MALDIVES

TECHNOLOGY NEEDS ASSESSMENT REPORT

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Abbreviations

ADB	Asian Development Bank
AR	Assessment Report
BAEF	Barrier Analysis and Enabling Framework
BUR	Biennial Update Report
CC	Climate Change
CCD	Climate Change Department
CCKP	Climate Change Knowledge Portal
CIA	Central Intelligence Agency
DTU	Danish Technical University
EST	Environmentally Sound Technologies
EPA	Environmental Protection Agency
ENSO	El Niño–Southern Oscillation
FAO	Food and Agriculture Organization
GDP	Gross Domestic Product
GIS	Geographic Information System
GHG	Green House Gas
GNI	Gross national income
ICZM	Integrated Coastal Zone Management
INDC	Intended Nationally Determined Contribution
IPCC	Intergovernmental Panel on Climate Change
MASPLAN	Master Plan for Sustainable Fisheries
MCA	Multi-Criteria Analysis
MCCPF	Maldives Climate Change Policy Framework
MECCT	Ministry of Environment Climate Change and Technology
MEE	Ministry of Environment and Energy
MEEW	Ministry of Environment Energy and Water
MMRI	Maldives Marine Research Institute
MTDF	Mariculture Training and Demonstration Facility
NAMA	Nationally Appropriate Mitigation Action
NAPA	National Adaptation Programme of Action
NBS	Nature Based Solutions
NC	National Communications
NEAP	National Environmental Action Plan
NGO	Non-Governmental Organization
NSC	National Steering committee
ODA	Official Development Assistance
RCP	Representative Concentration Pathways
SAP	Strategic Action Plan
SC	Steering Committee
SDG	Sustainable Development Goals
SLR	Sea Level Riyaz
SNC	Second National Communication
TAC	Total Allowable Catch
TAP	Technology Action Plans
TFS	Technology Fact Sheets
TNA	Technology Needs Assessment

TWG	Technical Working Group
UDP	UNEP DTU Partnership
UNDESA	United Nations Department of Economic and Social Affairs
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
USD	United States Dollar

Glossary

Adaptation	Adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities (IPCC, 2007a; glossary).
Mitigation	An anthropogenic intervention to reduce the anthropogenic forcing of the climate system; it includes strategies to reduce greenhouse gas sources and emissions and enhancing greenhouse gas sinks (IPCC, 2007a; glossary).
Multi Criteria Decision Analysis	A technique used to support decision making which enables evaluation of options on criteria, and makes trade-offs explicit. It is used for decisions with multiple stakeholders, multiple and conflicting objectives, and uncertainty.
Technology needs and needs assessment	A set of country-driven activities that identify and determine the mitigation and adaptation technology priorities of Parties other than developed country Parties, and other developed Parties not included in Annex II, particularly developing country Parties. They involve different stakeholders in a consultative process, and identify the barriers to technology transfer and measures to address these barriers through sectoral analyses. These activities may address soft and hard technologies, such as mitigation and adaptation technologies, identify regulatory options and develop fiscal and financial incentives and capacity building (UNFCCC, 2002, p.24).
Vulnerability	Vulnerability is the degree to which a system is susceptible to, and unable to cope with, adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the character, magnitude, and rate of climate change and variation to which a system is exposed, its sensitivity, and its adaptive capacity (IPCC, 2007a; glossary).

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Executive Summary

In order to meet the objectives of the Paris Agreement to mitigate and adapt to the impact of climate change (CC), developing countries that are party to the UNFCCC, are required to undertake a process to identify the country's development priorities and the technologies that will achieve lower emissions and stronger climate resilience. For this reason, a partnership agreement between UNEP and UDT is being implemented to assist Maldives to develop its Technical Needs Assessment (TNA) project.

The TNA process is executed following TNA guidebook recommended steps, namely: (a) Identification and prioritization of technologies for mitigation and adaptation, (b) Barrier analysis and enabling framework (BAEF) identification, and (c) Technology action plan (TAP). This report addresses only the first step which is the Identification and prioritization of technologies for adaptation.

Adaptation sectors for Maldives are identified based on the climate change vulnerabilities of the country addressed in the first and second National Communications and the national priorities articulated in the Intended Nationally Determined Contribution (INDC) of 2015 updated NDC of 2020 submitted to the UNFCCC. Eight sectors are identified for climate change adaptation in the above-mentioned national documents and they are; Coastal Adaptation and Disaster Management, Water, Agriculture and Food Security, Fisheries, Coral reef and Biodiversity, Tourism, Health, and Infrastructure Resilience.

The TNA process involved formation and activation of Project Steering Committee, and sectoral Technical Working Groups (TWG) to provide technical support. A series of workshops with key sectoral experts were also convened to allow participatory decision making regarding key project outputs and the validation of results. Workshops and meetings of TWG on adaptation technologies were convened separately for each sector.

Maldives being at the forefront of climate change impact the eight vulnerable sectors identified in the national policy documents were considered important as country's adaption priorities and cannot be cherry-picked as priority sectors. Also, exclusion/elimination of sectors may lead to divert adaptation focus on specific sectors only. Therefore, the Technical Working Group (TWG) for all eight sectors convened and conducted a pre-screening of the long list of identified technologies to determine which should be carried forward for further analysis. This activity involved in-depth discussions that were moderated and guided by the specific technical expert on the working group supported by the Consultant and the TNA coordinator. The technologies were shortlisted by the TWG members using the approach advocated in the TNA handbook following the preparation of technical factsheets. The technologies selected and their levels of

implementation within the country were reviewed, and the results for the final ranking of the technologies assessed and presented in a matrix. This process involved the summation of the weighted scores utilizing the weights determined by the sector working group.

Highest ranking two technologies from each sector is selected as the priority technology to include in the TNA. From the MCA process, a total of 16 different technologies are prioritized and selected. The technologies that have been retained for developing the BAEF and Technology Action Plan (TAP) are summarised below for each sector Table 1.

Table 1. Prioritized adaptation sectors and technologies from the TNA process

Sector	Technology
Fisheries	Improving fish finding harvesting and handling
	Improvement of boat design and equipment for reef fishery
Coastal adaptation & Disaster management	Sustainable infiltration and drainage management
	Integrated Land Use Planning (ICZM) Drone mapping, satellite imagery and GIS
Health	Green Climate Smart Healthcare facilities
	Health Sector Emergency Response to extreme events
Water resources	Rain Water Integration
	Flood water recovery
Critical infra structure	National Development Act and integration of CC into development planning
	Climate proofing of all critical infrastructure
Tourism	Climate proofing of resort infrastructure etc.
	Climate friendly utilities Electricity, waste, water and wastewater, food etc.
Agriculture and Food security	Community farming & community gardens and household therapeutic farming
	Agritourism developments
Coral reef and biodiversity	Coral reefs conservation through ecosystem approach as adaptation
	Continued monitoring of reef health, increased conservation effort and reduction of impacts of human activities

Chapter 1 INTRODUCTION

1.1 Country Background

Maldives is an archipelago consisting of 1192 low-lying islands, clustered into 26 natural coral atolls. Geographically these islands are situated in the central Laccadives-Maldives-Chagos submarine ridge. The atolls are dispersed over an area of 859,000 km^2 exclusive economic zone. The average elevation of the islands are 1.5 meters above the mean sea level and approximately 80% of the islands have an elevation of less than 1 meter, making the country one of the flattest countries in the world (SNC, 2016).

The population of Maldives is 579330 in 20221. The population is distributed in 187 islands. Tourism, contributes one third of the Gross Domestic Product (approximately GDP of 28.2%). Other important contributors to the economy include fisheries agriculture, communication, construction and real estate. Key development indicators of Maldives are shown in Table 2.

Table 2. Key development indicators of Maldives

Indicator	Value	Source
Population Undernourished	10.3% (2016–2018)	FAO, 2019
Population growth (annual % change)	3 (2019)	ADB 2020
GDP per capita	10,788.6 (2019)	ADB 2020
National Poverty Rate	8.2% (2016)	ADB, 2021
Population with access to basic drinking water (%)	99.3 (2017)	ADB 2020
Population with access to basic sanitation (%)	99.4 (2017	ADB 2020
Share of Wealth Held by Bottom 20%	8.3% (2016)	World Bank, 2020
Adult literacy (%)	97.7 (2016)	ADB 2020
Carbon dioxide emissions (kilo tons)	870 (2018)	ADB 2020
Carbon dioxide emissions per capita (tons	3.1 (2014)	ADB 2020
Forest area (square kilometer)	10 (2016)	ADB 2020

1 http://statisticsmaldives.gov.mv/nbs/wp-content/uploads/2022/04/MIF-FEB-2022-Infographic.pdf (Accessed 12th April 2022)

Net Migration Rate	2.3% (2015–2020)	UNDESA, 2019
Infant Mortality Rate (Between Age 0 and 1)	0.7% (2015–2020)	UNDESA, 2019
Average Annual Change in Urban Population	2.9% (2015–2020)	UNDESA, 2018
Dependents per 100 Independent Adults	30.2 (2020)	UNDESA, 2019
Urban Population as % of Total Population	41.1% (2021)	CIA, 2021
External Debt Ratio to GNI	48.0% (2018)	ADB, 2020
Government Expenditure Ratio to GDP	30.1% (2019)	ADB, 2020

1.2 About the TNA Project

The global TNA project is a strategic Program on technology transfer to assist developing countries to determine their technology priorities for reducing greenhouse gas emissions and adapting to climate change. UNEP DTU Partnership and the Global Environment Facility are supporting developing countries to undertake TNAs in Phase III to carry out Technology Needs Assessments to achieve national Sustainable Development Goals and the Paris Agreement. Maldives is a party to the UNFCCC and one of the first countries to ratify the Kyoto Protocol and the Paris Agreement demonstrating Maldives's commitment to address climate change in collaboration with the international community. Within the framework of the UNFCCC and under the Paris Agreement Maldives has been given the opportunity to assess the adaptation technologies that are best suited to the country's specific climate change situation. The TNA process is designed to support countries to carry out improved Technology Needs Assessments within the framework of the UNFCCC.

The Ministry of Environment, Climate Change and Technology (MECCT) in partnership with the UNEP-DTU is implementing the TNA project under United Nations Framework Convention on Climate Change (UNFCCC) for the Republic of Maldives.

The purpose of implementing TNA project is to assist Maldives identify and analyse priority technology needs, which can form the basis for a portfolio of Environmentally Sound Technology (EST) projects and programmes to facilitate the transfer of, and access to, the ESTs and know-how in the implementation of Article 4.5 of the UNFCCC Convention.

1.2.1 Objective of the assignment

The overall objective of the project is to identify and prioritize technologies that can contribute to climate change adaptation goals of the Maldives, while meeting the SDGs, National SAPs, INDCs, and priorities (TNA).

1. To identify and prioritize through country-driven participatory processes, technologies that can contribute to adaptation goals of the Country, while meeting national sustainable development goals and priorities
2. To identify barriers hindering the acquisition, deployment, and diffusion of prioritized technologies.
3. To develop Technology Action Plans (TAP) specifying activities and enabling frameworks to overcome the barriers and facilitate the transfer, adoption, and diffusion of selected technologies in the Maldives.

The TNA process will also develop Concept Notes for attracting funding to implement selected technologies in priority areas of national relevance. This report is based on objective 1, namely to identify and prioritize technologies that can contribute to the adaptation and mitigation goals of Maldives, while meeting the country´s national sustainable development goals and priorities.

1.3 Existing National Policies Related to technological innovation, Climate Change and Development Priorities

A listing of national policies related to climate change adaptation and mitigation is in Table 3. These documents address actions across numerous sectors and are not limited to the selected priority sectors addressed in this report.

Table 3: National Policies Related to Climate Change and National Development

Year	Policy document
2021	Climate Emergency Act (9/2021)
2021	Water and Sewerage Master Plan 2021-2035
2021	National Climate Change Research Strategy
2021	Guidance Manual for Climate Risk Resilient Coastal Protection in the Maldives
2020	National Strategic Framework to Mobilize International Climate Finance to Address Climate Change in the Maldives 2020 – 2024
2020	Maldives First Biennial Update Report
2020	Update of Nationally Determined Contribution of Maldives
2020	National Water and Sewerage Strategic Action Plan (2020-2025_
2019	Strategic Action Plan (2019-2023)
2019	National Action Plan on Air Pollutants (2019)
2019	SDG Communication Strategy and Action Plan 2019-2023
2019	National Fisheries and Agriculture Policy (2019-2029)
2019	Maldives First Biennial Update Report to the UNFCCC
2018	Master Plan for Sustainable Fisheries (MASPLAN)
2018	Disaster Management Act
2017	Maldives Water and Sewerage Policy (2017)
2016	National Biodiversity Strategy and Action Plan 2016-2025
2016	Second National Communication of Maldives to the UNFCCC
2016	Energy Policy and Strategy (2016)
2016	Health Master Plan (2016-2025)

2015	Maldives Climate Change Policy Framework (2015)
2015	Nationally Determined Contributions to Paris Agreement
2010	HCFC phase-out Management Plan for Maldives (2010-2020)
2010	Strategic National Action Plan for Disaster Risk Reduction and Climate Change Adaptation 2010-2020
2004	National Adaptation Programme of Action (NAPA)
2001	First National Communication of The Republic of Maldives to the UNFCCC

1.4 Country Vulnerability Assessments

Maldives is an archipelago of 26 low-lying coral natural atolls, stretching over 860 km from north to south and 80 to 120 km from east to west, in the Indian Ocean, southwest of the Indian subcontinent. The country consists of 1,192 small low-lying reef islands out of which 187[1] are inhabited about 164 are used for economic activities such as tourism, fisheries, agriculture and other industrial/economic activities (NC2 2016). 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 (FAO 2011). Maldives is also one of the lowest and flattest countries in the world2, as over 80% of the total land area is less than 1 meter above mean sea level.

The Maldives being located over the equator in the Indian Ocean experiences a warm and humid tropical climate, with the weather mainly being dominated by two monsoon seasons: the southwest monsoon (the wet season, from May to November); and the northeast monsoon (the dry period, from January to March). Annual rainfall over the country varies between 1779 - 2218 mm per year, while average temperatures range from 25°C to 31˚C.

Climate change vulnerabilities of the Maldives are due to extreme weather events, temperature increases, flooding, and sea level rise. In the (NC2 2016) submitted to UNFCCC the country has committed to increase its adaptive capacity, reduce beach erosion and land lost from uncontrolled human settlements. climate risks faced by Maldives includes rapid onset and long-term changes in key climate parameters, as well as impacts of these changes on communities, livelihoods and economies, many of which are already underway.

Cognizant of the threats posed by climate change, especially within vulnerable sectors, a number of policy initiatives have been undertaken to address the impacts of climate change in the country. A recent such efforts are listed below:

2 Union of concerned scientists Sea-Level Rise in the Republic of Maldives | Global Warming Effects (climatehotmap.org) Accessed 18th March 2022

1. Climate Change Policy Framework (MCCPF) adopted in 2015 consists of 5 thematic Strategic Goals;
2. Updated Nationally Determined Contributions to Paris Agreement ,2020. The country has pledged to reduce 26% of GHG emissions by 2030 and determined to achieve net zero by 2030 if adequate international support and assistance is received
3. National Climate Change Research Strategy 2021
4. Energy Policy and Strategy (2016)
5. National Action Plan on Air Pollutants (2019).
6. National Solid Waste Management Policy (2015)
7. Health Master Plan (2016-2025)
8. Presidential Decree to Ban the production and sales of single-use plastics (2021)[3]

Maldives current development challenges stem from risks from climate change, disaster resilience and environmental sustainability with rising levels of solid waste4. Vulnerability to sea level rise, coastal storms and flooding, and sensitivity of fisheries sector, population and housing structures, and over 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 (MEE 2015).5 Economic modelling done by ADB (2014) shows that Maldives may be the hardest hit out of the 6 South Asian countries in terms of total economic loss due to climate change — the simulated economic damage may be on average 2.3% of GDP in 2050, with estimates of 12.6% of GDP by 2100 (ADB 2014)6.

The first and the second National Communications submitted to the UNFCCC, INDC and Updated NDC 2020 are important guiding policy documents formulated after years of climate vulnerable sector assessments specific to the Atoll-island environmental setting of the Maldives. The vulnerable sectors identified and addressed in the above documents are equally significant and considered to be the priorities of the country, therefore, stakeholder and national TNA steering committee decided that there is no need for further narrow-down the list of vulnerable sectors and prioritizing for few selected sectors as it can be extremely bias and unjust for the unselected sectors and overall vulnerability focus of the country. Therefore, the following are considered as the climate vulnerable sectors of the Maldives that are equally significant and important for the TNA to be addressed in this document:

Agriculture and food security: Due to the small size of the islands, land scarcity, poor soil conditions and limited water resources in island aquifer, agriculture and food production is very limited in the Maldives. Limited agricultural production, heavy import dependency, limitations in storage and challenges in the distribution of food across the nation are major threats to national food security. About 90% of the food consumed in the country is imported and any impact on food production in the source countries/regions will directly affect Maldivian food security. In addition, any disruptions to transportation of food due to extreme climate events would put a halt to food supplies into the country. Therefore, meeting the need for staple food requirements

3 http://www.environment.gov.mv/v2/en/download/13872 (accessed 19th April 2022)

4 https://www.worldbank.org/en/country/maldives/overview#1 (accessed April 2022)

5 Ministry of Environment and Energy (2015). Maldives Climate Change Policy Framework.]

6ADB (2014). Assessing the Costs of Climate Change and Adaptation in South Asia. URL: https://www.adb.org/publications/assessing-costs-climate-change-and-adaptation-south-asia [accessed 10/07/2019]

and maintaining sufficient storage and distribution facilities is a huge logistical challenge due to the geographically dispersed nature of islands especially during severe and extreme events and unexpected market irregularities. The vulnerability assessment identified the need to increase food storage in local islands

Infrastructure resilience: Almost all the critical infrastructure is in close proximity to the coastline, hence, they are exposed to coastal hazards such as sea swells, storm surges and associated coastal flooding. Protection of critical infra such as airports, ports, utility services, hospitals, transport and communication infrastructures and water and sewerage network etc., from the potential adverse impacts of climate change through climate proofing, better spatial planning and increased connectivity between the islands and integration of climate change into development planning and other activities such as ecosystem management will contribute to increase the resiliency of critical infrastructures. Critical infrastructure vulnerability was highlighted in 2004 Indian Ocean Tsunami where one of the most significant impacts of the tsunami was the complete shutdown of the only international airport for several days.

Health care: The coronavirus (COVID-19) pandemic has demonstrated how the compounding impacts of multiple challenges will impact vulnerable populations to create devastating health, social, economic and environmental crises that can leave a deep, long-lasting mark. Warmer temperatures and wetter monsoon seasons projected with climate change could increase the prevalence of vector borne diseases. Extreme weather such as storm surges and flooding cause significant damage to health care facilities and the delivery of health services during emergencies. Also, heavy rainfall, flooding, poor sanitation and groundwater contamination promotes the transmission of water borne diseases when there are no proper mechanisms to ensure adequate food safety and disposal measures. Accessibility to health care is also a concern for the Maldives, especially due to the dispersed nature of the islands. Primary health facilities are available at each inhabited island but access to higher tiered facilities are limited to atoll capitals and population centers. At the event of extreme weather events, access to higher tiered health care facilities becomes a challenge.

Water resources: Ground water and rainwater are the main sources of fresh water in Maldives. In most of the islands, groundwater is not suitable for potable use due to saltwater intrusion and poor water quality. Climatic and non-climatic factors such as population growth, population concentration and pollution impact freshwater resources in the Maldives. Future climate projections show that the Maldives would experience issues with adequate availability of rainwater. The northern and central islands are currently more vulnerable to elongated dry periods with the need for emergency water supplied during dry periods.

Coastal Protection and Disaster Management: The severity and frequency coastal erosion are increasing. Both climate change and anthropogenic modification of coastal environments are attributed as causes of erosion. Small low-lying geographic nature of Maldives islands results in communities having to live in very close proximity to the shoreline and highly exposed to risks associated with coastal hazards such as sea swells, sea level rise and these impacts have

increased many folds over the past few decades. Hence, investments to early warning and systematic observation and improvement of disaster data collection, management and forecasting capabilities will increase coastal resilience and it is a critical need and priority for the Maldives. Given the characteristics of the country, coastal management is essential to increase resilience in other vulnerable sectors.

Tourism: The largest contributor to GDP and it is highly dependent the natural environmental resources. The major climate change impacts on the Maldives tourism sector include impacts due to increased temperatures, increased extreme events, sea level and SST rise and changes to marine biodiversity. Any negative impacts on the tourism sector would have dire economic consequences.

Fisheries: The key primary productivity sector that contributes to approximately 20% of the domestic employment. Climate change impact on oceans such as changes in sea surface temperature and ocean pH and marine life is expected to change distribution of fish stocks and their food which will have significant impact on fisheries dependent livelihood activities and food and nutrition security in the Maldives. Projected increase in frequency, intensity and magnitude of extreme events, with climate change, will have detrimental impact on fisheries sector. As over 90% of export is marine products, especially tuna, any significant change in the abundance and catch-ability of tuna will have economic consequences.

Coral reefs: The Maldivian atolls are extremely rich and diverse in its marine flora and fauna and it is the seventh largest reef system in the world and the largest in the Indian Ocean. Physical protection and formation of islands, livelihoods of the people and economy of the country depends on coral reefs. Coral reefs are highly sensitive to changing SST and ocean acidification. The severity and frequency of bleaching events and erosion of reef structures will increase significantly with projected climate change which will have long-term implications for coastal protection and degradation of reef framework with projected climate change.

Furthermore, due to a combination of political, geographic, and social factors, Maldives is recognized as highly vulnerable to climate change impacts, ranked 113th out of 181 countries in the 2020 ND-GAIN Index.[7] The ND-GAIN Index ranks 181 countries using a score which calculates a country's vulnerability to climate change and other global challenges as well as their readiness to improve resilience. Figure 1 is a time-series plot of the ND-GAIN Index showing progress of Maldives (Source: WB & ADB 2021)

7 Climate Risk Country Profile: Maldives (2021): The World Bank Group and the Asian Development Bank.

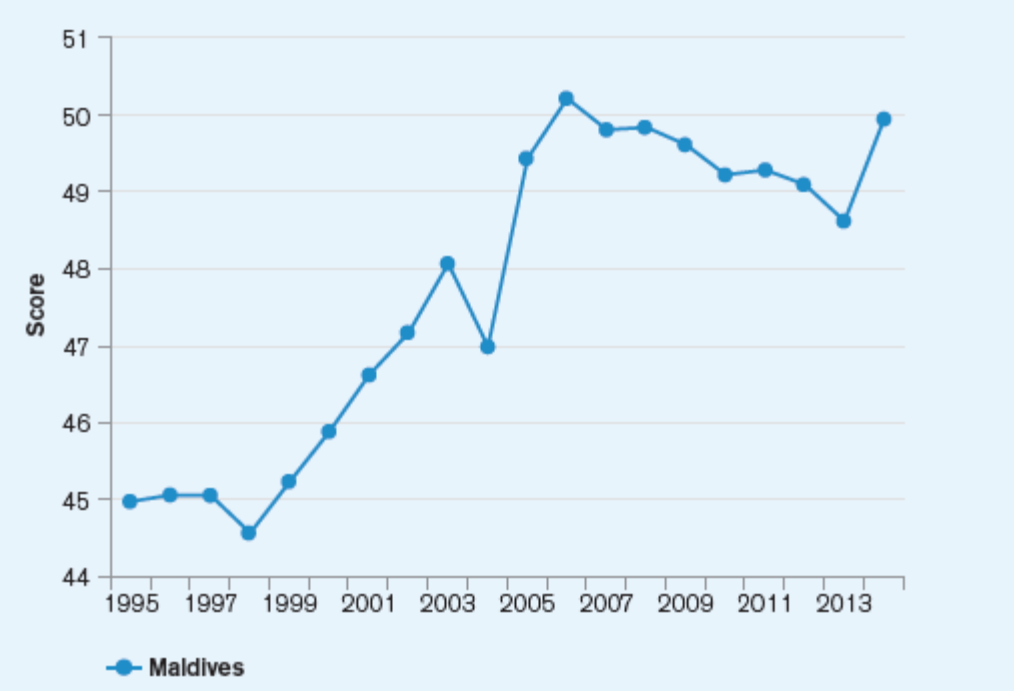

Figure 1. Time-series plot of the ND-GAIN Index showing progress of Maldives. The ND-GAIN index summarizes a country's vulnerability to climate change and other global challenges in combination with its readiness to improve resilience. It aims to help businesses and the public sector better prioritize investments for a more efficient response to the immediate global challenges ahead. (Source WB & ADB. 2021).

According to the first Biennial Update Reports (BUR) for Maldives, the total donor funded adaptation projects until 2017 was estimated to be 96,604,568.39 USD and for the period of 2014-2017 approximately 30% of finances for climate change are allocated towards adaptation while 59% towards climate mitigation. The annual climate finance attribution corresponds to about 2.4% of GDP (4.6 billion USD in 2017) and the direct national budget allocations correspond to 0.8% of Maldives' GDP in 2017.

1.4 Key climate trends and projections

1.4.1. Current trends

Temperature

Generally, temperatures in Maldives range from 25°C to 31°C, with higher temperatures in the north, and seasonal fluctuations due to the influence of the monsoon. The mean average temperature shows an increasing trend for Malé (0.267°C/decade) and Gan (0.168 °C/decade) while a decreasing trend is observed in the northern station in Hanimaadhoo (0.086°C/decade) (SNC 2016), Figure 2 and Figure 3.

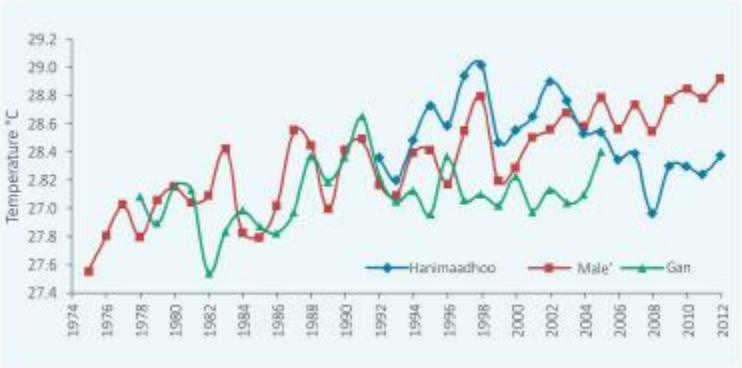

Figure 2. Annual mean temperature, for the period (1974-2012) from north, south and central part of Maldives (Source: SNC 2016)

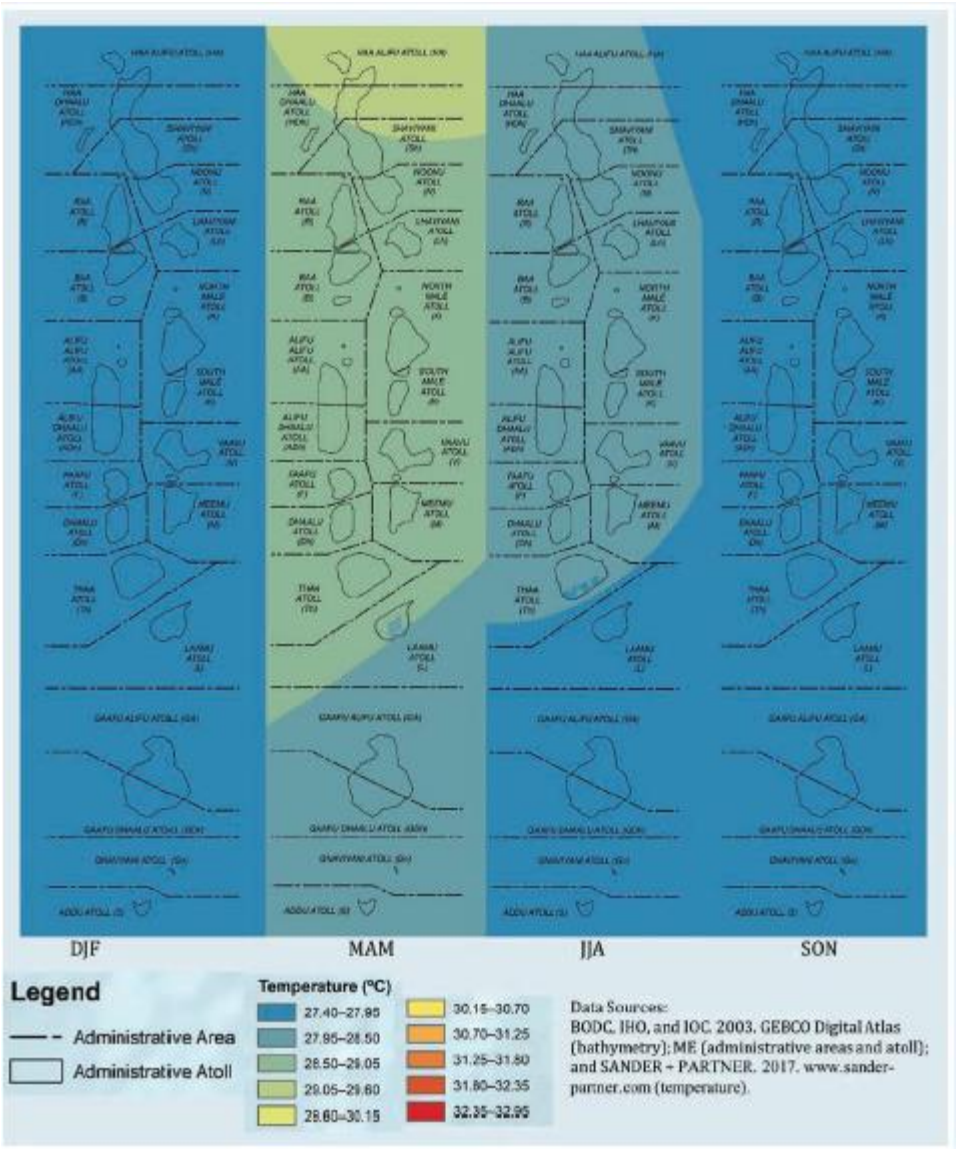

Figure 3 Seasonal average temperature 1970-2005 (Source: ADB 2020)

Sea level change

Due to the low-lying nature of the island in the Maldives sea level rise is considered to be most significant climate change threats that might be hampering the very existence of the country. Sea level records from 1993-2012 shows rise in sea level of 3.753 and 2.933 mm per year in Malé and Gan respectively Figure 4 (NC2 2016).

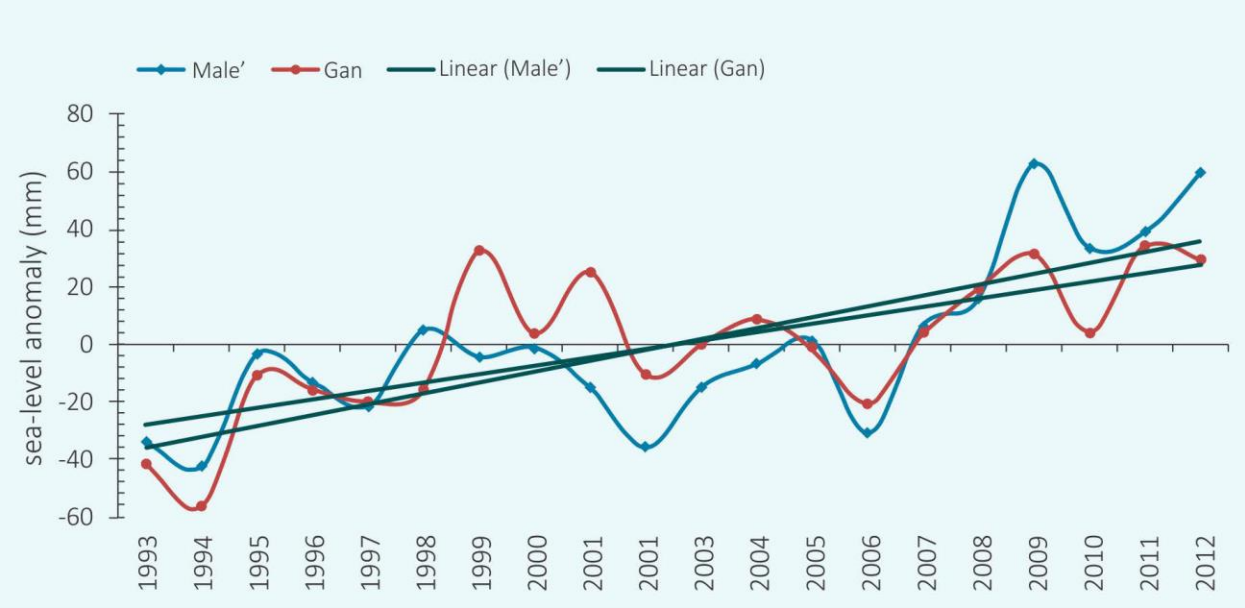

Figure 4. Regional seasonal anomaly for Maldives from 1993-2012 (Source SNC: 2022)

Precipitation

Inter annual variation is observed in the rainfall is recorded in the Maldives due to the two monsoon periods, and there is usually more rainfall during the southwest monsoon. The CCKP's8 respective analysis of annual rainfall totals from 1969–1998 for Malé (central) and Gan (south) show a decreasing trend of around 2.7 millimeters (mm)/year and 7.6 mm/year respectively. Similar analysis of annual rainfall totals from 1967–2011 show a decreasing overall trend of 0.02 mm and 2.21 mm per year Malé and Gan respectively Figure 5 (NC2 2016).

8 Maldives - Mean Projections Expert | Climate Change Knowledge Portal (worldbank.org) accessed 19th March 2022.

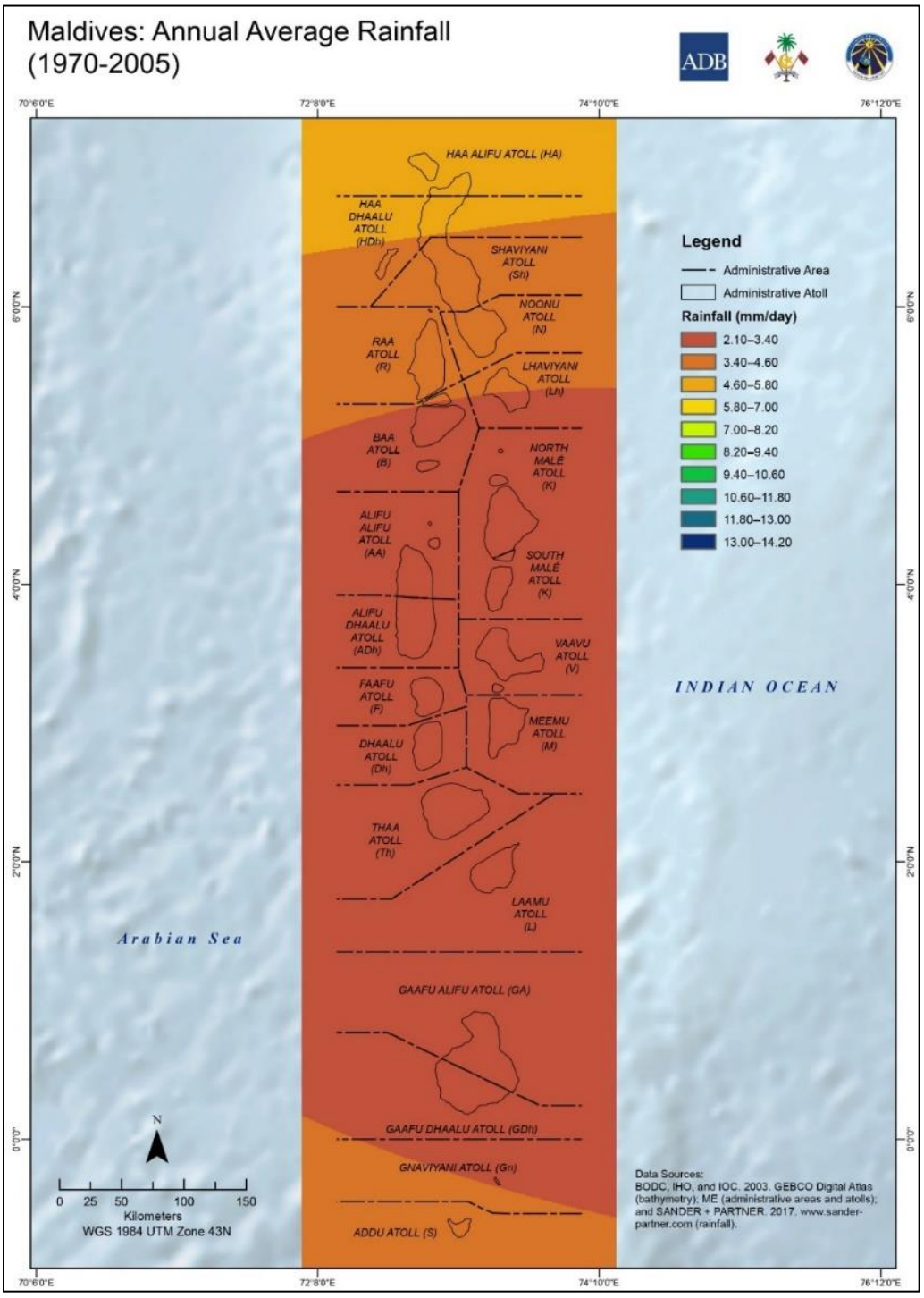

Figure 5. Average annual rainfall 1970-2005 (Source: ADB Multihazard Risk Atlas of Maldives, 2020)

1.4.2. Future climate projection

Based on the climate change models and projections the following shows climate change trends and regional patterns for Maldives:

Temperature

Projected average annual temperatures based on a moderate emission scenario (RCP 4.5), indicate that Maldives will be warmer, with a mean temperature of 28.5°C by the 2050s. Future warming in Maldives is likely to be about 1°C and 1.3°C under a moderate emissions scenario (RCP4.5) and a highest emissions scenario (RCP 8.5) respectively Figure 6.

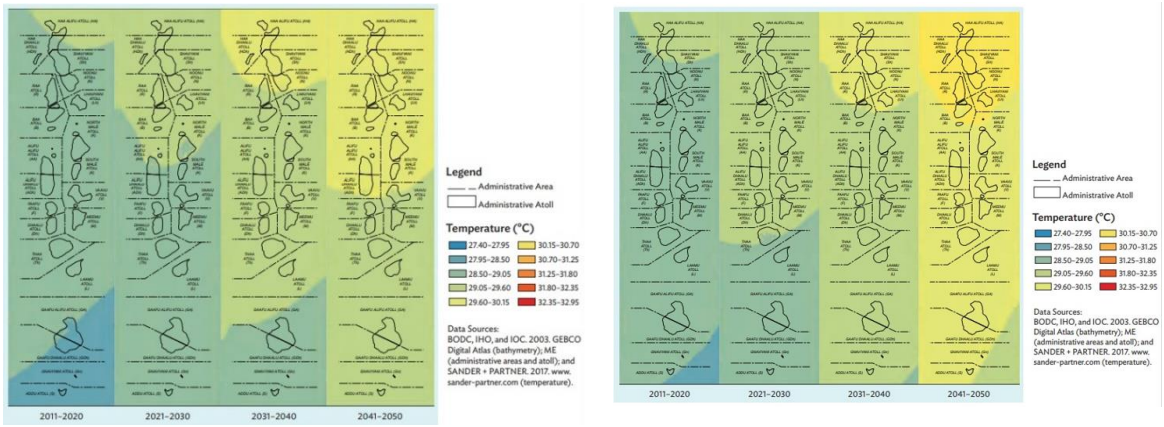

Figure 6. Average annual temperature projection, RCP 4.5 (left) and RCP 8.5 (right) (Source: ADB 2020)

Precipitation

Historical and projected changes in annual precipitation show increases of annual precipitations of about 7-10% above historical baseline. By 2050s, annual precipitation is predicted to be 2484.18 mm (1451.02 - 3230.58mm) and 2539.46mm (1365.38 - 3337.85mm) according to RCP4.5 and RCP8.5 Figure 7.

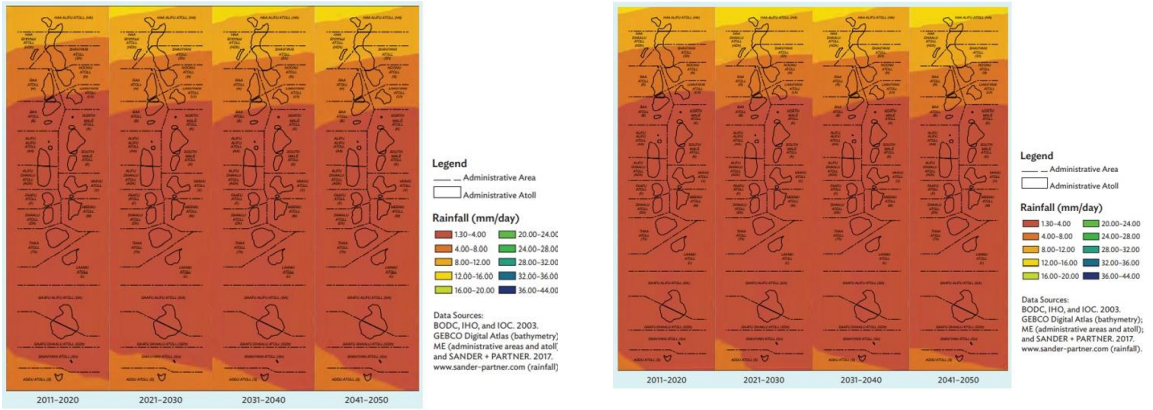

Figure 7. Average annual precipitation projection, RCP 4.5 (left) and RCP 8.5 (right) (Source: ADB 2020)

Sea level change

Climate projections for Maldives estimate that increase in global mean sea level will be between 0.17 - 0.28 m (RCP4.5) or 0.21 – 0.32 m (RCP8.5) by the 2050s and between 0.4-0.7 m by the 2090s (see Figure 8). Table 4 summarises projected sea level for Maldives as in chapter 13 of IPCC AR 5 report.

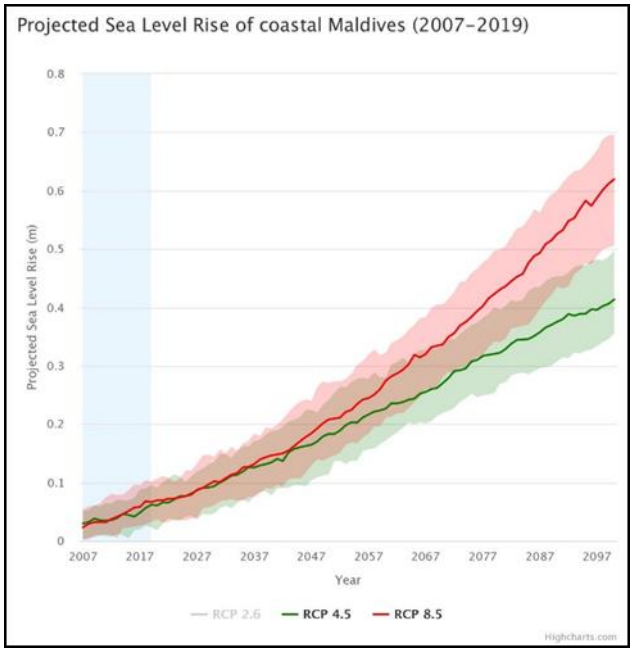

Figure 8. Sea level change projection for Maldives (Source: World Bank Climate Change Knowledge Portal)

Table 4. Projections of mean sea-level change compared to 1986–2005

Projection model	Sea-Level Rise in 2060 Compared to 1986–2005	Sea-Level Rise in 2100 Compared to 1986–2005
RCP 4.5	0.23 m (0.17 - 0.28) *	0.41 m (0.36–0.50)
RCP 8.5	0.27 m (0.21-0.32)	0.62 m (0.51–0.70)

**(likely range in brackets)*

1.5 Sector Selection

Adaptation sectors are identified based on the climate change vulnerabilities of the country addressed in the first and second National Communications and the national priorities articulated in the NAPA 2004, Intended Nationally Determined Contribution (INDC) of 2015 and the Update of Nationally Determined Contribution of Maldives of 2020. It is believed that the eight vulnerable sectors that has been identified and listed in these documents particularly first and second National Communications, Intended Nationally Determined Contribution (INDC) of 2015 and the Update of Nationally Determined Contribution of Maldives of 2020 are equally significant and important and narrowing down the list of priorities for selected few sectors will be extremely bias and may affect climate resilient development process. Therefore, stakeholder and national TNA steering committee decided that there is no need for further narrow-down the list of vulnerable sectors and prioritising for few selected sectors as it can be extremely bias and unjust for the unselected sectors. Prioritised vulnerable sectors for Maldives are:

1. Coastal Adaptation and Disaster Management
2. Water
3. Agriculture and food security
4. Fisheries
5. Coral reef and biodiversity
6. Tourism
7. Health
8. Infrastructure Resilience

Based on the literature reviews, national policy documents, and stakeholders' discussions the long list of technologies were formulated for each sector. Then a shortlist of technologies for each list is developed through consultation with sector specialists and stakeholder. The shortlisted technologies from each sector are assessed, prioritised and ranked through the MCA process. Highest ranking two technologies from each sector is selected for the TNA final list of priority technologies.

1.5.2 Limitations in the literature review

The limitations of a literature review for this process are briefly outlined below:

1. Heavy reliance on national documents and sectors plans and the limited availability of such documents for sector identification.
2. Sectors are discussed very broadly and subsectors are rarely mentioned in the national documents.
3. Technology details used in each sector is not provided in the documents
4. Reaching out stakeholder to cover all relevant to sector was challenging particularly the TNA development process took place during the COVID-19 Pandemic period.
5. Current capacity at national on climate change and adaptation issues is limited to a core group of experts within the Ministry of Environment, other Government agencies, and research institutions only.

Chapter 2 INSTITUTIONAL ARRANGEMENT FOR THE TNA AND STAKEHOLDER INVOLVEMENT.

The Ministry of Environment Climate Change and Technology (MECCT) is the designated national institution, and it leads and coordinates the TNA process in the Maldives. The Ministry is also the Focal Point for the United Nations Framework Convention on Climate Change (UNFCCC). The most prevalent mode of intervention is through projects employing varied technical teams and resources to make recommendations to reduce the impact of climate change. The Minister with responsibility for this Ministry is also part of the National Cabinet of Ministers, and so, directly influences policy decisions impacting climate change.

2.1 National TNA Team

The key elements of the institutional setup of the national TNA process include, the TNA project National Steering Committee (SC), the TNA Coordinator, the National Consultants and the Sectoral Working Groups Figure 9.

National Steering Committee (SC) for the TNA was established in the MECCT. Committee members had been selected for their level of expertise and availability to consult and provide directions and validation of work done within the environment and climate change domain. Further, their engagement in decision-making positions in key public sector and stakeholder institutions was also considered during the selection.

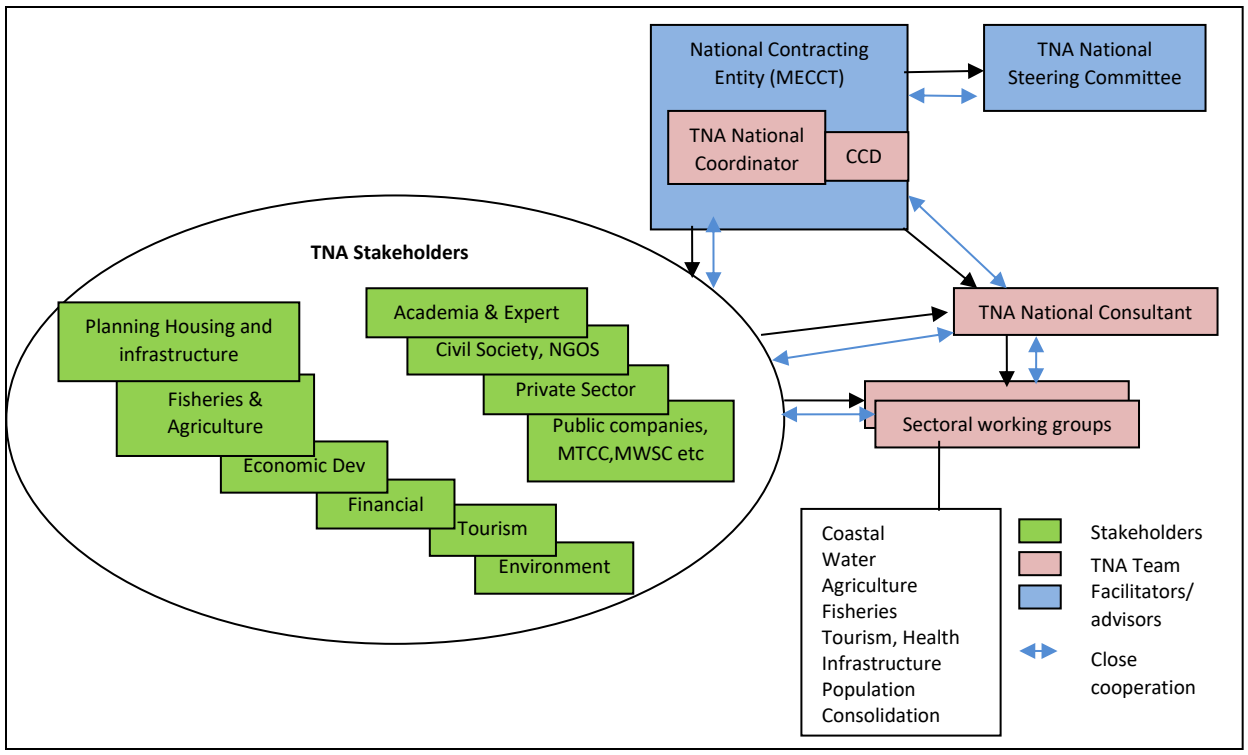

Figure 9 Organizational structure of TNA process adaptation sectors, Maldives

2.2 Stakeholder Engagement Process Followed in the TNA – Overall Assessment

The identification and engagement of stakeholders within the TNA process in the Maldives essentially followed the guidelines provided within the publication by UNEP-DTU[9]. Since TNA is a country driven process, it covers many technologies diverse information, opinions perspectives that were gathered from different people and groups involved in use of technology in various sectors. Stakeholder provided nationally specific information on the technology. Also, the involvement of stakeholders throughout the TNA development ensured the national ownership of the TNA process.

Climate adaptation sectors has been prioritized through the development planning process in the Maldives. National policy documents such as the first and the second National Communications, Intended Nationally Determined Contribution (INDC) of 2015 and the Update of Nationally Determined Contribution of Maldives of 2020 has prioritized eight climate vulnerable sectors to be the focus of adaptation of the country from a very long national stakeholder discussion

9 Identification and Engagement of Stakeholders in the TNA Process: https://tech-action.unepdtu.org/wp-content/uploads/sites/2/2019/05/identification-and-engagement-of-stakeholders-in-the-tna-process-a-gui-3.pdf

conducted during the development of above-mentioned national documents. The TNA steering committee as well as the stakeholder are in the opinion that it is not possible to narrow-down the list for selected few sectors which may affect climate resilient development process of the country. Therefore, the Technical Working Group (TWG) from eight sectors convened and conducted a pre-screening of the long list of identified technologies from the eight sectors to determine which should be carried forward for further analysis. This activity involved in-depth discussions that were moderated and guided by the specific technical expert on the working group supported by the Consultant and the TNA coordinator. The technologies were shortlisted by the TWG members using the approach advocated in the TNA handbook following the preparation of technical factsheets. The technologies selected and their levels of implementation within the country were reviewed, and the results for the final ranking of the technologies assessed and presented in a matrix. This process involved the summation of the weighted scores utilizing the weights determined by the sector working group.

Continuation of Coronavirus global pandemic significantly affected the organising of stakeholder consultation sessions during these processes. Consequently, there was a heavy dependence on electronic communication for the generation of adaptation technologies and most importantly the validation of selected approaches and fine tuning of MCA process.

2.3 Consideration of Gender Aspects in the TNA Process

The Constitution of the Maldives recognizes equal freedom and rights to all citizens without any discrimination. Article 17 of the Constitution prohibits any form of discrimination between men and women in access to any social service, employment or rights and freedoms specified within the Constitution. It further legitimizes affirmative action to redress inequalities faced by vulnerable groups, such as introducing quotas or special temporary measures that targets only a certain group of people. This has been recognized on a national level with the establishment and maintenance of a governmental Ministry of Family Gender and Social Services over the past two decades. The main mission of the Ministry is to improve the lives of women, elderly and vulnerable groups in the society with programmes and services that inform, educate and empower them by cultivating values of mutual respect, peace and equality though inclusive participation in various aspects of nation building processes. The work of the Ministry is ably supported by the civil society, NGOs and community groups to advocate on issues related to gender and other vulnerable groups in the society.

To ensure equal protection and benefits of the law for both men and women the Maldivian Parliament passed the Gender Equality Act in 2016. The Act seeks to facilitate measures taken towards prevention of gender discrimination and address all ideas and practices that promote

gender discrimination while ensuring that women are guaranteed equal rights and opportunities in economic, social, cultural, civil and political life. The Act further stipulates that all government offices and private businesses must take appropriate measures to abolish gender-based all types of systemic discrimination caused through established systems with unequal practices and to promote equal opportunities for men and women and to eliminate undesired preconceptions against a certain gender.

The Decentralization Act has provisions to increase female participation in local governance and decentralized decision making and 33% of all council seats are reserved exclusively for women[9]. Also Women's Development Committees (WDC) elected through an electoral process, is established within the formal structure of the local government and, 5% of the grant money that council attains needs to be given to WDC under the provision of the act.

During the TNA preparation process women representation on both the National Steering Committee (NSC) and the sector technical working groups (TWG) are actively encouraged to provide feedback and comments. Further, members of the sector working groups were required to consider and discuss specific gender related impacts of all selected technologies. The established protocol within the TNA process makes provision for inclusion of gender sensitivity analysis during the technology selection and analysis process. The same approach was adopted with representatives of people with disabilities and youth at risk.

Through this process inclusiveness of women and other vulnerable community group's active participation and their significant contribution to the TNA development process was ensured.

CHAPTER 3 TECHNOLOGY PRIORITISATION FOR ADAPTATION COASTAL ADAPTATION AND DISASTER MANAGEMENT SECTOR

3.1 Key Climate Change Vulnerabilities in Sector

Small low-lying geographic nature of Maldives islands results in communities having to live in very close proximity to the shoreline and highly exposed to risks associated with coastal hazards such as sea swells, sea level rise and these impacts have increased many folds over the past few decades. Over 80% of the total land area of the Maldives is less than 1 m above mean sea level (MSL). Approximately 44% of the settlement footprints of all islands are within 100 m of the coastline and more than 50% of the housing structures in 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 led to increased maladaptation countrywide. Hence, investments to early warning and systematic observation and improvement of disaster data collection, management and forecasting capabilities will increase coastal resilience and it is a critical need and priority for the Maldives. Given the characteristics of the country, coastal management is essential to increase resilience in other vulnerable sectors.

3.2 Decision context

The resilience of natural environment is the key to coping with climate change. Therefore, the adaptation technologies in coastal adaptation and disaster management sector must enhance maintain and where necessary restore the integrity of natural processes that are reducing hazards and vulnerability of both natural and physical systems. The decision context of the coastal adaptation and disaster management sector is based on the actions identified in the SNC and updated NDC report which include the following areas.

1. Promote use of evidence-based decision making on coastal adaptation planning and management of coastal zones.
2. Reduce exposure of communities to coastal hazards.
3. Mainstream climate change risks into coastal development policies.
4. Continue to facilitate investments in coastal protection of inhabited islands, industrial islands and resorts
5. Strengthen the early warning systems and disaster risk management.

Some of the recent efforts programmes and policies to reduce vulnerabilities and adaptation needs are development an enactment of relevant laws and regulations to ensure that climate change is addressed in all developmental aspects. Recent such activities are listed below

- Climate Emergency Act (9/2021)

- Guidance Manual for Climate Risk Resilient Coastal Protection in the Maldives
- Regulation for Protection and Preservation of Island Vegetation and Flora in the Maldives
- Ground Water Conservation Regulation (2021/R-22)
- Guidelines for building climate resilient safer islands in the Maldives

3.3 Overview of existing technologies in sector

The technology identification for coastal adaptation and disaster management sector exercise for the long list of technologies drew from multiple sources and the national context, including:

(1) adaptation technologies proposed in previous national documents (eg: SNC, NDC, INDC etc) ;
(2) technologies currently in practice and supported by national policies;
(3) initiatives in the pipeline/pilot /filed testing stage;
(4) appropriateness of technologies in the local context; and
(5) social acceptability.

Adaptation technologies for the coastal adaptation and disaster management technologies identified are then regrouped into sub sector and categories. Shortlisted technologies from sector discussions are summarized in the following Table 5.

Table 5. coastal adaptation and disaster management technologies and status of use in the Maldives

Adaptation technology	Description and status of use in Maldives
Habitable coastal structure	Soft and hard hybrid living coastal protection structures to increase coastal resilience Eg: use of natural infrastructure to protect permanent and temporary grey infra structure from erosion and waves until the natural features mature and become well established Commonly used in the Maldives
Floating island city (Maldives Floating City)	Project is still on its planning phase by Dutch Docklands — in cooperation with the Government of The Maldives —involves development of more than thousands of residences, all waterfront, floating along a flexible, functional grid across a 200-hectare lagoon. Initial pilot planning and implementation stage proposed by Dutch Dockland
Coastal data collection, planning and mapping, LUP, ICZM 1. Drone mapping, satellite imagery and GIS	A planning process where the allocation of land to different uses across a landscape in a way that balances economic, social and environmental values. Currently in use but not common can be implemented

Determination of water infiltration capacity of islands	Soil's ability to allow water movement into and through the soil profile. Determination of Infiltration rates/infiltration time number of minutes it takes soil to absorb water will determine the flood risk potential of an island
Weather radar systems in North and South improved weather forecast	weather surveillance radar (WSR) or Doppler weather radar, is a type of radar used to locate precipitation, calculate its motion, and estimate its type (rain, snow, hail etc.). capable of detecting the motion of rain droplets in addition to the intensity of the precipitation used for rain forecaster and prediction Only regional level north Central and South
National Environmental Data Center	To establish a centralized environmental and disaster management data in the country. At present data is different Ministries and Agencies

3.4 Adaptation technology options for coastal adaptation and disaster management sector and their main adaptation benefits

Table 6 gives the short-listed technology options for the coastal adaptation and disaster management sector the stakeholders agreed were relevant and would reduce the sectors vulnerability to the impacts of climate change listed section 3.1

Table 6 Adaptation technology options for coastal adaptation and disaster management sector and their main adaptation benefits

Adaptation technology	Climate change adaptation benefit for the sector
Habitable coastal structure	provides a high degree of protection against coastal flooding, storm surges and erosion can also be implemented as part of a wider coastal zone management plan which employs other technologies such as beach nourishment and managed realignment set-back etc. Stabilizes shorelines and reduces erosion Preserves natural storm surge defenses Enhances climate change mitigation through carbon sequestration and storage, known as blue carbon, if vegetation based (as opposed to cement or other structural material) Provides attenuation benefits for boat wakes and storm driven waves

Floating island city (Maldives Floating City)	The development will set new model for island set-ups to adapt and survive in the face of rising seas and climate change. The City will demonstrate environmental adaptation by a floating, island around the lagoon will serve as breakers down below. This will lessen the impact of lagoon waves while stabilizing the structures and complexes on the sea surface. The development lessens the need for reclamation and subsequent impacts on reef successful, and found to withstand rough weather conditions, Floating City can be adopted as the future lifestyle of the local community in the Maldives. Floating city structure can be dynamic, flexible adjustable, appended in response to environmental variables. Floating structures will provide enough open space and will act as huge aggregation devices for various types of marine life sessile coral colonies and enhance underwater life, allow flow of water, current and sediment underneath instead of causing any negative effect coral reefs
Coastal data collection, planning and mapping, LUP, ICZM 2. Drone mapping, satellite imagery and GIS	Understanding of coastal risk complements and strengthens other adaptation options, such as coastal erosion, island dynamics flood mitigation measures, emergency planning, provision and evacuation planning. As such, this approach could be applied almost universally, irrespective of the other adaptation technologies that are used. The technology is appropriate for present and future climatic conditions
Determination of water infiltration capacity of islands	Soil's ability to allow water movement into and through the soil profile. Determination of Infiltration rates/infiltration time number of minutes it takes soil to absorb water will determine the flood risk potential of an island. If this can be determined for island that have potential for flooding then can be better prepared for flood related disasters
Weather radar systems in North and South improved weather forecast	1. Strengthen disaster risk reduction and increase resiliency of islands to climate risk and extreme weather events through enhanced awareness, coordination and adaptive capacity of local communities, especially in the remote island 2. The installation of the weather radar system will activity enhance the skills and competences of MMC to issue more accurate early warnings and weather alerts 3. The focus on use of advanced technologies will contribute to advancement of weather forecasters. 4. The benefits for the islanders will be early warning of extreme hydro meteorological events, creating more resilient islands

	and better caretaking of people and property in the potential risk prone areas. 5. The system will enable better marine weather forecasting, potentially benefiting hundreds of thousands of fishermen and people travelling by sea day and night. 6. Advance knowledge of potential risk prone areas will enable better organized evacuation and reduce health risks for particularly vulnerable people.
National Environmental Data Center	7. National Data Center is proposed to be a solution to Country's Data and information challenge. The center is proposed to become a collaborative initiative of the Government agencies together with the Private sector, Universities, research institutions and other relevant stakeholders. The National Data Center can support in the following • Hydrometric, water quality and climate data integration • Community based monitoring • Environmental data interoperability and exchange • Stakeholder engagement • Web-GIS mapping and analysis • Satellite data integration and analysis • Cultural resource management

3.5 Criteria and process of technology prioritization

Criteria selection was completed using the guidelines established by the DTU for evaluating and prioritizing technologies for adaptation to climate change and with extensive discussion with the TWGs. This was prepared from undertaking desk review of TNAs conducted in other similar locales, the input of local experts to ensure that selected criteria were applicable and could be locally validated. Independence from other selected criteria, ease of assessment scalability and measurability presence/absence of technology were all considered in determining the final list of criteria selected. This listing was presented at the meeting of the working groups for consideration, and further refinement together with a description of each criterion (Table 7and Table 8) to ensure that all members of the working groups had a clear understanding prior to scoring the shortlisted technologies against the MCA criteria.

Table 7. Description of Assessment Criteria of Technologies

Criteria	Indicators	Scoring
Cost	Technology adoption capital cost costs of operation	5: V Low 1: V High

	costs of maintenance cost of impact in the absence of technology	Lowest value preferred
Economic	Improve economic activity (income generating activities jobs socioeconomic improvements) Increase/encourage private investment Economic benefits	5:V High 1: V Low
Environmental	Environmental resource protection and conservation Increased area under protection Contribute/support ecosystem service improvement	5 V High 1: V Low
	Negative environmental impacts Aesthetic impacts	5: V Low 1 V High
Social	Public acceptance of the technology Population under protection/benefitting Feel of ease security and safety Improvement of ~~living~~ standards Create more socioeconomic opportunities	5: V High 1: V Low
Technology	Have technical capacity in-country to set up and implement the technology Technically relevant to Maldivian environment and effectiveness in achieving desired effect/ output Degree of coherence with existing technologies Scalability Time frame Indigenous/ patent Availability spare parts	5: High 1: Low
Climate Change	Increase climate resilience and reduce vulnerability More resilient to flooding and other hydrometeorological -hazards Improvement of livelihood activities to cope with hazard	5: High 1: Low

The Multi Criteria Analysis (MCA) was performed to the short-listed technologies identified in each adaptation sector. Criteria for MCA was established after discussion with sector specific Technical Working Groups (TWG) and other stakeholders. Sector specific each adaptation technology was scored by the TWG of the sector after extensive discussions against the various criteria except for cost and negative environmental impacts on a scale of 1–5, with '1' being the least benefit (very low) and '5' the highest possible benefit (very high) derived from the

technology against the considered criterion. For cost and negative environment impacts the scoring scale of 1–5 was reversed, with '1' being the highest benefit (very low cost/negative impact) and '5' the lowest possible benefit (very high cost/negative impact) derived from the technology against the criterion Table 8.

The weighted score system was applied to the shortlisted technologies for adaptation sectors. The weighted score system takes into account criteria categories of: costs; benefits of economic, environmental, social technology related benefits and climate benefits and various criteria to assess each category. Criteria weights were assigned after discussion with stakeholders and consultation with national coordinator. The weighting contained in **Erreur ! Source du renvoi introuvable.** was agreed via consensus.

Table 8. Assigned Weight of criteria

Criteria Category		Criteria	Category weight	Criteria Weight
Cost	Cost	Investment & Capital cost	**20**	5
		Operational cost		5
		Cost/Impact in absence		4
		maintenance & management cost		6
Benefits	Economic	improve economic activity	**20**	6
		Economic benefits		8
		Private investment opportunity		6
	Environmental	Resource protection	**10**	2
		Contribute eco system service improvement		2
		Increased area under protection		2
		Aesthetic impacts		2
		Negative impacts		2
	Social	Public acceptance / familiarity	**20**	4
		Feel ease security & safety		4
		Population benefiting		4
		Improve living standards		4
		Create More socio-economic opportunities		4
	Technology related	Have local capacity to implement	**20**	4
		Relevancy to Maldives		4
		Coherence with existing technology		3
		Scalability		2
		Time frame		2
		Indigenous/patent		3
		Spare parts availability		2
	Climate related	Enhancing resilience	**10**	5

		Resilient to flood/hydrometeorological hazards		3
		Coping with hazards		2
Totals score			**100**	**100**

3.5.1 Sector Technology Selection

Based on the MCA result highest ranking two technologies are selected from each sector as the priority for TNA. Therefore, a total of 18 technologies are selected as the priority adaptation technology for TNA.

3.6 Results of technology prioritization for coastal adaptation and disaster management

Through this process shortlisted technologies for coastal adaptation and disaster management sectors are assessed, prioritised and ranked are presented in the matrix below. Highest ranking two technologies selected are highlighted in the following Table 9.

Table 9. Results of technology prioritization for coastal adaptation and disaster management sector

Technology	Weighted Score	Technology Rank in the category
Habitable coastal structure	321.5	4
Integrated Land Use Planning (ICZM) Drone mapping, satellite imagery and GIS	344.5	2
Establishment of Weather radar systems in North and South of Maldives Strengthen aeronautical meteorology and multi-hazard early warning capacity	305.3	5
Maldives Floating City (MFS) (Amilla Rah)	289.3	6
Sustainable infiltration drainage technology for flood and storm water drainage Management in islands	349.8	1
National Environmental Data Center	336.3	3

CHAPTER 4 TECHNOLOGY PRIORITISATION FOR WATER RESOURCES SECTOR

4.1 Key Climate Change Vulnerabilities in Sector

Groundwater and rainwater are the main sources of fresh water in Maldives. In most of the islands, groundwater is not suitable for potable use due to saltwater intrusion and poor water quality. Future climate projections show that Maldives will experience issues with adequate availability of rain water which increases risk to accessibility and quality of water sources.

Groundwater aquifers on islands lie at an average depth of 1-1.5m below the ground surface. Average, thickness of the freshwater lens is 3-5 m. The porous sandy soil in the islands make the thin freshwater lens highly vulnerable to SLR subsequent increase in salinity level due to saltwater intrusion. Contamination from inappropriate waste disposal and sub-standard sanitation practices makes the groundwater unsuitable for human consumption in many of the islands.

Flooding induced by heavy rain and inundations causes heavy impacts to livelihood and are likely to become more frequent in the future with changing climate conditions. Excess storm water, swell and tidal waves also cause flooding in the islands of the Maldives, causing extensive damages to critical infrastructure, properties and household goods. It also results in saltwater intrusion into groundwater aquifers, coastal erosion and impacts livelihoods (SNC,2016).

4.2 Decision Context

The national water and sewerage strategic plane 2020-2025 have laid the overall policy for water resource management in the country to ensure equitable access to clean drinking water and improved sewerage facilities in all inhabited islands, through financially and environmentally sustainable technologies. It also supports strengthening the legal framework, building capacity in the sector and promoting awareness and research. Decision context in Water resources sector include the following aspects:

1. Ensure water security and equitable access to safe water for island.
2. Adopt cost-effective and environment-friendly, water related infrastructure Promote conservation and management of the water resources
3. Protect and conserve natural water resources
4. Integrated Water Resource Management (IWRM) systems
5. Build flood resistant island communities
6. Decentralized water security and safety plans
7. Integrate stormwater management into infrastructure development projects
8. increase the efficiency of water use to reduce human pressure on the existing water resources

Some of the recent efforts programmes and policies on water resource management includes the following:

- National water and sewerage strategic plane 2020-2025
- Baseline assessment of groundwater resources in selected islands
- Guide to groundwater improvement measures in small low-lying islands, Maldives
- Ground Water Conservation Regulation (2021/R-22)
- National water and Sewerage policy
- National water and sewerage act (2020)
- Water and Sewerage master plan 2021-2035

4.3 Overview of existing technologies in water resource Sector

The technology identification for the water resource sector exercise for the long list of technologies drew from multiple sources and the national context, including:

(1) adaptation technologies proposed in previous national documents (eg: National Water and Sewage Plan 2020-2025, SNC, NDC, INDC etc) ;
(2) technologies currently in practice and supported by national policies;
(3) initiatives in the pipeline/pilot /filed testing stage;
(4) appropriateness of technologies in the local context; and
(5) social acceptability.

Adaptation technologies for water resources sector identified are then regrouped into sub sector and categories. Shortlisted technologies from sector discussions are summarized in the following Table 10.

Table 10. Water resources sector technologies and status of use in the Maldives

Adaptation Technology	Description and status of use in Maldives
Flood Water Recovery	Storm water and flood mitigation road drainage conducted as part of road development in some islands, However, flood water recovery is yet to be introduced to Maldives
RO Desalination	Sea water desalination is widely used in the Maldives in inhabited island, resorts and industrial establishments Need more on cost effective desalination techniques and innovative water filtration and purification systems
Thermal Desalination	This technology is not very widely used in the country but it has a potential which takes temperature gradient available at power plants
Waste Water Recovery	Waste water recovery and reuse, practiced in some resorts and possibly some industrial island not common in habited islands
Waste Water Technology	Different types of waste water technologies are used in both inhabited islands and resorts
Rain Water Integration	This is widely used under IWRM mostly in inhabited islands

	This technology involves combining water from two sources rainwater and desalinated water and distribution to households through piped network.
	Rain water harvesting involves harvesting rainwater run-off from designated roof areas followed by ultra-filtration and storing in storage tanks then pumping to the distribution network.
	Desalination of saline water sourced from deep boreholes or ocean feed water pipe using Reverse Osmosis Technology has been used as a mean for providing a sustainable source of portable water in IWRM systems
Ground water technologies - Domestic	This is mainly used in inhabited island for domestic uses improve water absorption and infiltration that facilitates recharge and helps avoid polluted water from entering groundwater.
	Promotes evaporation and does not absorb as much heat as paved surfaces reducing the urban heat island effect
Ground water technologies - Public	Technologies has potential to use in public water networks and facilities to provide piped water to the communities.

4.4 Adaptation technology options for water resource sector and their main adaptation benefits

Table 11 gives the short-listed technology options for the water resources sector the stakeholders agreed were relevant and would reduce the sectors vulnerability to the impacts of climate change listed section 4.1

Table 11. Adaptation technology options for water resource sector and their main adaptation benefits

Adaptation Technology	Climate change adaptation benefit for the sector
Flood Water Recovery	Make islands more resilient to flood damage and provide clean and abundant water supplies, places to rejuvenate ecosystem help regrow trees, and creates healthy habitat
RO Desalination	Solves water scarcity issues of islands, supply of high-quality drinking water and preserving existing ground water along with other environmental, socio-economic, and health benefits
	It is very expensive and energy intensive.
	Hybrid, renewable energy and desalination technologies will be promoted
Thermal Desalination	This is a hybrid desalination technology that will reduce emission and contribute to energy efficiency of the desalination process

Waste Water Recovery	Reduce household water demand and ease pressure on the main water supply, reducing upstream energy and environmental costs. saves high quality water for drinking, reduces the amount of polluted water released to the environment
Waste Water Technology	Reduce emission by using hybrid technologies, solves water scarcity issue by adequate production, preserve protect and reduce pressure on ground water aquifer by meeting the water demand
Rain Water Integration	Diversification of household water supply; increased resilience to ground water quality degradation; reduce the pressure on groundwater resources and other socioeconomic and environmental benefits
Ground water technologies - Domestic	groundwater recharge and infiltration technologies will help to maintain the groundwater aquifer and reduce the impact from saltwater intrusion related with Climate change and SLR Also reduce deterioration of the water lese through pollution.
Ground water technologies - Public	Reduce the impact from extraction of groundwater through piped networks

4.5 Criteria and process of technology prioritization (See section 3.5)

4.6 Results of technology prioritization for Water resources sector

Through this process shortlisted technologies for water resource sectors are assessed, prioritised and ranked are presented in the matrix below. Selected two technologies for TNA are highlighted in the following Table 12.

Table 12. Result of MCA for Water resource sector

Technology	Weighted Score	Technology Rank in the category
Flood Water Recovery	347	2
RO Desalination	263	7
Thermal Desalination	337	4
Waster Water Recovery	319	6
Waste Water Technology	258	8
Rain Water Integration	364	1
Ground water technologies - Domestic	336	5

Ground water technologies - Public	345	3

Chapter 5 TECHNOLOGY PRIORITISATION FOR AGRICULTURE AND FOOD SECURITY SECTOR

5.1 Key Climate Change Vulnerabilities in Sector

The agriculture and food security sector are prominent in the livelihoods of the rural population of Maldives and plays an important role in food and nutrition security, especially for those who are residing in the rural areas. Agriculture is important for food security in two ways; it provides food for consumption and perhaps even more important it provides the primary source of livelihood for farmers and their families. Growth in the agriculture sector is critical for the country's economy in the face of global climate change and its likely impact on the economy. Due to the small size of the islands, land scarcity, poor soil conditions and limited water resources in island aquifer, agriculture and food production is very limited in the Maldives. The economy is highly import dependent and meeting the need for staple food requirements and maintaining sufficient storage and distribution facilities is a huge logistical challenge due to the geographically dispersed nature of islands especially during severe and extreme events and unexpected market irregularities. The total cultivable land area is estimated at 30 km^2. 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 (about 90%), limited food storage and adhoc distribution also pose severe food security risk to the population. Long-term and emergency food storage facilities are virtually absent except for warehousing in Male' and nine other islands. Severe and extreme weather incidents disrupt the supply of food within the country. To ensure continued supplies of staple food, the government also maintains a reserve stock suitable for 2-3 months.

5.2 Decision context

The contribution of the agriculture sector to GDP is significantly low yet from a livelihood and employment perspective agriculture is vital to the economy in terms of its economic and social welfare value. Therefore, strengthening the agriculture and food security sector through enhancing the capacities of crop and livestock producers and improving the value of agriculture produces are important. Linking the farmers to market in order to achieve national food security and sustainable socio-economic development. and rural livelihood and mainstreaming cross cutting issue such as environment, gender and youth empowerment is vital. Therefore, decision context in this sector is mainly based on the following aspects.

1. Scale-up investments in building public food reserves and stocks and expanding regional distribution

2. Promote climate smart technologies and practices to address challenges facing the sector due to climate variabilities, seasonal changes and extreme events
3. implement climate smart and Integrated Pest Management (IPM) strategies and practices
4. increase farmer's capacity to enhance food security and to increase investments on production systems.

   Some of the recent efforts programmes and policies on Agriculture and food security includes the following:

   - National fisheries and agriculture policy 2019-2029
   - Implementation of Good Agriculture Practices (GAP) standards
   - Agriculture Master plan 2013-2017
   - Agronet initiative State-Owned cooperate style farming enterprise to grow and market agricultural products in islands

5.3 Overview of existing technologies in agriculture and food security sector

The technology identification for the agriculture and food security sector exercise for the long list of technologies drew from multiple sources and the national context, including:

1. adaptation technologies proposed in previous national documents (eg: National Fisheries and Agriculture Policy 2019-2029, SNC, NDC, INDC etc) ;
2. technologies currently in practice and supported by national policies;
3. initiatives in the pipeline/pilot /filed testing stage;
4. appropriateness of technologies in the local context; and
5. social acceptability.

Adaptation technologies for agriculture and food security sector are divided into 3 broad categories and they are;

1. Ecological resilience, basically different technologies that contribute to ecological resilience of agriculture sector. A total of 8 technologies are shortlisted and evaluated in this category
2. Education research and technology in the field agriculture. A total of 7 technologies are evaluated in this category
3. Food security related technologies. Six technologies are evaluated in this category. Agriculture and food security sector technologies from the discussions are summarized in the following Table 13.

Table 13. Agriculture and food security sector technologies and status of use in Maldives

Category	Technology	Description and status of use in Maldives
Ecological resilience	Onsite compost and fertilizer production Technologies to increase soil fertility	Most of these technologies are used in varying degree. Some technologies are already used

	Integrated pest management	AgroNat, State-Owned cooperate style farming enterprise
	Integrated nutrient management	
	GAP certification	
	Technologies to increase soil fertility	
	Improved, climate specific, high yielding crop varieties	
	Urban farming systems	
	Education, Research and Technology	Education, research and technology in the field of agriculture some already exists and others recently introduced or in pilot stage.
	Enhance and develop laboratory capacities	
Education Research & Technology	Establishment of national standards for product	
	Adaptation plans to constrain mass infections and outbreaks	
	Mobile and web applications for producers	
	Use of solar and renewable energy in farm systems	
	Promote crops that has the potential to attain self-sufficiency	Ongoing varying degree conducted in the name of AgroNat, State-Owned cooperate style farming enterprise. Food storages facilities are very limited heavily depend on few islands
	Community farming & community gardens and household therapeutic farming	
Food security and nutrition	forestry development and use of drone technology for crop monitoring and mapping	
	Agri-boats and reliable transport facilities	
	Post-harvest loss reduction technologies and storage facilities	
	Value-addition and food processing technologies	

Agritourism developments

5.4 Adaptation technology options for agriculture and food security sector and their main adaptation benefits

Table 14 gives the short-listed technology options for the agriculture and food security sector the stakeholders agreed were relevant and would reduce the sectors vulnerability to the impacts of climate change listed section 5.1

Table 14. Adaptation Technology Options for Agriculture and food security sector and their main adaptation benefits

Technology	Climate change adaptation benefit for the sector
Onsite compost and fertilizer production	Makes nutrient-rich soil onsite, add nutrients, such as carbon and nitrogen, decompose organic material, helps retain water for plant use, recycle and reduce kitchen waste, reduce landfill waste these all have climate befits
Technologies to increase soil fertility	Soil fertility can be enhanced through organic and inorganic fertilizers to the soil. Nuclear techniques provide data that enhances soil fertility and crop production while minimizing the environmental impact. Integrated soil fertility management maximizes crop production minimises the mining of soil nutrient reserves and the degradation of the physical and chemical properties of soil that can lead to land degradation, including soil erosion.
Integrated pest management	Reduces environmental risk associated with pest management by encouraging the adoption of more ecologically benign control tactics. Reduces the potential for air and ground water contamination.
Integrated nutrient management	Enables the adaptation of plant nutrition and soil fertility management in farming systems to site characteristics,
GAP certification	Good Agriculture Practices (GAP) with local standard for farmers local distributors of agricultural commodities and services
Improved, climate specific, high yielding crop varieties	Developing and applying locally specific and effective climate change adaptation strategies for crop production particularly high yielding crop varieties

	Introduction of new species and varieties are higher or stable crop have better adaptability of the crops to the environment and increase resilience of cropping systems to climate-related risks.
	Introducing a range of crop species and varieties leads to diversification of agricultural production that can generate positive effects on biodiversity, ecosystem services provision, and synergies with mitigation by improving the soil carbon storage.
Urban farming systems	production of food and food items beyond home consumption and using the produce to create an income through individual families or community groups. Innovative food-production methods that can maximize production in small areas and limited spaces
Education, Research and Technology Enhance and develop laboratory capacities Establishment of national standards for product	Education, research and technology in the field of agriculture some already exists and others recently introduced or in pilot stage.
Adaptation plans to constrain mass infections and outbreaks Mobile and web applications for producers	Gaining and sharing knowledge about changing climatic conditions and the sustained viability of adapted crop production practices are important to cope with the limiting factors affecting their crop system.
Use of solar and renewable energy in farm systems	improving capacity building, research and education, and enhancing farmers' capacities to implement them, reducing the perceived risks
Promote crops that has the potential to attain self-sufficiency	Ensure the existing agriculture system has reliable access to sufficient quantities of affordable, nutritious food to lead a healthy life. select locally gown field crops that has the potential to attain self-sufficiency (such as breadfruit, drumstick, taro, banana, watermelon, pumpkin, papaya and eggplant)
Community farming & community gardens and household therapeutic farming	Promote community gardens and household therapeutic farming, in order to positively impact the well-being, mental health and physical state of the population.

forestry development and use of drone technology for crop monitoring and mapping	Use of latest technologies to monitor health and to overcome the geographical constraints
Agri-boats and reliable transport facilities	Agri boats for marketing and distribution of agriculture produce between island
Post-harvest loss reduction technologies and storage facilities	improve the production, post-harvesting and processing of agricultural commodities in order to generate greater value-addition and profit margins.
Value-addition and food processing technologies	Promote onsite compost and biofertilizers production, in order to increase value-addition and improve sustainable waste management
Agritourism developments	Innovative and income-diversification programs that can effectively turn farming production systems into more profitable and sustainable business ventures

5.5 Criteria and process of technology prioritization (See section 3.5)

5.6 Results of technology prioritization for Water resources sector

Through this process shortlisted technologies for agriculture and food security sectors are assessed, prioritised and ranked are presented in the matrix below. Highest ranking two technologies selected for TNA is highlighted in the following Table 15.

Table 15. Result of MCA for agriculture and food security sector

Technology	Weighted Score	Technology Rank in the sector
Onsite compost and fertilizer production	338	6
Technologies to increase soil fertility	318	16
Integrated pest management	323	11
Integrated nutrient management	319	14
GAP certification	313	20
Technologies to increase soil fertility	319	14
Improved, climate specific, high yielding crop varieties	329	10
Urban farming systems	351	3
Education, Research and Technology	314	18
Enhance and develop laboratory capacities	323	11

Establishment of national standards for product	338	6
Adaptation plans to constrain mass infections and outbreaks	321	13
Mobile and web applications for producers	318	16
Use of solar and renewable energy in farm systems	314	18
Promote crops that has the potential to attain self-sufficiency	350	4
Community farming & community gardens and household therapeutic farming	352	2
forestry development and use of drone technology for crop monitoring and mapping	336	8
Agri-boats and reliable transport facilities	348	5
Post-harvest loss reduction technologies and storage facilities	309	21
Value-addition and food processing technologies	334	9
Agritourism developments	364	1

Chapter 6 TECHNOLOGY PRIORITISATION FOR FISHERIES SECTOR

6.1 Key Climate Change Vulnerabilities in Sector

Fisheries is the key primary productivity sector that contributes to approximately 20% of the domestic employment. The fisheries sector plays a critical role in food supply and economic development in the Maldives and is a major contributor to food availability and access. The Maldives fish catch is characterized by dominant proportion of tuna and tuna-like species, which correspond to approximately 95% of the total fish catch. Maldivians are among the highest consumers of fish as a protein source with per capita fish consumption at 181kg/year. Given the fact that the 99 percent of the Maldivian territory is comprised of ocean, fish especially tuna is the primary source of protein in the local diet. The sector is entirely dependent on the natural environmental resources. Amount of fish landing has been constantly declining since 2006, and since 2010 fish landings increased at an approximate annual rate of 12.5% till 2013. Studies have attributed the persistent decline in fish catch in the Maldives since 2006 to fuel price increase and higher water temperature in the ocean[10]. Climate change impact on oceans and marine life is expected to change distribution of fish stocks and their food which will have significant impact on fisheries dependent livelihood activities and food and nutrition security in the Maldives. Projected increase in frequency, intensity and magnitude of extreme events, with climate change, will have detrimental impact on fisheries sector. 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 change has led to the transformation of the biophysical conditions of the pelagic environment, resulting in decreased tuna catch in the islands.

6.2 Decision context

Promotion of sustainable and efficient use of fishery resources is the key for fisheries sector adaptation to climate change. Therefore, decision context in this sector is mainly based on the following aspects.

1. Resilience building of the sector towards managing the changing of fish stocks and its migration patterns, adapting to efficient technologies and investing in national capacity needs.
2. Diversification of the fisheries sector
3. Increase efficiency of fishing vessels, promoting technologies for reducing GHGs
4. Developing and upgrading land-based fisheries infrastructures and facilities for a low carbon foot- print
5. Increase fisheries contribution to sustainable blue growth

10 https://www.sciencedirect.com/science/article/abs/pii/S0308597X09001250?via%3Dihub https://doi.org/10.1016/j.marpol.2009.09.001 (accessed 27th April 2022)

Some of the recent efforts programmes and policies on fisheries sector includes the following:

- National fisheries and agriculture policy 2019-2029
- MASPLAN 2018 (fisheries masterplan)
- Fisheries Act of Maldives 2019. This Act provides for the sustainable management of fisheries and marine resources and their ecosystems in the maritime zones of the Maldives, provides for the control of fishing by all persons within the maritime zones of the Maldives
- Noo Raaje Blue economy Initiative
- Management plans for certain types of fisheries such as aquarium grouper etc.

6.3 Overview of existing technologies in fisheries sector

The technology identification for the fisheries sector exercise for the long list of technologies drew from multiple sources and the national context, including:

(1) adaptation technologies proposed in previous national documents (eg: National Fisheries and Agriculture Policy 2019-2029, MASPLAN, 2018 SNC, NDC, INDC etc) ;
(2) technologies currently in practice and supported by national policies;
(3) initiatives in the pipeline/pilot /filed testing stage;
(4) appropriateness of technologies in the local context; and
(5) social acceptability.

Adaptation technologies for fisheries sector, technologies identified are then regrouped into sub sector and categories. Shortlisted technologies from sector discussions are summarized in the following Table 16.

Table 16. Fisheries sector technologies and status of use in Maldives

Technology	Description and status of use in Maldives
Improving fish finding harvesting and handling,	Most of the activities are taking place different places different magnitude
Diversification of fisheries	Implemented in some islands, research ongoing, need improvement
establish aquaculture/ mariculture	Some of the activities are at pilot stage and some are at experimental stage
Improvement of boat design and equipment for reef fishery	Being experimented in some islands

experimenting new and alternative species and breeding / handling methods for live bait	Implemented in some islands, research ongoing, need improvement
Establishment of multi-species hatchery,	facilitate the small-scale operators to enter aquaculture business through better access to seed Still at conceptual stage
Establishment of milkfish seed production facilities to provide bait	Research ongoing, need improvement
Development of domestic fish feed	Not very common in early stages of development there is a project aiming to identify available resources and tests locally produced feeds to see their efficiency.
Adopt new technology (e.g. satellite, drone based and GIS) in coral reef health monitoring and reporting	Used in by some fishermen but not common
undertaking research and disseminate information on health of fisheries resources	MMRI is conducting research
Diversification of fisheries through establishing aquaculture/ mariculture	Not common Aquaculture is at its infancy stage in Maldives and there are few aquaculture activities carried out at commercial level except for one sea cucumber farm
Explore alternative types and methods of bait	Still under experimental stage
Refinement of existing aquaculture techniques)	Undertaking in existing aquaculture farms
Building training and demonstration capacity of Move to mariculture MTDF/MMRI	At present research is being conducted to expand mariculture and to reduce postharvest mortality in the live bait fishery.

6.4 Adaptation technology options for Fisheries sector and their main adaptation benefits

Table 17 gives the short-listed technology options for the fisheries sector the stakeholders agreed were relevant and would reduce the sectors vulnerability to the impacts of climate change listed section 6.1

Table 17. Adaptation technology Options for Fisheries sector and their main adaptation benefits

Technology	Climate change adaptation benefit for the sector
Improving fish finding harvesting and handling,	Reduce time and effort for fishing subsequently reduce energy and fuel consumption

	Reduce emission by increasing efficiency
Diversification of fisheries	Less pressure on single/few species, utilization of multi species, sustaining fish stock
establish aquaculture/ mariculture	Managing fish stock and sustaining the seafood production develop aquaculture/mariculture industry
Improvement of boat design and equipment for reef fishery	Design boats to design / equipment for fish handling, particularly for live grouper fishing, and ice / fish storage are identified; these improvements are subsequently implemented on a pilot basis then disseminated nationwide. Reduce emission by increasing efficiency
experimenting new and alternative species and breeding / handling methods for live bait	To reduce dependency on few species and explore potential alternative baits handling and techniques
Establishment of multi-species hatchery, Establishment of milkfish seed production facilities to provide bait	milkfish seed production facilities to provide bait reduce the dependency on few species of bait that is already declining and extremely sensitive to changes in the ocean
Development of domestic fish feed	Utilize the byproduct of fish processing, reduce waste to ensure sustainable consumption and production
Adopt new technology (e.g. satellite, drone based and GIS) in coral reef health monitoring and reporting	Fish finding, Total Allowable Catch (TAC) Management in real time, less time and effort increase efficiency and better management
undertaking research and disseminate information on health of fisheries resources	Research is needed to understand the severity of climate change impacts on tuna and related species and other fisheries resources
Diversification of fisheries through establishing aquaculture/ mariculture	Tuna fishery is affected by the seasonal monsoon and other oceanographic variations. Diversification will increase resilience to such seasonal changes
Explore alternative types and methods of bait	Pole and Line fisheries of Maldives is highly dependent on the bait fisheries which is declining therefore alternative types baits and handling methods needs to improved

Refinement of existing aquaculture techniques	The existing technology for seed production and grow-out production will be refined to better suit the Maldivian context; this is expected to improve production efficiency and possibly reduce cost of production of selected species.
Building training and demonstration capacity of Move to mariculture MTDF/MMRI	Existing facilities for mariculture such as MTDF/MMRI has to be upgraded to facilitate training and demonstration to carries out research on potential aquaculture species to be developed in the future.

6.5 Criteria and process of technology prioritization (See section 3.5)

6.6 Results of technology prioritization for fisheries sector

Through this process shortlisted technologies for fisheries sector are assessed, prioritized and ranked are presented in the matrix below, and the two technologies selected for TNA is highlighted in the Table 18.

Table 18 Result of MCA for fisheries sector

Technology	Weighted Score	Technology Rank in the sector
Improving fish finding harvesting and handling,	369	1
Diversification of fisheries	338	4
establish aquaculture/ mariculture	336	5
Improvement of boat design and equipment for reef fishery	354	2
experimenting new and alternative species and breeding / handling methods for live bait	331	6
Establishment of multi-species hatchery,	323	7
Establishment of milkfish seed production facilities to provide bait	341	3
Development of domestic fish feed	310	8
Adopt new technology (e.g. satellite, drone based and GIS) in coral reef health monitoring and reporting	255.5	14
undertaking research and disseminate information on health of fisheries resources	285.5	13

Diversification of fisheries through establishing aquaculture/ mariculture	298.5	16
explore alternative types and methods of bait	305.5	9
Refinement of existing aquaculture techniques)	299.5	15
Building training and demonstration capacity of Move to mariculture MTDF/MMRI	290	12

Chapter 7 TECHNOLOGY PRIORITISATION FOR CORAL REEF AND BIODIVERSITY SECTOR

7.1 Key Climate Change Vulnerabilities in Sector

The Maldivian atolls are extremely rich and diverse in its marine flora and fauna and it is the seventh largest reef system in the world and the largest in the Indian Ocean. Physical protection and formation of islands, livelihoods of the people and economy of the country depends on coral reefs. Coral reefs are highly sensitive to changing sea surface temperature and ocean acidification. The frequency and severity of bleaching events and erosion of reef structures will increase significantly with long-term implications for coastal protection and degradation of reef framework with projected climate change. Impact from man-made land-based pollution and developmental activities on reefs combined with the warming of the ocean surface leads to significant coral bleaching and mortality due to El-Nino phenomenon during the past two decades, as has been observed in the Maldives.

7.2 Decision context

The main adaptive measures to reduce vulnerability of coral reefs are continued monitoring of reef health, increased conservation effort and reduction of impacts of human activities. Coral bleaching has been observed in the Maldives in 1977, 1983, 1987, 1991, 1995, 1997, 1998 and 2016. The 1998 coral bleaching event was the most severe more than 90% of corals effected. International studies show that calcification rates from ocean acidification may decrease by up to 60% with a doubling of atmospheric CO_2 concentrations by end of 21st century. significant coral bleaching and mortality has been observed in the Maldives due to El-Nino phenomenon during the past two decades. Threat from human includes destruction of reef habitats, lagoons, beaches and mangroves due to land reclamation, for harbour building, channel construction, seawall construction and other infrastructure development activities. Therefore, decision context in this sector is mainly based on the following aspects.

1. Promote adaptation technologies that promotes coastal protection and reduce degradation of reef framework that provides habitats for several organisms that form part of the overall ecosystem.
2. Strengthen existing coral reef monitoring program by engaging partners and stakeholders and developing tools (such as remote sensing, projections) for predicting, measuring and monitoring effects of climate variabilities and changes on reefs, marine ecosystems and vulnerable species.
3. Promote sustainable and resilience-based management of coral reefs and marine ecosystems
4. Enhance resilience of coral reefs and ecosystems by developing policy tools and through management actions.

5. Reduce sources of pollution on coral reefs through appropriate policies, treatment facilities, management and safe disposal of solid waste taking into account the timely phasing-out of single use plastics.

Some of the recent efforts programmes and policies on Coral reef and biodiversity includes the following:

- National Biodiversity Strategy and Action Plan 2016-2025
- Coral reef restoration monitoring manual 2022
- Fisheries Act of Maldives 2019. Covers Coral reefs
- Noo Raaje Blue economy Initiative
- Management plans for certain types of reef fisheries such as aquarium grouper etc.

7.3 Overview of existing technologies in coral reef and biodiversity Sector

The technology identification for the coral reef and biodiversity sector exercise for the long list of technologies drew from multiple sources and the national context, including:

(1) adaptation technologies proposed in previous national documents (eg: SNC, NDC, INDC etc) ;
(2) technologies currently in practice and supported by national policies;
(3) initiatives in the pipeline/pilot /filed testing stage;
(4) appropriateness of technologies in the local context; and
(5) social acceptability.

Adaptation technologies for coral reef and biodiversity sector, technologies identified are then regrouped into sub sector and categories. Shortlisted technologies from sector discussions are summarized in the following Table 19.

Table 19. Coral reef and biodiversity sector technologies and status of use in Maldives

Technology	Description and status of use in Maldives
Coral reefs conservation through ecosystem approach as adaptation	Already there are over 42 Marine Protect areas (24,494 hectares) and 274 environmentally sensitive areas identified in the country.
Continued monitoring of reef health, increased conservation effort and reduction of impacts of human activities	MMRI has been monitoring sample reefs under national coral reef monitoring program. Planned to increase coral reef monitoring through a Coral Reef Monitoring Framework with a web-enabled database with remote data entry capabilities has been established.

Large scale Coral reef restoration	Small scale several coral restoration projects are implemented in island communities, resort islands and NGOs throughout the country. Largescale restoration projects are lacking

7.4 Adaptation technology options for coral reef and biodiversity sector and their main adaptation benefits

Table 20 gives the short-listed technology options for the fisheries sector the stakeholders agreed were relevant and would reduce the sectors vulnerability to the impacts of climate change listed section 7.1

Table 20 Adaptation Technology Options for coral reef and biodiversity sector and their main adaptation benefits

Technology	Climate change adaptation benefit for the sector
Coral reefs conservation through ecosystem approach as adaptation	Increase marine protected areas focusing predominantly on reducing local anthropogenic pressures on reefs. Reef management will focus on more damaged coral reefs in highly populated areas. management has to focus on whole seascape, as the complexity of reef ecosystem responses to climate change and local human stressors
Continued monitoring of reef health, increased conservation effort and reduction of impacts of human activities	Monitoring of coral reefs are an important part of developing adaptive and more integrated ecosystem management strategies under climate change. Monitoring will contribute to maintain resilience, retain diversity and reduce functional redundancy manage ecosystem connectivity

	Restoration is a coral reef management strategy. Reef restoration is an active intervention that aims to assist the recovery of reef structure, function, and key reef species in the face of rising climate and anthropogenic pressures.
Large scale Coral reef restoration	Restoration will promote reef resilience and the sustainable delivery of reef ecosystem services. Large scale coral reef restoration could help deliver on national commitments linked to Nature-Based Solutions (NBS) and (NDCs) support the UN Decade on Ecosystem restoration (2021-2030)

7.5 Criteria and process of technology prioritization (See section 3.5)

7.6 Results of technology prioritization for coral reefs and biodiversity sector

Through this process shortlisted technologies for coral reef and biodiversity sectors are assessed, prioritised and ranked are presented in the matrix below, and the highest ranking two technologies selected for TNA is highlighted in Table 21.

Table 21 Result of MCA for coral reef and biodiversity sector

Technology	Weighted Score	Technology Rank in the sector
Coral reefs conservation through ecosystem approach as adaptation	**301.5**	1
Continued monitoring of reef health, increased conservation effort and reduction of impacts of human activities	**289**	2
Large scale Coral reef restoration	**270**	3

Chapter 8 TECHNOLOGY PRIORITISATION FOR TOURISM SECTOR

8.1 Key Climate Change Vulnerabilities in Sector

Tourism is the largest contributor to GDP and the industry is capitalized on the natural environment such as clear water surrounding the islands, white sandy beaches and vibrant coral reefs. Projected increase in frequency, intensity and magnitude of extreme events, with climate change, will have cascading impact on the already vulnerable tourism sector. Protection of resort island's beach and its marine and coastal infrastructure is vital to deliver a high-quality tourist product and tourist facilities, which represent massive capital investments. Low elevation of the resort islands and near shore infrastructure makes it vulnerable to swell waves in the tropical and extra-tropical regions. Nearly 45% of tourist resorts have reported varying degrees of beach erosion. Flooding, swell waves contaminate the groundwater of the islands leaving a lasting damage on the vegetation that is used for either aesthetical or agricultural purposes on the resorts. Water bungalows, overwater structures and underwater infrastructures in the shallow lagoons and other nearshore areas are of resorts are subjected to a higher degree of risk from sea level rise and extreme events. The additional risks to tourism are indirect in many cases, with the initial impacts being imposed on the infrastructure, fisheries, water resources, agriculture and human health. Increased risk due to climate change is the increased insurance costs for Maldives.

8.2 Decision context

The major climate change impacts on the Maldives tourism sector include impacts due to increased temperatures, increased extreme events, sea level and SST rise and changes to marine biodiversity. Climate change adaptation is integrated into tourism development policy in all service sectors, including, critical infrastructure, tourist buildings/bungalows, waste, water, food etc. Therefore, decision context in this sector is mainly based on the following aspects:

1. Improve the tourism sector while ensuring environmental sustainability by investing in clean energy; solid waste management; and preservation of marine environment, climate adaptation, and disaster risk management.
2. Promote development and investment on high quality, climate proof physical infrastructure in resorts and operational infrastructures in tourist operators and contribute to conservation and protection of the bio-diversity in tourism sector.
3. Facilitate access to finance to increase the resilience and sustainable environmental management of the sector
4. Mainstream climate change risks into tourism sector policies.
5. Establish an insurance mechanism to reduce the impacts on the tourism sector.

Some of the recent efforts programmes and policies on tourism sector includes the following:

- Development of 5th Tourism master plan (ongoing)
- Climate proofing of physical infrastructures in resorts

- Investment in energy efficiency and clean energy (solar energy) in resorts
- Climate resilient developments in tourism sector

8.3 Overview of existing technologies in tourism sector

The technology identification for the tourism sector exercise for the long list of technologies drew from multiple sources and the national context, including:

(1) adaptation technologies proposed in previous national documents (eg: Fourth Tourism Master Plan, 2018 SNC, NDC, INDC etc) ;
(2) technologies currently in practice and supported by national policies;
(3) initiatives in the pipeline/pilot /filed testing stage;
(4) appropriateness of technologies in the local context; and
(5) social acceptability.

Adaptation technologies for tourism sector, technologies identified are then regrouped into sub sector and categories. Shortlisted technologies from sector discussions are summarized in the following Table 22.

Table 22 Tourism sector technologies and status of use in Maldives

Technology	Description and status of use in Maldives
Capital cost insurance mechanism	There is an existing insurance mechanism but it needs to further improved and integrated climate change component to it
Climate proofing infrastructure/Utilities	Some resorts are investing on climate proofing but many are still reluctant
Climate friendly utilities Electricity, waste, water and wastewater, food etc	Majority of resorts are investing on climate friendly utilities

8.4 Adaptation technology options for tourism sector and their main adaptation benefits

Table 23 gives the short-listed technology options for the tourism sector the stakeholders agreed were relevant and would reduce the sectors vulnerability to the impacts of climate change listed section 8.1.

Table 23 Adaptation technology options for tourism sector and their main adaptation benefits

Technology	Climate change adaptation benefit for the sector
Capital cost insurance mechanism	Climate resilience through affordable and sustainable risk transfer measures.

	Insurance solutions can help bolster early action and speed up recovery to restore and rebuild critical infrastructure so economies can rebound.
	Enhances adaptive capacity, implement precautionary principle to meet costs of adaptation Ensure that all projects are "climate proofed" at the design stage.
Climate proofing infrastructure/Utilities	Promote development and investment on high quality, climate proof physical infrastructure.
	To mainstream sector specific disaster risk management and adaptation to climate variability and extreme events, integrated into national risk management strategy and, national development planning process
Climate friendly utilities Electricity, waste, water and wastewater, food etc	Mainstream and promote clean energy and energy efficiency technologies to reduce the overall emission

8.5 Criteria and process of technology prioritization (See section 3.5)

8.6 Results of technology prioritization for tourism sector

Through this process shortlisted technologies for tourism sectors are assessed, prioritised and ranked are presented in the matrix and, the highest ranking two technologies selected for TNA is highlighted in Table 24 below:

Table 24. Result of MCA for tourism sector

Technology	Weighted Score	Technology Rank in the sector
Capital cost insurance mechanism	325	3
Climate proofing infrastructure/Utilities	343	1
Climate friendly utilities Electricity, waste, water and wastewater, food etc	342	2

Chapter 9 TECHNOLOGY PRIORITISATION FOR HEALTH SECTOR

9.1 Key Climate Change Vulnerabilities in Sector

The coronavirus (COVID-19) pandemic has demonstrated how the compounding impacts of multiple challenges will impact vulnerable island populations to create devastating health, social, economic and environmental crises that can leave a deep, long-lasting mark. Warmer temperatures and wetter monsoon seasons projected with climate change could increase the prevalence of vector borne diseases. Extreme weather such as storm surges and flooding cause significant damage to health care facilities and the delivery of health services during emergencies. Also, heavy rainfall, flooding, poor sanitation and groundwater contamination promotes the transmission of water borne diseases when there are no proper mechanisms to ensure adequate food safety and disposal measures. Due to the dispersed nature of the islands accessibility to health care facilities are difficult particularly the higher tiered facilities which are located only in atoll capitals and population centres only. It poses challenges to logistic management, particularly during extreme events in providing necessary supplies and equipment, assuring quality services and regular maintenance and administration of the health service delivery. The country will face new challenges in the years ahead from epidemiological, social and economic ones to mitigating the effects of Climate Change. Already the changes in temperature and rainfall regimes are causing higher incidence of vector-borne diseases. There is also evidence that dengue outbreaks are becoming more frequent and it appears that there is an association with ENSO events. The vulnerability to climate change-related health risks is further compounded by local characteristics such as the high 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.

9.2 Decision context

Climate change will have direct health impact from heat and extreme weather events, especially floods due to heavy rainfall and indirect health effects from changes in ecology and social systems. Vector borne diseases are the most prominent indirect impacts on the human health for the Maldives. Therefore, the decision context in this sector will promote adaptation technologies that makes efficient use of natural resources and effective delivery of health services that are responsive to epidemiological and population health needs which includes the following:

1. Integration of climate change into the national health systems to ensure sustainable and climate resilient adaptation measures.
2. Climate proofing and incorporating green and energy efficiency measures into heath infrastructure.

3. Reduce vector borne and other noncommunicable diseases including those driven by heat stress and poor air quality.
4. Promote research to understand the nexus between climate change and health such as its impacts on vector borne diseases, mental health, air quality etc.

Some of the recent efforts programmes and policies in health sector includes the following:

- Health Master plant 2016-2025
- Maldives healthcare qualities and standards 2022
- National mental health policy 2015-2025

9.3 Overview of existing technologies in health sector

The technology identification for the health sector exercise for the long list of technologies drew from multiple sources and the national context, including:

(1) adaptation technologies proposed in previous national documents (eg: Health Master Plan, 2016-2025 SNC, NDC, INDC etc) ;
(2) technologies currently in practice and supported by national policies;
(3) initiatives in the pipeline/pilot /filed testing stage;
(4) appropriateness of technologies in the local context; and
(5) social acceptability.

Adaptation technologies for health sector, technologies identified are then regrouped into sub sector and categories. Shortlisted technologies from sector discussions are summarized in the following Table 25.

Table 25 Health sector technologies and status of use in Maldives

Technology	Description and status of use in Maldives
Green Climate Smart Healthcare facilities	Green technologies are widely used in hospital but needs to expend more
Integrated disease surveillance system	The system is already in place but needs to improve to cater for emergencies and pandemic situations
Introduction of technological solutions to control vector borne diseases	Vector-borne diseases such as Malaria and Filaria has been eradicated in Maldives but Dengue, Chikungunya and Scrub typhus are immediate concern due to changing climate.
Health Sector Emergency Response to extreme events	Health sector response to emergencies such as flood, Udha and pandemics needs to be improved

9.4 Adaptation technology options for health sector and their main adaptation benefits

Table 26 gives the short-listed technology options for the health sector the stakeholders agreed were relevant and would reduce the sectors vulnerability to the impacts of climate change listed section 9.1

Table 26. Adaptation technology options for health sector and their main adaptation benefits

Technology	Climate change adaptation benefit for the sector
Green Climate Smart Healthcare facilities	Make hospitals more environmentally responsible, by adopting sustainable practices, such as composting food waste, use renewable energy water and energy saving practices, nutrient-rich soil used in landscaping around the hospital or adding dehydrators to disposal systems to reduce the volume of food waste sent to landfills etc., proper management of medical waste etc.
Integrated disease surveillance system	Implement integrated, modifiable diseases and disease surveillance system that links public, private and voluntary providers.
Introduction of technological solutions to control vector borne diseases	measures and practices for prevention and control of spread of communicable diseases and vector control.
	Re-define healthcare services and service levels on needs based priority
	Develops community capacity for emergency preparedness, first response including in public health epidemics and pandemics
Health Sector Emergency Response to extreme events	emergency medical service linked to other emergency services such as fire and rescue, coast guard and disaster management services
	establishment of integrated national emergency services

9.5 Criteria and process of technology prioritization (See section 3.5)

9.6 Results of technology prioritization for health sector

Through this process shortlisted technologies for health sector is assessed, prioritised and ranked are presented in the matrix below, and the two technologies selected for TNA is highlighted in Table 27.

Table 27. Result of MCA for health sector

Technology	Weighted Score	Technology Rank in the sector
Green Climate Smart Healthcare facilities	369	1
Integrated disease surveillance system	326	3
Introduction of technological solutions to control vector borne diseases	324	4
Health Sector Emergency Response to extreme events	328	2

Chapter 10 TECHNOLOGY PRIORITISATION FOR CRITICAL INFRASTRUCTURE SECTOR

10.1 Key Climate Change Vulnerabilities in Sector

Almost all the critical infrastructure of the country is situated in close proximity to the coastline, hence, they are exposed to coastal hazards such as sea swells, storm surges and associated coastal flooding. Protection of critical infra structure from the potential adverse impacts of climate change through climate proofing of airports, ports, hospitals, transport and communication infrastructures, powerhouses and other utilities are important adaptation measures. Better spatial planning and increased connectivity between the islands and integration of climate change into development planning and other activities such as ecosystem management etc., will contribute to increase the resiliency of critical infrastructures.

10.2 Decision context

The decision context in this sector will promote climate adaptation technologies mainstreamed into the infrastructure development to make it more resilient particularly in time of disasters. As part of increasing infrastructure resiliency, the (NDC 2020) recommended to undertake the following actions:

1. climate proofing of critical infrastructure such as airports, ports, powerhouses and other utilities
2. Improved spatial planning and increased connectivity between the islands
3. Establishment of a National Planning Act and Physical Planning Act. And enhance National Building Code to incorporate climate resilience including coastal infrastructure
4. Conserve and restore ecosystem based natural buffers and or barriers for flood mitigation

Some of the recent efforts programmes and policies in critical infrastructure sector includes the following:

- Protection of critical infrastructures such as harbors airports hospitals utilities etc.,
- Establish sea transport network between interisland and land transport in larger land masses such Addu Laamu Atoll and great Male region increase connectivity
- Maldives land act 2021 and
- Decentralization act 2010

10.3 Overview of existing technologies in critical infrastructure Sector

The technology identification for the critical infrastructure sector exercise for the long list of technologies drew from multiple sources and the national context, including:

(1) adaptation technologies proposed in previous national documents (eg: SNC, NDC, INDC etc) ;

(2) technologies currently in practice and supported by national policies;
(3) initiatives in the pipeline/pilot /filed testing stage;
(4) appropriateness of technologies in the local context; and
(5) social acceptability.

Adaptation technologies for critical infrastructure sector, technologies identified are then regrouped into sub sector and categories. Shortlisted technologies from sector discussions are summarized in the following Table 28.

Table 28 critical infrastructure sector technologies and status of use in Maldives

Technology	Description and status of use in Maldives
Climate proofing of all critical infrastructure, utility services, health care facilities,	New infrastructure development projects consider climate enhanced adaption measures
National Building Code (NBC) establish national standards	Existing NBC is performance-based code rather than established national standards
National Development Act to facilitate integration of climate change into development planning	The Act is under development stage

10.4 Adaptation technology options for critical infrastructure sector and their main adaptation benefits

Table 29 gives the short-listed technology options for the critical infrastructure sector the stakeholders agreed were relevant and would reduce the sectors vulnerability to the impacts of climate change listed section 10.1

Table 29 Adaptation technology options for critical infrastructure sector and their main adaptation benefits

Technology	Climate change adaptation benefit for the sector
	To ensure that actions to reduce climate related risks are an integral part of SDG.
Climate proofing of all critical infrastructure, utility services, health care facilities,	To mainstream adaptation guidelines for the country.
	Reducing both present and future risks related to climate variability and extremes.

	Locating critical infra structure in areas that are less exposed to climate hazards Better building standards are good for the climate, health, and economically more viable.
National Building Code (NBC) establish national standards	Building codes help potential energy savings less emission and cost reductions.
National Development Act to facilitate integration of climate change into development planning	Impact building efficiency, public health, and achieving climate goals. Helps to integrate national climate change commitments into development plans. Alignment between NDC, SDG and national planning

10.5 Criteria and process of technology prioritization

See the selection criteria in section 3.5

10.6 Results of technology prioritization for critical infrastructure sector

Through this process shortlisted technologies for critical infrastructure sector is assessed, prioritised and ranked are presented in the matrix below and the highest ranking two technologies selected for TNA is highlighted Table 30 below:

Table 30. Result of MCA for critical infrastructure sector

Technology	Weighted score	Technology Rank in the sector
Climate proofing of all critical infrastructure, utility services, health care facilities,	350	1
National Building Code establish national standards	342	3
National Development Act to facilitate integration of climate change into development planning	344	2

Chapter 11 SUMMARY AND CONCLUSIONS

The TNA was a country driven process, gender-inclusive process involving relevant stakeholders. It covers many technologies diverse information, opinions perspectives that were gathered from different people and groups involved in the use of technology sectors identified based on the climate change vulnerabilities of the country addressed in the first and second National Communications and the national priorities articulated in the NAPA, Intended Nationally Determined Contribution (INDC) of 2015 and the Update of Nationally Determined Contribution of Maldives of 2020.

The longlist of technologies identified for each sector drew from multiple sources and the national context which was later shortlisted according to the maturity, applicability, local availability, and stakeholder acceptability of each technology. The short-listed technologies underwent further analysis prioritization and ranking process using the MCA tools. Highest ranking two technologies from each sector is selected as the priority technology for the TNA. From the MCA process , a total of 16 different technologies are priotised and selected.

From the analysis following technologies were identified as the most preferred technology options for the respective sectors;

Fisheries sector

- Improving fish finding harvesting and handling
- Improvement of boat design and equipment for reef fishery

Coastal adaptation and disaster management sector

- Sustainable infiltration and drainage management
- Integrated Land Use Planning (ICZM) Drone mapping, satellite imagery and GIS

Health sector

- Green Climate Smart Healthcare facilities
- Health Sector Emergency Response to extreme events

Water Resources sector

- Rain water integration
- Flood water recovery

Critical infrastructure sector

- National Development Act and integration of Climate change into development planning
- Climate proofing of all critical infrastructure

Tourism sector

- Climate proofing of resort infrastructure
- Climate friendly utilities electricity, waste, water and wastewater, food etc.,

Agriculture and Food security

- Community farming & community gardens and household therapeutic farming
- Agritourism developments

Coral reef and biodiversity

- Coral reefs conservation through ecosystem approach as adaptation

- Continued monitoring of reef health, increased conservation effort and reduction of impacts of human activities

The prioritised technologies through this TNA exercise exists in the country to a variable degree, there is a need to promote and upscale these matured technologies to develop a climate-resilient economy. Barrier analysis will be carried out and the technology action plans will be developed for these prioritised technologies to reflect the need for such technology actions in the respective sectors and subsectors.

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Annex I: TECHNOLOGY FACTSHEETS FOR SELECTED ADAPTATION TECHNOLOGIES

1. Fisheries Sector

Technology Fact sheet -1

Technology: Improving fish finding harvesting and handling	
Introduction/background	In the Maldivians pole-and-line fishery is the main fishing method using live bait, which has existed for nearly 1000 years and is the most important pelagic fishery in Maldives. This fishery consists of two separate fisheries: live bait fishery and tuna fishery using the live bait caught. Once enough bait is harvested the same fishing vessel goes out to the open sea, outside the atolls and search for tuna school or directly go to Fish Aggregating Device (FADs). The main target species is skipjack tuna but small amount of juvenile yellowfin and juvenile bigeye tuna are also caught in this fishery. The pole-and-line skipjack tuna fishery of Maldives has been certified by the Marine Stewardship Council (MSC) as a sustainably managed fishery. The bait fish resources used for skipjack tuna pole-and-line fishing is thought to be declining. An appropriate bait fish resources management is necessary for the sustainable development of this fishery. In addition, skipjack tuna fished by this fishery is certified by MSC and the implementation of bait fish resources management is a prerequisite. Improving fish finding harvesting and handling is needed to increase fish yield and earnings.
Technology characteristics	In Maldives, fishing vessels have been mechanized and grew in size since the 1970's, and the fourth-generation fishing vessel has become mainstream at present. As their structure derives from the traditional hull form since sailboat times, improving their efficiency is the needs in terms of structure of live bait tank, refrigerating function of fish tank and fuel efficiency. Also appropriate technologies for further constructions of fishery infrastructure are needed: fish finding satellite data imagery, GPS etc., ice plants to maintain fish freshness and to improve value-addition, "Marinas" to provide fishers with rest/resupply/network facilities, as per the present Government's policy
Capital, Operating cost	Capital cost for improving fish harvesting technologies would be fairly high, but it has been used by the fishermen and maintenance and operational cost could be medium to high depending on the technology. Improvement in harvesting and handling would be fairly low cost which might need to have changes in the procedures and procurement of simple tools
Safety, Reliability, Maturity	Improving fish finding harvesting and handling technologies are fairly mature and reliable but some may not be applicable to all situations. Therefore, tailor made measures may be required for some facilities
Country specific applicability	Improving fish finding harvesting and handling must be adopted in the Maldives and the overall policy on this have been formulated and tried in some vessels in the Maldives.
Institutional Capacity	Existing capacity can be used in some of the measures technical and human capacity development in these fields are required.
Need for capacity building	Capacity development is needed for fish folks as well as those who are engaged in various activities of the fish handling and processing.

Scale of application	At present it is practiced to some degree in some vessels but there are plan for expansion to develop these in fisheries sector
Time horizon- Short /Medium/long term	Improving fish finding harvesting and handling is a continuing process short to medium term measures will be undertaken gradually by the fishermen
Status of technology in country	Improving fish finding harvesting and handling; measures identified above are already implemented in some fishing vessels
Acceptability to locals	Improving fish finding harvesting and handling will be acceptable for locals
Gender aspects	Women empowerment is very much promoted in this initiative. Empowerment of local community can be achieved through this initiative particularly handling and processing of fish for value addition
adaptation benefits	
Sustainability	• Fishing gear and methods for catching live bait are improved • The structure and equipment of in-board live bait tank of the fishing vessels is modified • Skills of fishers about handling of bait fish are improved. • Survival status of live bait in experimental boat is monitored.
Sustainability and Resilience	• to strengthen fisheries sector preparedness for climate related impacts on fish catch and bait availability • Sustainable bait catch and holding for improving their survival rate; • Better vessels meaning more time can be spent in fishing • Sustainable management of fish stock
Resilience	Better boats more time in fishing longer survival rates of bait fishing, appropriate handling will increase the freshness of the fish
Potential Development Benefits	
Economic, Social, Environmental	Creation of Jobs and economic opportunities in remote islands and fisheries sector Coordination of logistics and support to streamline distribution and improvement in fisheries sector Fisheries sector capacity development Fishing vessels equipped with better capacity to remain more time in the sea and catch more fish Promote fishing vessels that is adaptable for the local climatic conditions Promote climate resilient design of fishing vessels Improvements in socio economic earnings of the people engaged in fisheries sector

Technology Fact Sheet -2

Technology: Improvement of boat design and equipment for reef fishery	
Introduction/background	Reef fishery or coastal fishery is carried out throughout Maldives for marketing to resorts and export as well as self-consumption. Major target species include several species of snappers, jacks, breams and groupers. Lobster and sea cucumber are also important species exploited in the country, although their catches tend to

	significantly decline recently. The Fisheries Sector is still significant in terms of foreign currency and food self-sufficiency. A lot of workforce engaged in the fishery in the isolated islands except for capital Malé, The Government of Maldives pays special attention to the promotion of fisheries in order to create jobs, in particular in isolated islands. Although reef fishing has been carried out in the country for centuries, prior to the middle of 1970s it remained at a subsistence level. There was no demand for reef fish as local communities tended to prefer tuna to reef fish species. However, with the introduction of tourism demand was born for reef fish. Since then, reef fisheries have developed rapidly in Maldives. New opportunities in international market, growth in recreational fishing by locals and tourists and increasing demand for reef fish for local consumption have contributed to the expansion of this fishery. Main segments of the market which reef fishers cater are; • Fishers selling to resorts and to local markets • Fishers selling to overseas market (valued species such as live groupers for export • Recreational fishers from Malé and other islands (fishing for leisure, the fish being often used for home consumption) • Resort-based recreational reef fishing • Reef fishery is shows no decline in stock over the years, it brings good income and have potential for Increasing demand (national market and resorts, whose number is increasing) Technology is needed to maintain a good catch, sustained stock and to expand the market locally and internationally. Installation of FADs closer to the islands for the people engaged in reef fishery. Most of the reef fish supplied to resorts are caught by small fishing boats without adequate refrigeration. The improvement of techniques for storing fish on board and hygiene control is needed. Also there is an urgent need to increase the supply of ice in the whole country in order to maintain freshness of reef fish.
Technology characteristics	In Maldives, fishing vessels have been mechanized and grew in size since the 1970's, and the fourth-generation fishing vessel has become mainstream at present. As their structure derives from the traditional hull form since sailboat times, improving their efficiency is the needs in terms of structure of live bait tank, refrigerating function of fish tank and fuel efficiency. Also appropriate technologies for further constructions of fishery infrastructure are needed such as large boats, ice production capacity etc
Capital, Operating cost	Capital cost for improving boat design and equipment for reef fishery technologies would be fairly high, but it has been used by the fishermen and maintenance and operational cost could be medium to high depending on the technology. Improvement in freshness of fish and hygene would be fairly low cost which might need to have changes in the procedures and procurement of simple tools
Safety, Reliability, Maturity	Boat design and equipment for reef fishery technologies are fairly mature and reliable but some may not be applicable to all situations. Therefore, tailor made measures may be required for some facilities

Country specific applicability	boat design and equipment for reef fishery must be adopted in the Maldives and the overall policy on this have been formulated and tried in some vessels in the Maldives.
Institutional Capacity	Existing capacity can be used in some of the measures technical and human capacity development in these fields are required.
Need for capacity building	Capacity development is needed for fish folks as well as the general public who are engaged in various activities of reef fishing.
Scale of application	At present it is practiced to some degree in some vessels but there are plan for expansion to develop these in reef fisheries sector
Time horizon- Short /Medium/long term	Boat design and equipment for reef fishery is a continuing process short to medium term measures will be undertaken gradually by the fishermen
Status of technology in country	boat design and equipment for reef fishery; measures identified above are already implemented in some fishing vessels
Acceptability to locals	boat design and equipment for reef fishery will be acceptable for locals
Gender aspects	Women empowerment is very much promoted in this initiative. Empowerment of local community can be achieved through this initiative particularly boat design and equipment for reef fishery
adaptation benefits	
Sustainability	• Fishing gear and methods for catching reef fish are improved • The structure and equipment of reef fishing vessels is modified • Skills of fishers about handling of reef fish are improved. • Survival status of live reef fish in boats are properly monitored.
Sustainability and Resilience	• to strengthen fisheries sector preparedness for climate related impacts on reef fish catch and availability • Sustainable reef fish catch and holding for improving their survival rate for the export targeted fish; • Better vessels meaning more time can be spent in fishing • Sustainable management of fish stock
Resilience	Better boats more time in fishing longer survival rates of reef fish, appropriate handling will increase the freshness of the fish
Potential Development Benefits	
Economic, Social,	Creation of Jobs and economic opportunities in remote islands and fisheries sector Coordination of logistics and support to streamline distribution and improvement in fisheries sector Fisheries sector capacity development Reef fishing vessels equipped with better capacity to remain more time in the sea and catch more fish Promote reef fishing vessels that is adaptable for the local climatic conditions

Environmental	Promote climate resilient design of reef fishing vessels Improvements in socio economic earnings of the people engaged in fisheries sector

2- Coastal adaptation & Disaster management

Technology Fact Sheet -3

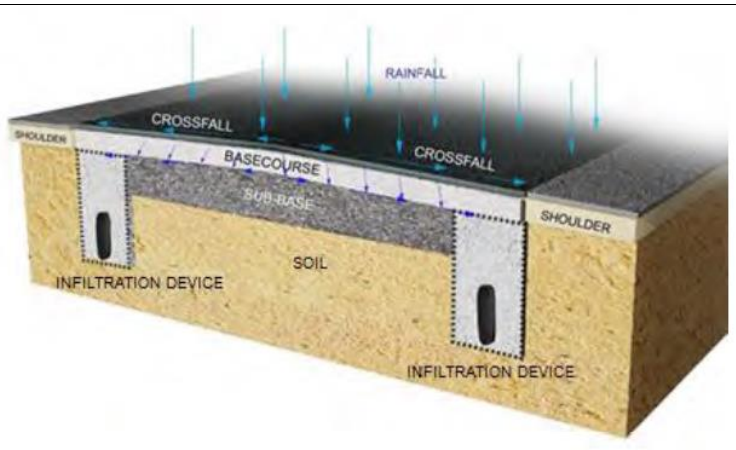
Technology : Integrated Land Use Planning (ICZM) Drone mapping, satellite imagery and GIS	
Introduction/background	One of the main challenges to implement impactful adaptation in Maldives is lack of contextualized and quantifiable historical and monitoring data and information on island to atoll level disaster risks, coastal erosion, flood prone areas, land uses biodiversity etc, as data acquisition is challenging for various parameters such as coastal, terrain, infrastructure, geology, weather history and hydro meteorological events etc to use for the decision-making purpose. The institutional framework to address climate change is also fragmented and requires capacity development at the local level. The existing capacities and data in relevant government authorities such as Maldives Land Survey Authority (MLSA), EPA, Ministry of Planning Infrastructure and Housing, and other private institutions needs to be integrated in a central database to make it available for decision making on climate adaptation
Technology characteristics	Mapping island dynamics and historical changes of shoreline extreme hydro meteorological events is a vital component for appropriate land use planning and to address climate change related vulnerabilities of islands. It creates easily-read, rapidly-accessible visual maps which facilitate the identification of areas at risk of erosion flooding etc., and also helps prioritise mitigation and response efforts. Such maps contribute to increase awareness of the likelihood of climate risks among the public, local authorities and other organizations and serve as an indispensable resource for integrated planning. Integrated Land Use Planning (ICZM) Drone mapping, satellite imagery and GIS will employ combination of existing latest technologies such as Drones, DGPS high resolution satellite imageries as well as conventional methods for data collection surveying and mapping. Establish, database, modeling and GIS platform for data analysis and integrated land use planning for decision support system and decision making to ensure that climate change is integrated into development planning decisions.
Capital, Operating cost	1. Capital cost will include hardware, software and human resource training 2. Drone Mapping system equipment (including maintenance and replacement costs) initial investment 5000/system or existing private local capacities can be improved/used. Drone mapping cost is estimated to be 2000-5000 USD/ island 3. Land surveying DGPS survey including topography and bathymetry of the reef 1500-7000 USD/island 4. Establishing Database/database management and GIS capacities in relevant Government Authorities (Computer hardware and software) 5. Acquiring satellite image data sets of relevant/appropriate resolutions

	6. Training of local experts on surveying integrated land-use planning, climate change risk assessment island dynamics and adaptation 7. Seek coastal and island dynamic modeling expertise on numerical modeling from academic institutions or commercial/research institutions and organisations 8. Monitoring of coral reef health, increased conservation effort and reduction of impacts of human activities
Safety, Reliability, Maturity	Very safe, reliable and mature technology recommended by the experts
Country specific applicability	Widely used in the private sector and some Government offices. High resolution mapping is required because the islands are small and the beach widths, length and area are small and the magnitude of change is also small. Therefore, centimeter level accuracy is required to determine the changes
Institutional Capacity	Maldives land Survey Authority already have system in places and GIS platforms are also used in the relevant authorities eg EPA, MPIH and MECCT and several NGOs as well as private companies have appropriate coastal mapping capacities. At present there is no one person authority or entity that has all these capacities and skills. Pooling them together and connecting and integrating them to a database is important for integrated land use planning for various development purposes.
Need for capacity building	Training and capacity development is needed estimated to be about 3-4 needs to be trained from each office involved in this process. Some of the trainings can be conducted by local companies
Scale of application	Commercially applied by private companies for tourism industry
Time horizon- Short /Medium/long term	Short to medium term 10-20 years survey data needs to be collected minimum twice a year
Status of technology in country	Applied to some extent not very widely used
Acceptability to locals	Acceptable
Gender aspects	There is a gender balance in using the technology also reasonable number of women are engaged in coastal development planning and survey sector. Use of technology will contribute to provide safety for vulnerable groups in the community
adaptation benefits	
Climate change vulnerability reduction potential	Understanding of coastal risk complements and strengthens other adaptation options, such as coastal erosion, island dynamics flood mitigation measures, emergency planning, provision and evacuation planning. As such, this approach could be applied almost universally, irrespective of the other adaptation technologies that are used. The technology is appropriate for present and future climatic conditions. Useful for monitoring of reef health, increased conservation effort and reduction of impacts of human activities

Potential Development Benefits	
Economic, Social Environmental	Will require investment in hardware software and resources, training and staff to coordinate and manage the initial establishment process and maintenance The technology has the benefit of providing maps and information that the public can use to manage and monitor coral reefs, coastal erosion and environmental issues on island and reef for climate risk preparedness, reduction and planning scenarios over time.

Technology Fact Sheet -4

Technology: Sustainable infiltration and drainage management in islands	
Introduction/background	Large number of inhabited islands in the Maldives are exposed to flooding from extreme precipitation events and Udha (storm surges, Tidal flooding). In general, nation-wide, over the past decade there has been a upward trend in the frequency and intensity of island flood incident associated with precipitation and Udha. Due to lack of proper flood and storm water management systems in most of the inhabited islands the impact of flood hazards risks with the climate change is predicted to be more severe and devastating in the Maldives. Therefore, artificial drainage facilities need to be constructed to discharge or infiltrate runoff collected on impervious land surfaces. Ministry of Environment (MoE, 2021) has recommended to adopt and promote sustainable infiltration drainage techniques in road drainage schemes in islands to maximise groundwater recharge
Technology characteristics	The idea of sustainable drainage is to intercept the hydrologic cycle, catch most of the rain before it reaches a piped drainage system and infiltrate it into the subsoil layer. Infiltration drainage systems (natural or artificial) are used in combination with underground piped system and conventional stormwater drainage system to prevent flooding and inundation. This method is suitable as on-site drainage solution for small-scale developments, thereby eliminating the need to build a piped stormwater drainage system to cater for the additional runoff. Instead of removing excess water from road surfaces and discharging to sea, drainage by infiltration techniques supports the replenishment of groundwater resources. The most important benefit of sustainable drainage methods is its potential for groundwater recharge when applied to urban road drainage schemes.



Schematic of a cross-section through a road which shows the concept of road drainage using infiltration devices constructed on either side of the road. (source: MoE 2021)

Implementation of infiltration drainage facilities without using a piped drainage system in Hulhumale (Source: MoE 2021)

Based on the water storage location infiltration drainage components can be categorized into two classes; ground surface and sub-surface types.

Ground Surface Components are; a) Filter Strips; b) Pervious Pavements; c) Swales; d) Infiltration Basins; and e) Retention Basins

Sub-surface Components are ; a) Infiltration Trenches; b) Filter Drains c) Bio-retention systems; d) Attenuation Storage Tanks; and e) Trees

Capital, Operating cost	Infra structure development cost will vary deepening on the island size and population 23,024,307 MVR in S. Feydho, 5,093,555MVR in N Holhuhoo 13,110,755.00 MVR in Gadhdhoo Maintenance cost is relatively low
Safety, Reliability, Maturity	Safe and reliable adopted by the MECCT
Country specific applicability	Suitable for small islands and small-scale developments
Institutional Capacity	Government and private sector has the capacity
Need for capacity building	Need capacity to maintain the system in islands
Scale of application	Widely applied in the Maldives and recommended by the MECCT
Time horizon- Short /Medium/long term	Medium to long term 30-100 years
Status of technology in country	Technology is widely applied in the country and most of the ongoing drainage development projects are adopting the technology
Acceptability to locals	Accepted by the locals
Gender aspects	
adaptation benefits	
Climate change vulnerability reduction potential	
Potential Development Benefits	
Economic, Social, Environmental	• Filtrates water, which in turn decreases polluted water volume entering the drainage and sea • Reduced loads on conventional storm water management systems may also help avoid extra expansion costs. • Improve quality of life for local communities. • Less costly than centralised treatment systems. Provides multiple benefits as a simple and low-cost solutions. • Affordable to construct and maintain. Can be implemented, managed and maintained by communities • To make the technology to spread across the country will require comprehensive awareness raising, communication, training and marketing plans as well as financial support to introduce in remote islands • Limit flow of heavy metals and other pollutants in contaminated water into the sea reduce the sedimentation related impact on corals an seawater • Ecologically sustainable and beneficial approach. Results in a higher biodiversity help to grow trees which provides a diversity of flora that serves as a habitat for fauna. • Can be constructed using locally available materials • Provides water absorption and infiltration that improves recharge and helps avoid polluted water from entering groundwater. • Promotes evaporation and does not absorb as much heat as paved surfaces reducing the urban heat island effect

3- Health sector

Technology Fact Sheet-5

Technology: Green Climate Smart Healthcare facilities	
Introduction/background	Green Climate-Smart Hospitals is intended to make healthcare facilities mitigate their contribution to climate change, and provide environmentally sustainable healthcare

	services on an ongoing basis by being resilient to the impacts of and in the face of climate change and related emergencies. Green Climate-Smart Hospitals focus on establishing nationwide climate-smart and environmentally friendly health care system. The aim of Green Climate-Smart Hospitals infrastructures and the whole health care system is to make it more resilient to withstand extreme weather conditions coupled with climate change that could quickly overwhelm island infrastructure and significantly impact health care service delivery in emergencies. This will include the following: 1. Establish Climate Resilient Health Care Facilities that are structurally and functionally able to withstand the impacts of all types of natural hazards and mitigate the impacts of climate change enabling them to operate without interruption to safely shelter patients in place; provide key ambulatory and community health services during and following extreme weather, or other natural disasters. 2. Make Health Care Facilities Low-Carbon to reduce their carbon footprint through energy efficient building design, mechanical and electrical systems, building operations, clean renewable energy generation and implementation of low-carbon procurement, transportation, food, water and waste management activities. 3. Green and Healthy Hospitals will protect the lives and health of patients, health workers and their communities by reducing their environmental footprint in each of the Global Green and Health Hospitals (GGHH).
Technology characteristics	Adoption of the technology will ensure that the health care facilities in the country will be able to remain operational during and after storms, floods and other disaster situations. The health care facilities will be modified to have the ground floor of the facility and critical equipment, mechanical, plumbing and electrical services above anticipated flood levels; or protecting the facility from flooding by other means. The facilities will have appropriate backup systems, and supplies to provide electricity, water and other essential services. On-site rainwater harvesting and safe storage also contribute to resilience if community water is disrupted. Measuring and tracking energy use before and after the implementation of conservation and efficiency measures, Energy efficiency measure in Health care facilities such as passive cooling, cooling technologies, lighting, equipment and controls. For example, passive cooling strategies include: shading entrances and windows, light colored roofs, walls with high thermal mass, insulation in walls and roofs and maximizing the use of operable windows to enable breezes to provide natural ventilation
Capital, Operating cost	The overall operational cost after the implementation of green smart measures will decrease, but the overall capital cost might increase
Safety, Reliability, Maturity	Green Climate Smart Healthcare facilities is not a new concept and some components are already implemented in hospitals. The technologies are fairly mature and reliable but some may not be applicable to all situations. Therefore, tailor made measures may be required for some facilities

Country specific applicability	Green Climate smart healthcare facilities are very applicable and it must be adopted in the Maldives and the overall policy on this have been formulated and started implementation in some health care facilities in the Maldives.
Institutional Capacity	Existing capacity can adopt and implement some of the measures to make healthcare facilities green and climate smart, but for adoption of some technologies technical and human capacity is required.
Need for capacity building	Capacity development is needed for local communities as well as those who are engaged in various activities of the Green Climate Smart Healthcare facilities.
Scale of application	At present it is practiced to some degree in all regional hopitals and large healthcare facilities in Male region but there are plan for expansion to develop Green Climate Smart Healthcare facilities in all the hospitals
Time horizon- Short /Medium/long term	Green Climate Smart Healthcare facilities long term development plan and policy has been formulated and short to medium term measures will be undertaken gradually in all hospitals
Status of technology in country	Green Climate Smart Healthcare facilities; measures identified above are already implemented in some hospitals and clinics
Acceptability to locals	Green Climate Smart Healthcare facilities will be acceptable for locals
Gender aspects	Women empowerment is very much promoted in this initiative. Empowerment of local community can be achieved through this initiative
adaptation benefits	
Sustainability	Lifestyle disease prevention Care closer to home Low VOC materials Local food suppliers Waste recycling
Sustainability and Resilience	Health system strengthening Universal health coverage Energy, water efficiency Daylighting Natural ventilation Rainwater capture Solar shading
Resilience	Risk and disaster preparedness and planning Climate related disease monitoring Flood barriers Elevation Backup generators
Potential Development Benefits	
Economic, Social,	Create economic resiliency through better health carefacilities Creation of Jobs and economic opportunities in remote islands and healthcare professional Coordination of logistics and support to streamline distribution and delivery of healthcare services Healthcare professionals' capacity development

Environmental	Promote health care facilities that is adaptable for the local climatic conditions Promote climate resilient design and energy water etc saving measures in health sector Reducing waste, segregating, disabling sharps, implementing safe and low carbon infectious waste treatment technologies rather than combustion should be a high priority for sustainability objectives. implementing sustainable operations, investing in healthier food and transport systems, and buying green; the medical sector can promote environmental health.

Technology factsheet 6

Technology : Health Sector Emergency Response to extreme events	
Introduction/background	The health care delivery system of Maldives is organized into a tier system with island level primary health centers, a higher level of health facilities with specialty care hospitals at atoll level and tertiary care facility at the urban level. Each atoll has a hospital catering to the population of that atoll. Country 's referral health facilities such as Indira Gandhi Memorial Hospital (IGMH), Hulhumale hospital and Villimale Hospital, Senehiya are Government hospitals located in Greater Male region. Private Hospitals such as ADK Treetop AMDC and many other healthcare facilities are only located in Male region. Health Sector Emergency Response facilities and capacities required for the public health system in emergency preparedness and response to extreme events needs to be established in remote islands and Atoll levels. To prepare for and respond to an emergency of a nationwide public health emergency that may cause numerous fatalities, severe illness and/or injuries, disruption of normal life systems and, possibly, property loss will have a powerful impact on country 's economic, physical, and social infrastructures. Depending on the severity and magnitude of large-scale calamities will require rapid response surveillance and communications systems, a trained and available public and private health and medical workforce, and volunteers to help perform essential tasks. Health Emergency Operations Plan (HEOP) for Maldives which is intended to be used by authorities and agencies responsible for managing emergencies, incidents, or events where the health of populations is at risk. The plan is implemented upon the occurrence of emergency and disaster, to save lives, and protect property and infrastructure The aim of HEOP is to strengthen health sector emergency preparedness in order to ensure a timely, efficient and effective response to events including: local and national outbreaks of infectious diseases that have national significance; epidemics and pandemics; and other types of emergencies caused by natural, technological and societal hazards that can have a substantial impact on people's health and on society. This will include the following: • Assessing and identifying public health and medical needs • Organizing, mobilizing, coordinating, and directing health and medical services during emergencies

	• Coordinating the distribution of health information during a public health emergencies and disaster events with health consequences • Coordinating medical and environmental surveillance and monitoring activities, including responder safety • Coordinating the surveillance for, investigating the causes for, and treatment of diseases • Implementing measures to prevent the spread of disease or environmental contamination
Technology characteristics	For the proper implementation of HEOP soft, hard and org-ware technologies for the functioning of a Multi-Agency Coordination System (MACS) is required, which is a combination of facilities, equipment, personnel, procedures, and communications integrated into a common system with responsibility for coordinating agency resources and supporting agency emergency operations.
Capital, Operating cost	Initial establishment and implementation of HEOP would require external financial assistant as capital cost for setting up the system. Day-to-day operation and functioning of the system can be funding through the government budget. Event based assistance would require external support depending on the severity and magnitude of the hazard event responding.
Safety, Reliability, Maturity	HEOP is not a new concept and some components are already implemented in hospitals. The technologies are fairly mature and reliable but some may not be applicable to all situations. Therefore, tailor made measures may be required for some facilities
Country specific applicability	Health Sector Emergency Response to extreme events must be adopted in the Maldives and the overall policy on this have been formulated and started implementation in some health care facilities in the Maldives.
Institutional Capacity	Existing capacity can adopt and implement some of the measures to make healthcare facilities response to extreme events, but for adoption of some technologies technical and human capacity is required.
Need for capacity building	Capacity development is needed for local communities as well as those who are engaged in various activities of the Health Sector Emergency Response to extreme events.
Scale of application	At present it is practiced to some degree in all regional hospitals and large healthcare facilities in Male region but there are plan for expansion to develop Health Sector Emergency Response to extreme events in all the hospitals
Time horizon- Short /Medium/long term	Health Sector Emergency Response to extreme events long term development plan and policy has been formulated and short to medium term measures will be undertaken gradually in all hospitals
Status of technology in country	Health Sector Emergency Response to extreme events; measures identified above are already implemented in some hospitals and clinics
Acceptability to locals	Health Sector Emergency Response to extreme events will be acceptable for locals

Gender aspects	Women empowerment is very much promoted in this initiative. Empowerment of local community can be achieved through this initiative
adaptation benefits	
Sustainability	• Resilience to natural disaster through appropriate response and coordination mechanism • Receive and disseminate health alerts, warnings, advisories and other • Notifications in a timely manner to the public. • Coordinate and support health sector to conduct public health emergency response and recovery operations at various levels from strategic to operational and tactical levels. • Provide technical assistance and guidance in the provision of response actions and areas requiring emergency management expertise. • Assist and support rapid risk assessment and mobilization of rapid response • teams. • Coordinate appeal for international assistance and assist in obtaining international • funding for response and recovery operations.
Sustainability and Resilience	to strengthen health sector emergency preparedness in order to ensure a timely, efficient and effective response to events including: • local and national outbreaks of infectious diseases that have national significance; • epidemics and pandemics; and • other types of emergencies caused by natural, technological and societal hazards that can have a substantial impact on people's health and on society
Resilience	Risk and disaster preparedness and planning Climate related disease monitoring
Potential Development Benefits	
Economic, Social, Environmental	Creation of Jobs and economic opportunities in remote islands and healthcare professional Coordination of logistics and support to streamline distribution and delivery of healthcare services Healthcare professionals' capacity development Health care facilities equipped with better capacity to respond to extreme events Promote health care facilities that is adaptable for the local climatic conditions Promote climate resilient design and energy water etc saving measures in health sector Reducing waste, segregating, disabling sharps, implementing safe and low carbon infectious waste treatment technologies rather than combustion should be a high priority for sustainability objectives.

	implementing sustainable operations, investing in healthier food and transport systems, and buying green; the medical sector can promote environmental health.

4- Water Resource management

Technology Fact Sheet -7

Technology : Integrated Water Resource Management (IWRM) and rain water integration	
Introduction/background	Integrated water resource management is the policy adopted by the country to provide portable water for the islands and local community. IWRM involves combination of protection and conservation of fresh ground water lens, integration of rainwater for domestic consumption and aquifer recharge, inclusion of rainwater in public supply, demand management through use of efficient water fixtures and consumer practices, leakage control in the system and at consumer level. The IWRM system is designed to provide portable water from the following two sources to the households through piped network Community and household-based rainwater harvesting system integration Desalination Plant to secure minimum water requirement in all situations potable water produced from the two independent sources (rainwater and seawater) would be directly connected to the household to realize the ultimate goal of safe and sustained piped water supply system. The proposed system embraces non-climate reliance desalination option due to unpredictable climate-induced rainfall pattern and the polluted groundwater. This approach is economically viable and environmentally friendly, involve cost-effectively sound capital investment and minimum affordable production cost (operation and maintenance) to the end users.

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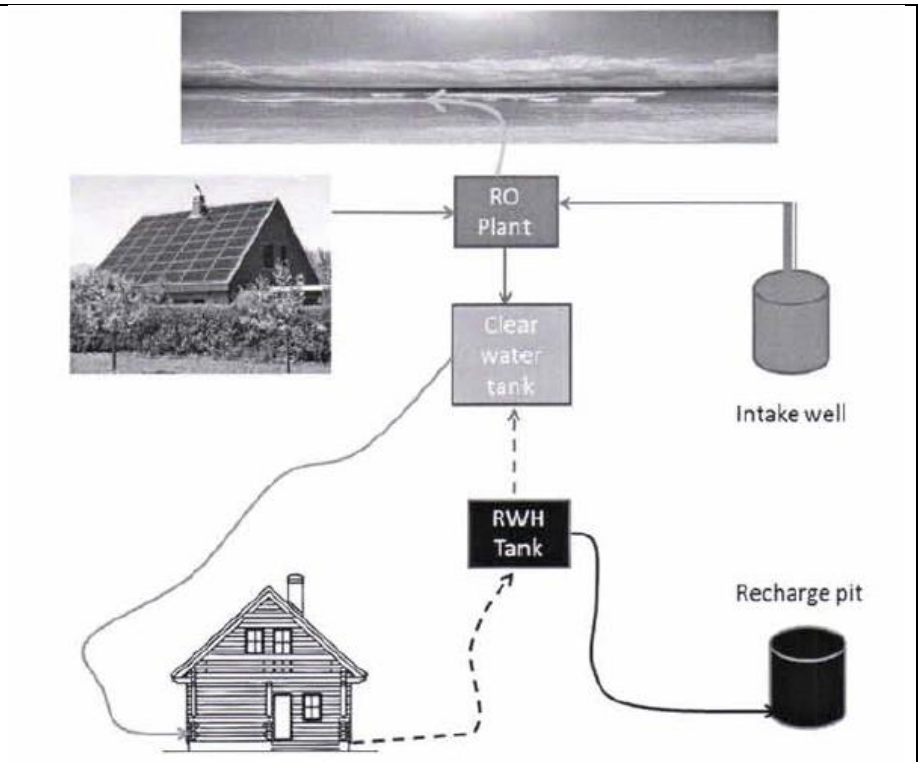
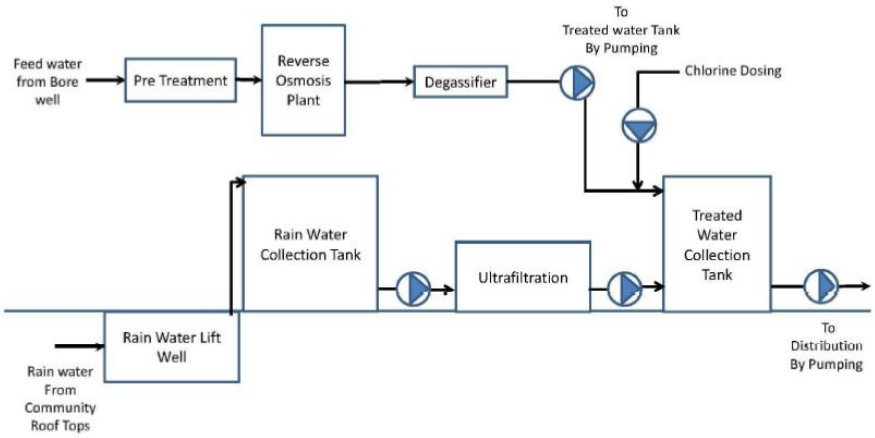
<tr><td></td><td> 

IWRM system design</td></tr>
<tr><td>Technology characteristics</td><td>This technology involves integration of rainwater and desalinated water into the households distribution systems to through piped network

Rain water harvesting involves harvesting rainwater run-off from designated roof areas followed by ultra-filtration and storing in storage tanks then pumping to the distribution network.
Desalination of saline water sourced from deep boreholes or ocean feed water pipe using Reverse Osmosis Technology has been used as a mean for providing a sustainable source of portable water in IWRM systems.

IWRM water supply scheme and rainwater integration</td></tr>
<tr><td>Capital, Operating cost</td><td></td></tr>
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Safety, Reliability, Maturity	This is the safest and adopted technology in most of the island in the Maldives financed through GCF and adaptation fund and others. Technology is mature and reliable
Country specific applicability	Widely applied in most of the islands
Institutional Capacity	IWRM is the policy adopted the country
Need for capacity building	Currently most of the design work is done by the local engineers, but most of the construction work is carried-out by foreign contractors
Scale of application	Very widely adopted in most of the islands
Time horizon- Short /Medium/long term	Construction is about 2-3 years and design is about 35 years
Status of technology in country	Accepted by the experts and the government organization and the local community
Acceptability to locals	Highly accepted by the local community
Gender aspects	Minimizes social
adaptation benefits	
Climate change vulnerability reduction potential	
Potential Development Benefits	
Economic, Social Environmental	Establishment of rainwater integrated water network will improve the livelihood of the community and contribute health and wellbeing of the people and increase of economic activities

5- Critical Infrastructure

Technology fact Sheet-8

Technology : Habitable multi-purpose living coastal structures for Climate proofing of critical Infrastructure and Coral reefs conservation through ecosystem approach as adaptation	
Introduction/background	These are deployment of shoreline protection hard structures such as breakwaters, groyne revetments that are inspired and supported by nature. These structures will contribute to the climate proofing of critical infra structures in inhabited islands as well as in resort islands. The structures also can be used to rehabilitate coral reefs conservation through ecosystem approach as adaptation. These types of interventions – also referred to as green infrastructure, natural infrastructure, living shorelines or hybrid soft and hard engineering – include coastal habitat restoration, vegetation replanting and beach nourishment schemes. Nature-based solutions look beyond protection and resilience, focusing on the relationship between people and their natural environment and the delivery of long-term sustainable outcomes for communities. The basic idea is to make greener sea defense through providing habitable areas within the structure. Under mutual benefit/value theme, these structures create symbiosis between artificial sea defense and natural sea defense through habitation of trees or corals within the structure

A long concrete breakwater with green trees with waves on a bright summer day

Tetrapod® the green sea defense mangrove plantation

	 Multi functional coastal revetment placing habitat-promoting tiles in Singapore similar settings can be used eg: breakwater, seawall or groynes for example specifically painted tiles to attract corals and other sessile organism in a breakwater
Technology characteristics	
Capital, Operating cost	Depending on the construction material the cost may range between 36,000 MVR - 11,000MVR /m

	Maintenance cost will also depend on the construction material may range 2-50 years and maintenance required may be 5-20% of the total cost
Safety, Reliability, Maturity	Technology is mature enough; safe and reliable it has been applied in many countries around the world including few places in the Maldives
Country specific applicability	
Institutional Capacity	Supporting regulatory, institutional and policies exist in the country
Need for capacity building	Existing capacities in the country can start but need widespread application through appropriate means
Scale of application	Not very much applied as most of the coastal protection structures are gray
Time horizon- Short /Medium/long term	Long term 10-50 years or even 100 years
Status of technology in country	In few harbor development it has been applied eg ….
Acceptability to locals	Locally acceptable aesthetically appealing and visually more pleasing
Gender aspects	Woman engineers' involvement particularly during the design stage, project planning and implementation stage
adaptation benefits	
Climate change vulnerability reduction potential	provides a high degree of protection against coastal flooding, storm surges and erosion, greatly contribute to protection of critical infrastructures particularly in the vicinity of coastline can also be implemented as part of a wider coastal zone management plan which employs other technologies such as beach nourishment and managed realignment set-back etc. Stabilizes shorelines and reduces erosion Preserves natural storm surge defenses Enhances climate change mitigation through carbon sequestration and storage, known as blue carbon, if vegetation based (as opposed to cement or other structural material) Provides attenuation benefits for boat wakes and storm driven waves
Potential Development Benefits	
Economic, Social and Environmental	• Provide protection to the critical infra structure in inhabited islands and resorts. • Reduces repair/maintenance costs after storms as natural systems have the capacity to self-repair • Supports eco-tourism through fishing, hunting and wildlife viewing activities • Enhances recreational opportunities • Protects and/or creates habitat for near-shore organism, invertebrates, and other sessile and benthic species such as coral reefs

	• Attracts more birds and other organisms and Provides food resources and roost sites for marine and shore birds • Provides habitat continuum for fish and wildlife migration between aquatic and terrestrial habitats • Supports habitat migration within the shore zone and inland • Enhances recreational opportunities

6. Agriculture and food security

Technology Fact Sheet -9

Technology : Community farming & community gardens and household therapeutic farming	
Introduction/background	Subsistence agriculture have played a vital role as main sources of food security and livelihoods in the islands of Maldives, vastly helping the local communities for their needs. Agriculture production in Maldives has been increasing in recent years particularly after the COVID-19 pendamic. Some islands have developed specialized production of certain crops, such as Kandoodhoo for their bonnet chillis, Thoddoo for their watermelons, and Fuahmulah for their taros. To this day, locally grown produce lives up to their reputations and have always been valued higher over imported products among Maldivian locals. Community farming & community gardens and household therapeutic farming is production of food and food items beyond home consumption and using the produce to create an income through individual families or community groups. These are a small scale, supplementary food production system by and for household members that mimics the natural, multi-layered ecosystem. Home gardens generally cover small areas near to home but have wider diversity of crop species which are crucial to brining resilience in vulnerable regions by reducing the risks. The objectives of community farming & community gardens and household therapeutic farming is aligned with numerous strategies of the Government's Strategic Action Plan (SAP), falling under Blue Economy for Small and Medium Enterprises and Agriculture sectors. Specifically, the strategies and actions related to development of Agri-centres, standardizing food production and quality of produce, establishing urban gardening models, strengthening agricultural data collection mechanisms and increasing the efficiency of resource allocation through capacity building. Apart from this, management of home gardens helps to increase food availability and better nutrition through food diversity, income and rural employment and environmental benefits of recycling water and wastes and provide shade and alter the microclimate around the house. The overall aim is to minimize dependency on imported fruits and vegetables that can grown locally. Through community farming & community gardens and household therapeutic farming locally grown crops that are somehow climate resilient adaptable to local conditions with less fertilizer and pesticides will be promoted. Community farming & community gardens and household therapeutic farming will work with local farmers and in development of agriculture related infrastructure and food storage facilities to pursue food security and self-sufficiency that will boosts local production, facilitate value-addition in the agriculture sector and increase overall resiliency of the country.
Technology characteristics	Through the ongoing community farming & community gardens and household therapeutic farming pilot project in the urbanized area in Hulhumale 48 farmers are growing various types of crops and therapeutic plants. Existing community farming & community gardens and household therapeutic farming initiative contract with farmers undertake farming within the standards and guidelines and receive subsidies and other benefits provided to the members.

	As all enabling infrastructure exists, this activity will serve as a pilot phase to test the community farming & community gardens and household therapeutic farming process to stimulate immediate production and income for farmers. Through community farming & community gardens and household therapeutic farming process the role of women in farming is expanding and empowering local community to achieve economic targets relating to food security, import substitution, creation of jobs, improving the trade balance, enabling market access to farmers and production capacity development.
Capital, Operating cost	
Safety, Reliability, Maturity	community farming & community gardens and household therapeutic farming started fairly recently in early 2020, and it is growing very fast now it is expanding across Maldives. Community farming & community gardens and household therapeutic farming expected to reach maturity in the coming year
Country specific applicability	This initiative is specific to Farmers in the Maldives
Institutional Capacity	Community farming & community gardens and household therapeutic farming is in initial trial period if successful it can be implemented all over the country .
Need for capacity building	Capacity development is needed for farmers as well as those who are engaged in various activities of the community farming & community gardens and household therapeutic farming
Scale of application	At present it is mostly in urbanized areas in the country. It will be expanded to less urban island to develop more resilient and self-sufficient communities through community farming & community gardens and household therapeutic farming
Time horizon- Short /Medium/long term	At present community farming & community gardens and household therapeutic farming is though short terms contract but in the future long term contract will be established and short to medium term development strategy will be formulated
Status of technology in country	This initiative is very new but it proves to be working fairly well
Acceptability to locals	The whole project is about involvement of local farmers particularly in urbanized islands
Gender aspects	Women empowerment is very much promoted in this initiative. Empowerment of local community can be achieved through this initiative
adaptation benefits	
Climate change vulnerability reduction potential	Addressing food security and self sufficiency which will contribute to reduce the vulnerability in these areas Promotion of climate resilient crops that are suitable for the specific environmental conditions in the Maldives. Economic diversification and reduce dependency to imports particularly for fruits and vegetables that grown in local conditions

Potential Development Benefits	
Economic, Social,	Creation of Jobs and economic opportunities in remote islands Connecting farmers with the market Enabling Market Access for Farmers Coordination of logistics and support to streamline distribution and delivery to overcome supply chain issues arising due to the geographic dispersion Production capacity development
Environmental	Promote locally available fruits and vegetables, therapeutic plants and discourage and reduce dependency on imports Promote climate resilient crops growth in the country Strengthen productive capacity and entrepreneurship in agriculture

Technology Fact Sheet 10

Technology : Agritourism	
Introduction/background	Agritourism is a new concept that has been floating as a diversification of tourism sector in the Maldives. The overall idea of the concept is to add the agritourism components into the islands designated for agricultural islands. Agritourism is a form of commercial enterprise that links agricultural production and/or processing with tourism to attract visitors onto the designated islands for agricultural business for the purposes of entertaining or educating the visitors while generating income for the farm, or business owner. Agritourism is a field that is growing in popularity particularly between the local tourist as producers try to diversify and increase profits. By combining agriculture and tourism, agritourism offers new sources of revenue and includes the following factors: • combines the essential elements of the tourism and agriculture industries; • attracts members of the public to visit agricultural operations; • is designed to increase farm income; and • provides recreation, entertainment, and/or educational experiences to visitors. Agritourism presents a unique opportunity to combine aspects of the tourism and agriculture industries to provide a number of financial, educational, and social benefits to tourists, producers, and communities. Agritourism gives producers an opportunity to generate additional income and an avenue for direct marketing to consumers. It diversifies the existing tourism industry by increasing the volume of visitors to an area

	and the length of their stay. Agritourism also provides communities with the potential to increase their local tax bases and new employment opportunities. Additionally, agritourism provides educational opportunities to the public, helps to preserve agricultural lands, and allows island and communities to develop business enterprises.
Technology characteristics	Inhabited islands/communities with extensive farming, as well as designated island for agricultural development can be used for the promotion of Agritourism with proper established standards and guidelines for the operation of both agriculture and tourism. As all enabling infrastructure exists in most of the inhabited islands, this activity will serve as a pilot phase to test the agritourism using local guest houses and facilities. For the agricultural island accommodation and other ancillary facilities has to be developed. Through promotion of agritourism role of women and local community in farming and tourism can be empowered to achieve economic targets relating to food security, import substitution, creation of jobs, improving the trade balance, enabling market access to farmers and production capacity development to created economic resiliency of the local communities through diversification of tourism and agriculture.
Capital, Operating cost	
Safety, Reliability, Maturity	Agritourism is a fairly new concept for the Maldivian tourism industry started recently in early 2021 after the 2019 COVI situation. , Agritourism is growing very slowly now it has relevant policies and regulation favoring the enterprise is expected to reach maturity in the coming years.
Country specific applicability	This initiative is specific to local community farms and designated island for agriculture in the Maldives
Institutional Capacity	Agritourism is in initial trial period if successful it can be implemented all over the country .
Need for capacity building	Capacity development is needed for local communities as well as those who are engaged in various activities of the agritourism.
Scale of application	At present it is practiced only in few islands at community levels, but there are plan for expansion to develop Agritourism in designated agricultural as well as in inhabited islands
Time horizon- Short /Medium/long term	At present it is on trial but in the future long term development plan will be developed and short to medium term development strategy will be formulated
Status of technology in country	This initiative is very new but it proves to be working fairly well
Acceptability to locals	The whole project is about involvement of local communities and farmers
Gender aspects	Women empowerment is very much promoted in this initiative. Empowerment of local community can be achieved through this initiative

adaptation benefits	
Climate change vulnerability reduction potential	Diversification of tourism product to make it more resilient to external shocks Addressing food security and self-sufficiency which will contribute to reduce the vulnerability in these areas Promotion of climate resilient crops that are suitable for the specific environmental conditions in the Maldives. 17 crops are farmed at this stage Economic diversification and reduce dependency to imports particularly for fruits and vegetables that grown in local conditions Through this initiative solar-powered post-harvest infrastructure (cold storage and chilling facilities) can be promoted to enhance food security. This is particularly critical infrastructure given the geographic set-up of the country and the absence of efficient sea transport networks
Potential Development Benefits	
Economic, Social, Environmental	Create economic resiliency through diversification of tourism and agriculture sector Creation of Jobs and economic opportunities in remote islands and farmers Coordination of logistics and support to streamline distribution and delivery agritourism business Production capacity development Promote locally available fruits and vegetables and discourage and reduce dependency on imports Promote climate resilient crops growth in the country Strengthen productive capacity and entrepreneurship in agriculture

ANNEX II: LIST OF STAKEHOLDERS AND TECHNICAL WORKING GROUPS

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Coral reef and biodiversity sector

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Agriculture and food security sector

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