



Maldives

Innovations for Climate Adaptation and Resilience

**Current Status and Needs Assessment
2021**

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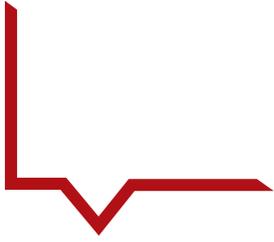


Table of Contents

<i>EXECUTIVE SUMMARY</i>	2
<i>1. BACKGROUND</i>	4
<i>2. CLIMATE RISK PROFILE OF MALDIVES</i>	5
2.1: MALDIVES VULNERABILITY TO CLIMATE INDUCED DISASTERS.....	5
2.2: NATIONAL ADAPTATION POLICIES AND STRATEGIES OF MALDIVES.....	8
2.3: PRIORITY ADAPTATION ACTIONS OF MALDIVES.....	9
2.4: CLIMATE CHANGE PROJECTION AND IMPACTS ON KEY SECTORS.....	9
<i>3. ONGOING CLIMATE RESILIENCE INITIATIVES</i>	11
<i>4. NEED ASSESSMENT FOR INNOVATIONS</i>	12
4.1: PROBLEM STATEMENT.....	12
4.2: CLIMATE INNOVATION NEEDS ASSESSMENT.....	12
<i>5. STAKEHOLDER CONSULTATION ON CLIMATE INNOVATION</i>	14
5.2: SUMMARY OF THE DISCUSSION.....	14
5.3: OUTCOME OF THE NATIONAL CONSULTATION.....	14
<i>6. KEY RECOMMENDATIONS</i>	15
<i>7. ANNEXES</i>	17
ANNEX-1: KEY STAKEHOLDERS CONSULTED.....	17

Executive Summary

Maldives faces undeniable challenges to its future progress due to significant threats posed by climate change. High population density — ranked 8th in the world — and dependence on climate-sensitive industries such as fisheries and tourism that exacerbate the country's vulnerability. Maldives, in 2006, adopted its National Action Plan for Adaptation and a zero emissions plan; target of carbon neutrality by 2020. In 2011, the country announced it had signed the world's first Strategic National Action Plan that integrates disaster risk reduction and climate change adaptation. The policy is viewed as a landmark initiative within the disaster risk reduction and adaptation communities. This report also outlines the status of the ongoing various climate initiatives in the country funded by external agencies for building climate resilience.

Coastal erosion related sea level rise, storm surges, swells and waves generated by storms has increased over the past decade. Over 80% of the island faces erosion and nearly 62% of inhabited islands report erosion, of which 38% reported severe erosion. About 30 islands are identified as severely eroded with loss of beaches, vegetation, critical infrastructure and damage to human settlements. In addition a storm surge coupled with high tide could completely inundate the low islands and create waves of up to 2.78 m enough to completely flood a medium to small island. Maldives also faces other climate related cyclone, hurricane and typhoon risk in the north due to its proximity to northern latitudes' cyclonic belt. The marine ecosystems and associated livelihoods could face the consequences of a projected change in heatwave for small islands in the Pacific and Atlantic.

The Government of Maldives has recognized climate change and its impacts as a key risk to the country's economy and its citizens, and has initiated climate risk management policies and strategies. It acknowledges that leveraging innovative technologies to engineer new solutions to address climate change represents a significant opportunity to accelerate efforts to achieve Sustainable Development Goal (SDG) 13: 'Take urgent action to combat climate change and its impacts,'

The Climate Change Policy Framework for Maldives cites the key sectors that are most vulnerable to climate change. It includes coastal zones, critical infrastructures, tourism, fisheries, human health, water resources, agriculture and food security. Consequently, underlying socio economic, and physical vulnerabilities render Maldives to adverse impacts of climate change cross cutting across all the sectors. These include a high dependency on coastal resources for livelihoods, low disaster preparedness, lack of climate data, and limitations in technical and financial capability to mitigate and reduce climate risks.

The current climate scenario in Maldives presented an imperative situation and explored the vast potential of innovative technologies to help assess, mitigate and adapt to climate change. The CIC consultation in Maldives brought together potential end users and government of Maldives to assess and identify a series of innovative and demand-driven technology-based solutions with local partners to enhance climate resilience in the country. Besides assessing and identifying the needs in various sectors, the consultation process sensitized the participants on an open global call for invitations for innovators to identify and pilot solutions to address challenges in reducing climate risk and build the resilience of governments and communities. The consultative process led to understanding the key focus areas of Maldives' NDMA on disaster risk reduction and building resilience to climate change.

The Maldivian NDMA focuses on disaster risk reduction and building resilience to climate change emphasizing the need for the two institutions - the NDMA and Ministry of Environment to collaborate and incorporate climate adaptation into disaster risk reduction framework and vice versa. At the same time, the application of social and environmental safeguards for the innovation technology was recommended to avoid residual negative impacts from the technology or its by-products.

There is ongoing technology innovation helping the Maldives prepare for emergency response, mapping the island of Maabaidhoo that will empower communities to better prepare for development challenges caused by climate change. While drones alone cannot resolve the challenges brought about by climate change, enhancing the use of drones on other islands is expected to offer visual data and clues to disaster planning and relief missions. At the same time enhancing the ongoing capacity building in terms of training in drone flight, mapping, and processing data into 2D mosaic maps would contribute to a growing national information hub and leveraging ArcGIS technology. With improved and localized maps and data, new collaborative processes for geographic information, the response time in emergencies would be higher.

It is crucial to identify a number of existing and emerging that can help protect Maldives from changing climate conditions, improve productivity, and help in the more efficient use of threatened resources such as water. Climate change adaptation technologies could offer the greatest value to Maldives in meeting its current national development priorities. Based on the assessment of innovation needs, key thematic areas focusing on partnerships, applicability and scalability of innovations and technologies were identified in the following areas:

Theme 1:

Community -level-early warning systems

Theme 2:

Land, beach and human settlements

Theme 3:

Critical Social Infrastructure

Theme 4:

Flood management and urban waste management

Theme 5 :

Island Transport System: Low emission city and intra-island transport system

Theme 6:

Human health

Theme 7:

Agriculture and Food Security

Theme 8:

Fisheries and Tourism

Theme 9:

Coral reef biodiversity

1. Background

1.1 Climate Innovation Challenge

Climate change is a major driver of disaster losses and failed development. Climate related disasters, including the extreme weather events, have dominated the global disaster landscape in the 21st Century, which is shaping new approaches to science and practice in disaster risk reduction, resilience building and climate change adaptation.

The Climate Adaptation and Resilience (CARE) for South Asia project implemented by the Asian Disaster Preparedness Center (ADPC) and supported by the World Bank empowers decision-makers with tools, products, and services to act locally on climate-sensitive issues such as disaster related public policy and planning, agriculture, water, and transport. The Climate Innovation Challenge (CIC) for South Asia and the Tech-Emerge Resilience India Challenge are two important initiatives being administered by ADPC through the Program for Asia Resilience to Climate Change, a trust fund administered by the World Bank funded by the United Kingdom's the Foreign, Commonwealth & Development Office (FCDO).

The CIC for South Asia aims to identify innovations to reduce climate risk and build climate resilience of communities vulnerable to such risks and extremes through award of grants to innovators and scale-up pilots across different sectors, and tiers (national, sub-national and local/community) for greater impact/optimal results. Selected innovators will receive support and grant funding from a pool of USD 2 million to pilot their innovations regionally and/or in the selected countries.

Any innovation and the factors that contribute to it depend on its applicability aimed at spurring priority economic sectors and/or targeted areas for which the technology is needed. The technological innovation in addressing climate adaptation and resilience must address societal problems. There has been growing interest in recent years on ways to foster such innovation, in particular, the role that governments can and should play in that process. The Climate Innovation Challenge is a global call for innovators who can bring forward technological solutions that aims to enhance climate resilience, local market and institutional capacity building and create a higher degree of awareness and knowledge among the different types of stakeholders on the use of technology. Scaling up and scaling out pilot initiatives in addressing climate adaptation and resilience is important with appropriate technology and policy planning and implementation.

1.2 Country Overview

Maldives is an archipelago of 25 low-lying coral atolls in the Indian Ocean, southwest of the Indian subcontinent. The country consists of just under 1,190 small tropical islands out of which about 358 are used for economic activities and human settlement. Local inhabitants occupy around 198 of these 358 islands, with the remainder mostly known as “one-island-one-resort” or “resort-islands”. While the double- chain of islets is around 860 kilometers (km) long and

varies from 80 to 120 km in width, the total land area of the Maldives is estimated to be approximately 298 km², making the country the sixth smallest in terms of land area, as well as one of the world's most geographically dispersed sovereign states. It is also one of the lowest and flattest countries in the world, as over 80% of the total land area is less than 1 meter above mean sea level. Due to its location over the equator in the Indian Ocean, Maldives experiences a typical equatorial monsoonal climate with warm and humid climate throughout the year, and seasonal fluctuations in temperature and rainfall due to the monsoons.

With a population of 533,900 in 2019, Maldives is a unique society in terms of its cultural and ethnographic heritage, with its people known as the Dhivehin. The driving force of its' economy is tourism, which contributes about one third of the gross domestic product (GDP) and is also the fastest growing economic sector within the country. Though the contribution of fisheries and agriculture to GDP has declined to 3.5% and 1.7% respectively, these sectors are major sources of income and subsistence for rural communities.

Maldives' current development challenges stem from climate change, disaster risk and environmental sustainability with increasing generation of solid waste. Specifically, the country's economy and society are sensitive to sea level rise, coastal storms and flooding, since a vast portion of the tourism industry's infrastructure, fisheries sector, population and housing structures, and other critical infrastructure (including communications, the four international airports and over 100 harbors), are primarily located in regions that are within 100 m of the coastline. Economic modelling done by ADB (2014) shows that Maldives may be the hardest hit out of the 6 South Asian countries (including Bangladesh, Bhutan, India, Maldives, and Sri Lanka) in terms of total economic loss due to climate change — the mean outcome of the simulation indicates that the economic damage may be on average 2.3% of GDP in 2050, with estimates of 12.6% of GDP by 2100. At the same time the country will still experiences challenges related to multi-dimensional poverty and undernourishment.

2. Climate Risk Profile

2.1 Climate Change Risks

Increasing Coastal Erosion - Climate change related coastal erosions from sea level rise, storm surges, sea swells and storm generated waves have increased over the last decade. Over 80 percent of the island faces erosion with nearly 62 percent of the inhabited islands reporting erosion, out of which 38% reported severe erosion status (MEE, 2017). About 30 islands are identified as critically eroded with loss of beaches, vegetation, critical infrastructure and human settlement damages. Even with a high rate of coastal erosion challenge faced daily by the Maldivian communities, there is a lack of monitoring due to inadequate resources and analysis of historical aerial images of case study islands show land loss between 0.81ha (2004-2008) to 3.66 ha (1969- 2013) per island, 0.8-6.3% of its total island area (SNC, 2016).

Inundation - Historical data with a maximum storm surge height of 0.48m coupled with high tide could generate a storm tide of 1.82m completely inundating the low-lying islands due to storm surges and sea level rise considering that the average height of the islands is 1.2 above sea level. In addition, storm surges can create up to 2.78m waves under medium prediction, enough to completely inundate a

medium to small sized islands. A storm surge at higher-end prediction could cause a 3.18m wave that could inundate even the largest islands (UNDP, 2006).

Climate related disaster risks - Although, cyclone hazard risk is classified as low in the south as compared to other tropical small islands in the Pacific or Atlantic regions, hurricane and typhoon hazard risk is highest in the north due to its proximity to the northern latitudes' cyclone belt. Past cyclone occurrences such as the Very Severe Cyclonic Storm Vayu in June 2019, and the Very Severe Cyclonic Storm Ockhi in November 2017, have caused damage to households and properties.

Heatwaves and marine ecosystems - The projected change in heat wave probability (compared to 1986–2005), for Maldives approaches a value of 1 by 2100 with a higher probability for the tropics where systematic warming might lead to the largest increases in heat waves. In addition, Maldives' marine ecosystem and the livelihoods dependent on these ecosystems potentially could face the consequences of marine heatwaves with research showing increases in the global average marine heatwave frequency and duration. While such research has not specifically identified Maldives under threat, the consequences of these trends may be serious for marine ecosystems in the region, which are adapted to survive under very stable temperature regimes, as well as the livelihoods dependent on them.

Droughts - Although the projections for severe droughts are clouded with significant uncertainty, the likelihood of drought with prolonged dry conditions are expected with projections showing that southern atolls are more likely to face severe drought compared to northern atolls in the near long term.

2.1 Vulnerability to climate induced disasters

Climate Change Vulnerable Sectors

The Climate Change Policy Framework for Maldives cites key sectors that are most vulnerable to climate change. It includes coastal zones, critical infrastructures, tourism, fisheries, human health, water resources, agriculture and food security (See Table 1 below).

Table 1: Climate change vulnerable sectors (Source: fao.org)

SECTOR	VULNERABILITY
COASTAL ZONE MANAGEMENT	<ul style="list-style-type: none"> Over 80% of the total land area of the Maldives is less than 1 m above mean sea level. Approximately 44% of the settlement footprints of all islands are within 100 m of the coastline More than 50% of the housing structures in 121 islands are within 100 m of the coastline More than 67% of inhabited islands reported beach erosion in 2013 at different scales and of different severity. The adaptation measures to mitigate erosion in the islands, due to its lack of planning and poor design have lead to increased maladaptation countrywide
CRITICAL INFRASTRUCTURE	<ul style="list-style-type: none"> The infrastructure of the four international airports are within 50 m of the coastline. More than 90% of all resort infrastructure and 99% of all tourist accommodation are within 100 m of the coastline Approximately 70% of all fisheries infrastructure is within 100 m of the coastline Utility facilities including most powerhouse and waste facilities are located within 100 m of the coastline. More than 75% of communications infrastructures are located within 100 m of the coastline
TOURISM	<ul style="list-style-type: none"> Nearly 45% of tourist resorts have reported varying degrees of beach erosion. Rise in temperature leads to coral bleaching, loss of beach, saltwater intrusion and loss of tropical vegetation. Maldivian tourism product is based on sea, sand and sun. Adverse impacts on climate variability will have negative consequences to the tourism industry.
FISHERIES	<ul style="list-style-type: none"> During the 1997/1998 El Niño event the Indian Ocean purse seine fishery shifted to the east, unlike other years, owing to the elevated depth of the 20°C isotherm Over the last few years ocean temperature changes has lead to the transformation of the biophysical conditions of the pelagic environment, resulting in decreased tuna catch in the islands.
HUMAN HEALTH	<ul style="list-style-type: none"> Changes in temperature and rainfall regimes are causing higher incidence of vector-borne diseases. There is evidence that dengue outbreaks are becoming more frequent and it appears that there is an association with El Niño Southern Oscillation events. The vulnerability to climate change-related health risks is further compounded by local characteristics such as the level of malnutrition in children, accessibility and quality of healthcare, high population congestion and low income levels Climate change-related impacts on fisheries and agriculture threaten food security in the Maldives. Such impacts will have a direct effect on the nutrition status of children and overall health of the population.
WATER	<ul style="list-style-type: none"> Rainwater is the main source of potable water in the outer islands. After the 2004 Indian Ocean Tsunami, there is observed increased demand of bottled water as drinking water, mainly associated with groundwater contamination and reduced precipitation. 7 out of 196 inhabited islands including Capital Male' have access to piped desalinated water.
AGRICULTURE AND FOOD SECURITY	<ul style="list-style-type: none"> The total cultivable land area is estimated at 27 km², including 18 km² on inhabited islands and 9 km² on uninhabited islands The agriculture sector is constrained by the limited availability of cultivable land, poor quality of soil and the abundance of cheap imports of vegetables and fruits Due to the high import dependency, the food security of Maldives is vulnerable to climate change-related impacts on the agriculture of other countries Heavy import dependency, limited food storage and ad hoc distribution also pose severe food security risk to the population. The Maldives imports almost all food items except fresh tuna and coconut. Long-term and emergency food storage is virtually absent except for warehousing in Male' and nine other islands

Climate Vulnerabilities

Scarce, low-lying land, and geographically dispersed islands – Over 80 % of Maldives is less than 1m and its highest point is at around 2.4m above sea level, making it the lowest natural high point of any country in the world. With the IPCC (2014) projection of 0.98 m global sea level rise by 2100, the islands are prone to flooding and inundation.

Low lying, near shore critical infrastructures – Approx.44% of the settlement footprints, 47% of all housing structures, 70% of all fisheries infrastructures, 80% of the powerhouses, 75% of communication infrastructures, and 90 % of waste disposal sites are within 100m of coastline, indicating the high risk of critical infrastructure and vulnerability of the local livelihood to climate change.

Lack of climate change impact modelling capacity – In addition to the key sectors that are vulnerable to climate change, there is a lack of climate change impact modelling system to correctly predict its future impacts.

High economic dependency on vulnerable coastal resources –Maldives is dependent on tourism accounting for 25.3 percent the total GDP. The fishing sector accounts for a limited 1.3% of GDP, although employs half of the country's workforce and 98% of export products. However, this indicates that Maldives economy is dependent on coastal resources, which is forcing the country's economy to become highly vulnerable to predicted climate change impacts.

Weak disaster preparedness – In the face of impending climate related disaster, there is insufficient early warnings in terms of both accessibility and a lack of information transmission to the general public. At the same time, awareness on disaster risks and risk reduction is low among the population making the country and its people more vulnerable.

Limitations in technical and financial capacity for coastal protection- Although the Maldives government itself has been investing in coastal protection annually, its financing is insufficient to provide a longer term solutions to the coastal erosions that integrates coastal ecosystem protection.

2.2: National Adaptation Policies and Strategies

Maldives is a very active and visible player in the international climate conferences and negotiation meetings. And, even though its own greenhouse gas emissions are insignificant, Maldives has declared a national ambition to become a carbon neutral country by 2020.

Maldives completed its Initial National Communication to the United Nations Framework Convention on Climate Change (UNFCCC) in 2001. In addition to identifying key vulnerabilities, the report proposed 12 high-priority adaptation and mitigation projects, clearly underlining the finance gap and indicating that adaptation action would have to be carried out using external resources. The Second National Communications to the UNFCCC was sent in 2016.

As a follow up, Maldives initiated its NAPA process in 2004. Progress towards its completion was immediately interrupted in December 2004 by the Indian Ocean tsunami. This single event changed Maldives' status from a developing country back to a least developed country (LDC), clearly demonstrating how vulnerable this small country is to natural calamities. Maldives eventually completed the NAPA in 2007.

The Ministry of Housing and Environment carried out the National Economic Environment Development Studies in 2010. The scope of the study was to bridge the gap between the national development plans and the initiatives in climate change domain. One of the specific tasks was setting the priorities and costs of adaptation to climate change in the short, medium and long term

In 2011, Maldives announced it had signed the world's first Strategic National Action Plan that integrates

disaster risk reduction and climate change adaptation. The policy was formulated using broad consultations with key sectors including housing, construction, environment and health, and focuses on governance and decentralization as key to the success of risk reduction and adaptation. The policy is viewed as a landmark initiative within the disaster risk reduction and adaptation communities

The Maldives' Intended Nationally Determined Contributions (INDC) was developed and submitted in 2015 through extensive consultations with representatives of the general public, government institutions, the private sector, non-governmental organizations and other relevant stakeholders. It intends to reduce 10% of its Greenhouse gases for the year 2030 by achieving a low emission development future and ensuring energy security. It also aims to undertake adaptation actions and opportunities and build climate resilient infrastructure to address the current and future impacts of climate change.

The Strategic Action Plan (SAP) 2019 - 2023 of the Government of Maldives is a central policy framework and planning document that guides the overall development direction of the Maldives for the next five years. It will help to take forward several long-term visions set in the SAP achieve the transformation on areas such as blue economy, climate resilience, sustainability and good governance through a long-term process. It has highlighted the need for mainstreaming climate smart and sustainable agricultural practices.

2.3: Priority Adaptation Actions

The National Adaptation Programme of Action prioritized the following adaptation needs:

- ✓ Build capacity for coastal protection, coastal zone management and flood control.
- ✓ Consolidate population and development
- ✓ Introduce new technologies to increase local food production
- ✓ Acquire support for the speedy and efficient implementation of Safer Island Strategy.
- ✓ Develop coastal protection for airports and development focus islands.
- ✓ Integrate climate change adaptation into national disaster management framework.
- ✓ Strengthen tourism institutions to coordinate climate response in the tourism sector.
- ✓ Develop measures to protect coral reefs from development activities
- ✓ Undertake recharging of aquifers and other measures to reduce salinisation from saltwater intrusion and storm surge flooding.
- ✓ Undertake research and disseminate information on climate change related diseases.
- ✓ Strengthen the capacity for healthcare delivery.
- ✓ Strengthen capacity for planning and design of ports, harbours and jetties.
- ✓ Develop climate change adaptation policy and strategy for tourism.
- ✓ Protect house reef to maintain natural defense of islands.
- ✓ Protect and preserve natural water catchment areas.
- ✓ Experiment new and alternative species and breeding methods for live bait.
- ✓ Enforce and strengthen quarantine and integrated pest control to prevent pests and diseases.
- ✓ Strengthen regulatory and institutional capacity for vector control.
- ✓ Protect beaches and tourist infrastructure.
- ✓ Review the marketing strategy of tourism to diversify the tourism product and reduce over-dependency on coral.
- ✓ Acquire desalination technologies appropriate for small island Improve building designs to increase resilience and strengthen enforcement of building code.
- ✓ Acquire appropriate sewage treatment and disposal technologies to protect water resources.
- ✓ Incorporate climate change adaptation measures to upcoming resorts.
- ✓ Promote healthy lifestyles, healthy islands and healthy buildings.

- ✓ Enhance the capacity for waste management to prevent pollution of marine environment.
- ✓ Provide alternatives to coral and sand as construction materials and enforce the ban on coral mining.
- ✓ Streamline the planning of healthcare services and strengthen medical emergency response.
- ✓ Integrated reef fishery management.

2.4: Climate Change projection and impacts on key sectors

Climate Change Projection

The main data source for the World Bank Group's Climate Change Knowledge Portal (CCKP) is the Coupled Model Inter-comparison Project Phase 5 (CMIP5) models, which are utilized within Fifth Assessment Report (AR5) of Intergovernmental Panel on Climate Change (IPCC), providing estimates of future temperature and precipitation. Four Representative Concentration Pathways (i.e. RCP2.6, RCP4.5, RCP6.0, and RCP8.5) were selected and defined by their total radiative forcing (cumulative measure of GHG emissions from all sources) pathway and level by 2100. In this analysis, RCP2.6 and RCP8.5, the extremes of low and high emissions pathways, are primary focus where RCP2.6 represents a very strong mitigation scenario and RCP8.5 assumes business as-usual scenario.

Temperature

Based on model projections, there is a likelihood that future temperature increases in Maldives may be below the global average. Under RCP8.5, the highest emission pathway, ensemble-based median annual temperatures in Maldives are projected to reach around 3.4°C by the 2090s, compared to around 3.7°C globally.

Precipitation

As it is for many tropical regions, considerable uncertainty clouds projections of local long-term future precipitation trends in Maldives, and little definitive trends can be offered regarding changes in average monthly or annual rainfall. As reported in AR5 regional trends for the North Indian Ocean area show a general tendency for increasing precipitation.

Climate Impact on Key Sectors

Climate Change impacts on the vulnerable systems and key sectors were assessed and well stated in the Climate Change Policy Framework of Maldives. The high-risk sectors are (i) Land, Beach and Human Settlements; (ii) Critical Infrastructure; (iii) Tourism; (iv) Fisheries; (v) Human Health; (vi) Water Resources; (vii) Agriculture and Food Security and, (viii) Coral Reef Biodiversity.

In a projected worst case scenario, 80 percent of the coral islands that make up the archipelago of the Maldives would be submerged. Currently, severe weather events such as floods and storm surges affect human settlements causing significant loss and damage to people's property and critical public infrastructures. Considering that sea level rise is projected to be approximately 100–115 cm in a 4°C world and 60–80 cm in a 2°C world by the end of the 21st century relative to 1986–2005, small changes in sea level could mean extensive land inundation, and the island nation is especially at risk. In the long run, coastal infrastructure may be threatened by permanent inundation.

Tourism is the main economic activity in Maldives, accounting for 23% of the Gross Domestic Product (GDP) generating more than one third of government revenue from the sector. This makes Maldives highly reliant on tourism and the economy thrives on the multiplier effects of the industry. However, in a critical review of the literature examining the dynamics between climate change and tourism, there appeared to be multiple indications that the tourism sectors of small island states, such as Maldives, are particularly vulnerable to climate change. Already, about 45% of tourist resorts have reported varying degrees of beach erosion, affecting the "sun, sea and sand" tourism product. In the long-term,

the dual combination of rising sea levels and of coastal erosion will reduce the quantity and quality of available beach space without significant adaptation measures and could therefore reduce the attractiveness of the country as a tourist destination. Another area of vulnerability is the recreational diving sector, threatening environmental degradation, loss of reefs, and coastal erosion, as has been the case in some Pacific islands

Maldives does not have surface freshwater with the exception of a limited swampy areas. While groundwater, found as basal aquifers is a scarce resource, traditionally people depended on shallow wells to get access to the groundwater lens for drinking water. However, the quantity of groundwater is determined by net rainfall recharge while the aquifers are already stressed from both over extraction and saltwater intrusion. Nearly 90% of the population now use rainwater as the principal source of drinking water. Climate change is likely to disproportionately affect the sections of the society that are least able to afford desalinated water sources or otherwise local rainwater storage options.

In Maldives, agriculture plays a minor role in the economy and the sector (including fisheries) contributed 5.2% to the Gross Domestic Product (GDP). However, agriculture constrained by limited cultivable land, high dependency on imports, challenges in both storage, difficulties in food distribution across the dispersed islands. Extreme weather events further exacerbate this vulnerability, considering localized flooding due to surges and disruptions in sea-based transport and the global scale prediction of climate change impacts on food production via direct and indirect effects on crop growth processes.

Maldives has the seventh largest reef systems forming one of the richest in the world in terms of species diversity, and providing critical coastal protection functions. According to a study conducted by the ADB, coral reefs are linked to the fisheries sector with the growing reef fishery as an important contributor to tourism, and demand for reef fish increasing over the years. However, corals are highly sensitive to changes in temperature and, as a result, incidence of bleaching will increase in frequency and intensity with the projected rise in sea surface temperatures. Changes will be influenced by global circulation phenomena, and their interaction with climate change, notably the poorly understood interaction with El Niño. The evidence from the reefs of Maldives supports information that warming of the ocean surface leads to significant coral bleaching.

3 Ongoing Climate Resilience Initiatives

Compared to other South Asia countries, the number of discrete adaptation projects underway in Maldives appears to be low, although each addresses Maldives' adaptation priorities as identified through its national policies.

The Climate Trust Fund was established in December 2009 by the European Union and the World Bank for the Maldives. It aims to build a climate resilient economy through various mitigation and adaptation activities. A majority of the projects focuses on policy formulation and integration, although the areas of risk reduction, coastal zones, water, forestry and meteorology are also being addressed. Funding agencies for these projects include the Australia, European Commission, French Global Environment Fund, Germany, the Least Developed Countries Fund (LDCF), Norway, Sweden, the United States Agency for International Development (USAID), and the World Bank.

The Green Climate Fund is supporting vulnerable communities in Maldives to manage climate change-induced water shortages. The adaptation project amounting to USD 28.2 million will provide safe and secure freshwater to 105,000 people on the outer islands in response to climate change-induced water shortages. The project will scale up an integrated water supply system based on rainwater, groundwater, and desalinated water into a low-cost delivery system for vulnerable households. This will provide uninterrupted supply to 49 islands that currently rely on emergency water deliveries for three months in a year.

In October 2020, The Asian Development Bank approved a \$7.74 million concessional loan and a \$2.73 million project grant to expand renewable-energy-ready grid systems in 12 outer islands in the Maldives. The bank is also developing project on building coastal resilience in Asia-Pacific is an urgent priority. It requires adopting long-term and integrated planning approaches that favor adaptive management, a risk-based approach, inclusive processes, and consider the full spectrum of coastal resilience options. Given their potential benefits, nature-based solutions should be considered as part of integrated plans combining grey and green solutions and soft measures such as awareness raising, policy making, land use planning and early warning.

Supported by the GEF's LDCF, the project on "Increasing Climate Change Resilience of Maldives through Adaptation in the Tourism Sector" provided regulatory support, technical skills and knowledge to protect the tourism industry from the adverse effects of climate change. It established over 10 new investment projects to retrofit operational infrastructure to increase resilience to the impacts of climate change, and implemented 10 community-based adaptation projects between tourism-associated communities and operators.

The USAID strengthens the capacity of the Maldivian government, private sector, and local environmental and community groups to manage and adapt to the impact of climate change. USAID activities continues to support innovative approaches to climate risk resilience and mobilize private sector funding for actions that reduce risks associated with extreme weather, climate variability, and climate change. Reefs Generate Environmental and Economic Resiliency for Atoll Ecosystems (REGENERATE) works to improve marine and coastal resource management to mitigate the adverse effects of climate change in Maldives through research, training, financing, and governance.

4 Need Assessment for Innovations

4.1: Problem Statement

Maldives is one of the most vulnerable countries to the adverse impacts of climate change. Located in the Indian Ocean, the island nation has been described as "ground zero" for monitoring the impact of climate change. This is mainly due to its low-lying nature and other geographical features, environmental and socio-economic factors such as its size and widely dispersed population across the atolls, a high exposure to environmental degradation and to natural disasters. Over 80 per cent of the land area of Maldives is less than one meter above mean sea level; as such, a sea level rise of even a meter would cause the loss of the entire land area of Maldives (MHAHE, 2001) In addition, economic vulnerability due to limited ability to exploit economies of scale, limited natural resources, low diversified economy, dependence on narrow range of exports and high dependence on imports of strategic goods makes Maldives amongst the most vulnerable countries to face climate change impacts.

A review of the occurrence of disasters between 1988 and 2007 concluded that 80% of all disaster events is climate-related and that such hydrological, meteorological and climatological events account for 45% of deaths and 79% of economic losses. The data for the period from 2000-2007 revealed a strengthening upward trend with an average annual growth rate of 8.4% in reported hydro-meteorological disasters worldwide.

The vulnerability of the islands is magnified further by extreme dependence on imported basic commodities like food, clothing, fuel and construction materials, usually from neighboring India, Sri Lanka and other traditional sources which, it is important to note, are likewise facing challenges due to climate change and extreme weather events.

Various studies predict that climate change will affect disaster risks through increase in weather and climate hazards and in the vulnerability of communities to natural hazards due to ecosystem degradation, reduction in water and food availability, and changes in livelihood. In the case of the Maldives, the temperature spike during the 1998 El Nino event devastated the coral reefs, and the fishing industry.

The country's natural assets such as coral reefs, beaches and mangrove ecosystems and their biodiversity are highly susceptible to sea level rise and ocean acidification resulting from climate change.

Popularly known for its white-sand beaches and scenic water locations, the islands have been a luxury holiday destination, though conditions are deteriorating at a much higher level. As per the country's Environment Ministry in 2016, the Maldives spends around USD10 million annually for coastal protection works, whereas it needs and estimated USD 8.8 billion to shield all of its inhabited islands, failing which nearly 530,000 of its population are vulnerable to storm surges, sea swells and severe weather. In 2014, more than 100 of the archipelago's inhabited islands were already reporting erosion, and around 30 islands are identified as severely eroded.

The Maldives Climate Change Policy Framework and its Nationally Determined Contribution (NDC) highlight the importance for engagement of stakeholders and different cross sections of the society in undertaking climate actions in the country.

4.2: Climate Innovation Needs Assessment

The Maldives Climate Change Policy Framework highlights the need for two component under which five

strategic goals are identified to foster its sustainable development in priority sectors¹.

1. The need to ensure and integrate sustainable financing in climate change adaptation opportunities and low emission development measures.
2. The need to strengthen low emission development future and ensure energy security.
3. Strengthen adaptation actions and build climate resilient infrastructure and communities to address current and future vulnerabilities.
4. The need to inculcate climate change advocacy and awareness nationally and internationally.
5. The need to foster sustainable development through ensuring security and sovereignty; and economic, social and environmental sustainability from the negative consequences of climate change

The NAPA project in the Maldives is implemented as part of the Integrated Climate Change Strategy (ICCS) that included the Technology Needs Assessment for mitigation and adaptation and, the National Capacity Self-Assessment. Maldives' National Adaptation Programme of Action (NAPA) identified the following key areas of climate change related vulnerabilities:

Land, beach and human settlements;

Critical infrastructure;

Tourism; fisheries;

Human health;

Water resources; agriculture and food security; and

Coral reef biodiversity.

Innovation in these areas would enhance climate resilience and adaptability of Maldives to climate induced risks and vulnerabilities.

¹ <http://extwprlegs1.fao.org/docs/pdf/mdv172920.pdf>

5 Stakeholder Consultation on Climate Innovation

The Climate Innovation Challenge National Consultation in Maldives sought to identify the innovation needs of Maldives, guidance from government and other stakeholders on the current themes and categorizing new innovation needs relevant to Maldives. Understanding the needs of the end users, the consultation discussed the overarching principles that will help ensure sustainability of the piloted approaches.

Understanding the needs of the end users, the consultation with relevant government agencies, (Ministries/Departments) and other concerned stakeholders to discuss the following overarching principles that will help ensure sustainability of the piloted approaches:

Objectives of the Consultation

- Explore possibility of co-development of products and tools with the end-users.
- Identify innovation projects that demonstrate regional applicability and scalability.
- Discuss the innovations and technologies that can be applied in Maldives and transferred among SAR countries.
- Familiarize the audience with ADPC and CARE for South Asia project.

5.1 Summary of the Discussion

The result of risk assessment undertaken on the safe island project highlighted that there are no safe islands in Maldives. As each island has a maximum threshold level for events such as flooding. Once the threshold is met, flooding can inundate and enter island irrespective of natural and built environment of the island.

Reports from UNFCC and other organizations has revealed startling climate projections in the Maldives. These reports indicate that Maldives need to explore innovative solution that will help adapt and mitigate impacts of climate change. A project like World Bank funded CIC would support Maldives to expedite efforts in mitigating these pressing climate concerns.

The central idea of CIC is to help identify certain needs on innovation on climate resilience and adaptation that would help in creating better awareness for any kind of climate extreme events affecting Maldives. The CIC call entails the elicitation of suggestions provided from the CIC country consultations and subsequently announcing as a call for proposal.

Process Challenges

Need for handholding and minimizing and simplifying application processes and protocols for applicants who may not have the required skills to apply and implement.

Need for integrating CC and disaster management because NDMA and Ministry of Environment have distinct mandates.

Need for Environmental safeguards for each the innotech proposed so as to avoid by-products that are do not serve the climate solution proposition.

Food security and climate-based innovations in relation to disaster risks and information for the public

(Information based innovation on food security related disaster information).

The Ministry of Environment made references to the Strategic Action Planning for climate resilience. That document should specific country needs for Maldives with succinct climate information.

The NDMA made distinct mention of the safe islands document which should become part of this assessment.

5.2 Outcome of the National Consultation

The current climate scenario in Maldives presented an imperative situation and explored the vast potential of innovative technologies to help assess, mitigate and adapt to climate change. Besides, most importantly as part of the CIC process for South Asia, this report draws up the results of National Consultation on CIC aimed at assessing the needs for cutting-edge technology solutions as one of the key tools for bridging the gap of adaptation and reducing disaster risk.

The CIC consultation created the scope in discussing its overall objective along with active participation from concerned government officials and key sector specialists that contributed in validating the basic idea of CIC. The CIC specifically encourages innovators to demonstrate tech solutions that are potentially scalable and transferable. The CIC consultation provided an opportunity to ADPC in technically providing suggested thematic areas for possible innovation challenge in Maldives and was also able to extract suggestions as well from the concerned Ministries/Departments. It is expected that the findings and conclusions of this report will be valuable in stimulating further research into the success of innovation technologies to combat climate change.

The CIC consultation in Maldives was held on [...] that brought together potential end users and government of Maldives to assess and identify a series of innovative and demand-driven technology-based solutions with local partners to enhance climate resilience in the country.

Besides assessing and identifying the needs in various sectors, the consultation process sensitized the participants on an open global call for invitations for innovators to identify and pilot solutions to address challenges in reducing climate risk and build the resilience of governments and communities. The discussions led to acknowledging a potential partnership between ADPC and experts in Maldives to build institutional capacity and the local market for further improvement and application of those innovations.

The consultative process led to understanding the key focus areas of Maldives' NDMA on disaster risk reduction and building resilience to climate change.

Key Recommendations

The NDMA's major focus is on disaster risk reduction and building resilience to climate change emphasizing the need for the two institutions - the NDMA and Ministry of Environment to collaborate and integrate disaster risk reduction and climate adaptation.

The application of social and environmental safeguards for the innovation technology was recommended to avoid residual negative impacts from the technology or its by-products. *"The CIC grant innovation should directly or indirectly as well as any of its by-production contributes in creating a new environmental risk rather should aim to serve the basic purpose of effectively using the Technology."*

An emerging issue on food security and the need for climate -based innovation on increasing food security is crucial looking beyond natural disasters and its impacts. A related priority need should include fisheries and marine resources. In addition, it was recommended that the CIC should have a focus on local innovations from existing expertise.

Maldives is working toward enhancing disaster preparedness in the country with drones joining the fight against climate change risks. UNDP’s technology innovation partners are helping the Maldives prepare for emergency response, mapping the island of Maabaidhoo in 3D to empower communities to better prepare for development challenges caused by climate change. While drones alone cannot resolve the challenges brought about by climate change, enhancing the use of drones on other islands is expected to offer visual data and clues to disaster planning and relief missions.

At the same time enhancing the ongoing capacity building in terms of training in drone flight, mapping, and processing data into 2D mosaic maps would contribute to a growing national “information hub” leveraging ArcGIS technology, with improved and localized maps and data, new collaborative processes for geographic information, and a legion of trained voluntary works spread throughout the country that may be able to respond quickly in times of emergency.

Over the period of time, extensive capacity building to these local CSOs have been carried out to collaborate on joint research studies, implementation projects, and regional knowledge-sharing programmes, grant application and shared fundraising opportunities. Besides, the private sector is also actively involved in climate innovations in Maldives. within this backdrop, and considering that ADPC places much emphasis on investing in community resilience, the grant challenge initiative is a good opportunity to build innovations in community resilience by engaging civil society organizations and grassroot communities and placing emphasis of grant challenge in continuing opportunities for CSOs to engage with communities as all as working on technological innovations is both timely and appropriate. Such key potential CSOs needs further handholding by ADPC in terms of honing their capacity that would enable them in making grant application.

Despite the strength of CSOs, academic institutions and communities in delivering effective community services, they lack such technical capacities in grant writing and subsequently can emerge as strong contender to diverse funding opportunities available. With the purpose to fill such crucial gap, it essentially calls for providing technical guidance to the civil society organizations by ADPC and its country partners in demystifying and simplifying innovative concepts and ideas and translating them into actionable proposals and programs.

Considering the nature of grant ceiling, there are untapped opportunities for agencies and entities to collaborate, co-develop and generate innovations through startups and disruptive technologies engaging the youth, CSOs, academic institutions and communities to gain a comparative advantage of CIC grants. Besides innovations, investments in research have always been a necessity to look at solutions to climate challenges in the sectors most vulnerable to climate change.

A key component of adaptation is technology that can help protect society from changing climate conditions, improve productivity, and help in the more efficient use of threatened resources such as water. It is crucial to identify a number of existing and emerging technologies that can help Maldives adapt to climate change. This will encompass identifying and analyzing adaptation technologies that can ameliorate the potential adverse impact of climate change.

Development benefits define climate change adaptation technologies, which offer the greatest value to Maldives in meeting its current national development priorities. Implementation potential defines scale of implementation and diffusion of the technology, which can be realistically achieved if key barriers are overcome. Contribution to climate change response goals defines technologies, which will make the biggest contributions to facilitating adaptation to climate change that will in turn, contribute the achieving the country’s climate-resilient development strategies and actions. Based on the assessment of innovation needs, the following key thematic areas focusing on partnerships, applicability and scalability of innovations and technologies were identified:

Key thematic areas for innovation challenge in Maldives

Theme 1: Community -level-early warning systems
Theme 2: Land, beach and human settlements
Theme 3: Critical Social Infrastructure
Theme 4: Flood management and urban waste management
Theme 5 : Island Transport System: Low emission city and intra-island transport system
Theme 6: Human health
Theme 7: Agriculture and Food Security
Theme 8: Fisheries and Tourism
Theme 9: Coral reef biodiversity

Annexure

Annexure-2: Key Stakeholders Consulted

		Name	Designation
1	Ministry of Health	Aminath Shaufa	Director
2	Ministry of Higher Education	Dr.Abdul Raheem Hassan	Director General
3	Ministry of Fisheries and Agriculture	Ismail Rasheed	Director
		Ali Amir	Director
		Munshidha Ibrahim	Senior Fisheries Officer
		Maleeha Haleem	Senior Fisheries Officer
4	Minsitry of Environment	Ali Shareef	Director
		Ahmed Waheed	Director
5	Ministry of Gender Family and Socail Services		

6	Ministry of Education	Hussain Rasheed Moosa	Deputy Director General
		Sahula Wajeeh	Education Officer
7	Ministry of National Planning, Housing and Infrastructure		
8	Ministry of Finance	Aminath Nashia	Resource Mobilization Executive
		Azlifa Yoosuf	UNDP consultant
		Ahmed Ifthikhar	Director
9	NDMA	Sofeenaz Hassan	Director General
		Mariyam Shizna	A. Program Coordinator
		Aminath Shaufa	A. Project Officer
		Izdhiha Rusdhy	Admin Officer



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