MALDIVES

TECHNOLOGY NEEDS ASSESSMENT REPORT

MITIGATION

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TNA TECHNOLOGY NEEDS ASSESSMENT

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TECHNOLOGY NEEDS ASSESSMENT REPORT

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List of Acronyms

ADB	Asian Development Bank
BUR	Biennial Update Report
CO_2	Carbon dioxide
CH_4	Methane
EST	Environmentally Sound Technology
GDP	Gross Domestic Product
GHG	Greenhouse Gases
HDI	Human Development Index
INDC	Intended Nationally Determined Contribution
LPG	Liquidified Petroleum Gas
MCA	Multi-Criteria Analysis
STELCO	State Electric Company
MCCPF	Maldives Climate Change Policy Framework
MECCT	Ministry of Environment, Climate Change and Technology
MWSC	Male' Water and Sewerage Company
NDC	Nationally Determined Contribution
N_2O	Nitrogen dioxide
PV	Solar Photovoltaics
SAP	Strategic Action Plan
SOP	Standard Operational Procedure
TNA	Technology Needs Assessment
TAP	Technology Action Plan
TMA	Trans Maldivian Airways
UNFCCC	United Nations Framework Convention on Climate Change
WAMCO	Waste Management Corporation
WEC	Wave to Energy Convertor

Executive Summary

This report presents the mitigation technology needs assessment and prioritization processes along with the results for priority sectors for Maldives.

The aim of the Technology Needs Assessment project is to support Maldives to 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. Hence, TNAs are central to the work of Parties to the Convention on technology transfer and present an opportunity to track an evolving need for new equipment, techniques, practical knowledge, and skills, which are necessary to mitigate GHG emissions and/or reduce the vulnerability of sectors and livelihoods to the adverse impacts of climate change.

The Republic of 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 115,300 km^2. 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. The islands of the Maldives are extremely small. Most of the vegetated islands are less than 0.5 square kilometers in land area.

Maldives is divided into 23 administrative regions, which consist of 20 atoll councils and 4 city councils. There are total of 1192 islands in the country, of which 187 islands are residential islands inhabited by local population. There are 132 tourist resorts operational in the country. The remaining 873 islands are uninhabited islands which are mostly used for different agricultural purposes such as agriculture or currently being developed as tourist resorts. The total Exclusive Economic Zone (EEZ) is approximately 859,000 km2.

Maldives is an active party to the UNFCCC negotiation process and is active with implementation of climate actions including for climate change adaptation and mitigation actions.

The main objective of this Technology Needs Assessment (TNA) report is to

1. Identify the existing technologies in terms of climate change mitigation in the country
2. Select the key sectors in which technologies need to be prioritized
3. Determine a long list of technologies for the selected sectors
4. In consultation with stakeholders determine a criteria to conduct a Multi-criteria Analysis (MCA)
5. Prioritize the technologies for the selected sectors.

Stakeholders were involved in the form of formal meetings, online meetings, and consultation workshops. Sectorial working groups were established, and their feedback was obtained on a regular basis. The initial inception workshop was held on 20th September 2021 and the MCA scoring and endorsement workshop was held on 22nd December 2021.

Priority sectors as agreed by the TNA team and stakeholders are Electricity Generation and Consumption, Waste Management and Transport sector.

Priority technologies for the Electricity Generation and Consumption Sector include;

- Roof top Solar Photovoltaics (PV) with Energy Storage System including Battery
- Floating Solar Platforms

Priority technology for the Waste Management sector include;

- Waste to Energy Facilities in Regional Waste Management Facilities

Priority technologies for transport sector include;

- Electric Vehicles
- Hybrid Solar Boats.

SUMMARY AND CONCLUSIONS

Climate change mitigation technology prioritization took multiple factors into account. The prioritized technologies were reviewed and endorsed by National TNA team of Climate Change Directorate, Ministry of Environment, Climate Change and Technology (MECCT).

CHAPTER 1: INTRODUCTION

1.1 About the TNA project

The Technology Needs Assessment (TNA) is crucial for a developing country like Maldives. The purpose of the TNA project is to assist participant developing country Parties 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. Hence TNAs are central to the work of Parties to the Convention on technology transfer and present an opportunity to track an evolving need for new equipment, techniques, practical knowledge and skills, which are necessary to mitigate GHG emissions and/or reduce the vulnerability of sectors and livelihoods to the adverse impacts of climate change. The main objectives of the project are:

To identify and prioritize through country-driven participatory processes, technologies that can contribute to mitigation and adaptation goals of the participant countries, while meeting their national sustainable development goals and priorities (TNA).

1. To identify barriers hindering the acquisition, deployment, and diffusion of prioritized technologies.
2. 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 participant countries.
3. Further, the TNA process will develop Concept Notes for attracting funding to implement selected technologies in priority areas of national relevance.

1.2 Existing National Policies Related to technological innovations, Climate Change Mitigation and Development Priorities

This section will include the National Policy Framework on Climate Change Mitigation in the Maldives, Development Priorities for the Maldives, and rationale for selection of the sectors for technology prioritization.

1.2.1 National Policy Framework on Climate Change Mitigation

This section of the report discusses the key regulations and polices which are relevant to climate change mitigation in the Maldives.

1.2.1.1 Maldives Climate Change Policy Framework (MCCPF)

The MCCPF is the key policy for addressing adverse impacts of global climate change. The policy was formulated and adopted in 2015. The MCCPF include 5 key policy goals; These goals are: 1) Ensure and integrate sustainable financing into climate change adaptation opportunities and low emission development measures; 2) Strengthen a low emission development future and ensure energy security in the Maldives; 3) Strengthen adaptation actions and opportunities and build climate resilient infrastructure and communities to address current and future vulnerabilities; 4) Assume national, regional and international climate change advocacy role in leading international negotiations and awareness in cross-sectorial areas in favor of the most vulnerable and small developing states and; 5) Foster sustainable

development while ensuring security, economic sustainability and sovereignty from the negative consequences of climate change.

The most relevant policy goal for climate change mitigation and TNA process is Goal 2: Strengthen a low emission development future and ensure energy security in the Maldives.

1.2.1.2 Maldives Intended Nationally Determined contribution (INDC)

Initial Intended Nationally Determined Contribution (INDC) was communicated to United Nations Framework Convention Framework (UNFCCC) in September 2015. The INDC outlined both a conditional and unconditional targets for the Maldives in terms of climate change mitigation. The proposed mitigation actions included in the initial INDC covers three main sectors. They are Energy (Electricity Generation, Energy Efficiency – Domestic consumption, Energy Efficiency – processes and product use), Transport and Waste Management.

The unconditional target outlined in the initial INDC was 10% of GHG (below the Business-As-Usual (BAU)) scenario by 2030. Maldives also comminated that this unconditional target can be further increase up to 24% (below BAU) by 2030 depending on the availability of financial resources, technology transfer and capacity building.

1.2.1.3 Updated Nationally Determined Contribution (NDC)

The update of Nationally Determined Contribution (NDC) was submitted by the Maldives to UNFCCC on December 2020. This update was aimed to increase the ambition of the NDC in terms of climate change mitigation as well as update the aspirational climate change adaptation goals outlined in the previous INDC. The updated NDC includes implementation of climate change mitigation measures in the energy and waste sector as key actions to achieve the NDC targets. The key mitigation activities which was presented in the update NDC include the following (Table 1);

Table 1: Mitigation Actions identified and their corresponding sectors in the update NDC communicated to UNFCCC

Mitigation Actions	Corresponding Sector
Increase of energy production by Renewable Energy (RE) with storage and grid stabilization.	Energy sector
Increase supply and demand side efficiency	Energy sector
Installation of waste to energy power plants	Waste Management Sector
Establishment of vehicles/vessels emission standard	Transport Sector
Establishment of efficient transport management system	Transport Sector
Promotion of Hybrid Vehicles	Transport Sector
Utilization of Liquified Natural Gas (LNG) for electricity generation by replacing the diesel used for power generation.	Energy Sector

Fuel switching from Liquidified Petroleum Gas (LPG) to LNG	Energy Sector

The mitigation target of the Updated NDC is 26% reduction of emissions in 2030 (under a BAU) in a conditional manner, in the context of sustainable development, supported and enabled by availability of financial resources, technology transfer and capacity building. However, if the assistances are significantly increased, Maldives intends to achieve net zero emissions by 2030.

1.2.1.4 Maldives Climate Emergency Act (2020)

Maldives Climate Emergency Act (2020) was ratified in August 2020. The main provisions of the Act include

1. State a mechanism for the Maldives to lay down the adaptation and mitigation actions to combat climate change in Maldives;
2. Establish a reporting mechanism in relation to the implementation of international targets of Maldives related to climate change;
3. Mainstream climate change responses into development planning and implementation.
4. Formulate programs and plans to enhance the resilience and adaptive capacity of human and ecological systems to the impacts of climate change.
5. Provide mechanisms for and facilitate climate change research and development, training and capacity building;
6. Establish the administrative framework required to implement climate change actions in Maldives.
7. Establish the duties of the State to combat climate change in Maldives
8. Establish a National Climate Change Fund in Maldives and
9. Enhance climate resilience and low emission development for the sustainable development of Maldives
10. Allocate Carbon Budget for the private and public sector companies of the Maldives.

1.2.1.5 Maldives Energy Act (2021)

The Maldives Energy Act was gazetted on 11 October 2021. The Act details the duties and responsibilities of the respective institutions and places emphasis on the usage of renewable energy. The Act and Regulations made pursuant to the Act is intended to provide the framework for Maldives transitioning towards the net zero carbon goal by increasing the usage of renewable energy.

In addition to promoting technology related to renewable energy in Maldives, MECCT is required under the Act to establish a target for the production of electricity from renewable energy sources. The Act further requires service providers to make arrangements to feed renewable energy to the electricity grid.

MECCT is mandated to survey renewable energy resources in Maldivian territory and publish an inventory of the resources identified by the survey within 24 months.

1.2.2 Other key polices and regulations

The following Table 2 enlist the other key policies relevant for climate change mitigation in the Maldives.

Table 2: Other key policies relevant to climate change mitigation in the Maldives

Policy/Regulation	Provisions for Climate Change Mitigation
Strategic Action Plan of Government of Maldives 2019-2023	• The SAP include key targets for both Clean Energy, Waste Management and some activities for Transport sector; **Clean Energy:** • By 2023, increase by 20% the share of renewable energy in the national energy mix compared to 2018 level. • By 2023, reduce fuel usage for electricity generation by 40 million litres. • At least 30% of the Island Waste Management Centres utilize renewable energy for their operations. • By 2023, 30% of energy consumption for all water and sewerage services are met by renewable energy. **Waste Management:** • By 2023, open burning of waste will be minimized by 50% in all inhabited islands. • Transport • Reduce CO2 emissions in the Maldivian airspace and minimize noise pollution near aerodromes and floating platforms • Provide recommendations to the relevant authorities on setting fuel emission standards for vessels, vehicles and aircrafts • Review and revise regulations to address road congestion, vehicle importation, management of emission levels, traffic violations, and management of parking. • Review and revise emission standards to enforce the road worthiness standards • Develop national standards on fuel quality, vehicle and vessel emissions
Maldives Water and Sewerage Act (2020)	The Act provide provision to maximize renewable energy in water and sewerage services in the Maldives.
Maldives Energy Policy (2016)	The Maldives Energy Policy and Strategy (2016) has provisions which is very much relevant to climate change mitigation. They include; • Promote energy conservation and energy efficiency • Promote renewable energy technologies
Net-Metering Regulation (2015)	Net metering regulation (2015) enabled connecting renewable energy systems managed by private parties to state-owned utility power grids.

National Water and Sewerage Strategic Plan (2020-2025)	The policy two of National Water and Sewerage Strategic Plan (2020 – 2025) is aimed to adopt cost-effective and environment-friendly, water and sewerage infrastructure and sets a target of 30% of energy consumption for water and sewerage facilities across the Maldives will be met with renewable energy by 2023.

1.3 Development Priorities

Maldives is a middle-income developing country. Maldives faces significant development challenges due to its vulnerability to climate change, geographically scattered islands and heavy reliance of imports. All most all the commodities required for economic activities are imported to the country. The geographical isolation and scattered of the islands across the Indian Ocean make transportation and transfer of cargo a costly challenge. Maldives is considered as one of the most vulnerable countries to adverse impacts of global climate change. Despite of these challenges, Maldives economy have seen significant growth prior to the on-going COVID19 pandemic. The economy of the Maldives is highly dependent on two major sectors namely fisheries and tourism, with minimal diversification. This lack of diversification and heavy dependence on the fossil fuel make the economy highly vulnerable to external shocks. Tourism contributed approximately 19.9% of the nominal Gross Domestic Production (GDP) prior to the COVID-19 pandemic. Fisheries is the other main sector of the economy contributing approximately 4% of the nominal GDP in 2016. The COVID-19 pandemic is expected to have a significant adverse impact on the Maldivian economy. Due to closure of the national borders and COVID-19 outbreak in the Greater Male' region, the annual growth rate of nominal GDP is expected to decrease in 2020.

The national Human Development Index (HDI) for Maldives, placed it in the medium human development category, with an HDI of 0.688.2 The human development performance of Maldives shows progress as well as the underlying income disparity of the population. According to the national poverty line, 8.2% of the population lives below the poverty line.

The development priorities of the country are clearly outlined in the Strategic Action Plan of the Government of Maldives 2019-2023. SAP identifies 5 main sectors and 33 sub-sectors which will be focused for development for the time period of 5 years (2019 to 2023). The following Table 3 includes the sectors and sub-sectors which are considered as development priorities for the government of Maldives.

Table 3: Sectors identified in the Strategic Action Plan of the Government of Maldives as development priorities

Main sectors identified in the SAP as development priorities	Sub-sectors corresponding to the main sectors.
Blue Economy	1. Tourism 2. Small and Medium Enterprises 3. Fisheries and Marine Resources 4. Agriculture 5. Labor 6. Employment and Migration 7. Economic Diversification

Caring State	1. Health 2. Education 3. Higher Education 4. Social Protection 5. Prevention of Narcotics and Drug Rehabilitation
Dignified Families	1. Housing 2. Youth 3. Community Empowerment 4. Islamic Faith 5. Sports 6. Family
Jazeera Dhiriulhun (island lifestyle)	1. Clean Energy 2. Waste as a resource 3. Environment Protection and Preservation 4. Resilient Communities 5. Information 6. Communication and Technology 7. Water and Sanitation 8. Transport Network 9. Arts, Culture and Heritage 10. Decentralization
Good Governance	1. National Security and Public Safety 2. Accountable state 3. Independent Institutions and Public Service Reforms 4. Rule of Law and Judicial Reform 5. Gender Equality 6. Foreign Affairs 7. Eliminating Corruption

There are policies, strategies and actions identified for each of the sub-sectors outlined in the SAP. Furthermore, there are Monitoring and Evaluation scheme prescribed for tracking the progress of SAP implementation.

1.4 Sector Selection

This section of the report provides information the process followed to select the sectors which require technology prioritization for climate change mitigation.

1.4.1.1 GHG emission status and trends for selected sectors

The total emissions of Maldives for the year 2015 is 1,536.04 Gg of CO2 equivalent. The following Table 4 is a breakdown of total emissions of 2015.

Table 4: Breakdown of Total Emissions for the year 2015 (Adapted from Ministry of Environment (2019))

Greenhous Gas Source and Sink Categories	CO_2 (Gg)	CH_4 (Gg)	N_2O (Gg)	Total (Gg) CO_2eq
Total National Emissions and Removals	1476.887	2.013	0.054	1536.04
1 – Energy	1463.635	0.104	0.020	1472.05
1.A Fuel Combustion Activities	1463.635	0.104	0.020	1472.05
1.A.1 Energy Industries	1020.502	0.041	0.008	1023.93
1.A.3 Transport	376.095	0.056	0.012	380.8
1.A.4. Other Services	67.038	0.007	0.000	67.27
4 – Waste	13.252	1.909	0.034	63.99
4.C – Incineration and Open Burning of Waste	13.252	1.909	0.034	63.99
Memo Items				
International Bunkers	320.202	0.002	0.009	
1.A.3.a.i - International Aviation (International Bunkers)	320.202	0.002	0.009	323.03

The CO_2 accounts for 96% of the GHG emissions in the Maldives. 3% of GHG emissions in the Maldives is CH_4 and only 1% of the GHG emissions is N_2O. The Figure 1 illustrates GHG emissions for the year 2015 classified based on the type of GHG.

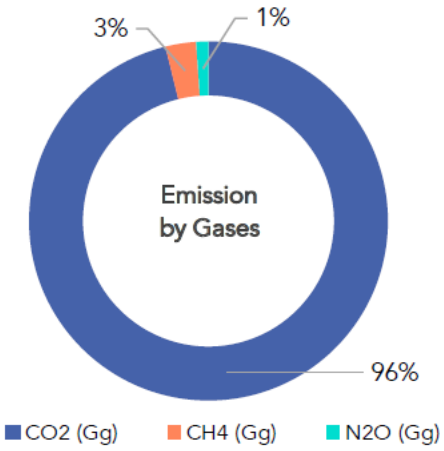

Figure 1: Emission by Gases for 2015 GHG inventory (Adapted from Ministry of Environment (2019))

The most significant sector in terms of GHG emissions was Energy industries which is electricity generation. It accounts for 67% of the total GHG emissions in Maldives. Next largest is transportation which is 25% of the total emissions. Emissions from waste is 4% and from Other sectors is also 4% of the total emissions. The following Figure 2 classifies GHG emission for 2015 in terms of IPCC sectors for GHG inventory.

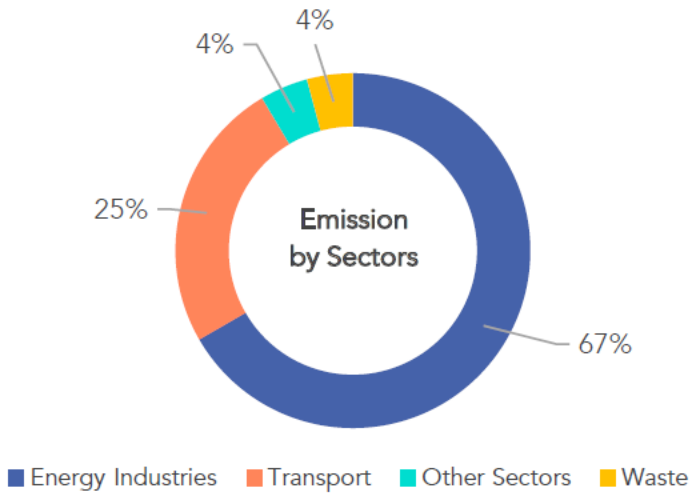

Figure 2: GHG emissions by IPCC sectors (adapted from Ministry of Environment (2019))

1.4.1.1.1 GHG emission from Electricity Generation and Consumption Sector

Almost all the power generation in Maldives is from diesel-based fossil fuel. Every island and every resort have their own power facility. With the growing population and growth in economic industries, the demand for power production is increasing. There are two state owned companies, STELCO and FENAKA who provides electricity services. Resorts and large industries have their own power generation facilities.

GHG Emissions by energy industries is the largest contributor to the national emissions and it is mainly fuel combustion for electricity generation. 47% of the GHG emissions was from the tourism sector while

a 26% of the emissions is from residential use. The residential use includes electricity production for household uses for all islands. Commercial use (excluding tourism) shares a 15% of the emissions by electricity production. A total of 1023.93 Gg of CO_2 equivalent is emitted from electricity production. The Figure 3 shows the GHG emissions classification for electricity production.

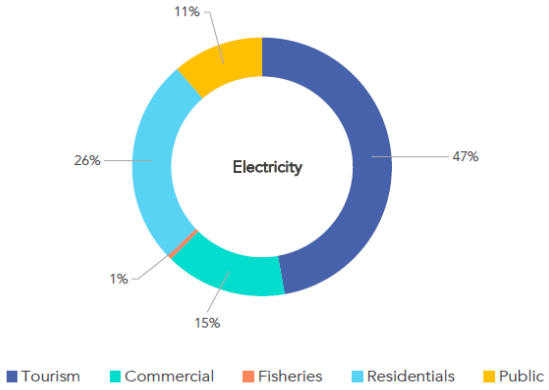

Figure 3: GHG emission for electricity production (Adapted from Ministry of Environment (2019)

1.4.1.1.2 GHG emissions for waste management sector

With the growing population, management of solid waste has been one of the biggest environmental challenges faced by Maldives. Waste produced are disposed and open burnt. Waste segregation is not a common practice at household although a minimal sorting is done at IWMCs. Waste generated in Greater Male' Region, nearby islands and most of the resorts are transferred to Thilafushi island where waste is open burnt. To manage the waste, IWMCs are being established on the islands and regional waste management centres are also being established.

GHG emissions from the waste sector was estimated assuming that all waste is open burnt. Emissions from anaerobic decay in waste dumping sites are not estimated as the waste is pre-burned and due to mixing with salty high-water table. A total of 63.99 Gg of CO_2 equivalent is emitted from the waste sector. The Figure 4 illustrates breakdown of GHG emissions for waste sector. Most of the emissions (44%) from the waste is generated by burning of waste in the atolls. Greater Malé composes of 40% while emissions from tourism sector is 16%.

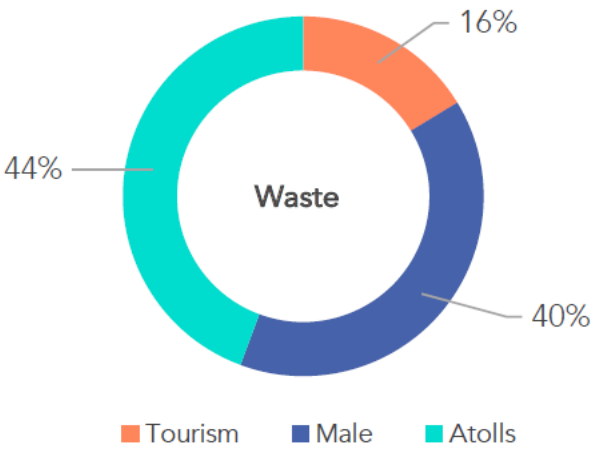

Figure 4: GHG emission breakdown for waste sector in 2015 GHG inventory (adapted from Ministry of Environment (2019))

1.4.1.1.3 GHG emissions from the transport sector

Transport sector accounts for the second largest GHG emissions in the Maldives as per the GHG inventory of 2015. Due to the dispersed nature of the islands, main mode of transport is via either diesel or petrol-based sea transport. Land transportation involves cars, buses, lorries and a significant amount of motor bikes. There are no railways in Maldives. In recent years number of domestic airports has increased and domestic air transfer is also getting as a popular mode of transport.

A total emission of 380.84 Gg of CO2 equivalent is emitted from transport sector. Figure 5 shows the breakdown of emissions from the transportation sector. It shows that 28% of the emissions is from the tourism (passenger transport by speed boats, leisure, safari) and the second largest is from domestic air transportation while 24% and 22% is from land and other marine transportation respectively. With the increase in number of resorts and domestic airports, the largest share from these sectors is envisaged

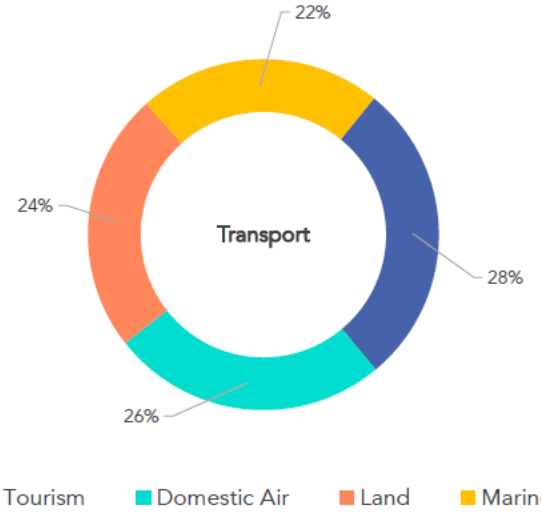

Figure 5: Breakdown of GHG emissions for Transport sector in 2015 (Adapted from Ministry of Environment (2019))

1.4.1.1.4 Emission Trends for the selected sectors

GHG inventory data from 2011 to 2015 suggest that emissions are increasing for all the sectors other than the other sectors. The other sectors emissions are mainly from fisheries sector mobile combustion, LPG usage from residential sector and LPG usage for tourism sector. This decline in GHG emissions from other sectors is mainly due to decline in fisheries sector mobile combustion. The most significant increase in GHG emissions is seen in the energy industries and transport sector. Waste sector has seen an increase trend in emissions but not as significant as other two main sectors (Energy industries and transport sector). The following Figure 6 displays the emission trends from year 2011 to 2015 for all the GHG emission sectors.

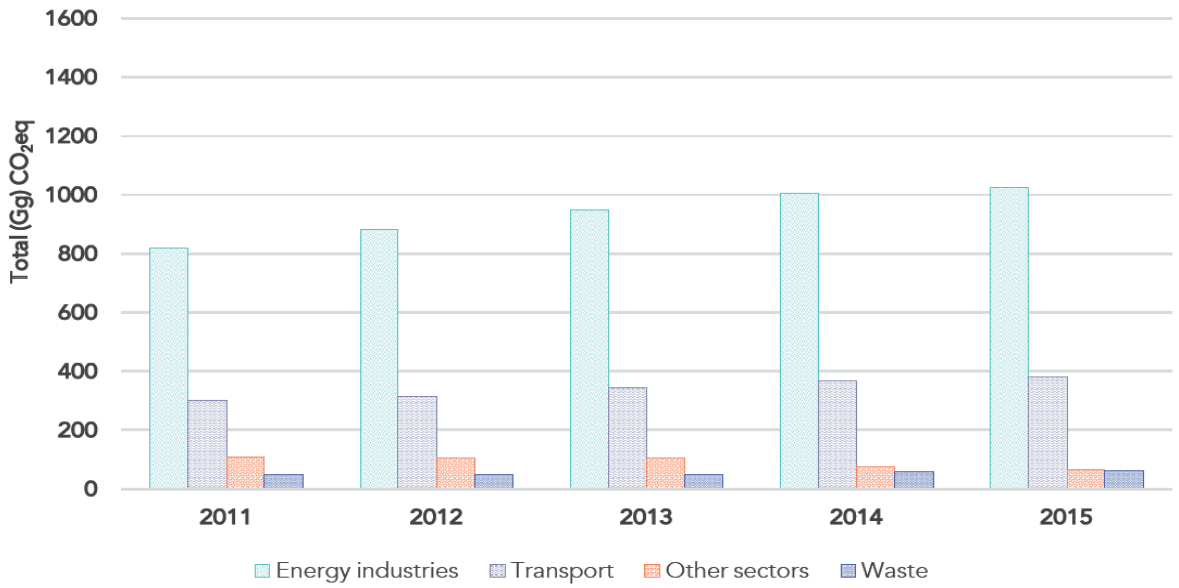

Figure 6: Trends in GHG emissions from 2011 to 2015 for all the sectors (adapted from Ministry of Environment (2019))

1.4.1.2 Rationale for the selected sectors

The process for prioritizing mitigation sectors took multiple factors into account. Firstly, considerations were given to alignment with the relevant policies and plans of the Cook Islands outline above. These were able to provide direction on priority actions.

The INDC and Updated NDC proposed mitigation actions for GHG intensive sectors. The electricity generation and consumption, transport and waste were identified as the potential sectors. The findings of the National Inventory report in the First Biennial Update report used to inform the sector selection decision.

The rationale for selection also considered the current capacity needs and strengths of potential sector. This included the level of activity already underway in various sectors as well as the extent to which regulatory and institutional arrangements were in place to support the climate technology developments in each sector. The progress against RE actions already underway was also a consideration.

Deliberations on sector selection included some consultations with stakeholders. A stakeholder endorsement of the sectors was obtained during the Initial Inception workshop held on 20th September

2021. The Initial Inception workshop involved stakeholders from line ministries and government departments, academia, private sectors and NGOs.

Based on the process and rationale above and taking into consideration time constraints, the three priority mitigation sectors prioritized for this TNA process are:

1. Electricity Generation and Consumption
2. Waste Management Sector
3. Transport Sector

A detailed long list of technologies for each of the sector selected is attached in the Annex 3 of this report.

CHAPTER TWO: INSTITUTIONAL ARRANGEMENT FOR TNA AND STAKEHOLDER ENGAGEMENT

2.1 National TNA Team

Maldives Technology Needs Assessment Project (Maldives TNA) is based at the Ministry of Environment, Climate Change and Technology (MECCT). The Climate Change Directorate of MECCT coordinate the Technology Needs Assessment project. The main Maldives TNA project team include a National TNA coordinator and two national consultants (One Mitigation Expert and One Adaptation Expert). The Maldives TNA team works with technical working groups in the selected sectors. Furthermore, the Maldives TNA team also consulted with relevant stakeholders in the whole process of the project.

2.1.1 National TNA coordinators

The Climate Change Directorate of MECCT designated Mr. Mareer Mohamed Husny and Ms. Zainab Gulisthan as the National TNA co-coordinators.

The TNA co-coordinators are the focal points for the overall management and coordination of the TNA process. The TNA co-coordinators are responsible for facilitating, managing the project and most importantly communicate with national consultants, sectoral working groups, stakeholders, regional agencies and UDP and UNOPS.

2.1.2 National Project Steering Committee

The national steering committee is key in guiding the project. Members are to provide high level guidance to the national TNA team and are responsible for policy making. Their role includes providing guidance to the national team and assist in securing political acceptance for the Technology Action Plan (TAP).

The National steering committee consists of personnel from MECCT, the inline ministries, private sector and key stakeholders.

The National Project Steering Committee consist of representatives from the following organizations;

Table 5: Project Steering Committee details

Stakeholder	**Role and Responsibilities**	**Role in the project**
Climate Change Directorate, MECCT	The main policy making institution for climate change mitigation and adaptation in the Maldives.	Coordinate the TNA process in the Maldives.
Energy Department, MECCT	The main policy making institution for energy sector in the Maldives.	Consult on the long list of technologies, technologies prioritization and MCA criteria.
Ministry of Fisheries, Marine Resources and Agriculture	The main policy making institution for fisheries and agriculture in the Maldives.	Consult on adaptation TNA matters.
Ministry of Health	The main institution for policy making in health sector and	Consult on adaptation TNA matters.

	implementation of public health programme.	
Ministry of Transport and Civil Aviation	The main regulatory and policy making institution for transport sector in the Maldives.	Consult on the long list of technologies, technologies prioritization and MCA criteria.
Ministry of National Planning, Housing and Infrastructure	Implementation of infrastructure project such as harbours, roads and water and sewerage projects.	Consult on adaptation TNA matters.
Utilities Regulatory Authority (URA)	The regulatory institution for energy, water and sewerage and waste management sector.	Consult on the long list of technologies, technologies prioritization and MCA criteria.
Environmental Protection Agency (EPA)	The regulatory institution for environmental sector in the Maldives.	Consult on adaptation TNA matters.
Maldives Meteorological Services	The government institution responsible for weather forecasting and systematic observation.	Consult on adaptation TNA matters.
National Disaster Management Authority (NDMA)	The national authority for Disaster Management and Disaster Risk Reduction.	Consult on adaptation TNA matters.
Maldives Marine Research Institute (MMRI)	The national institution responsible for marine coral reef conservation.	Consult on adaptation TNA matters.

2.1.3 National Consultants

The lead national consultants were selected by Climate Change Directorate of MECCT, national TNA co-coordinators in close consultation with UDP following national tendering processes, and an open and transparent selection process.

MECCT selected Dr. Mahmood Riyaz as the Maldives TNA adaptation expert and Mr. Hamdhoon Mohamed as the mitigation expert.

The adaptation and mitigation national experts are responsible for consulting relevant stakeholders; identifying and prioritizing technologies for specific sectors; leading the process of analyzing with stakeholders and sector working groups; participating in capacity-building workshops; working in close partnership with the national co-coordinators, sector working groups, and stakeholders; and preparing the TNA, BAEF and TAP reports

2.1.4 Sectorial Working Groups

The Climate Change Directorate of MECCT, at the suggestion of the National co-coordinators and national consultants, established three working groups on mitigation technologies for Electricity Generation and Consumption, transport and waste sector, and working groups on adaptation technologies.

The sectoral working group consists of representatives from the government ministries, private sector, academia, climate change experts and civil society. The following Table 6 enlist the composition of the mitigation sectorial working groups and their respective mandates.

Table 6: Composition of sectorial working groups and their main mandates

Institution	Type of Stakeholder	Mandate
Electricity Generation and Consumption Working Group		
Energy Department, MECCT	Government Institution	The policy making institution for energy sector in the Maldives.
Utility Regulatory Authority (URA)	Government Institution	The Regulator of the Energy Sector in the Maldives.
Utility Companies (FENAKA Corporation, Stelco and MWSC)	State Owned Enterprise	State owned companies responsible for the generation and supply of electricity to customers throughout the Maldives
Ministry of Tourism	Government Institution	The main focal point of National TNA team to tourism sector in the Maldives
Maldives Customs Service (MCS)	Government Institution	Maintains and regulate import duty and related data
Maldives Industrial Fisheries Company (MIFCO)	State Owned Enterprise	Energy intensive industrial company which operates fish canning factories.
Waste Management Sector		
Pollution Control and Waste Management	Government Institution	The policy making institution for waste management and pollution control sector in the Maldives.
Waste Management Cooperation (WAMCO)	State Owned Enterprise	With a mandate to provide a sustainable waste management solution throughout the country, WAMCO is responsible for the waste management functions of the Greater Male' Region.
Transport Sector		
Ministry of Transport/ Transport Authority	Government Institution	Policy making and regulator for transport sector in the Maldives. Transport authority collects and maintains data regarding land and sea transport.
Transport Companies and companies with transport fleets (Maldives Transport and Contracting Company (MTCC) Maldives Ports Limited (MPL)	State-owned Enterprises	Provide public transport service
Civil Aviation Companies (Manta Air, Villa Air and Island Aviation)	State owned Enterprise and Private sector	Domestic civil aviation

2.1.5 Stakeholders

The composition of stakeholders includes representatives of the government ministries, private sector, academia, climate change experts and civil society. The list of stakeholders is provided in Annex 2. The Figure 7 illustrates the implementation arrangement of Maldives TNA project.

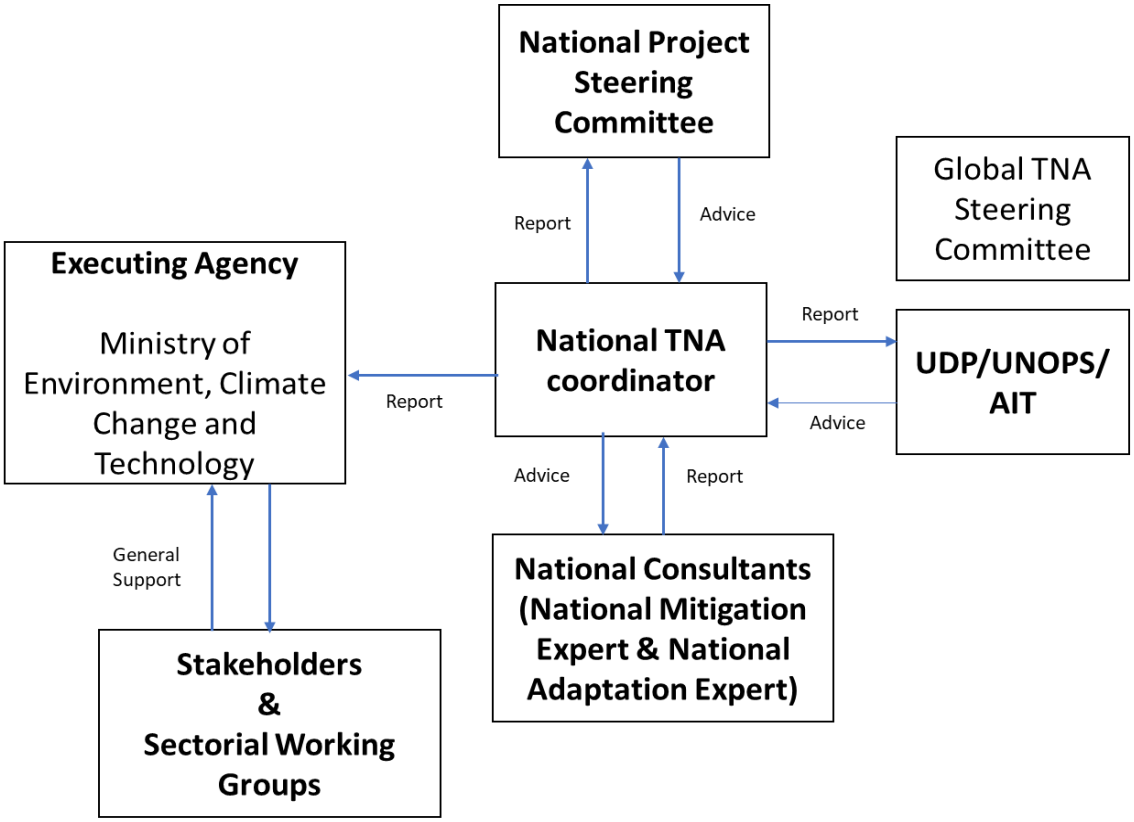

Figure 7: Implementation of the Maldives TNA project

2.2 Stakeholder Engagement Process followed for TNA process

The initial stakeholder engagement was done through a Project Inception workshop held on 20th September 2021. The stakeholders were consulted regarding the rationale for the mitigation sector selection and determine the composition of each sectorial working group.

The Project Inception workshop was attended by stakeholders from government, civil society and private sector.

Formal communications in the form of official letters were sent to the identified stakeholders to nominate a focal point who will be representing the respective organization in the sectorial working groups.

Stakeholder engagement included a mix of bilateral and technical working group meetings and stakeholder workshops to identify and prioritize technologies. Due to on-going COVID19 pandemic online meetings were conducted to minimize the risk of infection.

The following Table 7 enlist the key stakeholder engagement processes involved.

Table 7: Key stakeholder engagement process for MCA and TNA report elaboration

Meeting/ Workshop	Date and Venue	Participants	Main Discussion Points
TNA inception workshop	20th September 2021, Salt Café' Meeting Room	All the stakeholder for all the three mitigation sectors.	• Discussion on the composition of the sectorial working groups. • Workplan of the sectorial working groups. • Inclusion or omission of any other sectorial working groups. • How can gender aspects be mainstreamed into TNA process.
Initial Meeting for Technology Prioritization for waste sector	10th October 2021, Fourth Floor Meeting Room, MECCT	Waste management sector working group	• Existing technologies for climate change mitigation in the waste sector. • Discussion on the criteria used for waste sector MCA. • Key categories in GHG emission in waste sector GHG inventory.
Initial Meeting for Technology Prioritization for Electricity Generation and Consumption sector	13th October 2021, Online Meeting via Microsoft Teams	Electricity Generation and Consumption working group	• Existing technologies for climate change mitigation in the Electricity Generation and Consumption sector. • Discussion on the criteria used for Electricity Generation and Consumption sector MCA. • Key categories in GHG emission in waste sector Energy Sector

Initial Meeting for Technology Prioritization for Transport sector	28th October 2021, Online Meeting via Microsoft Teams	Transport Sector working group	• Existing technologies for climate change mitigation in the Transport sector. • Discussion on the criteria used for Transport sector MCA. • Key categories in GHG emission in Energy Sector
Scoring and Weighting Exercise	9th December 2021, First Floor Meeting room, MECCT	Waste management sector working group	• Scoring and Weighting based on the technology factsheets.
Workshop for MCA discussion	22nd December 2021, Auditorium, MECCT	All the stakeholder for all the three mitigation sectors.	• Scoring and Weighting based on the technology factsheets. • Discussions on the results of the MCA analysis.

In addition, all the MCA findings were shared with all the stakeholders for their inputs and for sensitivity analysis.

2.3 Consideration of Gender Aspects in the TNA process

Gender is considered a key aspect of the TNA process and was considered through the different stages of preparing this TNA report. Composition of the Electricity Generation Consumption sector working group was balanced with men and women representatives. The following Table 8 gives the composition of sectorial working group.

Table 8: The percentage of women in sectorial working group

Sectorial Working Group	Men	Women	% of women representative
Electricity Generation and Power Consumption	7	3	30%
Waste Management	3	1	33.33%
Transport Sector	8	1	12.5%

The MCA also included gender relevant criteria as part of the assessment.

CHAPTER THREE: TECHNOLOGY PRIORITIZATION FOR ELECTRICITY GENERATION AND CONSUMPTION SECTOR

This chapter explains the prioritization for the Electricity Generation and Consumption sector based on the MCA of technologies.

3.1 GHG Emissions for the sector and existing technologies in the Electricity Generation and Consumption sector.

3.1.1 GHG emissions from Electricity Production sector

Electricity Generation and Consumption is the biggest contributor to GHG emission in the Maldives according to 2015 GHG inventory.[1] The total GHG emissions from Electricity Production was estimated to be 1023.93 Gg of CO2 equivalent for the year 2015.[2] A detailed GHG emission scenario has been provided in the Section 1.4.1.1.1.

3.1.2 Existing technologies in the Electricity Production Sector

Inhabited islands in Maldives have a total installed capacity of about 290 MW diesel generators in 186 powerhouses, and more than 22 MW in renewable energy installations in 186 powerhouses.[3] Almost all of the Powerhouses are operated by State Owned Enterprises. The FENAKA cooperation operates 148 powerhouses. State Electric Company (STELCO) operates 35 powerhouses including the powerhouses at the Greater Male' Region and Male' Water and Sewerage Company (MWSC) operates 1 powerhouse in R. Dhuvaafaru island. The remaining 2 powerhouses are operated by the island councils of the respective island. Resorts islands have an additional 144 MW of power generation capacity (which are managed independently of the government) and industrial islands have about 20 MW of power generation capacity.[4]

Maldives achieved universal access to electricity across the country in 2008. However, despite of this great achievement Maldives has one of the highest cost power generations amongst South Asia countries.[5] The prime reason for this is electricity is mainly produced by diesel generators. Furthermore, the geographic scatteredness of the islands mean transportation of fuel is very costly.

The prime renewable energy technology implemented in the country is Rooftop Solar Photovoltaics (PV) systems without battery systems for storage. However, most of the systems are Diesel, Solar and Battery Hybrid systems. With the assistance of donors from ADB and World Bank Group significant amount of PV installations has been done in Greater Male' Region as well as other outer islands of the Maldives. In 2018, the total installed capacity of renewable energy systems in Maldives was 16.5 Megawatt with estimated

[1] Ministry of Environment (2019) "Maldives First Biennial Update Report"
[2] ibid
[3] Asian Development Bank (2020) "A Brighter Future for Maldives Powered By Renewables Road Map for the Energy Sector 2020–2030".
[4] World Bank Group (2020) "Project Appraisal Document of the Accelerating Sustainable Private Investments in Renewable Energy (ASPIRE) Project"
[5] Asian Development Bank (2020) "A Brighter Future for Maldives Powered By Renewables Road Map for the Energy Sector 2020–2030".

production of 26-Gigawatt Hour annually.[6] Furthermore, the Solar PV installation growth rate is in the range of 45-55% annually since 2016.[7]

Other renewable energy technologies such as wind turbines are not very common in Maldives. However, these technologies are being piloted by the private sector as well as utility companies such as FENAKA corporation and STELCO.

Energy consumption in buildings and households accounts for a large share of the total end use of energy in Maldives. However, there are no data available on their energy consumption and their levels of energy efficiency. Most buildings in Maldives suffer from large energy losses. The majority of residential buildings have been designed for the use of fans as the source of comfort air. These buildings later adopted air-conditioners. Unfortunately, not many dwellings are designed to keep comfortable room temperatures. Inefficient lighting and household appliances are additional factors for the low levels of energy efficiency in Maldives' buildings.[8]

3.2 Decision Context

The decision context of prioritizing technologies in the electricity generation and consumption sector considers the economic, political, social and technological environment that informs the technology prioritization decision.

In terms of sustainable development, the transport sector is important due to it being able to address the issues and challenges related to energy security and economic development as set out in the INDCs, Updated NDC and SAP.

Policies discussed earlier show that there are objectives in the sector which aim to reduce GHG emissions and pollution as well as improve economic efficiencies. The Electricity Generation and consumption is a large GHG emitter with electricity generation being the largest consumer of imported oil. Reducing dependence on imported fossil fuels is an important objective. Additionally, the Electricity production sector is responsible for producing high levels of air pollution therefore another important objective is air pollution reduction.

The main technologies considered for the MCA are expected to have additional economic and social benefits including job creation, mainstreaming gender aspects, capacity building for implementation of the technologies.

3.3 Overview of Mitigation technology options for Electricity Generation and Consumption sector

This section will describe the main climate change mitigation technologies options and their mitigation potential and co-benefits.

3.3.1 Roof top Solar Photovoltaics (PV) with Energy Storage System including Battery

Solar PV energy is an indigenous resource with the most immediate exploitation possibilities in Maldives. Solar radiation is in the order of 1,200 kWh/m^2/year, which is considered good for any solar PV project.

[6] Maldives Energy Authority (2019) "Island Electricity Data Book 2019"
[7] Ibid.
[8] Asian Development Bank (2020) "A Brighter Future for Maldives Powered By Renewables Road Map for the Energy Sector 2020–2030".

The solar PV project is being successfully implemented in hybrid systems in several inhabited islands through donor financed projects. PV panels are installed on the roofs of diesel power plants, schools, water desalination plants, sewage plants, and public buildings. PV panels are connected to the diesel power plants through an energy management system (EMS) that enhances the regulation of power supply. This hybrid configuration can offer short pay back times when compared to current prices of electricity produced by diesel generation sets. Rooftop solar PV is also being installed in the country, under net metering.

3.3.2 Floating solar platforms

Floating solar PV platforms is a good alternative for some islands. These are platforms moored in the sea with mounted PV arrays on top. These PV floating platforms are connected to the island's grid using a submarine cable. These platforms must be placed in areas close to the islands and with low wave activity to ensure their operations withstand. Effects of salinity over the solar panels must also be considered in the design.

Figure 8: Floating solar platforms in LUX South Ari Resort (Photo credit: Maldives Insider website)

3.3.3 On-shore wind energy and small scale urban vertical axis rooftop wind turbines

Similar to rooftop solar, the urban small vertical axis rooftop wind turbines have the potential to operate in all inhabited islands under the same net-metering arrangement given to solar rooftop. These urban turbines are specifically designed to work under low windspeed conditions (2 to 6 meters per second [m/s]) found in an urban environment.

Conventional horizontal axis onshore wind turbines are also possible in Maldives, under certain conditions. Wind resources are not equally distributed across the country. The wind energy resource maps indicate that the northern half of the country is relatively richer in wind resource than its southern part of the country.

Note: Offshore wind projects with current technologies are not economically feasible for Maldives. Seawaters in the Greater Male' Region (region with the largest power demand) are very deep and the atolls have very steep slopes. This is a huge challenge for the foundations of the turbines.

3.3.4 Wave to Energy Convertors

A collaboration between Okinawa Institute of Science and Technology and Ministry of Environment, Climate Change and Technology (MECCT) a small-scale installation of Wave to Energy Convector (WEC) units in Holiday Inn Kandooma Maldives resort. The results have shown immense potential hence commercial scale WEC units has been installed and is under operation in the resort. There is immense potential to replicate this technology in other inhabited islands and tourist facilities in the Maldives.

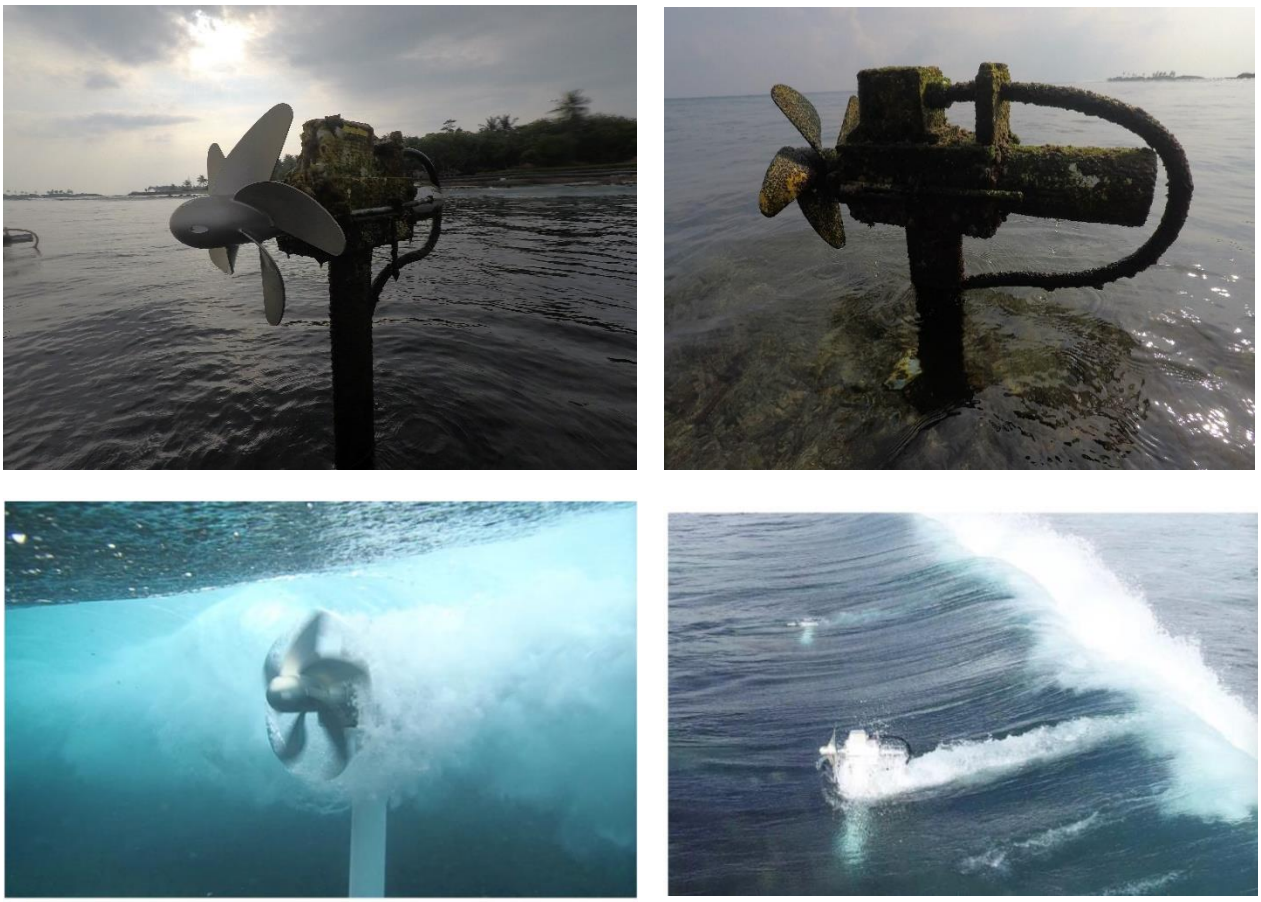

Figure 9: Wave to Energy Convertor (WEC) units installed in Holiday Inn Kandooma Resort (Photo credit: Ocean Paradise Maldives Pvt Ltd)

3.4 Identified Policy Interventions

3.4.1 Standards and Labeling Program for Electrical Appliances

MECCT is introducing "Hakathari" – an energy efficiency labeling program for appliances and equipment. The purpose of this program is to promote the use of energy-efficient appliances and equipment.

The Hakathari program provides the consumers with a simple and clear indication of the energy-saving potential of electrical appliances, at the point of purchase. This is achieved via the Hakathari label affixed on the appliances that showcase a five-star rating system. A greater number of stars on the label indicate a higher level of energy efficiency and energy savings.

The purpose of the program is;

- To encourage the purchase of energy-efficient appliances.
- To help consumers make informed choices and save money on their household electricity bills.
- To encourage importers and manufacturers to promote energy efficient technologies and products in the Maldivian market, bringing about a market transformation.
- To reduce the emission of greenhouse gases and progress towards a sustainable future

3.4.2 Energy policy and regulatory interventions

Supply Side interventions

- Continuous revision of the tariff system
- Development of technical codes and standards
- Development of regulations for implementation of the newly ratified Maldives Energy Act
- Net-metering regulation

Demand Side interventions

- Improvement of the building codes for better energy efficiency

3.5 Criteria and Process for Technology Prioritization for Electricity Generation and Consumption Sector

The criteria were elaborated and presented to the working group members by the national consultant on Initial meeting held on 13th October 2021. The proposed criteria were finalized in consultation with the working group members.

The assigning of weight for each of the criteria was done during the MCA exercise on 22nd December 2021. The following Table 9 describe the criteria and assigned weights used for the MCA for the Electricity Generation and Consumption sector. The Table 10 are the detailed information on the criteria used by the working group during the MCA exercise.

Table 9: The criteria finalized and assigned weightage for each criteria by working group members for electricity generation and consumption sector

Level 1	Level 2	Level 3	Weight Assigned
Cost (40%)	Capital Cost (USD per MWh)		20%
	Maintenance Cost (USD per KW per year)		15%
	Sustainable Financing		05%

Benefits (60%)	Economic	Job Creation	05%
	Social	Gender Impacts	05%
		Capacity Building	05%
	Environmental	Reduces Priority Waste Streams	05%
		Support Ecosystem Services	07%
	Climate related	Alignment with National Priorities	10%
		Avoid/Reduce GHG	10%
		Reduce Climate change vulnerabilities	13%

Table 10: The detailed information on the criteria for the scoring exercise as part of the multi-criteria analysis

Category	Subcategory	Criteria	Potential Indicator	Type of Score (Qualitive/ Quantitative)	Preferred Value	Data Source
Cost	Cost	Capital cost Operation and Maintenance cost	Capital Cost per unit of energy produced	Quantitative	Lower	Technology provider/ specifications
		Sustainable funding options (Private sector, public sector, Development Partner)	No. of projects funded by donor agencies and private sector	Qualitative (High/Low)	Higher	Expert Judgement/financial data
Benefit	Economic	Job Creation	No. of jobs created per project	Qualitative (High/Low)	Higher	Expert Judgement
	Social	Potential for gender impacts and reduces inequity	No. of women benefited from the technology	Qualitative (High/Low)	Higher	Expert Judgement
		Capacity development	No. of staff trained per project	Qualitative (High/Low)	Higher	Expert Judgement
	Environmental	Reduces priority waste streams	Types of waste stream generated or managed by the technology	Qualitative (High/Low)	Higher	Expert Judgement
		Support ecosystem services	Potential to improve air quality	Qualitative (5 – point scale)	Higher	Expert Judgement/ monitoring data

	Climate Related	Alignment with national Priorities	Endorsement by SAP and NDC	Qualitative (High/Low)	Higher	Review of Literature
		Reduce/avoid GHG	GHG emission reduction ($kgCO_2e$)	Qualitative (High/Low)	Higher	Technical Specifications and modelling
		Potential to reduce vulnerability and build climate resilience	Any co-benefits for climate change adaptation	Qualitative (5 – point scale)	Higher	Expert Judgement

3.6 Results of Technology Prioritization in Electricity generation and consumption sector

The following section of the report will provide information on the MCA used for prioritization of the technologies.

3.6.1 Performance Matrix

The following Performance Matrix table was used for stakeholder consultations for MCA. The stakeholders were asked to assign the scores based on the information of the criteria as given above (Table 10) and the fact sheets.

Table 11: Performance Matrix for the Electricity Generation and Consumption Sector

List of Technologies	Costs			Benefits							
				Economic	Social		Environmental		Climate related		
	Capital Cost (USD per MWh)	O&M Cost (USD per KW per year)	Sustainable Financing	Job Creation	Gender Impact	Capacity Building	Reduces Priority Waste Stream	Support Ecosystem Services	Alignment with National Priority	Reduce/Avoid GHG	Reduce Climate Vulnerability
Roof top Solar Photovoltaics (PV) with Energy Storage System including Battery	57.98	15.33	High	Low	Low	High	Low	4	High	High	5
Floating Solar platforms	23.52	24.93	High	Low	Low	High	Low	4	High	High	5
On-shore wind energy and small scale urban vertical axis rooftop wind turbines	27.01	26.47	Low	Low	Low	Low	Low	4	High	Low	5
Wave to Energy Convertors	80.56	10.54	Low	High	Low	High	Low	4	High	Low	5
Standards and Labeling Program for Electrical Appliances	0	0	Low	High	High	High	High	4	High	High	5
Energy policy and regulatory interventions	0	0	Low	High	High	High	High	4	High	Low	5

3.6.2 Normalization and Scoring Matrix

The information provided by the stakeholders on the performance matrix was normalized and scoring was done by the national consultant.

Table 12: Normalization and Scoring Matrix for Electricity Generation and Consumption Sector

List of Technologies	Costs			Benefits							
				Economic	Social		Environmental		Climate related		
	Capital Cost	O&M Cost	Sustainable Financing	Job Creation	Gender Impact	Capacity Building	Reduces Priority Waste Streams	Support Ecosystem Services	Alignment with National Priority	Reduce/Avoid GHG	Reduce Climate Vulnerability
Roof top Solar Photovoltaics (PV) with Energy Storage System including Battery	39.6	69.9	100	0	60	100	40	80	100	100	100
Floating Solar platforms	100	9.6	80	20	0	80	60	80	80	80	100
On-shore wind energy and small scale urban vertical axis rooftop wind turbines	93.8	0	60	40	40	0	20	80	60	40	100
Wave to Energy Convertors	0	100	40	100	20	60	0	80	40	20	100
Standards and Labeling Program for Electrical Appliances	0	0	20	80	100	40	100	80	20	60	100
Energy policy and regulatory interventions	0	0	0	60	80	20	80	80	0	0	100

3.6.3 Decision Matrix

Based on the normalized scores the technologies were prioritized and the results were shared and endorsed by the stakeholders in the working group.

Table 13: Decision Matrix for Electricity Generation and Consumption Sector

List of Technologies	Costs			Benefits								Total score	Rank
				Economic	Social		Environmental		Climate Related				
	Capital Cost	O&M Cost	Sustainable Financing	Job Creation	Gender Impact	Capacity Building	Reduces Priority Waste Streams	Support Ecosystem Services	Alignment with National Priority	Reduce/Avoid GHG	Reduce Climate Vulnerability		
Roof top Solar Photovoltaics (PV) with Energy Storage System including Battery	792	1048.5	500	0	300	500	200	560	1000	1000	1300	7200.5	1
Floating Solar platforms	2000	144	400	100	0	400	300	560	800	800	1300	6804	2
On-shore wind energy and small scale urban vertical axis rooftop wind turbines	1876	0	300	200	200	0	100	560	600	400	1300	5536	3
Wave to Energy Convertors	0	1500	200	500	100	300	0	560	400	200	1300	5060	4
Standards and Labeling Program for Electrical Appliances	0	0	100	400	500	200	500	560	200	600	1300	4360	
Energy policy and regulatory interventions	0	0	0	300	400	100	400	560	0	0	1300	3060	
Criterion weight	20	15	5	5	5	5	5	7	10	10	13	100	

3.6.4 Sensitivity Analysis

The following are the scoring matrix and results matrix for the sensitivity analysis. The results suggest that the prioritized technologies are consistent after the sensitivity analysis.

Table 14: The sensitivity analysis for the Electricity Generation and Consumption Sector

	Costs			Benefits							
				Economic	Social		Environmental		Climate related		
	Capital Cost (USD per MWh)	O&M Cost (USD per KW per year)	Sustainable Financing	Job Creation	Gender Impact	Capacity Building	Reduces Priority Waste Streams	Support Ecosystem Services	Alignment with National Priority	Reduce/Avoid GHG	Reduce Climate Vulnerability
Roof top Solar Photovoltaics (PV) with Energy Storage System including Battery	39.6	69.9	100	0	60	100	40	80	100	100	100
Floating Solar platforms	100	9.6	80	20	0	80	60	80	80	80	100
On-shore wind energy and small scale urban vertical axis rooftop wind turbines	93.8	0	60	40	40	0	20	80	60	40	100
Wave to Energy Convertors	0	100	40	100	20	60	0	80	40	20	100
Standards and Labeling Program for Electrical Appliances	0	0	20	80	100	40	100	80	20	60	100
Energy policy and regulatory interventions	0	0	0	60	80	20	80	80	0	0	100
Criterion weight	20	15	5	5	5	5	5	7	10	10	13
Criterion weight, sensitivity	10	10	10	15	15	15	5	5	5	5	5

	Costs			Benefits									
				Economic	Social		Environmental		Climate related				
	Capital Cost (USD per MWh)	O&M Cost (USD per KW per year)	Sustainable Financing	Job Creation			Reduces Priority Waste Streams	Support Ecosystem Services	Alignment with National Priority	Reduce/Avoid GHG	Reduce Climate Vulnerability	Total Benefit	Technology Rank
Roof top Solar Photovoltaics (PV) with Energy Storage System including Battery	396	699	1000	0	600	1000	400	800	1000	1000	1000	7895	1
Floating Solar platforms	1000	96	800	200	0	800	600	800	800	800	1000	6896	2
On-shore wind energy and small scale urban vertical axis rooftop wind turbines	938	0	600	400	400	0	200	800	600	400	1000	5338	5
Wave to Energy Convertors	0	1000	400	1000	200	600	0	800	400	200	1000	5600	4
Standards and Labeling Program for Electrical Appliances	0	0	200	800	1000	400	1000	800	200	600	1000	6000	3
Energy policy and regulatory interventions	0	0	0	600	800	200	800	800	0	0	1000	4200	6
Criterion weight	10	10	10	15	15	15	5	5	5	5	5	100	

The priorities that are identified for carrying out barrier analysis and action plan are;

1. Roof top Solar Photovoltaics (PV) with Energy Storage System including Battery
2. Floating Solar Platforms

CHAPTER FOUR: TECHNOLOGY PRIORITIZATION FOR WASTE MANAGEMENT SECTOR

This chapter explains the prioritization for the Waste Management sector based on the MCA of technologies.

4.1 GHG Emissions for the sector and existing technologies in the waste management sector.

From the IPCC sectors for GHG inventory, waste sector has the smallest contribution to the GHG emissions in Maldives. A total of 63.99 Gg of CO_2 equivalent is emitted from the waste sector. A detail analysis of waste sector emission is given in the section1.4.1.1.2 of this report.

The current solid waste practices in Maldives include management of the solid waste at island level through utilization of equipment such as compactors, crushers as well as composting technologies such as windrow composting and in-vessel composting. Each inhabited island has a designated site known as Island Waste Management Centre for management of solid waste produced in that island. Solid waste which are unable to be management at an island level are transferred to regional waste management centre.

Donor agencies including ADB and World Bank group is implementing large scale solid waste management project in Maldives. These projects are focused on establishment of waste to energy plants, bio-gas production plants and facilities for management of hazardous waste.

4.2 Decision Context

The decision context of prioritizing technologies in the waste management sector are determined by economic, political, social and technological influences. In terms of sustainable development, the solid waste sector is important in addressing challenges related to population health, environment protection and economic development. Solid waste management is considered as one of the most significant environmental challenges faced by Maldives.

Policies discussed earlier show that there are objectives in the sector relevant to mitigating GHG emissions through improved waste management practices.

4.3 Overview of Mitigation technology options

4.3.1 Waste to Energy Facilities in Regional Waste Management Facilities

Two waste to Energy plants are planned one for Greater Male' Region and one for southern most atoll of the Maldives.

- 8MW waste to energy plant to be installed at Thilafushi as solution for regional waste management
- 1.5MW waste to energy plant installed at Addu City as solution for regional waste management.

4.3.2 Biogas Production from Organic Waste

Biogas production from the organic waste has been proposed for the islands of Zone 6 & 7 as a waste management solution. The organic waste undergoes anaerobic composting and produce gas which is suitable for cooking or electricity production.

4.3.3 In vessel aerobic Composting

In vessel composting is planned to be practice is many Island Waste Resources Management Centres across the country. This aerobic technology requires a small Organic Waste Convertor (OWC) machine and will replace traditional manual composting (windrow based systems). The following Figure 10 is a picture of the OWC machine.

Figure 10: OWC machine used for production of compost

4.4 Identified Policy Interventions for the Waste Management Sector

4.4.1 A national policy framework for Waste Management and Pollution Prevention.

The main strategy in the Strategic Action Plan of the Government of Maldives 2019 to 2023 include the following in terms of waste sector policy and regulatory framework

- Review and revise the current legislative, regulatory and institutional framework on waste management;

The main actions under this strategy include the following;

- Review and enact Waste Management Law;
- Review the existing protocol on approving new infrastructure projects related to waste management in light of the amendments brought to the waste management governance framework
- Review mandates of local councils on waste management
- Develop the regulatory framework for Public Private Partnership in waste management services
- Develop regulations and guidelines for use, handling, and disposal of all types of chemical and hazardous waste

- Develop legal and regulatory framework to reduce import, use, and manufacture of single-use plastics
- Develop a national policy framework on pollution prevention
- Develop a framework for extended producer responsibility or other product stewardship programmes
- Develop and implement a National Recycling Strategy
- Enforce regulation on Anti Littering through stricter fines, policing and strengthened reporting mechanisms
- Develop and implement an SOP for waste segregation at the household level in all administrative islands.

4.4.2 Improvement of waste sector data collection including waste audits

New amendments to the Waste Management Regulation (2013) are aimed to improve the data collection for the waste sector. Waste Management and Pollution Prevention Department of Ministry of Environment, Climate Change and Technology is currently developing a database along with the newly assigned mandates to the local government council is expected to improve the data collection for GHG inventory purposes as well as policy formulation process.

4.5 Criteria and Process for Technology Prioritization for Waste Management Sector

The criteria were elaborated and presented to the waste management sector working group members by the national consultant on Initial meeting held on 10th October 2021. The proposed criteria were finalized in consultation with the working group members.

The assigning of weight for each of the criteria was done during the MCA exercise on 09th December 2021. The following Table 15 describe the criteria and assigned weights used for the MCA for the Waste Management sector. The Table 16 gives the detailed information on the criteria used by the working group during the MCA exercise.

Table 15: The criteria finalized and assigned weightage for each criteria by working group members for waste management sector

Level 1	Level 2	Level 3	Weight Assigned
Cost (30%)	Capital Cost		10%
	Maintenance Cost		15%
	Sustainable Financing		05%
Benefits (70%)	Economic	Job Creation	05%
	Social	Gender Impacts	05%
		Capacity Building	10%
	Environmental	Reduces Priority Waste Streams	10%
		Support Ecosystem Services	10%

	Climate related	Alignment with National Priorities	15%
		Avoid/Reduce GHG	10%
		Reduce Climate change vulnerabilities	05%

Table 16: The detailed information on the criteria for the scoring exercise as part of the multi-criteria analysis

Category	Subcategory	Criteria	Potential Indicator	Type of Score (Qualitive/ Quantitative)	Preferred Value	Data Source
Cost	Cost	Capital cost Operation and Maintenance cost	Capital Cost per unit of energy produced	Qualitative (High/Low)	Lower	Technology provider/ specifications
		Sustainable funding options (Private sector, public sector, Development Partner)	No. of projects funded by donor agencies and private sector	Qualitative (High/Low)	Higher	Expert Judgement/financial data
Benefit	Economic	Job Creation	No. of jobs created per project	Qualitative (High/Low)	Higher	Expert Judgement
	Social	Potential for gender impacts and reduces inequity	No. of women benefited from the technology	Qualitative (High/Low)	Higher	Expert Judgement
		Capacity development	No. of staff trained per project	Qualitative (High/Low)	Higher	Expert Judgement
	Environmental	Reduces priority waste streams	Types of waste stream generated or managed by the technology	Qualitative (High/Low)	Higher	Expert Judgement
		Support ecosystem services	Potential to improve air quality	Qualitative (5 – point scale)	Higher	Expert Judgement/ monitoring data

	Climate Related	Alignment with national Priorities	Endorsement by SAP and NDC	Qualitative (High/Low)	Higher	Review of Literature
		Reduce/avoid GHG	GHG emission reduction ($kgCO_2e$)	Qualitative (High/Low)	Higher	Technical Specifications and modelling
		Potential to reduce vulnerability and build climate resilience	Any co-benefits for climate change adaptation	Qualitative (5 – point scale)	Higher	Expert Judgement

4.5 Results of Technology Prioritization in Waste Management Sector

The following section of the report includes the performance matrix, normalization and scoring matrix and decision matrix for the waste management sector MCA.

4.5.1 Performance Matrix

The following Performance Matrix table was used for stakeholder consultations for MCA. The stakeholders were asked to assign the scores based on the information of the criteria as given above (Table 16) and the fact sheets.

Table 17: The performance matrix for the waste management sector MCA

List of Technologies	Costs			Benefits							
				Economic	Social		Environmental		Climate related		
	Capital Cost	O&M Cost	Sustainable Financing	Job Creation	Gender Impact	Capacity Building	Reduces Priority Waste Stream	Support Ecosystem Services	Alignment with National Priority	Reduce/Avoid GHG	Reduce Climate Vulnerability
Waste to Energy Facilities in Regional Waste Management Facilities	High	High	Low	High	High	High	High	3	High	High	4
Biogas Production from Organic Waste	High	High	High	High	High	High	High	4	High	Low	3
In vessel aerobic Composting	Low	High	High	High	High	High	High	4	High	Low	3
A national policy framework for Waste Management and Pollution Prevention.	Low	Low	High	High	High	High	High	5	High	Low	5
Improvement of waste sector data collection including waste audits	Low	Low	High	High	High	High	High	5	High	Low	5

4.5.1 Scoring and Normalization Matrix

The information provided by the stakeholders on the performance matrix was normalized and scoring was done by the national consultant.

Table 18: The scoring and normalization matrix for the waste management sector

List of Technologies	Costs			Benefits							
				Economic	Social		Environmental		Climate related		
	Capital Cost	O&M Cost	Sustainable Financing	Job Creation	Gender Impact	Capacity Building	Reduces Priority Waste Streams	Support Ecosystem Services	Alignment with National Priority	Reduce/Avoid GHG	Reduce Climate Vulnerability
Waste to Energy Facilities in Regional Waste Management Facilities	0	0	0	60	60	60	60	60	60	100	80
Biogas Production from Organic Waste	20	20	20	20	20	20	20	80	20	0	60
In vessel aerobic Composting	40	40	60	0	0	0	0	80	0	20	60
A national policy framework for Waste Management and Pollution Prevention.	100	100	100	100	100	100	100	100	100	80	100
Improvement of waste sector data collection including waste audits	80	80	80	80	80	80	80	100	80	60	100
Criterion weight	10	15	5	5	5	10	10	10	15	10	5

4.5.2 Decision Matrix

Based on the normalized scores the technologies were prioritized and the results were shared and endorsed by the stakeholders in the working group.

Table 19: Decision Matrix for the Waste Management Sector

List of Technologies	Costs			Benefits								Total score	Rank
				Economic	Social		Environmental		Climate Related				
	Capital Cost	O& M Cost	Sustainable Financing	Job Creation	Gender Impact	Capacity Building	Reduces Priority Waste Streams	Support Ecosystem Services	Alignment with National Priority	Reduce/Avoid GHG	Reduce Climate Vulnerability		
Waste to Energy Facilities in Regional Waste Management Facilities	0	0	0	300	300	600	600	600	900	1000	400	4700	3
Biogas Production from Organic Waste	200	300	100	100	100	200	200	800	300	0	300	2600	4
In vessel aerobic Composting	400	600	300	0	0	0	0	800	0	200	300	2600	5
A national policy framework for Waste Management and Pollution Prevention.	1000	1500	500	500	500	1000	1000	1000	1500	800	500	9800	1
Improvement of waste sector data collection including waste audits	800	1200	400	400	400	800	800	1000	1200	600	500	8100	2
Criterion weight	10	15	5	5	5	10	10	10	15	10	5	100	

The priorities that are identified for carrying out barrier analysis and action plan are;

Policy Interventions

1. A national policy framework for Waste Management and Pollution Prevention.
2. Improvement of waste sector data collection including waste audits

Technologies

1. Waste to Energy Facilities in Regional Waste Management Facilities

CHAPTER FIVE: TECHNOLOGY PRIORITIZATION FOR TRANSPORT SECTOR

This chapter explains the prioritization for the Waste Management sector based on the MCA of technologies.

5.1 GHG Emissions for the sector and existing technologies in the transport management sector.

Transport sector is the second main contributors to GHG emissions in Maldives. Transport sector accounts for 380.84 Gg of CO_2 equivalent in the year 2015. A detail overview of GHG emissions from transport sector is provided in the section 1.4.1.1.3 of this report.

The country's isolation and highly scattered population makes transport of people, goods, and services fuel-intensive and very expensive. While all inhabited islands are served by a basic nationwide transportation network of ferries and jetties, connectivity across the low-lying islands needs to be improved to sustain the development efforts of Maldives.

The estimated consumption of diesel fuel used in sea transport has grown at a rapid pace in the past decade. Between 2017 and 2019, the annual consumption of diesel used in vessels grew from 149,000 tons to 195,000 tons. The number of registered vessels has increased in the period 2010–2018 from 9,687 to 14,003.[9]

A large part of the fuel used in land transportation is consumed in the Greater Male' Region and in Addu City. Other inhabited islands and resorts, industrial, and agricultural islands also have vehicles, though they are lower in number. The estimated consumption of petrol used in road transport also grew at a rapid pace in the past decade. Between 2017 and 2019, the annual consumption of petrol used in road transport grew from 58,000 tons to 85,000 tons. The number of registered vehicles has more than doubled in the period 2010–2018, from 46,028 to 108,532. Motorcycles account for 83% of all vehicles with an active registration in 2018. Same as with vessels, there is no information on the year of manufacturing, efficiency, and amount of CO2 emissions of registered road vehicles.[10]

5.2 Decision Context

The decision context of prioritizing technologies in the transport are determined by economic, political, social and technological influences. Even though, transport sector has one of the highest contribution to not many climate change mitigation activities has been implemented for the transport sector.

Maldives Low Carbon Development Strategies (2014) outlines some of the potential mitigation measures which can be implemented in the transport sector and these mitigation actions are included in the INDC (2015) and updated NDC (2020). The SAP 2019-2023 confirms the intention of the government to implement climate change mitigation actions in the transport sector.

[9] Asian Development Bank (2020) "A Brighter Future for Maldives Powered By Renewables Road Map for the Energy Sector 2020–2030".
[10] ibid

5.3 Overview of Mitigation technology options

The following Table 20 provides the mitigation technology options for the transport sector including some of the identified policy incentives.

Table 20: Proposed mitigation technologies for the transport sector

Proposed Technology	Description
Fuel Switching and Introduction of bio-fuels	Introduction of biodiesel and bio-ethanol along with incentives to modify the existing vessels and vehicles.
Hybrid Solar Boats	Introduce hybrid solar boats for short-distance travel, particularly for tourism purposes. Electric motors in hybrid vehicles run on batteries charged with power supplied by solar panels mounted on the boat. Hybrid solar boats have the advantage of no sound and vibrations and fuel odor free when propelled by the electric motor
Electric Vehicles	Introduction of electric buses, vehicles and motorbikes with appropriate infrastructure like charging stations.

5.4 Identified Policy Interventions

The following policy interventions has been identified for the transport sector through stakeholder consultations.

Table 21: Identified Policy Interventions for transport sector

Proposed policy intervention	Description
Replacement of old vehicles	Replace existing vehicles, motorbikes with more efficient units, including hybrid vehicles, with the support of a government incentives program
Reduction in vehicle registrations	The global trend is to move from the use of personal vehicles to efficient and sustainable public transportation. This trend may be facilitated by placing restrictions on the issuance of new registrations or putting restrictions on the age of vehicles allowed on the roads.

5.5 Criteria and Process for Technology Prioritization for Transport Sector

The criteria were elaborated and presented to the waste management sector working group members by the national consultant on Initial meeting held on 13th October 2021. The proposed criteria were finalized in consultation with the working group members.

The assigning of weight for each of the criteria was done during the MCA exercise on 22nd December 2021. The following Table 22 describe the criteria and assigned weights used for the MCA for the Transport sector. The Table 23 are the detailed information on the criteria used by the working group during the MCA exercise.

The assigning of 50% for cost and 50% to benefit was based on the discussion in the transport sector working group and consensus was achieved during the prioritization exercise.

Table 22: The criteria used for MCA of Transport Sector

Level 1	Level 2	Level 3	Weight Assigned
Cost (50%)	Capital Cost		10%
	Maintenance Cost		20%
	Sustainable Financing		20%
Benefits (50%)	Economic	Job Creation	05%
	Social	Gender Impacts	05%
		Capacity Building	10%
	Environmental	Reduces Priority Waste Streams	05%
		Support Ecosystem Services	10%
	Climate related	Alignment with National Priorities	05%
		Avoid/Reduce GHG	05%
		Reduce Climate change vulnerabilities	05%

Table 23: The detailed information on the criteria for the scoring exercise as part of the multi-criteria analysis

Category	Subcategory	Criteria	Potential Indicator	Type of Score (Qualitive/ Quantitative)	Preferred Value	Data Source
Cost	Cost	Capital cost Operation and Maintenance cost	Capital Cost per unit of energy produced	Qualitative (High/Low)	Lower	Technology provider/ specifications
		Sustainable funding options (Private sector, public sector, Development Partner)	No. of projects funded by donor agencies and private sector	Qualitative (High/Low)	Higher	Expert Judgement/financial data
Benefit	Economic	Job Creation	No. of jobs created per project	Qualitative (High/Low)	Higher	Expert Judgement
	Social	Potential for gender impacts and reduces inequity	No. of women benefited from the technology	Qualitative (High/Low)	Higher	Expert Judgement
		Capacity development	No. of staff trained per project	Qualitative (High/Low)	Higher	Expert Judgement
	Environmental	Reduces priority waste streams	Types of waste stream generated or managed by the technology	Qualitative (High/Low)	Higher	Expert Judgement
		Support ecosystem services	Potential to improve air quality	Qualitative (5 – point scale)	Higher	Expert Judgement/ monitoring data

	Climate Related	Alignment with national Priorities	Endorsement by SAP and NDC	Qualitative (High/Low)	Higher	Review of Literature
		Reduce/avoid GHG	GHG emission reduction ($kgCO_2e$)	Qualitative (High/Low)	Higher	Technical Specifications and modelling
		Potential to reduce vulnerability and build climate resilience	Any co-benefits for climate change adaptation	Qualitative (5 – point scale)	Higher	Expert Judgement

5.6 Results of Technology Prioritization in Transport Sector

The following section of the report includes the performance matrix, normalization and scoring matrix and decision matrix for the transport sector MCA.

5.6.1 Performance Matrix

The following Performance Matrix table was used for stakeholder consultations for MCA. The stakeholders were asked to assign the scores based on the information of the criteria as given above (Table 23) and the fact sheets.

Table 24: Performance Matrix for the Transport sector

List of Technologies	Costs			Benefits							
				Economic	Social		Environmental		Climate related		
	Capital Cost	O&M Cost	Sustainable Financing	Job Creation	Gender Impact	Capacity Building	Reduces Priority Waste Stream	Support Ecosystem Services	Alignment with National Priority	Reduce/Avoid GHG	Reduce Climate Vulnerability
Fuel Switching and Introduction of bio-fuels	High	High	Low	Low	Low	Low	Low	4	Low	High	2
Hybrid Solar Boats	High	High	High	High	Low	High	Low	5	High	High	5
Replacement of old vehicles	Low	Low	High	Low	High	Low	Low	5	High	High	3
Electric buses, vehicles, and motorbikes.	High	High	High	Low	High	High	Low	5	High	High	4
Reduction in vehicle registrations	Low	Low	High	High	High	High	Low	5	High	High	4

5.6.2 Scoring and Normalization Matrix

The information provided by the stakeholders on the performance matrix was normalized and scoring was done by the national consultant.

Table 25: Scoring and Normalization Matrix for Transport Sector

List of Technologies	Costs			Benefits							
				Economic	Social		Environmental		Climate related		
	Capital Cost	O&M Cost	Sustainable Financing	Job Creation	Gender Impact	Capacity Building	Reduces Priority Waste Streams	Support Ecosystem Services	Alignment with National Priority	Reduce/Avoid GHG	Reduce Climate Vulnerability
Fuel Switching and Introduction of bio-fuels	40	40	0	20	20	0	60	50	0	0	20
Hybrid Solar Boats	20	20	60	80	0	60	100	100	40	60	100
Replacement of old vehicles	60	80	80	60	60	20	0	100	60	80	60
Electric buses, vehicles, and motorbikes.	0	0	100	0	100	100	80	100	100	20	80
Reduction in vehicle registrations	100	100	20	100	80	80	20	100	80	100	80
Criterion weight	10	20	20	5	5	10	5	10	5	5	5

5.6.3 Decision Matrix

Based on the normalized scores the technologies were prioritized and the results were shared and endorsed by the stakeholders in the working group.

Table 26: Decision Matrix for the Transport Sector

List of Technologies	Costs			Benefits								Total score	Rank
				Economic	Social		Environmental		Climate Related				
	Capital Cost	O&M Cost	Sustainable Financing	Job Creation	Gender Impact	Capacity Building	Reduces Priority Waste Streams	Support Ecosystem Services	Alignment with National Priority	Reduce/Avoid GHG	Reduce Climate Vulnerability		
Fuel Switching and Introduction of bio-fuels	400	800	0	100	100	0	300	500	0	0	100	2300	5
Hybrid Solar Boats	200	400	1200	400	0	600	500	1000	200	300	500	5300	4
Replacement of old vehicles	600	1600	1600	300	300	200	0	1000	300	400	300	6600	2
Electric buses, vehicles, and motorbikes.	0	0	2000	0	500	1000	400	1000	500	100	400	5900	3
Reduction in vehicle registrations	1000	2000	400	500	400	800	100	1000	400	500	400	7500	1

The priorities that are identified for carrying out barrier analysis and action plan are;

Policy Interventions

1. Reduction in vehicle registrations Improvement of waste sector data collection including waste audits
2. Replacement of old vehicles

Technologies

1. Electric buses, vehicles, and motorbikes.
2. Hybrid Solar Boats

CHAPTER SIX: SUMMARY AND CONCLUSION

Climate change mitigation technology prioritization took multiple factors into account. Relevant policies, regulations and plans in Maldives provided directions on selection of sectors as well selection of technologies for each of the key sector selected. The high GHG emissions from Electricity Generation and consumption sector and transport sector provided rationale for selection of these sectors. Waste Management sector is a key development priority for Maldives and it is considered as a GHG intensive sector due to lack of proper infrastructure and means for management of solid waste. The rationale for selection also considered the current capacity needs and strengths of sectors including the level of activity already underway in various sectors, and the extent to which regulatory and institutional arrangements were in place to support climate technology developments in each sector. The progress against RE actions already underway was also a consideration.

The stakeholders were consulted during the elaboration of the long list of technologies, determination of criteria for MCA, assigning of weightage for the identified criteria and during the MCA process. The process relied heavily on the expertise and experience of the Working group members who established a common understanding of the criteria for appraising technologies. The following are the results of prioritizing sectors and technologies;

For **Electricity Generation and Consumption sector**, prioritized technologies for the barrier analysis and action plans are:

1. Roof top Solar Photovoltaics (PV) with Energy Storage System including Battery
2. Floating Solar Platforms

For **Waste Management sector**, prioritized technology for the barrier analysis and action plan is:

Policy Interventions

1. A national policy framework for Waste Management and Pollution Prevention.
2. Improvement of waste sector data collection including waste audits

Technologies

3. Waste to Energy Facilities in Regional Waste Management Facilities

For **Transport sector**, prioritized technology for the barrier analysis and action plans are:

Policy Interventions

1. Reduction in vehicle registrations Improvement of waste sector data collection including waste audits
2. Replacement of old vehicles

Technologies

3. Electric Vehicles
4. Hybrid Solar Boats.

Reference List

Asian Development Bank (2020) “A Brighter Future for Maldives Powered by Renewables Road Map for the Energy Sector 2020–2030”.

Maldives Energy Authority (2019) “Island Electricity Data Book 2019”

Ministry of Environment and Energy (2015) “Intended Nationally Determined Contribution (INDC)”

Ministry of Environment (2019), “Maldives First Biennial Update Report under the UNFCCC”

Ministry of Environment (2020), “Updated Nationally Determined Contribution”

Ministry of Environment and Energy (2015), “Maldives Climate Change Policy Framework”

UNDP (2010), “Guidebook for conducting Technology Needs Assessment”.

UNEP DTU Partnership (2018), “Guidance for a gender responsive Technology Needs Assessment”.

UNEP DTU Partnership (2019), “TNA Step by Step – A guidebook for countries conducting a Technology Needs Assessment and Action Plan”.

UNEP Riso Centre (2014), “Low Carbon Development Strategies”

World Bank Group (2020) “Project Appraisal Document of the Accelerating Sustainable Private Investments in Renewable Energy (ASPIRE) Project”

List of Annexes

ANNEX 1: TECHNOLOGY FACTSHEETS FOR SELECTED TECHNOLOGIES
ANNEX 2: LIST OF STAKEHOLDERS INVOLVED AND THEIR CONTACTS

ANNEX 3: LONG-LIST OF TECHNOLOGIES FOR 3 SECTORS

ANNEX 1: TECHNOLOGY FACTSHEETS FOR SELECTED TECHNOLOGIES

These factsheets and long list of technologies were used to inform the stakeholders during the MCA process.

Electricity Production & Consumption Fact Sheet 1

Technology:	Roof top Solar Photovoltaics (PV) with Energy Storage System including Battery
Sector:	Electricity Generation and Consumption sector
Priority Alignment	SAP 2019-2023, Maldives Energy Policy, INDC and NDC
Background:	Solar PV energy is an indigenous resource with the most immediate exploitation possibilities in Maldives. Solar radiation is in the order of 1,200 kWh/m2/year5, which is considered good for any solar PV project. The solar PV project is being successfully implemented in hybrid systems in several inhabited islands through the Preparing Outer Islands for Sustainable Energy Development (POISED) project. PV panels are installed on the roofs of diesel power plants, schools, water desalination plants, sewage plants, and public buildings. PV panels are connected to the diesel power plants through an energy management system (EMS) that enhances the regulation of power supply. This hybrid configuration can offer short pay back times when compared to current prices of electricity produced by diesel generation sets. Rooftop solar PV is also being installed in the country, under net metering.
Climate Change Rationale:	Installation of the Solar PV will enable significant reduction in the cost for transport and purchase of fossil fuel and reduce the GHG from diesel-based electricity generation. Furthermore, the Solar PV with battery systems will enhance the energy security on the country.
Implementing Agency:	Ministry of Environment, Climate Change and Technology and private sector
Estimated Cost:	A solar-plus-storage system costs about $25,000–$35,000 for KWH, depending on the size of the battery and other factors in 2020. The battery system itself cost between $12,000 to $22,000 for KWH in 2020.[11]

[11] Due to lack of local costs, international cost used.

Developmental Impacts: Economic, Environmental, Social and Political	**Economic:** Though initial investment is high, all the electricity produced is free and is profitable in the long run. Incentives and rebates offered by governments and utilities can compensate for the high prices. Further, with advancements in the technology, cost of solar panels are decreasing while efficiency is increasing. **Social:** Solar energy can help provide a source of energy to far-flung and isolated island communities. There can be many jobs created in the solar sector, such as meet the demand for trainers and technicians. **Environmental:** Solar PV systems, once manufactured, are closed systems; during operation and electricity production they require no inputs such as fuels, nor generate any outputs such as solids, liquids, or gases (apart from electricity). They are silent and vibration free and can broadly be considered, particularly when installed on brownfield sites, as environmentally benign during operation. The main environmental impacts of solar cells are related to their production and decommissioning.
Present Status:	There are number of projects funded by donor agencies which install roof-top solar PVs and battery storage.

Electricity Production & Consumption Fact Sheet 2

Technology:	Floating Solar Platforms
Sector:	Electricity Generation and Consumption Sector
Priority Alignment	SAP 2019-2023, Maldives Energy Policy, INDC and NDC
Background:	Floating solar PV platforms is a good alternative for some islands. These are platforms moored in the sea with mounted PV arrays on top. These PV floating platforms are connected to the island's grid using a submarine cable. These platforms must be placed in areas close to the islands and with low wave activity to ensure their operations withstand. Effects of salinity over the solar panels must also be considered in the design.
Climate Change Rationale:	Installation of the Solar PV will enable significant reduction in the cost for transport and purchase of fossil fuel and reduce the GHG from diesel-based electricity generation. Furthermore, the Solar PV with battery systems will enhance the energy security on the country.
Implementing Agency:	Ministry of Environment, Climate Change and Technology and Private sector particularly tourism sector

Estimated Cost:	Capital costs of floating PV are still slightly higher or comparable to those of ground-mounted PV, in 2018 generally ranging between USD 0.8–1.2 per Wp depending on location.[12] However, the levelized cost of electricity (LCOE) for a generic 50 MW floating PV system does not differ significantly from that of a ground-mounted system.[13]
Potential Issues	• Electrical safety and long-term reliability of system components: Operating on water over its entire service life, the system is required to have significantly increased corrosion resistance, particularly when installed over salt water. • Waves: The floating PV system needs to be able to withstand wind and heavy waves, particularly in off-shore or near-shore installations. • Maintenance complexity: Operation and maintenance activities are as a general rule more difficult to perform on water than on land
Developmental Impacts: Economic, Environmental, Social and Political	**Economic:** Though initial investment is high, all the electricity produced is free and is profitable in the long run. Incentives and rebates offered by governments and utilities can compensate for the high prices. Further, with advancements in the technology, cost of solar panels is decreasing while efficiency is increasing. **Social:** Solar energy can help provide a source of energy to far-flung and isolated island communities. There can be many jobs created in the solar sector, such as meet the demand for trainers and technicians. **Environmental:** The floating solar platforms may affect the benthic organism found under the platform.
Present Status:	World Bank Group Funded project "Accelerating Renewable Energy Integration and Sustainable Energy" (ARISE) is implementing floating solar platforms in various islands of Maldives.

Waste Management Fact Sheet 1

Technology:	Waste to Energy Facilities in Regional Waste Management Facilities
Sector:	Waste Management Sector

[12] Asian Development Bank (2020) "A Brighter Future for Maldives Powered by Renewables Road Map for the Energy Sector 2020–2030"
[13] ibid

Priority Alignment	SAP 2019-2023, INDC and NDC
Background:	Two waste to Energy plants are planned one for Greater Male' Region and one for southern most atoll of the Maldives. • 8MW waste to energy plant to be installed at Thilafushi as solution for regional waste management • 1.5MW waste to energy plant installed at Addu City as solution for regional waste management.
Climate Change Rationale:	Waste to Energy Plants is expected to reduce the waste which are open burnt and the incineration process is controlled hence the GHG emissions from open burning process is avoided.
Implementing Agency:	Ministry of Environment, Climate Change and Technology and WAMCO
Estimated Cost:	The capital cost of Waste to energy is considered to be extremely high. Currently, feasibility studies are being conducted to determine the O&M cost of the Waste to Energy Plants in Maldives.
Developmental Impacts: Economic, Environmental, Social and Political	**Economic:** The energy produced from Waste to energy plants will be less costly than diesel-based electricity generation. Furthermore, the indirect benefits arising from the proper management Municipal Solid Waste would be enormous **Social:** Eliminate the health risk involved in open burning of Municipal Solid waste and improper management of Municipal Solid waste. **Environmental:** Improvement in air quality since open buring of Municipal solid waste will be significantly reduced. The controlled incineration process of Waste to Energy Plant will have pollution control measures installed.
Present Status:	Donor funded projects are being implemented in the Greater Male' Area and Addu City.

Transport Fact Sheet 1

Technology:	Electric Vehicles
Sector:	Transport Sector
Priority Alignment	SAP 2019-2023
Background:	Introduction of electric buses, vehicles and motorbikes with appropriate infrastructure like charging stations.
Climate Change Rationale:	The fossil fuel used for land based transport will be significantly reduced through introduction of Electric Vehicles.

Implementing Agency:	Ministry of Transport
Estimated Cost:	Capital Cost: Conventionally, EVs were about 2-3 times more expensive than the internal combustion engine vehicles (ICEV) mainly due to high cost of the batterypack. This cost will be significantly higher for a country like Maldives since the cost of transportation and other logistical costs are extremely high. Operational Cost: EVs have low operating costs in terms of energy use and maintenance. IRENA (2013) and Simpson (2011) stated that battery costs dominate the costs of EVs.
Developmental Impacts: Economic, Environmental, Social and Political	**Economic:** • The introduction of EVs will improve energy security and reduce dependence on imported petroleum-based products. • EVs can be recharged with electricity produced from local sources. • EVs can be supported through augmentation of existing electrical energy infrastructure in the short term. It is important to ensure that the electrical energy is from renewable sources. **Social:** • Electric motors are cheaper and more efficient than internal combustion engines and reduce local pollutant emissions, providing indirect health benefits. • EVs are economical to operate, thus, allowing for cost savings from the use of less energy and maintenance. It means more money is available for other purposes. **Environmental:** • As a result of producing zero tailpipe exhaust emissions such as soot or NOx, EVs contribute to improvements in local air quality, especially in urban areas. • EVs are characteristically more silent than conventional vehicles with internal combustion engines and therefore reduce the overall noise levels in urban areas.
Present Status:	Electric Motorcycles are being utilized however the official statistics on the no. of electric vehicles are missing in the country. A GEF funded project on Electricity Mobility and Vehicles is currently implemented by the MECCT.

Transport Factsheet 2

Technology:	Solar Hybrid Boats

Sector:	Transport Sector
Priority Alignment	SAP 2019-2023
Background:	Introduce hybrid solar boats for short-distance travel, particularly for tourism purposes. Electric motors in hybrid boats run on batteries charged with power supplied by solar panels mounted on the boat. Hybrid solar boats have the advantage of no sound and vibrations and fuel odor free when propelled by the electric motor
Climate Change Rationale:	The fossil fuel used for tourism sector speed boats especially for short trips will be reduced thus decreasing the GHG emission from transport sector.
Implementing Agency:	Ministry of Transport
Estimated Cost:	N/A
Developmental Impacts: Economic, Environmental, Social and Political	**Economic:** • Enhance energy security by reduction of fossil fuel import particularly diesel and petrol. **Social:** • Reduce health impacts involved with air pollutants from diesel and petrol-based sea transport. **Environmental:** • Improve air quality by reduction of air pollutants from diesel-based sea transport.
Present Status:	Currently not piloted in the country

ANNEX 2: LIST OF STAKEHOLDERS INVOLVED AND THEIR CONTACTS

Electricity Generation and Consumption Sector

Name	Organization	Email Address	Consultation Approach	Topics
Mohamed Shujuan Ibrahim	Utilities Regulatory Authority (URA)	mohamed.shujuan@ura.gov.mv	Face to Face and workshop	MCA
Abdul Rasheed	Energy Department	abdul.rasheed@environment.gov.mv	Face to Face and Workshop	MCA
Fathimath Fiuna Rasheed	Energy Department	Fathimath.fiuna@environment.gov.mv	Face to Face and Workshop	MCA
Mariyam Mooha Midhath	STELCO	Mariyam.moohamidhath@stelco.com.mv	Face to Face and Workshop	MCA
Rifaah Ali Jaleel	FENAKA Corporation	jaleel@fenaka.com.mv	Face to Face and Workshop	MCA
Ibrahim Fikree	Ministry of Tourism	Ibrahim.fikree@tourism.gov.mv	Online meeting, Email communication	Mitigation options in tourism sector, MCA, mitigation policies regarding tourism sector
Iqbal Ismail	Maldives Customs Service	Ismail.iqbal@customs.gov.mv	Online meeting, Email communication	Fuel imports data and MCA criteria
Abdul Malik Thaufeeq	STELCO	malik@stelco.com.mv	Online meeting, Email communication	RE projects implemented by STELCO and MCA criteria
Abdulla Nashith	FENAKA Corporation	Nashith@fenaka.mv	Online meeting, Email communication	RE Projects implemented by FENAKA corporation and MCA criteria
Ahmed Azleem	FENAKA Corporation	Azleem@fenaka.mv	Online meeting, Email communication	RE Projects implemented by

				FENAKA corporation and MCA criteria

Waste Management Sector

Name	Organization	Email Address	Consultation Approach	Topics
Aishath Sanaya Shimree	Waste Management Corporation	Sanaya.shimree@wamco.com.mv	Face to Face Meeting	Potential Mitigation Technologies in Waste management sector and Criteria for MCA
Ismail Ubaidh	Waste Management Corporation	Ismail.ubaidh@wamco.com.mv	Face to Face Meeting	Potential Mitigation Technologies in Waste management sector and Criteria for MCA
Ismail Ajmal	Waste Management and Pollution Control Department, MECCT	Ismail.ajmal@wamco.com.mv	Face to Face Meeting, Email communications Workshop	MCA, Potential Mitigation Technologies in Waste Management Sector and criteria for MCA

Transport Sector

Name	Organization	Email Address	Consultation Approach	Topics
Ismail Firag	Maldives Transport and Contracting Company (MTCC)	Ismail.firaq@mtcc.com.mv	Email communications and online meetings	Potential Mitigation options from Transport sector and Criteria for MCA

Hussain Abdul Gadhir	Maldives Airports Company Limited (MACL)	hussain.qadir@macl.aero	Email communications and online meetings	Potential Mitigation options from Transport sector and Criteria for MCA
Abdulla Hussain Rasheed	Maldives Airports Company Limited (MACL)	Abdulla.hussain@macl.aero	Email communications and online meetings	Potential Mitigation options from Transport sector and Criteria for MCA
Wahby Ismail Rasheed	Island Aviation Services Limited	Wahby.rasheed@iasl.aero	Email communications and online meetings	Potential Mitigation options from Transport sector and Criteria for MCA
Shinwaan Afeef	Manta Air	Shinwaan.afeef@mantaair.mv	Email communications and online meetings	Potential Mitigation options from Transport sector and Criteria for MCA
Shimaaz Ali	Ministry of Transport and Civil Aviation	Shimaaz.ali@transport.gov.mv	Face to Face Meeting and workshop	MCA
Aishath Maharath Muneer	Trans Maldivian Airways (TMA)	Maharath.muneer@transmaldivian.com	Face to Face Meeting and workshop	MCA
Indhra Bushan	Trans Maldivian Airways (TMA)	Indhra.bushan@transmaldivian.com	Face to Face Meeting and workshop	MCA

Participants of inception workshop

Name of the participant	Designation	Organization	Type of Stakeholder
Furugaan Ibrahim	Senior Research & Development	Male' Water and Sewerage Company (MWSC)	State-owned Enterprise
Mohamed Bassam	Assistant Engineer, Environmental	Male' Water and Sewerage Company (MWSC)	State-owned Enterprise

Ismail Ubaid	Business Development & Marketing General Manager	Waste Management Corporation (WAMCO)	State-owned Enterprise
Mohamed Zaid	System Administrator	Waste Management Corporation (WAMCO)	State-owned Enterprise
Mariyam Shizna	S. Training and Advocacy Officer	National Disaster Management Authority (NDMA)	Government Institution
Abdulla Muaz	Assistant Met Engineer	Maldives Meteorological Services (MMS)	Government Institution
Ibrahim Humaid	Seismologist	Maldives Meteorological Services (MMS)	Government Institution
Mohamed Shujuan Ibrahim	Assistant Oceanographic Observer	Utilities Regulatory Authority (URA)	Government Institution
Aleef Abdulla Naseem	Consultant	Water Solutions Pvt Ltd	Private company
Hashma Hameed	Engineer	Energy Department, Ministry of Environment, Climate Change and Technology	Government Institution
Mahid Abdul Rahman	Assistant Director	Environment Department- Coastal Protection and Disaster Risk Reduction Unit	Government Institution
Ilham Atho Mohamed	Director	Environment Department - Biodiversity	Government Institution
Mohamed Inaz	Project Manager	LECI Project	Government Institution
Fathimath Raufa Moosa	Monitoring and Evaluation Officer	LECI Project	Government Institution
Thibyan Ibrahim	Programme Officer	Environment Department - National Ozone Unit	Government Institution

ANNEX 3: LONG LIST OF TECHNOLOGIES USED FOR 3 SECTORS

Portfolio of Technologies for Maldives' Technology Needs Assessment – Climate Change Mitigation

Introduction

This document is aimed to provide the long list of technologies currently being implemented in the Maldives or currently being piloted in the Maldives. This list will provide technologies for three main sectors involved in climate change mitigation in the Maldives. These sectors include Power Production & Power Consumption, Waste Management and Transport.

This document outlines as the following; First, the methodology used for the elaboration of this long list and methodology to be utilized for prioritization of these technologies will be described. Second, the long list of technologies will be enlisted along with brief information about the technology. Third, the criteria to be utilized for the multi-criteria Analysis will be described.

Methodology

Literature review and findings from the stakeholder consultation meetings were the main method used for elaboration of the long list of technologies. The following are the main literatures reviewed.

1. Low Carbon Development Strategies (2014)
2. Low Carbon Strategy for the Transport Sector (2014)
3. Strategic Action Plan of Government of Maldives 2019 - 2023
4. Maldives' Nationally Determined Contribution (2020)
5. Biennial Update Report for the United Nations Framework Convention on Climate Change (2020)
6. A Brighter Future for Maldives Powered by Renewables – Road Map for the Energy Sector 2020 to 2030

The following were table 01 provide information on the stakeholder meetings.

Table A27: Information on the stakeholder consultations conducted

Date	Sector	Participants
20th September 2021	TNA inception workshop	30 participants from different sectors
10th October 2021	Waste Sector	Aishath Sanaya Shimry, Waste Management Cooperation Ismail Ajmal, Waste Management and Pollution Control Department, Ministry of Environment, Climate Change and Technology Mareer Mohamed Husny, TNA national coordinator Zainab Gulisthan, TNA project coordinator

13th October 2021	Power Production and Power Consumption Sector	Ahmed Nashith, Fenaka Corporation Ahmed Azleem, Fenaka Corporation Hashma Hameed, Energy Department, Ministry of Environment, Climate Change and Technology, Abdul Malik Thaufeeq, Stelco Iqbal Ismail, Maldives Customs Services Mareer Mohamed Husny, TNA national coordinator Zainab Gulisthan, TNA project coordinator
28th October 2021	Transport	Ahmed Shahmeem, Ministry of Transport Wahby Ibrahim Rasheed, Island Aviation Services Limited (IASL) Ismail Fariq, Maldives Transport and Contracting Company (MTCC)

The Main steps involved in the Multi-Criteria Analysis

The following figure 01 illustrates the key steps involved in the Multi-Criteria Analysis which will be used for prioritization of the technologies listed in the long list below.

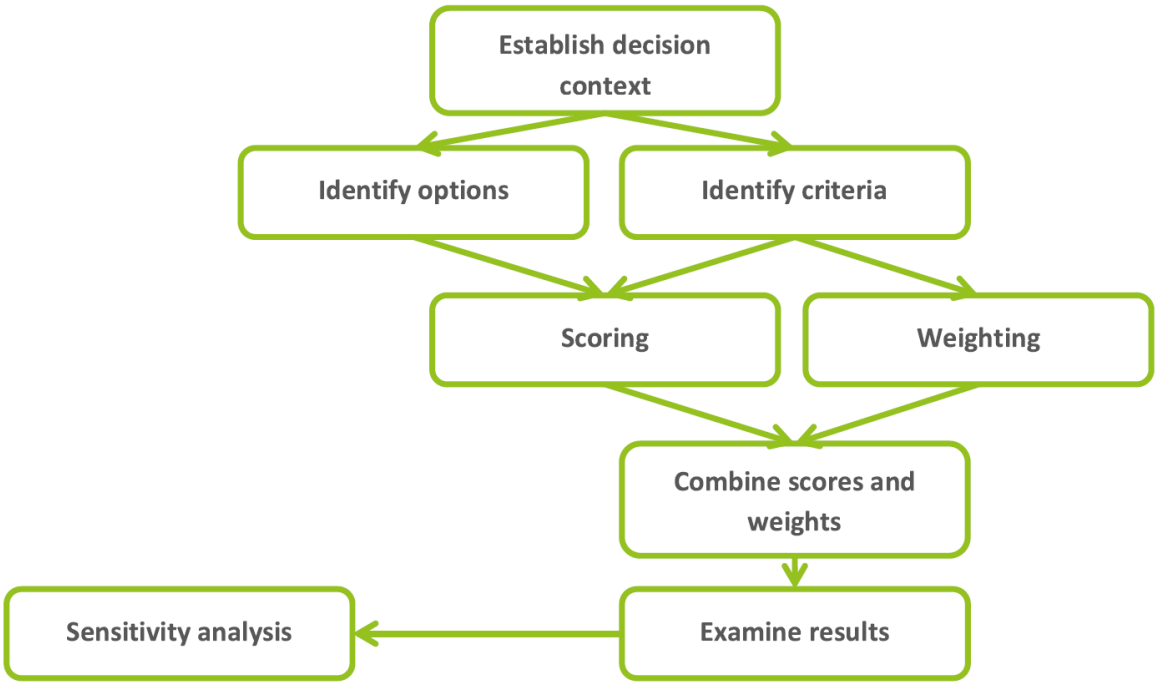

Figure A11: Steps involved in a multi-criteria analysis

The following Table 02 provide detailed information on each of the above step involved in the multi-criteria analysis.

Table A28: Detailed information on each of the step involved in the multi-criteria analysis

Steps	Involved Parties	Actions to be taken
Setting the decision context	National TNA PMU, Mitigation Expert	Analyze the current situation, assess the context in which the TNA is being carried out and establish a decision-making body. How does the TNA process relate to other national processes and/or analyses, and what goals can it help achieve?
Identifying the options of technologies and criteria for Multi Criteria Analysis (MCA) most relevant to Maldives	National TNA PMU, Mitigation Expert Sectorial Working Groups	To undertake a review of existing planning documents Prepare technology factsheets and other information for input into the MCA template
Identify the criteria and stakeholder consultation	National TNA PMU, Mitigation Expert and Working Group for Mitigation Inline stakeholders	Suggest criteria that reflect countries development priorities and conduct a validation workshop with the stakeholders.
Scoring and Weighting	National TNA PMU, Mitigation Expert and Working Group for Mitigation	1. Conduct a desk study of the existing Net Zero Plans followed by consultations with stakeholders on the performance of technology options, or the validation of quantitative values. This information should be inputted into the MCA template. 2. Organize a stakeholder discussion, facilitate discussion to obtain decision on weights, and input this information into the MCA template.
Results and Sensitivity Analysis	National TNA PMU, Mitigation Expert and Working Group for Mitigation	Calculate the overall scores of each technology option and rank them accordingly. If there are significant discrepancies among stakeholder views, then a sensitivity analysis should be performed. The main tool to be used here is the MCA template.

Long list of Technologies

The following table 02 enlist the long list of technologies and brief information on them. The list consists of three main sectors including, power production and power consumption, waste management and transport.

Table A29: Long list of Technologies for Climate Change Mitigation

Sector	Technology	Brief Information on the Technology
Power Production & Power Consumption	1. Roof top Solar Photovoltaics (PV) with Energy Storage System including Battery	Solar PV energy is an indigenous resource with the most immediate exploitation possibilities in Maldives. Solar radiation is in the order of 1,200 kWh/m2/year[14], which is considered good for any solar PV project. The solar PV project is being successfully implemented in hybrid systems in several inhabited islands through donor financed projects. PV panels are installed on the roofs of diesel power plants, schools, water desalination plants, sewage plants, and public buildings. PV panels are connected to the diesel power plants through an energy management system (EMS) that enhances the regulation of power supply. This hybrid configuration can offer short pay back times when compared to current prices of electricity produced by diesel generation sets. Rooftop solar PV is also being installed in the country, under net metering.[15]
	2. Floating Solar platforms	Floating solar PV platforms is a good alternative for some islands. These are platforms moored in the sea with mounted PV arrays on top. These PV floating platforms are connected to the island's grid using a submarine cable. These platforms must be placed in areas close to the islands and with low wave activity to ensure their operations withstand. Effects of salinity over the solar panels must also be considered in the design.[16]
	3. On-shore wind energy and small scale urban vertical axis rooftop wind turbines	Similar to rooftop solar, the urban small vertical axis rooftop wind turbines have the potential to operate in all inhabited islands under the same net-metering arrangement given to solar rooftop. These urban

[14] ADB (2014) "Toward a Carbon-Neutral Energy Sector: Maldives Energy Roadmap", 2014–2020, Manila.
[15] ADB (2020) "A Brighter Future for Maldives Powered by Renewables – Road Map for the Energy Sector 2020 to 2030", Manila.
[16] ibid

		turbines are specifically designed to work under low windspeed conditions (2 to 6 meters per second [m/s]) found in an urban environment. Conventional horizontal axis onshore wind turbines are also possible in Maldives, under certain conditions. Wind resources are not equally distributed across the country. The wind energy resource maps indicate that the northern half of the country is relatively richer in wind resource than its southern part of the country.[17] Note: Offshore wind projects with current technologies are not economically feasible for Maldives. Seawaters in the Greater Male' Region (region with the largest power demand) are very deep and the atolls have very steep slopes. This is a huge challenge for the foundations of the turbines
	4. Wave to Energy Convertors	A collaboration between Okinawa Institute of Science and Technology and Ministry of Environment, Climate Change and Technology (MECCT) a small-scale installation of Wave to Energy Convector (WEC) units in Holiday Inn Kandooma Maldives resort. The results have shown immense potential hence commercial scale WEC units has been installed and is under operation in the resort. There is immense potential to replicate this technology in other inhabited islands and tourist facilities in the Maldives.
	5. Standards and Labeling Program for Electrical Appliances	The Ministry of Environment, Climate Change and Technology (MECCT) is introducing "*Hakathari*" – an energy efficiency labeling program for appliances and equipment. The purpose of this program is to promote the use of energy-efficient appliances and equipment. The *Hakathari* program provides the consumers with a simple and clear indication of the energy-saving potential of electrical appliances, at the point of purchase. This is achieved via the *Hakathari* label affixed on the appliances that showcase a five-star rating system. A greater number of

[17] National Renewable Energy Laboratory (2003) "Wind Energy Resource Atlas of Sri Lanka and Maldives". <https://www.nrel.gov/docs/fy03osti/34518.pdf>

		stars on the label indicate a higher level of energy efficiency and energy savings. The purpose of the program is; • To encourage the purchase of energy-efficient appliances. • To help consumers make informed choices and save money on their household electricity bills. • To encourage importers and manufacturers to promote energy efficient technologies and products in the Maldivian market, bringing about a market transformation. • To reduce the emission of greenhouse gases and progress towards a sustainable future
	6. Energy policy and regulatory interventions	Supply Side interventions • Continuous revision of the tariff system • Development of technical codes and standards • Development of regulations for implementation of the newly ratified Maldives Energy Act Demand Side interventions • Improvement of the building codes for better energy efficiency
Waste Management	7. Waste to Energy Facilities in Regional Waste Management Facilities	Two waste to Energy plants are planned one for Greater Male' Region and one for southern most atoll of the Maldives. • 8MW waste to energy plant to be installed at Thilafushi as solution for regional waste management • 1.5MW waste to energy plant installed at Addu City as solution for regional waste management
	8. Biogas Production from Organic Waste	Biogas production from the organic waste has been proposed for the islands of Zone 6 & 7 as a waste management solution. The organic waste undergo anaerobic composting and produce gas which is suitable for cooking or electricity production.
	9. In vessel aerobic Composting	In vessel composting is planned to be practice is many Island Waste Resources Management Centres across the country. This aerobic technology require a small Organic Waste Convertor (OWC) machine and will replace traditional manual composting (windrow based systems).

	10. A national policy framework for Waste Management and Pollution Prevention.	The main strategy in the Strategic Action Plan of the Government of Maldives 2019 to 2023 include the following interms of waste sector policy and regulatory framework • Review and revise the current legislative, regulatory and institutional framework on waste management; The main actions under this strategy include the following; • Review and enact Waste Management Law; • Review the existing protocol on approving new infrastructure projects related to waste management in light of the amendments brought to the waste management governance framework • Review mandates of local councils on waste management • Develop the regulatory framework for Public Private Partnership in waste management services • Develop regulations and guidelines for use, handling, and disposal of all types of chemical and hazardous waste • Develop legal and regulatory framework to reduce import, use, and manufacture of single-use plastics • Develop a national policy framework on pollution prevention • Develop a framework for extended producer responsibility or other product stewardship programmes • Develop and implement a National Recycling Strategy • Enforce regulation on Anti Littering through stricter fines, policing and strengthened reporting mechanisms • Develop and implement an SOP for waste segregation at the household level in all administrative islands
	11. Improvement of waste sector data collection including waste audits	New amendments to the Waste Management Regulation (2013) is aimed to improve the data collection for the waste sector. Waste Management and Pollution Prevention Department of Ministry of Environment, Climate Change and Technology is currently developing a database along with the newly assigned mandates to the local government council is expected to improve the data collection for GHG inventory purposes as well as policy formulation process.

Transport	12. Fuel Switching and Introduction of bio-fuels	Introduction of bio-diesel and bio-ethanol along with incentives to modify the existing vessels and vehicles.
	13. Hybrid Solar Boats	Introduce hybrid solar boats for short-distance travel, particularly for tourism purposes. The aim is to achieve a 2.5% share of hybrid solar boats by 2030 in both scenarios. Electric motors in hybrid boats run on batteries charged with power supplied by solar panels mounted on the boat. Hybrid solar boats have the advantage of no sound and vibrations and fuel odor free when propelled by the electric motor
	14. Replacement of old vehicles	Replace existing vehicles, motorbikes with more efficient units, including hybrid vehicles, with the support of a government incentives program
	15. Electric buses, vehicles, and motorbikes.	Introduction of electric buses, vehicles and motorbikes with appropriate infrastructure like charging stations.
	16. Reduction in vehicle registrations	The global trend is to move from the use of personal vehicles to efficient and sustainable public transportation. This trend may be facilitated by placing restrictions on the issuance of new registrations or putting restrictions on the age of vehicles allowed on the roads.

The Criteria for Multi-criteria Analysis

The following Table 04 provides the proposed criteria for the multi-criteria analysis. It provides categories, sub-categories, criteria, potential indicators, type of score, preferred value and date sources for the scoring exercise.

Table A30: The detailed information on the criteria for the scoring exercise as part of the multi-criteria analysis

Category	Subcategory	Criteria	Potential Indicator	Type of Score (Qualitive/ Quantitative)	Preferred Value	Data Source
Cost	Cost	Capital cost Operation and Maintenance cost	Capital Cost per unit of energy produced	Quantitative	Lower	Technology provider/ specifications
		Sustainable funding options (Private sector, public sector, Development Partner)	No. of projects funded by donor agencies and private sector	Qualitative (High/Low)	Higher	Expert Judgement/financial data
Benefit	Economic	Job Creation	No. of jobs created per project	Qualitative (High/Low)	Higher	Expert Judgement
	Social	Potential for gender impacts and reduces inequity	No. of women benefited from the technology	Qualitative (High/Low)	Higher	Expert Judgement
		Capacity development	No. of staff trained per project	Qualitative (High/Low)	Higher	Expert Judgement
	Environmental	Reduces priority waste streams	Types of waste stream generated or managed by the technology	Qualitative (High/Low)	Higher	Expert Judgement
		Support ecosystem services	Potential to improve air quality	Qualitative (5 – point scale)	Higher	Expert Judgement/ monitoring data

	Climate Related	Alignment with national Priorities	Endorsement by SAP and NDC	Qualitative (High/Low)	Higher	Review of Literature
		Reduce/avoid GHG	GHG emission reduction ($kgCO_2e$)	Qualitative (High/Low)	Higher	Technical Specifications and modelling
		Potential to reduce vulnerability and build climate resilience	Any co-benefits for climate change adaptation	Qualitative (5 – point scale)	Higher	Expert Judgement