In future, more variable precipitation patterns are likely to reduce the supply of safe water, increasing risks of water-borne diseases like cholera and other diarrhoeal diseases;
- Vector-borne diseases: Warmer temperatures (and other changing parameters) are likely to lengthen the transmission season and alter the geographic range of dengue and malaria vectors; The first outbreak of dengue occurred in 1979, and cases have been reported every year since 1998, with a continued high prevalence since mid-2005. In 2005 the case load increased about 52 over the previous year. Scrub typhus,

which was endemic 60 years ago, re-emerged in 2002 with mortality rates as high as 10 percent (Moosa 2006). Chikungunya, a relatively rare form of viral fever, was for the first time diagnosed in December 2006 and reached epidemic proportions. Children and the population living in remote islands where diagnostic and treatment facilities are lacking are particularly vulnerable to these climate related vector-borne diseases.

- Malnutrition: Rising temperatures and variable precipitation are likely to decrease the production of staple foods which could trigger a permanent food crisis lead by soaring prices, leading to increased risks of malnutrition and hunger; The high morbidity of diarrhea and ARI is linked to high malnutrition in children. About 22% of the children in the country were stunted in 2004, indicating inadequate nutrition over a long period of time. At the same time, the discrepancy in disease pattern between children in Male and the atolls is linked to the lower nutritional status of children in the atolls compared to their counterparts in Male' causing them more vulnerable to infections. 17% of the children in the atolls are stunted while it is only 17% in Male'

In addition to these, climate related communicable diseases there has been an increase in conditions of the skin, subcutaneous tissue, and eyes that has close linkages to increased exposure to UV radiation, also linked to climate change impacts.

6. Water resources

The freshwater aquifer lying beneath the islands is a shallow lens, 1-1.5 m below the surface and no more than a few meters thick. Surface freshwater is lacking throughout the country with the exception of a few swampy areas in some islands. Traditionally people depended on shallow wells to get access to the groundwater lens for drinking water. However, 90 percent of the atoll households now use rainwater as their principal source of drinking water. In Male', 100 percent of the population has access to piped desalinated water. Following the tsunami 38 islands have been provided with desalination plants, which are being operated daily or on an emergency basis.

Already stressed from over-extraction, the freshwater aquifers face the risk of total depletion if dry periods extend. With the predicted sea level rise and during periods of wave-induced flooding, there is a very high risk of saltwater intrusion into the freshwater lens. Saltwater

intrusion would also adversely affect soil and vegetation, damaging agriculture and terrestrial ecosystems.

Rainwater is the main source of drinking water in the atolls. Although the global average precipitation is projected to increase during the 21st century, a marginal decline in precipitation is projected for the Indian Ocean region (Nurse and Sem 2001). The predicted changes have the potential to affect rainwater harvesting across all the atolls and in particular the northern atolls. Even today drinking water shortages during dry periods pose a significant challenge to the atoll population. In 2004, for example, water shortages were reported by 30 percent of the atoll population (MPND 2005).

7. Agriculture and food security

Agriculture is vital to the food security, nutritional status, and livelihoods of the atoll population and contributed 2.6 percent to GDP in 2005 (MPND 2006). Climate hazards will affect agriculture through heat stress on plants, changes in soil moisture and temperature, loss of soil fertility through erosion of top soil, less water available for crop production, changes in height of water table, salinization of freshwater aquifer, and loss of land through sea level rise. The consequences of such impacts are likely to be particularly severe in the Maldives because agriculture is already under stress due to poor soil, limited available land, and water scarcity.

Heavy import dependency, limited food storage, and ad hoc distribution also pose a severe food security risk to the population. The Maldives imports almost all food items other than fresh tuna and coconut. Every year more than 17 million kilograms of rice and flour and 10 million kilograms of sugar are imported (MCS 2006). In 2003 the Maldives imported US$32.4 million worth of vegetable products (MFAMR 2006).

Long-term and emergency food storage is virtually absent except for warehousing in Male' and nine other islands (STO 2006). Since food distribution is by boat from Male' to the islands and the quantity that can be transported in a single trip is small (MHAHE 2001), higher frequency of extreme events associated with climate change would further exacerbate food security problems. In 2003, 7 percent of the population experienced some form of food crisis (MPND 2004).

8. Coral reef biodiversity

Coral reef ecosystems in the Maldives are significant both at the national and international level, forming the seventh largest reef system in the world and one of the richest in terms of species diversity. The Maldives has two of the largest natural atolls in the world: Thiladhunmathi Atoll, with a total surface area of 3,788 square km, and Huvadhoo Atoll, with a total surface area of 3,278 square km.

The coral reef system of the Maldives supports rich marine biological diversity. Over 1,090 species of fish, 36 species of sponges, 180 species of stony corals, and 250 species of hermatypic corals have been identified. In addition, nine species of whales, 15-20 species of sharks, seven species of dolphins, and five species of turtles have also been observed (MHAHE 2002; MEC 2004).

Corals are highly sensitive to changes in temperature, and some species of corals live at or near their thermal limits (Goreau 1992). As a result, the incidence of bleaching will increase in frequency and intensity with the projected rise in SST. Coral reefs in the Maldives are also vulnerable to the projected rise in sea level. Most reefs appear to be at the point where they are sea level limited and with no potential for upward growth. Reefs appear to be now growing outwards laterally and filling up inside (Naseer 2006). It is predicted that sea level rise would induce reefs to grow vertically upwards. But reefs may not be able to keep pace with the predicted rise in sea level as a result of SST, reducing the chances of the islands to naturally adapt to the predicted rise in sea level.

Population Consolidation and Adaptation to Climate Change

The dispersed nature of the population is a unique challenge to the development of the Maldives. The 194 inhabited islands of the country are scattered over an archipelago more than 800 km long, and 131 inhabited islands have fewer than 1,000 people. This extreme dispersal of the population combined with poorly developed transportation systems, result in severe diseconomies of scale and makes the provision of basic infrastructure and delivery of social services costly. The cost of providing and maintaining socio-economic services in the Maldives is often 4-5 times higher than in other small island developing states. To address the challenges posed by environmentally vulnerable islands, that are currently experiencing severe impacts from climate change and associated sea level rise, with remote and dispersed population, the Government formulated the Population and Development

Consolidation (PDC) program. Under this program the Government seeks to resettle populations through incentives to migrate from islands that are environmentally vulnerable.

The vulnerability of the Maldives was truly exposed following the Indian Ocean Tsunami of December 2004. Most of the islands that suffered damage had little or no coastal protection as the islands are fully exposed to the dangers of wave action, erosion and flooding. While a tsunami of the magnitude experienced in December 2004 is an extremely rare event, with the predicted sea level rise, flooding may become a more frequent phenomenon. As one of the key adaptation measures for the predicted climate change, the Government have formulated the National Adaptation Programme of Action. The NAPA has identified coastal protection of 7 islands as immediate and urgent priority for adaptation. The implementation of NAPA is one of the highest priorities of the Government of Maldives and this is outlined in the 7th National Development Plan.

The Population consolidation policy by the government of Maldives is that investments would focus on selected islands and resettlement would be entirely voluntary. The government would only provide a platform (attraction) for relocation, where major infrastructure would be focused with opportunities to create economies of scale.

Priority Adaptation Actions

The following priority adaptation needs have been identified in the NAPA:

1. Integration of Future Climate Change Scenarios in the Development of Selected Population Centres or Islands to Adapt Sea Level Rise and Extreme Weather Risks Associated with Climate Change
2. Protect Human Settlements: Innovative Coastal Protection for Development of Selected Population Centres or Islands
3. Improve and promote Eco-Friendly Sustainable housing Technology
4. Build Resilience of Fisheries
5. Acquire Technologies and Appropriate Tools to Manage Water Resources
6. Strengthen capacity for health services
7. Strengthen agricultural production and increase food security

Urgent and immediate adaptation project identified in NAPA

1. Integration of Future Climate Change Scenarios in the Safer Island Strategy to Adapt Sea Level Rise and Extreme Weather Risks Associated with Climate Change
2. Coastal Protection of Safer Islands to Reduce the Risk from Sea Induced Flooding and Predicted Sea Level Rise
3. Coastal Protection of Male' International Airport to Reduce the Risk from Sea Induced Flooding and Predicted Sea Level Rise
4. Improve resilience of Island communities to climate change and variability through sustainable building designs
5. Protection of human settlements by coastal protection measures on safer islands.
6. Enhance capacities at the community level to conserve and protect ground water sources through recharge, safe disposal of excreta and other wastes and other appropriate measures
7. Enhance adaptive capacity to manage climate change related risks to fresh water availability by appropriate wastewater treatment technologies
8. Flood control measures for vulnerable Islands
9. Enhance adaptive capacity to manage climate change related risks to fresh water availability by appropriate wastewater treatment technologies
10. Increase the resilience of local food production through enhancing the capacity of farmers, local communities to address food security issues caused by climate change and climate variability
11. Improve the health status of the population by the prevention and management of vector-borne diseases caused by changes in temperature and flooding due to extreme rainfall.
12. Develop capacity to assess and address the implications of climate change for health and health systems, including tools and methodologies;
13. Develop and implement strategies and measures relating to climate change and their cost-effectiveness;
14. Assess health impacts of potential adaptation and mitigation measures undertaken by other sectors
15. Improve resilience of Island communities to climate change and variability through sustainable building designs
16. Investigating alternative live bait management, catch, culture and holding techniques in the Maldives to reduce vulnerability of the tuna fishery sector to the predicted climate change and variability.

17. Protection of human settlements by coastal protection measures on safer islands.
18. Increase resilience of coral reefs to reduce the vulnerability of islands, communities and reef dependant economic activities to predicted climate change.
19. Create awareness among the population on the impact of climate change on water resources, the need to use water efficient devices and promote behaviours that are water conscious.

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