

ADAPTATION TO CLIMATE CHANGE

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

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

5.1 ADAPTIVE MEASURES

5.1.1 Land loss and beach erosion

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

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

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

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

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

Coastal Protection

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

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

Population consolidation

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

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

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

Ban on coral mining

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

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

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

5.1.2 Infrastructure damage

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



Project 7.3: Upgrading of Gan Airport for international operations

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

Protection of the International Airport

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

Upgrade existing airports

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

Increase elevation in the future

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

5.1.3 Damage to coral reefs

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

Reduction of human impacts on coral reefs

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

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

Assigning protection status for more reefs

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

5.1.4 Damage to Tourism Industry

Coastal protection of resort islands

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

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

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

Reduce dependency on diving as a primary resort focus

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

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

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

Economy Diversification

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

5.1.5 Agriculture and Food Security

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

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

5.1.6 Water Resources

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

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

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

Protection of groundwater

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

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

Increasing the rainwater harvesting and storage capacity

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

Use of solar distillation

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

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

Management of storm water

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

Allocation of groundwater recharge areas in the islands

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

5.2 Capacity to adapt

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

5.2.1 Human resource development

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

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

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

Some of the other areas expertise is required include:

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

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

Overseas Training

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

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

Coastal Zone Management - (island training)

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

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

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

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

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

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

Box 5-2: CZM island training

5.2.2 Institutional strengthening

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

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

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

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

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

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

5.2.3 Research and systematic observation

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

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

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

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

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

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

5.2.4 Public awareness and education

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

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

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

- Hosting of the 13th session of the IPCC in the Maldives in September, 1997.
- Hosting of the Small States Conference on Sea Level Rise in Malé, in November, 1989. The outcome of the conference was the “Malé Declaration on Global Warming and Sea Level Rise.” which paved the way for the establishment of an Action Group among small island states, to co-ordinate a joint approach on the issues of climate change, global warming and sea level rise, and to pursue and follow up on global and regional response strategies. This Action Group later transformed into the Alliance Of Small Island States (AOSIS) at the Second World Climate Conference.
- Participation in the SAARC Regional Study on the Causes and Consequences of Natural Disasters and the Protection and Preservation of the Environment in 1992.
- Participation in the Commonwealth study on the Implications of Sea level rise for the Republic of the Maldives in 1989.
- Development of national sustainable development policy statement, which includes the National Environment Action Plan (NEAP) and the National Development Plan (NDP). The NEAP is the comprehensive policy framework that is used in a six-yearly cycle to ensure environmental protection and sustainable development in the Maldives. This complements the NDP, which is policy framework for the development issues for five-year period.

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

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

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

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

Policy Workshop on Climate Change

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

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

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