MALDIVES

BARRIER ANLYSIS AND ENABLING FRAMEWORK REPORT- ADAPTATION

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BARRIER ANALYSIS AND ENABLING FRAMEWORK REPORT

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Abbreviations

AI	Artificial Intelligence
BAEF	Barrier Analysis and Enabling Framework
BUR	Biennial Update Report
CC	Climate Change
DGPS	Differential Global Positioning System
DTU	Danish Technical University
EPA	Environmental Protection Agency
FAO	Food and Agriculture Organization
GCF	Global Climate Fund
GFD	Gravity-Fed Drip
GIS	Geographic Information System
GHG	Green House Gas
ICT	Information and Communication Technology
ICZM	Integrated Coastal Zone Management
IKLK	Indigenous Knowledge and Local Knowledge
ILUP	Integrated Land Use Planning
INDC	Intended Nationally Determined Contribution
IPCC	Intergovernmental Panel on Climate Change
IPM	Integrated Pest Management
IWRM	Integrated Water Resource Management
LIDAR	Light Detection and Ranging
LPA	Logical Problem Analysis
LUP	Land Use Planning
MASPLAN	Master Plan for Sustainable Fisheries
MCA	Multi-Criteria Analysis
MCCPF	Maldives Climate Change Policy Framework
MoECCT	Ministry of Environment Climate Change and Technology
MEE	Ministry of Environment and Energy
MEEW	Ministry of Environment Energy and Water
MLSA	Maldives Land Survey Authority
MNPHI	Ministry of National Planning Housing and Infrastructure
MNU	Maldives National University
MoFA	Ministry of Fisheries Agriculture
NC	National Communications
NCIT	National Center for Information Technology
NFT	Nutrient Film Technique
NEAP	National Environmental Action Plan
NGO	Non-Governmental Organization
NSC	National Steering committee
OT	Objective Tree
PT	Problem Tree
SAP	Strategic Action Plan
SC	Steering Committee
SDG	Sustainable Development Goals
SMEs	Small and Medium Enterprises
SNC	Second National Communication
SOE	Sate-Owned Enterprise
TFS	Technology Fact Sheets
TIS	Technology Innovation System

TNA	Technology Needs Assessment
TVET	Technical and vocational education and training
UNDP	United Nations Development Programme

Contents

List of Tables

List of Figures

Executive Summary

This report is the output of the second phase of the TNA process which covers Barrier Analysis and Enabling Framework (BAEF) for transfer and diffusion of the prioritised adaptation technologies in the selected three sectors across the country. This (BAEF) Report identifies and summarises potential barriers to the deployment and diffusion of adaptation technologies identified for Agriculture and Food Security, Water Resources, Coastal Adaptation and Disaster Management sectors in the Maldives. These three sectors were selected for BAEF by the national Steering Committee of the Government Maldives from the eight sectors identified by the first phase of the Technology Needs Assessment (TNA) process. The first step in the TNA process is the identification of technologies to meet adaptation for the selected sectors.

The climate technologies identified and prioritized through an extensive process of stakeholder consultations, document review, and TNA Multi-Criteria Analysis 16 technologies from eight sectors are selected and listed below:

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

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

During the TNA process 16 technologies from 8 sectors were selected in the TNA report. During the TNA process Government envisaged that Maldives being at the forefront of climate change impact the eight vulnerable sectors were considered important as country's adaption priorities and cannot be cherry-picked as priority sectors and exclusion of sectors may lead to divert adaptation focus on specific sectors only. Therefore, decided to retain the eight sectors and selected two technologies from each sector. However for

the BAEF process the Government decided after discussions with the international consultant and local stakeholder to concentrate on few prioritised sectors as it will be exhaustive to address the 16 technologies selected in the TNA report. After extensive consultations with the stakeholders, TNA steering committee and through MCA process the government decided shortlist to three technologies from three different sectors. The selected technologies broadly represented all the different technologies included in selected sector. Table 2 below shows the technologies selected for BAEF.

Table 2. Adaptation technologies selected for BAEF

Sector	Technology
Coastal adaptation & Disaster management	Integration of technologies (drone, satellite imagery and GIS) into existing land use planning processes
Water resources	Promotion of rainwater integration into, irrigation, industrial purposes, building code
Agriculture and Food security	Promotion of community farming, community gardens and Agritourism

In this report, barriers hindering the acquisition and diffusion of selected adaptation technologies for the water resources, agriculture and food security, coastal adaptation and disaster management sectors have been identified, and measures to overcome the barriers and facilitate the transfer, adoption and diffusion of these technologies are elaborated. To facilitate the identification of barriers, logical problem analysis (LPA) was used to identify the root causes of the main barriers that hinder the implementation of each adaptation technology. Using a Problem Tree (PT), the main barriers were decomposed to identify the root causes of barriers, and an Objective Tree (OT) that mirrors the PT was developed to identify possible measures to overcome the root causes. In addition, Technology Innovation System (TIS), value chain market mapping was used to analyse the non-economic barriers to diffusion of each technology. Further, the enabling environments that will support the reduction or elimination of barriers confronting each technology are discussed.

Agriculture and food security sector

Maldives prioritised the Agriculture and Food Security sector for technical assistance under the Technology Needs Assessment (TNA) project as it is one of the most vulnerable sectors to climate change. Agriculture is important for food security in two ways; it provides food for consumption and perhaps even more importantly it provides the primary source of livelihood for farmers and their families. Due to the small size of the islands, land scarcity, poor soil conditions and limited water resources in island aquifer, agriculture and food production is very limited in the Maldives. The economy is highly import dependent and meeting the need for staple food requirements and maintaining sufficient storage and distribution facilities is a huge logistical challenge due to the geographically dispersed nature of islands especially during severe and extreme events and unexpected market irregularities. To ensure continued supplies of staple food, the government also maintains a reserve stock suitable for 2-3 months.

The primary target for the deployment of Promotion of community farming community gardening and agritourism technologies to achieve self-sufficiency by strengthening the agriculture and food security sector through enhancing the capacities of urban farming and community gardening producers and improving the value of agriculture.

The overall aim is to minimize dependency on imported fruits and vegetables that can grow locally through community farming & community gardens and agritourism farming crops that are somehow climate resilient adaptable to local conditions with less fertilizer and pesticides.
Community farming & community gardens and agritourism farming is characterized by stakeholder as having technology components consists of consumer goods, capital good, publicly provided goods and other non-market goods.

The main barriers identified are scarcity of land and high land fees and existing regulations on land allocations. Unavailability of micro financing options and high cost of agriculture inputs. Market barriers identified were the unregulated expatriate labour involvement in market chain; lack of produce diversification; value chain restrictions and challenges to access tourism markets/resort industries. Unavailability of financial or economic incentives for promoting community farming, community gardening and agrotourism technologies were identified as the main economic and financial barriers discouraging woman the youth engagement in the sector.

A range of measures and enabling environment required to overcome the barriers were identified including supportive policy instruments, economic incentives, increasing the financially attractive opportunities, establishing national standards and regulations, addressing the overlapping mandates of various institution, improving the awareness and knowledge on agriculture technologies and increase the availability of good quality cost effective fertilizers plant material, plant nutrition irrigation systems, and hydroponic systems.

Coastal adaptation and Disaster Management

Maldives prioritised integration of technologies (drone, satellite imagery and GIS) into existing land use planning processes in the Technology Needs Assessment (TNA) as the resilience of natural environment is the key to coping with climate. One of the main challenges to implement impactful adaptation in Maldives is lack of contextualized and quantifiable historical and monitoring data and information on island to atoll level disaster risks, coastal erosion, flood prone areas, land uses biodiversity etc, as data acquisition is challenging for various parameters such as coastal, terrain, infrastructure, geology, weather history and hydro meteorological events etc to use for the decision-making purpose.

The primary target for the diffusion of integrated technologies (drone, satellite imagery and GIS) into existing land use planning processes is to facilitate the identification of areas at risk of land loss, flooding etc., and to prioritise coastal risks and strengthens other adaptation options, such as coastal erosion, island dynamics flood mitigation measures, emergency planning, provision and evacuation planning.

The overall aim is to establish, surveying mapping and monitoring database, modelling and GIS platform for data analysis and integrated land use planning for decision support system and decision making to ensure that climate change adaption is integrated into development planning and decision-making process.

Main barriers identified for the diffusion of integration of technologies (drone, satellite imagery and GIS) into existing land use planning processes includes: lack of technology means and tools available to aid LUP; high costs for purchasing, and low funding to achieve. Mapping projects are sporadically financed through project grants, private developments or in-kind support. Lack of data sharing mechanisms between institutions and integration between institutions on common interests. The Government of Maldives does not invest in mapping and surveying; therefore, it owns very little data, and the data are fragmented; Government is not providing budgetary support, financial or economic incentives for promoting mapping and surveying technologies; skill and training developments in the field are very much project based in Government offices. Unregulated expatriate involvement in market chain results in substandard maps and survey products and loss of opportunity for local professionals .

Measures and enabling framework required to overcome the barriers were identified including investment in surveying, mapping and monitoring equipment, as well as computer hardware and software for storing and processing data, budgetary support for capacity developments and costs of the equipment maintance and training. Establishing a centralised authority responsible for coordinating and harmonizing data between the different government and non-government stakeholders, mandate stakeholder Government agencies to share data and reports generated by all projects with the centralised authority, enforcement of existing laws and regulations on engagement of foreign firms in the sector. Enhancing the MNU environmental science and IT curricula related to GIS, mapping, data management, modelling, etc., Include survey mapping and monitoring, short courses on hydrography levelling and survey set-out, measuring beach profiles, drone survey, analysis of satellite images, collecting and processing LIDAR data in TVET education curriculum. Integration of Indigenous Knowledge and Local Knowledge (IKLK) into LUP development process.

Water Resources Section

Integrated Water Resource Management (IWRM) is the policy adopted by the country to provide portable water for the islands and local community. IWRM involves combination of protection and conservation of fresh ground water lens, integration of rainwater for domestic consumption and aquifer recharge, inclusion of rainwater in public supply, demand and management through use of efficient water fixtures and consumer practices, leakage control in the system at consumer level.

Maldives prioritized and selected promotion of rainwater integration into, irrigation, industrial purposes, building code technologies in the Technology Needs Assessment (TNA) as the resilience of natural environment and key to coping with climate change in the water sector.

The primary target for the diffusion of rainwater integration into, irrigation, industrial purposes, building code technologies is to facilitate community and household-based rainwater harvesting system integration into irrigation and industrial purposes to secure minimum water requirement in all situations. This will be

in combination with sustainable drainage aimed to intercept the hydrologic cycle, catch most of the rain water instead of removing excess water from road surfaces and discharging to sea, use drainage infiltration techniques supports the replenishment of groundwater resources in urban road drainage schemes.

The technology includes harvesting and storage of rainwater to use in different types of micro-irrigation technologies such as the low-head, low-cost gravity-fed drip (GFD) irrigation kits, micro sprinklers, micro tube drip system suited for smallholder farmers to highly sophisticated, capital intensive pressurised commercial micro-irrigation systems. Technologies discussed under industrial water use includes waste water recovery and reuse which is widely practiced in some resorts and possibly some industrial island. Storm water recovery and reuse after filtration and treatment is also included in this category. This method is suitable as on-site drainage solution for small-scale developments, thereby eliminating the need to build a piped stormwater drainage system to cater for the additional runoff. The above-mentioned rainwater harvesting and integrated technologies have to be incorporated into the national building code to be effectively implemented and enforced throughout the country.

Main barriers identified for the diffusion of promotion of rainwater integration into, irrigation, industrial purposes, building code technologies include: Lack of government funding for establishment of rainwater harvesting systems for individual household level. System repair and maintenance budget for rainwater harvesting systems established from doner funding projects is often not available. Lack of financial resources to train skilled staffs to undertake regular cleaning, repair and maintenance of the existing rainwater harvesting systems. Regular checking and testing of harvested rainwater quality is not available in local islands; No economic incentives or financial mechanism to promote rainwater harvesting and storage for irrigation systems. maintenance and management of water supply including harvested rainwater and water produced from IWRM systems through compliance monitoring and safety planning is yet to been established at island levels. There is a need to establish a strategic policy to ensure the quality levels of safe and clean water at very minimum cost. There is no overreaching national water institution for promoting IWRM. Regulations/guidelines related to water efficiency for new real estate development as well as at household levels in local communities is not included in the building code. Lack of knowledge and awareness on maintaining the cleanliness and safety of rainwater harvesting systems and issues related to water -climate change and water efficiency is not established.

Measures and enabling framework required to overcome the barriers were identified including financial support mechanism to encourage local households/ community to invest in basic equipment for rainwater harvesting and storage systems and for agriculture sector to encourage small-scale farmers to invest in harvested rainwater-based irrigation system, storage facility, pump and tanks. Review water pricing to take care of agriculture sector. Create funding opportunities to establish rainwater harvesting infrastructure and disincentives to encourage optimal use of harvested rainwater water using water efficient micro-irrigation system. Import duty exemption from components of renewable energy-based and energy efficient rainwater harvesting system to make the technology more affordable. Development of national standards and guidelines for rainwater harvesting and review the building code regulations to include regulations related to rainwater harvesting for new real estate development, with provision for ground water infiltration in road construction and infrastructure development. Establish an institution to conduct research in water sector

technologies relevant to small islands. Establish a clear policy or high-level coordination mechanism for cross-sectoral cooperation to promote collaboration between public and private sectors. Train locals on setup, safe operation, collection and maintenance of health and hygiene and chemical treatment, of rainwater collection systems.

Chapter 1 Introduction

This is the Barrier Analysis and Enabling Framework (BAEF) report to the implementation of the prioritized technologies identified for adaptation to climate change in the three sectors selected through stakeholder consultation process by the Government of Maldives, namely, Agriculture and food security , Water Resources, Energy, and Coastal adaptation & Disaster management. The document is the second deliverable in the Technology Needs Assessment (TNA) Project for Maldives. It outlines the process followed to identify and prioritize barriers and presents measures and an enabling framework for overcoming the identified barriers.

1.1 Overview of the TNA process

The Global Technology Needs Assessment project is funded by the Global Environment Facility (GEF) and executed by the United Nations Environment Programme (UNEP) in collaboration with the UNEP DTU (Technical University of Denmark) Partnership on Energy, Climate and Sustainable Development. In order to meet the objectives of the Paris Agreement to mitigate and adapt to the impact of climate change (CC), developing countries that are party to the UNFCCC, are required to undertake a process to identify the country's development priorities and the technologies that will achieve lower emissions and stronger climate resilience. TNAs are considered to be central to the tracking of an evolving need for new equipment, techniques, practical knowledge, and skills, which are necessary to reduce the vulnerability of sectors and livelihoods to the adverse impacts of climate change.

The TNA process is executed following TNA guidebook recommended steps, namely: (a) Identification and prioritization of technologies for mitigation and adaptation, (b) Barrier analysis and enabling framework (BAEF) identification, and (c) Technology action plan (TAP). This report addresses the second step which is the Barrier analysis and enabling framework for adaptation technologies selected from the TNA process.
Following the above TNA process in the Maldives steering committee members and sector working groups were discussed to select the three sectors that will be addressed in the BAEF.

Then from the three selected sectors MCA was conducted to select the technologies that will be addressed in the BAEF. Members of the technical committees and the steering committee participated; however, it was agreed to keep the technologies as broad as possible to address to include most of the technologies highlighted in the technologies selected for the sector. Therefore the heading of the technologies names are adjust to address this aspect in the selected three sector.

1.2 Objectives of the TNA

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

1. To identify and prioritize through country-driven participatory processes, technologies that can contribute to adaptation goals of the Country, while meeting national sustainable development goals and priorities
2. To identify barriers hindering the acquisition, deployment, and diffusion of prioritized technologies.

3. To develop Technology Action Plans (TAP) specifying activities and enabling frameworks to overcome the barriers and facilitate the transfer, adoption, and diffusion of selected technologies in the Maldives.

The TNA process will also develop Concept Notes for attracting funding to implement selected technologies in priority areas of national relevance.

1.3 Prioritized Technologies for Maldives

The first deliverable of the Technology Needs Assessment Project for Maldives was completed in August 2022. Adaptation sectors are identified based on the climate change vulnerabilities of the country addressed in the first and second National Communications and the national priorities articulated in the NAPA 2004, Intended Nationally Determined Contribution (INDC) of 2015 and the Update of Nationally Determined Contribution of Maldives of 2020. During the TNA process it was envisaged that the the eight vulnerable sectors are equally significant and important and narrowing down the list of priorities for selected few sectors will be extremely bias and may affect climate resilient development process. Therefore, stakeholder and national TNA steering committee decided that there is no need for further narrow-down the list of vulnerable sectors and prioritising for few selected sectors as it can be extremely bias and unjust for the unselected sectors. Prioritised vulnerable sectors for Maldives are:

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

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

Table 3. Prioritized adaptation sectors and technologies from the TNA process

Sector	Technology
Fisheries	Improving fish finding harvesting and handling
	Improvement of boat design and equipment for reef fishery
Coastal adaptation & Disaster management	Sustainable infiltration and drainage management
	Integrated Land Use Planning (ICZM) Drone mapping, satellite imagery and GIS
Health	Green Climate Smart Healthcare facilities
	Health Sector Emergency Response to extreme events
Water resources	Rain Water Integration
	Flood water recovery
Critical infra structure	National Development Act and integration of CC into development planning

	Climate proofing of all critical infrastructure
Tourism	Climate proofing of resort infrastructure etc.
	Climate friendly utilities Electricity, waste, water and wastewater, food etc.
Agriculture and Food security	Community farming & community gardens and household therapeutic farming
	Agritourism developments
Coral reef and biodiversity	Coral reefs conservation through ecosystem approach as adaptation
	Continued monitoring of reef health, increased conservation effort and reduction of impacts of human activities

1.4 Process for the Identification of Barriers

The Barrier Analysis and Enabling Framework (BAEF) is the second step in the Technology Needs Assessment (TNA) process. The objective of the BAEF is to analyse market conditions for each selected technology, identifying the barriers to their enhanced deployment, followed by the identification of enabling frameworks to support their deployment and diffusion in Maldives.

The BAEF for the prioritized technologies for adaptation in the eight sectors for Maldives (Table 1) was developed following the guidelines provided in the various TNA guidebooks. These included:

1. TNA Step by Step: A guidebook for countries conducting a Technology Needs Assessment Action Plan (Haselip, Narkevicicute, Rogat, & Traerup, 2019);

2. Overcoming Barriers to the Transfer and Diffusion of Climate Technologies, Second Edition (Nygaard & Hansen, 2015);

3. Guidance for a gender-responsive Technology Needs Assessment (De Groot, 2018).

1.5 The Process for Maldives

The first stage of TNA process Maldives selected 16 technologies from 8 sectors. Selected technologies further screaned to identify technologies are repeated in multiple sectors, enabling activities/ongoing activities and sector/technologies that can be combined (Table 4). Then the shortlisted technologies from this process went through MCA and the highest scoring three technologies were selected for BAEF analysis. After extensive consultations with the stakeholders, TNA steering committee and through MCA process the government decided to highest scoring three technologies from three different sectors (Table 5).

Table 4. screening of prioritized technologies through TNA process

Sector	Prioritized Technology in the TNA Report	Suggested Improvement for Technology Name	Remarks
Fisheries	Improving fish finding, harvesting and handling	Enhancing fish finding and processing technologie	Selected for MCA
	Improvement of boat design and equipment for reef fishery	Develop codes/guidelines for fishing vessel designs	enabling activity
Coastal adaptation & Disaster management	Sustainable infiltration and drainage management	Provision of sustainable infiltration systems and drainage management options	Selected for MCA
	Integrated Land Use Planning (ICZM) Drone mapping, satellite imagery and GIS	Integration of technologies (drone, satellite imagery into existing land use planning processes)	Selected for MCA
Health	Green Climate Smart Healthcare facilities	Promotion of Green Climate smart healthcare facilities	Selected for MCA

	Health Sector Emergency Response to extreme events	Build capacities to implement health sector response during extreme events	enabling activity
Water resources	Rain Water Integration	Promotion of rain water integration into? (irrigation, industrial purposes, building code etc)	Selected for MCA
	Flood water recovery		
Critical infra structure	National Development Act and integration of climate change into development planning	Development of national development act (taking into consideration climate change impacts)	enabling activity
	Climate proofing of all critical infrastructure	Develop policies and enhance existing policies to climate proof all critical infrastructure including resorts	enabling activity
Tourism	Climate proofing of resort infrastructure etc.	Covered under critical infrastructure	
	Climate friendly utilities Electricity, waste, water and wastewater, food etc.	Develop regulations for climate proofing of utility services in the resort sector	Enabling activity
Agriculture and Food security	Community farming & community gardens and household therapeutic farming	Promotion of community farming including agritourism and home gardening by considering viable technologies	Selected for MCA
	Agritourism developments	Covered	
Coral reef and Biodiversity	Coral reefs conservation through ecosystem approach as adaptation	Build capacities to conserve coral reefs through ecosystem approaches and utilizing viable technological solutions	enabling activity
	Continued monitoring of reef health, increased conservation effort and reduction of impacts of human activities	Covered	

Table 5. Technologies selected for BAEF

Sector	Technology
Coastal adaptation & Disaster management	Integration of technologies (drone, satellite imagery and GIS) into existing land use planning processes
Water resources	Promotion of rainwater integration into, irrigation, industrial purposes, building code
Agriculture and Food security	Promotion of community farming, community gardens and Agritourism

Then a two step process was followed for barrier analysis and enabling framework development for identified adaptation technologies in Maldives. In the first step, secondary research was conducted in which Maldives's policies and other studies were referred to for the selected technologies for BAEF. In the second step, a stakeholder workshop was organized in Male in which TNA stearing committee and (TWG) provided their inputs on key barriers and the enabling framework presented. Following this, focused sector

specific roundtable discussions were held with relevant experts to seek specific information on barriers and enabling measures for each technology.

To facilitate the identification of barriers, logical problem analysis (LPA) was used to identify the root causes of the main barriers that hinder the implementation of each adaptation technology. Using a Problem Tree (PT), the main barriers were decomposed to identify the root causes of barriers, and an Objective Tree (OT) that mirrors the PT was developed to identify possible measures to overcome the root causes. In addition, Technology Innovation System (TIS), value chain market mapping was used to analyse the non-economic barriers to diffusion of each technology.

Chapter 2 Agriculture and food security sector

Maldives prioritised the Agriculture and Food Security for technical assistance under the Technology Needs Assessment (TNA) project as it is one of the most vulnerable sectors to climate change in Maldives (Agriculture Master plan, 2013-2017). Agriculture is important for food security in two ways; it provides food for consumption and perhaps even more important it provides the primary source of livelihood for farmers and their families. Growth in the agriculture sector is critical for the country's economy in the face of global climate change and its likely impact on the economy. The choice of this sector is also aligned with the Maldives Nationally Determined Contributions (NDC) that has been submitted to the UNFCCC (NDC, 2015a and SNC 2016). Promotion of community farming including agritourism and community gardening by considering viable technologies were selected for further analysis after the first stage of the TNA project (TNA Report, 2022).

In this chapter, barriers hindering the acquisition and diffusion of community farming, community gardening and agritourism technologies in agriculture and food security are identified and measures to overcome the barriers and facilitate the transfer, adoption and diffusion of these technologies are elaborated. Based on the analysis on the linkages of the barriers and possible solutions are suggested on how the barriers can be addressed, and what the resource required and the strengths and weaknesses of each solution are discussed. Further, the enabling environment that will support the reduction or elimination of barriers confronting the technology is discussed.

2.1 Preliminary targets for technology transfer and diffusion in Agriculture and food security sector

Due to the small size of the islands, land scarcity, poor soil conditions and limited water resources in island aquifer, agriculture and food production is very limited in the Maldives. The economy is highly import dependent and meeting the need for staple food requirements and maintaining sufficient storage and distribution facilities is a huge logistical challenge due to the geographically dispersed nature of islands especially during severe and extreme events and unexpected market irregularities. The total cultivable land area is estimated at 30 km^2. The agriculture sector is constrained by the limited availability of cultivable land, poor quality of soil and the abundance of cheap imports of vegetables and fruits. Due to the high import dependency, the food security of Maldives is vulnerable to climate change-related impacts on the agriculture of other countries. Long-term and emergency food storage facilities are virtually absent except for warehousing in Male' and nine other islands. Severe and extreme weather incidents disrupt the supply of food within the country. To ensure continued supplies of staple food, the government also maintains a reserve stock suitable for 2-3 months.

The primary target for the deployment of promotion of community farming, community gardening and agritourism technologies is to achieve self-sufficiency by strengthening the agriculture and food security sector through enhancing the capacities of urban farming and community gardening producers and improving the value of agriculture. Linking the farmers to market in order to achieve national food security

and sustainable socio-economic development. and rural livelihood and mainstreaming cross cutting issue such as environment, gender and youth empowerment is vital.

Community farming & community gardens and agritourism farming involves production of food and food items beyond home consumption and using the produce to create an income through individual families or community groups. These are a small scale, supplementary food production system by and for household members that mimics the natural, multi-layered ecosystem. Community gardening generally cover small areas near to home but have wider diversity of crop species which are crucial to brining resilience in vulnerable regions by reducing the risks. The objectives of community farming & community gardens and agritourism farming is aligned with numerous strategies of the Government's Strategic Action Plan (SAP 2019), falling under Blue Economy for Small and Medium Enterprises and Agriculture sectors. Specifically, the strategies and actions related to development of Agri-centers, standardizing food production and quality of produce, establishing urban gardening models, strengthening agricultural data collection mechanisms and increasing the efficiency of resource allocation through capacity building.

The overall aim is to minimize dependency on imported fruits and vegetables that can grown locally. Through community farming & community gardens and agritourism farming locally grown crops that are somehow climate resilient adaptable to local conditions with less fertilizer and pesticides will be promoted with local farmers in development of agriculture related infrastructure and food storage facilities to pursue food security and self-sufficiency that will boosts local production, facilitate value-addition in the agriculture sector and increase overall resiliency of the country.

2.2 Barrier analysis and possible enabling measures for promotion of community farming & community gardening and agritourism technologies

2.2.1 General description of technology

In the Maldives community farming & community gardens and agritourism farming started fairly recently in early 2020, and it is growing very fast now and expanding across Maldives. Agriculture technologies used in the farming are expected to reach maturity in the coming year. Already pilot project in the urbanized areas such as the one in Hulhumale where, 48 farmers are growing various types of crops and therapeutic plants and other project by UNDP such as the Binheyo[1] which is an urban farming plus farm-to-table project, conceptualized with the aim of addressing the effects of COVID-19 pandemic as well as the climate change crisis. Existing community farming & community gardens and household farming initiative contract with farmers undertake farming within the standards and guidelines and receive subsidies and other benefits provided to the members. Some of the technologies that is used in the community farming & community gardens and agritourism farming are

- Onsite compost and fertilizer production compost-making using household waste
- Technologies to increase soil fertility
- Integrated pest management and nutrient management
- Improved, climate specific, high yielding crop varieties

[1] https://undpmv.exposure.co/launch-of-binheyo-farmtotable-sustainable-development-youthled-action

- hydroponic farming
- irrigation
- Use of solar and renewable energy in farm systems
- Promote crops that has the potential to attain self-sufficiency
- Post-harvest loss reduction technologies and storage facilities
- Value-addition and food processing technologies
- Agritourism developments

2.2.2. Technology category and market characteristics

Community farming & community gardens and agritourism farming are characterized by stakeholder as having technologies from the following categories:

1- consumer goods

- Small farm Irrigation systems,
- Planting materials (tissue culture, grafted cultivars, resistant cultivars)
- Plant nutrition (organic fertilizers, simple composting machines, soil amendments, field soil testing kits)
- Pest and disease management (natural pesticides, pest replant technologies, IPM)
- Harvesting and packaging (protection bags, sponge nets, climbing equipment's, field drying technologies)
- Post harvest handling (cleaning reagents)
- Rainwater harvesting systems.

2- Capital goods

- Greenhouses, Shade house, Net houses,
- Various types of hydroponics technologies (Vertical system, media system, NFT, Autopot),
- Prefab plant factories,
- Central Irrigation system,
- Soil tilling technologies and machineries
- Inflatable water storage tanks
- Solar energy pumps/machineries
- Prefab cold storage units.
- Mini weather stations for farm use
- Fences /

3- Publicly provided goods

- Permits and licenses (import/ export permits of technologies)
- Standards and certificates (IPM, INM, GAP, inputs regulation regulation)
- PSIP (agriboats, national storage facilities for staples, quarantine facilities, community demonstration farms)

4- Other non-market goods

- Lab testing of goods and raw materials
- Research and development work
- Digital marketing platforms,
- Agri information and advisory services
- Technical and capacity building

As shown above community farming, community gardening and agrotourism can have components in different categories of technologies depending on the context and scale of the farming project.

A market supply chain analysis was carried out and it is shown in Figure 3 (Market Map for community farming, community gardening and agrotourism). The supply chain includes importers of irrigation systems fertilizers, retailers of fittings, local producers of fertilizers, transporters, installers and maintenance contractors, and end users. The diffusion community farming, community gardening and agrotourism technologies requires an enabling environment for the demand-supply chain, and the services and inputs providers the technologies and skills. Such enabling environment should include a community farming, community gardening and agrotourism policies, standards, license, laboratories, financial incentives and information and advisory services.

2.2.3 Identification of barriers to the diffusion of community farming, community gardening and agrotourism technology

Stakeholders in the Agriculture Sector both at the policy and technical levels, and private and NGO partners in the sector, listed a series of barriers to consider in community farming, community gardening and agrotourism technologies barriers were identified in the demand-supply chain as illustrated by the Problem Tree (PT) in Figure 1. They are as follow:

- Economic and financial
- Market conditions
- Legal and regulatory
- Institutional and organizational capacity
- Human skills
- Information and Awareness
- Technical
- Social, cultural, and behavioral

Table 6. Barriers and measures for diffusion of community farming, community gardening and agrotourism technology

Category	Barrier	Measure
Economic and financial	Land scarcity High land fees and unavailability of micro financing options High cost of agriculture inputs No economic incentives Unregulated expatriate labor involvement in market chain lack of produce diversification value chain restrictions and challenges to access tourism markets/resort industries to the local community and involvement of middle man	Create awareness on financial market opportunities and available products to support Opportunity to access tourism industry Provide need based financial options Donor finance options
Institutional and organizational l …	No Supportive policy and regulatory instruments; There are no national standards and regulations; Overlapping mandates of various institution ; and Inefficient institutional arrangement	Adequate policy and regulatory framework Reduce institutional overlapping mandates Overarching mechnis
Human skill	Lack of skilled agriculture technical personnel Labor market issues	Develop locally skilled labour Regulate expatriate labour

	Domination of unregulated and illegal expatriate cheap labor involvement in agricultural farms	
Information, awareness and capacity	limited access to relevant information on technologies lack of information dissemination and training, limited coordination among key actors in the market chain	Awareness campaigns Atoll and island level exhitions and taining activities
Technical Barriers	Lack of skilled persons to properly install and maintain complex small systems Few qualified, trained and knowledgeable Agronomists and Horticulture technicians Lacking R&D	Short term training cources Development of Agronomists horticulture and agrobussiness technicians
Social, cultural, and behavioral barriers	lack of youth and women involvement in farming Foreign unskilled labor involvement in farming and farmland management distribution chain of agricultural produces in the country	Youth & woman enouragement Expetriate labour regulate

2.2.3.1 Economic and financial barriers

Major economic and financial barriers for the diffusion of community farming, community gardening and agrotourism technologies arise from the following

- Scarcity of land and high land fees and existing regulations on land allocations.
- Unavailability of micro financing options
- High cost of agriculture inputs to diffuse the technologies at for small scale farmer.

Market barrier identified by the stakeholders to diffuse the technologies at community level are:

- Unregulated expatriate labor involvement in market chain;
- Lack of produce diversification;
- Value chain restrictions and challenges to access tourism markets/resort industries to the local community
- Involvement of middle man which significantly reduce the overall benefit for the local farmer.

Currently, the government is not providing any financial or economic incentives for promoting community farming, community gardening and agrotourism technologies. There are few pilot projects on community farming, community gardening and agrotourism technologies and they only exist within the urban areas in greater Male region. However, community gardening is widely practiced by local hobbyist in home balconies and rooftops. To promote the technology a secured loan scheme with low interest rates may attracts more people. There is therefore a lack of cheap capital available to practice community farming, community gardening and agrotourism technologies.

2.2.3.2. Non-financial barriers

The main non-financial barriers identified by stakeholders are; Institutional and organizational capacity; Human skills; Information and Awareness; Technical; Social, cultural, and behavioral illustrated in the Problem Tree (see PT in Figure 1). These are discussed below:

Institutional and organizational barriers

Currently there is no national policy towards promotion of community farming, community gardening and agrotourism in the Maldives. Government objectives on this is not aligned with the private sector therefore each sector is going on its own way. Existing projects are mainly doner funded largely adhoc and lacks cohesion and integration with the existing systems. This is mainly due to insufficient institutional arrangements and overlapping of mandates of various institutions such as SOEs, MoFA AgroNet etc. The barriers identified in this category can be summarized into:

- No Supportive policy and regulatory instruments;
- There are no national standards and regulations community farming, community gardening and agrotourism;
- Overlapping mandates of various institution; and
- Inefficient institutional arrangement

Human skill related barriers

Major barriers to diffuse community farming, community gardening and agrotourism technologies identified in this category are lack of properly trained skilled people to engage and guide in the field. Scarcity of interested and skilled Maldivians willing to work on community farms and community gardening is a major barrier to promote the technology. Domination of unregulated and illegal expatriate cheap labor involvement in agricultural farms as well as all stages of agriculture is also identified as a major barrier to promote technologies in this field. The barriers identified in this category can be summarized into:

- Lack of skilled agriculture technical personnel
- Labor market issues

Information, awareness and capacity barriers

Information barriers include limited access to relevant information on technologies, which could provide potential customers with a knowledge on the viability of investing in new technologies. Prices and quality of household compost and fertilizer production, technologies to increase soil fertility, integrated pest management and nutrient management, improved, climate specific, high yielding crop varieties, hydroponic systems, use of solar PV components and miscellaneous parts for the various technologies can vary, so customers need to know which model will yield better return on their investments. Information barriers may arise due to poor extension services, lack of information dissemination and training, and limited coordination among key actors in the market chain (importers and retailors, service providers and maintenance, and market end users/clients).

Technical Barriers

Maldives has very few skilled persons who has knowledge and can provide information and instructions to properly install and maintain small systems for community farming and community gardening such as improved drip/sprinkler irrigation systems, "certified" grain seed production and storage, and plant micro-propagation technology, technologies to increase soil fertility, integrated pest management and nutrient management, improved, climate specific, high yielding crop varieties, hydroponic systems, and marketing. In Maldives, there are usually adhoc groups providing information however qualified, trained and knowledgeable Agronomists and Horticulture technicians numbered. Research and Development services both in private and public sector are lacking. Agrobusiness technicians, and other professional groups/companies who can provide technical service for installation and maintenance of complex small-scale agricultural technologies and renewable energy systems are needed. Lack of adequate maintenance, or inferior model/brand of equipment may result in failure or lead to delayed of returns on investments or a loss of investments, and unprofitable yields that may discourage acceptance of community farming and community gardening as a profitable agro-businesses and farmers in the usage of the new technology.

Social, cultural, and behavioral barriers

Stakeholder discussion also identified some social cultural and behavioral barriers to diffuse community farming, community gardening and agrotourism in agriculture and food security sector. One major barrier to the diffuse technology is lack of youth and women involvement in farming and most of the farmers of old age which prevents from introducing new technologies in the sector. Another important cultural and social barriers was the Foreign unskilled labor involvement in farming and farmland management distribution chain of agricultural produces in the country. This has potentially discouraged involvement of youth in the agriculture sector.

2.3 Identified measures

Based on the stakeholder consultations identified, measures that will enable diffusion of community farming, community gardening and agrotourism technologies are evaluated using objective tree (OT) method Figure 2. This was done by identifying corresponding measures or interventions to address challenges and problems identified by the stakeholder to scale up the diffusion of rooftop of community farming, community gardening and agrotourism technologies. As shown in the OT for the proposed measures are articulated around the following components.

- Increasing the financially attractive opportunities to support community farming, community gardening and agrotourism technologies;
- Strengthening the institutional, policy and legal framework for agriculture development;
- Improving the awareness and knowledge on agriculture technologies; and
- Improving the availability of good quality cost effective fertilizers plant material, plant nutrition irrigation systems, and hydroponic systems etc.

2.3.1. Economic and financial measures

Leveraging donor financing options- Government should provide and channel donor financial opportunities to the farming communities and interested groups to develop small scale community farming, community gardening and agrotourism technologies and try to develop dedicated need-based financing options.

Create awareness on financial market- opportunities and available products to support and develop community farming, community gardening and agrotourism technologies. Also, the government should regulate and prevent illegal unregulated expatriate community domination in agriculture in the Maldives.

Access to tourism industry- The tourism industry is the largest consumer of agricultural produce; however, the local farmers have very limited access to the resort industry in the Maldives. Therefore, sustainable collaboration with tourist market is necessary to encourage community farming, community gardening and agrotourism technologies to incentivize local producers.

2.3.2. Non-financial measures

Legal, Institutional and organizational measures

It is proposed that the institutional, policy and regulatory framework for promotion and implementation of community farming, community gardening and agrotourism technology is established to ensure that promoting efficient, equitable and sustainable methods of urban farming and agritourism is practices in the agriculture sector. Sector specific objectives of the Government must be aligned with the private sector. Institutional arrangements to reduce the overlapping of mandates of various institutions such as SOEs, MoFA AgroNet etc should be addressed and established. An overreaching community farming, community gardening and agrotourism mechanism should be established to promote and monitor the activities. The mechanism should also be able to regulate and promote community farming, community gardening and agrotourism technologies in urbanized centers throughout the country.

Human skill related measures

Skill development in agriculture sector in general and community farming, community gardening and agrotourism technologies in particular is an important measure to diffuse related technologies in the Maldives. Implementation of laws and regulation on expatriate labor will regulate foreign labor involvement in the agriculture sector.

Information, awareness and capacity measure

A nationwide knowledge, information and awareness campaign is needed to increase the awareness on climate change issues in general and food security, agriculture related adaptation in particular to provide practical information on community farming, community gardening and agrotourism. The objectives of such a campaign would be to explain how do community farming in limited spaces and urban environment, introduce existing technologies and benefit of community farming, promote measures in place to support the adoption community farming at household level. The campaign will target the general public and could include:

- Setting up a website or webpages, social media pages with basic information about community farming, how it works, its benefits and its drawbacks, and contact details for technical assistance etc.

- Writing and publishing a series of articles leaflets broachers with easy access for locals and general public focusing on the same content as the website or social media pages.
- Creating and broadcasting an animated TV spot introducing community farming community gardening and agrotourism and its benefits.
- Holding exhibitions in atoll and island levels on the technologies availabilities local suppliers based on current practices.

Technical measures

Short-term training courses and TVET education can be provide to develop skilled people to properly install and maintain small systems for community farming and community gardening such as improved drip/sprinkler irrigation systems, "certified" grain seed production and storage, and plant micro-propagation technology, technologies to increase soil fertility, integrated pest management and nutrient management, improved, climate specific, high yielding crop varieties, hydroponic systems, and marketing.

Tertiary and higher diploma level

Agronomists and Horticulture technicians needs to be trained both in private and public sector. Agrobusiness technicians, and other professional groups/companies who can provide technical service for installation and maintenance of complex small-scale agricultural technologies and renewable energy systems must be developed nationwide to guide and support agro-businesses and farmers in the usage of the new technology.

Social, cultural, and behavioral measures

Youth and woman must be encouraging to undertake community farming, community gardening and agritourism though various types of economic and social incentive and other supportive measures. Existing expatriate labor issues has to be properly regulated with strict implementation existing laws and regulations.

2.4. Linkages of the barriers identified

Technology selected for barrier analysis in Agriculture and food security sector is community farming, community gardening and agritourism technologies. The title given for the selected technology involves and embedded to include many technological advancements that are used in urban agriculture where land space and other resources are very constrained. Some of the technologies that is used in the community farming & community gardens and agritourism farming are

- Onsite compost and fertilizer production compost-making using household waste
- Technologies to increase soil fertility
- Integrated pest management and nutrient management
- Improved, climate specific, high yielding crop varieties
- hydroponic farming
- irrigation
- Use of solar and renewable energy in farm systems
- Promote crops that has the potential to attain self-sufficiency
- Post-harvest loss reduction technologies and storage facilities
- Value-addition and food processing technologies

- Agritourism developments

Barriers for diffusion of Individual technologies mentioned above are not assessed, however, broadly community farming & community gardens and agritourism technologies are evaluated. The technologies for agriculture and food security adaptation (eg: increase soil fertility, integrated pest management and nutrient management, improved, climate specific, high yielding crop varieties, hydroponic systems, drip/sprinkle/micro irrigation systems etc) are closely interrelated because they all are included in the community farming & community gardens and agritourism related agriculture development. Many of the barriers to the implementation of these technologies are closely interlinked, such as:

Economic and financial linkages

Major economic and financial barriers for adoption and promotion of community farming, community gardening and agrotourism technologies arise from high land fees unavailability of financial or economic incentives for promotion of small-scale urban agriculture in populated areas as well as small communities in islands. Unavailability of micro financing options and high cost of agriculture inputs to diffuse the technologies at for small scale farmer

Regulatory institutional and organizational linkages

The absence of a national policy to promote urban agriculture to address climate change is recognised as a key barrier to foster development of human and institutional capacity to develop adaptation technologies as well as create of enabling environment for promoting community farming, community gardening and agrotourism to improve the resilience of the agricultural and food security sector to climate change impacts. national policy support in terms of regulatory framework such as standards, promoting efficient irrigation systems and, climate specific, high yielding crop varieties, monitoring of pesticide residue on agricultural products and investment in small scale urban farming initiatives.

Technical expertise

Maldives has a very limited number of skilled and trained knowledgeable people in the agriculture sector for most of the technologies identified in this sector. Agronomists and Horticulture technicians are numbered. Research and Development services both in private and public sector are lacking. Agrobusiness technicians, and other professional who can provide technical service for installation and maintenance of complex small-scale agricultural technologies and renewable energy systems are few. Technical capacity building at vocational level required for these climate adaptation technologies could be a module within the curriculum of MNU and specialized training and educational institutes.

2.5. Enabling framework for overcoming the barriers in community farming, community gardening and agrotourism technology

This section explores the possible solutions to address the barriers for diffusion of community farming, community gardening and agrotourism technology. The enabling framework to address the common barriers include: increasing the financial attractiveness of opportunities to support technologies; strengthening institutional, policy and legal framework and public and private partnership for agriculture development; raising awareness and knowledge on agriculture technologies; and increasing availability of good quality cost effective fertilizers plant material, plant nutrition irrigation systems, and hydroponic systems etc.

Due to the small size of the islands, land scarcity, poor soil conditions and limited water resources in island aquifer, agriculture and food production is very limited in the Maldives. Community farming, community gardening and agrotourism technology is broadly urban farming concept promoted in areas where land availability is limited. Climate change can exacerbate the land scarcity issue though land loss from coastal erosion other natural resources through reduced rainfall, and high evaporation regimes and worsen pest and disease pressure which is a threat to food security hence need to provide the appropriate enabling environments to overcome the barriers to diffuse adoption of community farming community gardening and agritourism technologies in agriculture and food security sector is of economic importance were discussed as follows:

Table 7. Measures and enabling framework for diffusion of community farming, community gardening and agrotourism technologyg

Measure	Enabling framework
Increasing the financial attractiveness	• channel donor financing opportunities to the farming communities and interested groups • Develop dedicated need-based financing options and appropriate schemes • Create awareness on financial market opportunities available to support and develop technologies in this field. • Pave direct market access opportunities to tourism industry (resorts and hotels) for local farmers
Strengthening institutional, policy and legal framework	• Establish institutional, policy and regulatory framework for promotion of efficient, equitable and sustainable methods of urban farming and agritourism is practices. • Prevent illegal unregulated expatriate community engagement and domination in agriculture in the Maldives • Establish institutional arrangements to reduce the overlapping of mandates of various institutions such as SOEs, MoFA AgroNet etc ., • Establish an overreaching mechanism to promote and monitor community farming, community gardening and agrotourism technologies in urbanized centers throughout the country.
Technical social, cultural, knowledge and awareness related enabling framework	• Raise awareness on climate change issues in general, food security and agriculture related adaptation in particular to achieve self-sufficiency and food security through promotion of urban agriculture, community farming, community gardening and agrotourism technologies . • Educate the public on agriculture technologies applicable for small urban settings and its benefits to support adoption of community farming at household level • Raise awareness through various means such as websites social media articles series TV and radio broadcasting, animated sports on advertising screens, exhibitions etc., • Develop short-term courses to train skilled people on installation and maintenance of small systems for drip/sprinkler irrigation systems, “rain seed production and storage, plant micro-propagation technology, soil fertility and integrated pest management technologies, improved, climate specific, high yielding crop varieties, hydroponic systems, and marketing etc., • Develop and implement tertiary and higher diploma level training in Agronomy, Horticulture and Agrobusiness technicians

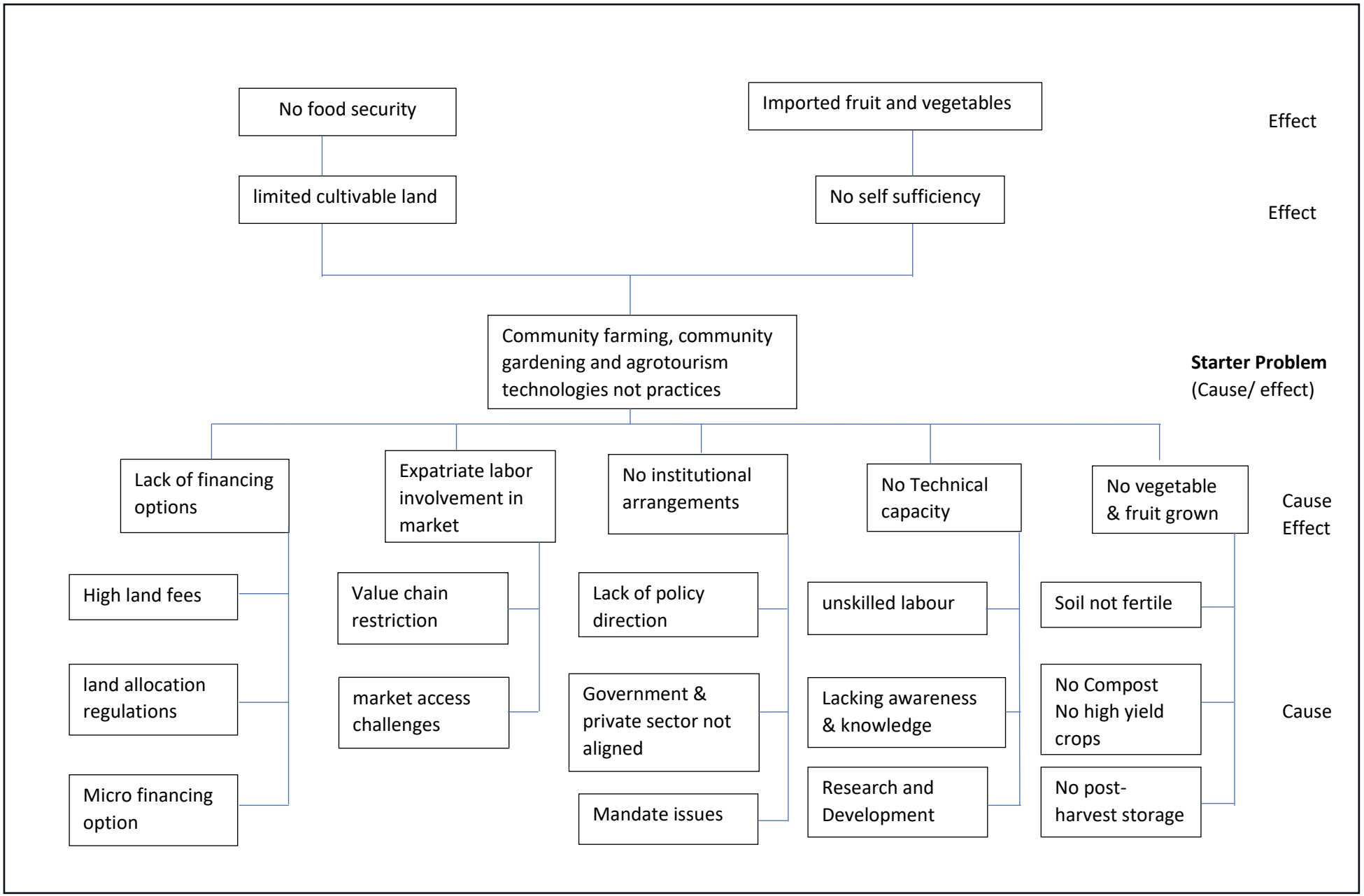

Figure 1 Problem tree, Community farming, community gardening and agritourism

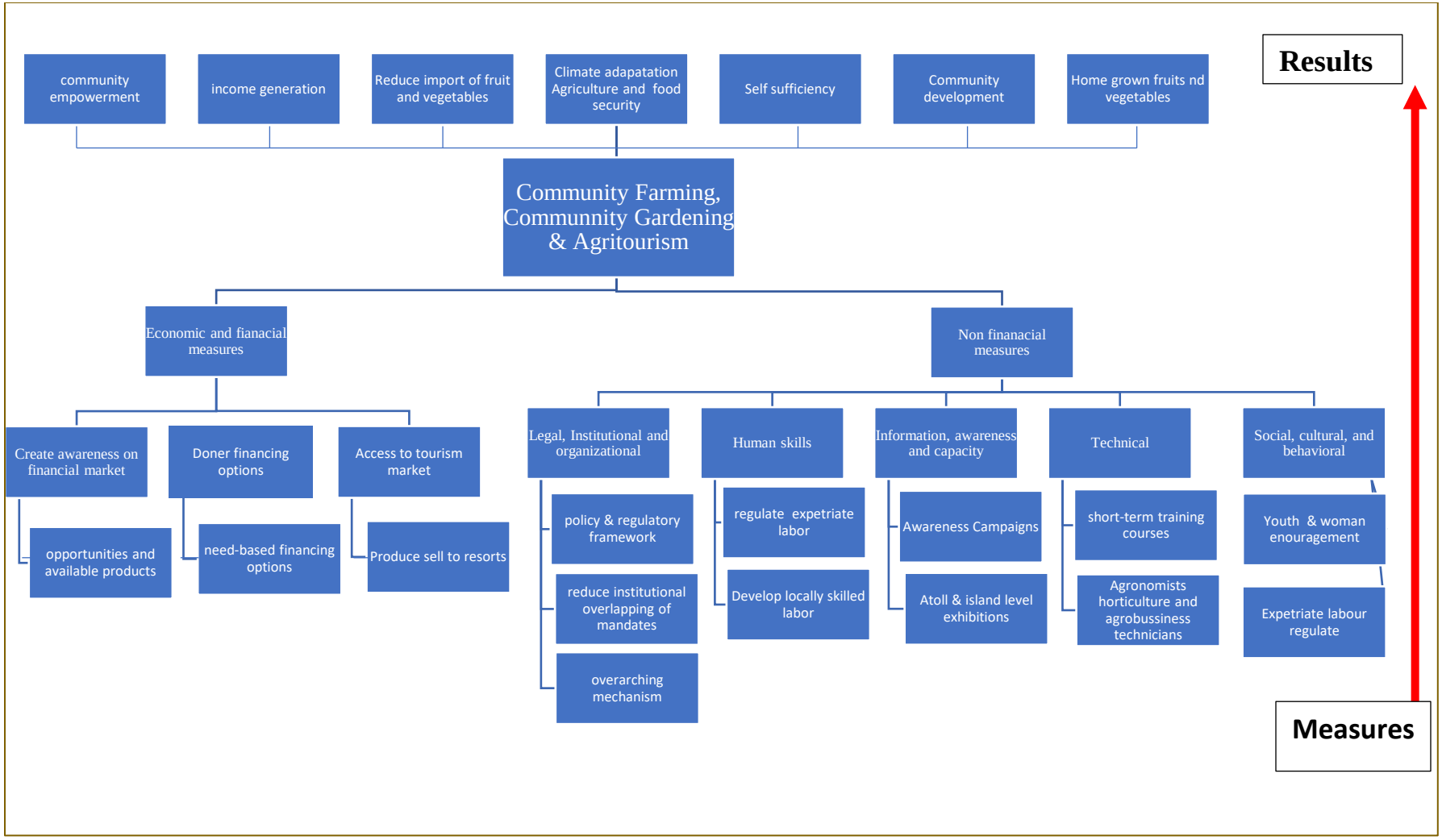
Results
community empowerment
income generation
Reduce import of fruit and vegetables
Climate adapatation Agriculture and food security
Self sufficiency
Community development
Home grown fruits nd vegetables
Community Farming, Communnity Gardening & Agritourism
Economic and fianacial measures
Non finanacial measures
Create awareness on financial market
Doner financing options
Access to tourism market
opportunities and available products
need-based financing options
Produce sell to resorts
Legal, Institutional and organizational
Human skills
Information, awareness and capacity
Technical
Social, cultural, and behavioral
policy & regulatory framework
reduce institutional overlapping of mandates
overarching mechanism
regulate expetriate labor
Develop locally skilled labor
Awareness Campaigns
Atoll & island level exhibitions
short-term training courses
Agronomists horticulture and agrobussiness technicians
Youth & woman enouragement
Expetriate labour regulate
Measures

Figure 2: Objective tree for community farming community gardening and agritourism

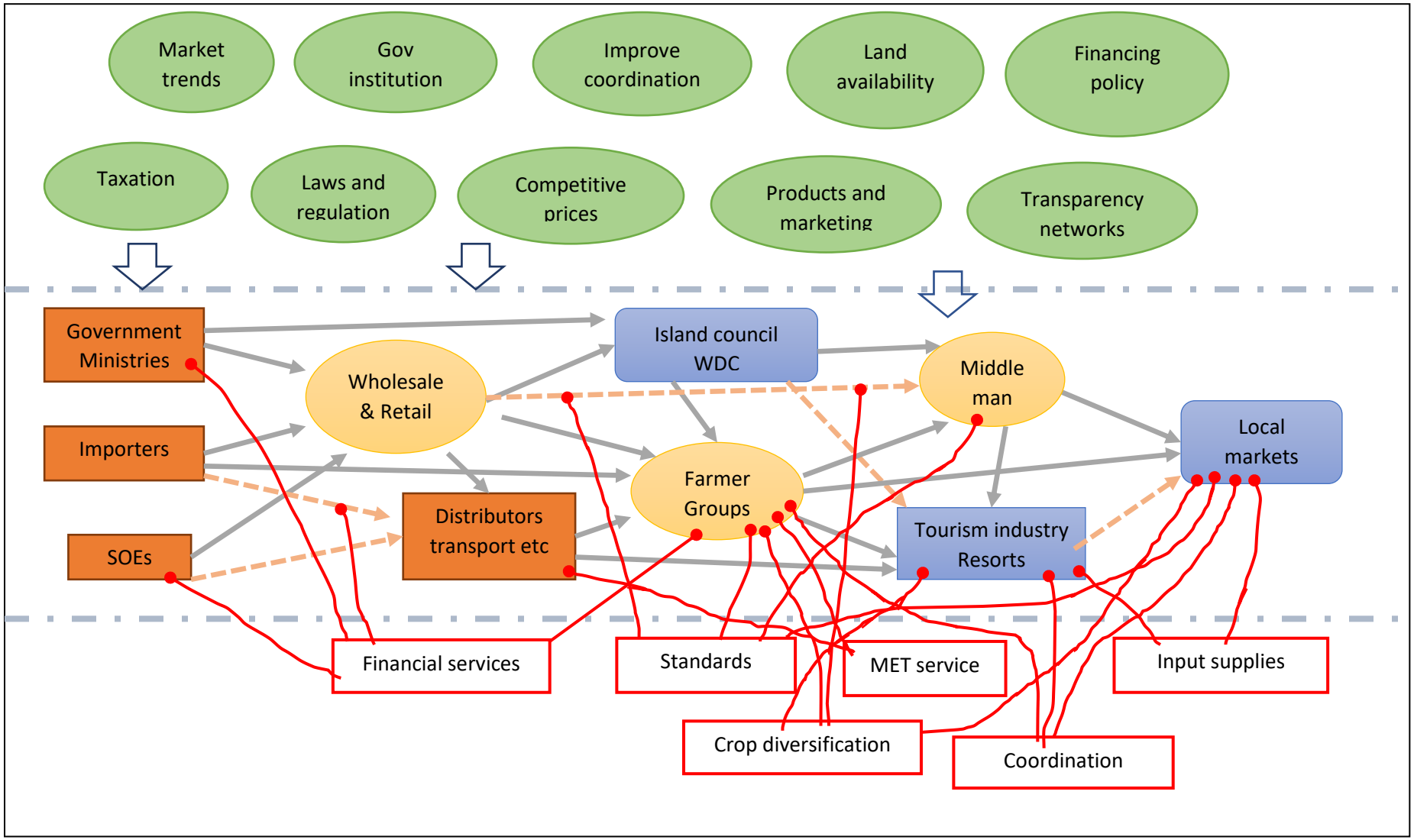

Figure 3: Market chain actors and links Community farming community gardening and agritourism technologies

Chapter 3 Coastal Adaptation and Disaster Management

Maldives prioritised Integration of technologies (drone, satellite imagery and GIS) into existing land use planning processes in the Technology Needs Assessment (TNA) as the resilience of natural environment is the key to coping with climate. One of the main challenges to implement impactful adaptation in Maldives is lack of contextualized and quantifiable historical and monitoring data and information on island to atoll level disaster risks, coastal erosion, flood prone areas, land uses biodiversity etc, as data acquisition is challenging for various parameters such as coastal, terrain, infrastructure, geology, weather history and hydro meteorological events etc to use for the decision-making purpose. The institutional framework to address climate change is also fragmented and requires capacity development at the local level. The existing capacities and data in relevant government authorities such as Maldives Land Survey Authority (MLSA), EPA, Ministry of Planning and Infrastructure and Housing, and other private institutions needs to be integrated in a central database to make it available for decision making on climate adaptation. Integration of technologies (drone, satellite imagery and GIS) into existing land use planning processes in the coastal adaptation and disaster management sector is based on the actions identified in the SNC and updated NDC report which include the following areas.

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

In this chapter, barriers hindering the acquisition and diffusion of Integration of technologies (drone, satellite imagery and GIS) into existing land use planning processes are identified and measures to overcome the barriers and facilitate the transfer, adoption and diffusion of these technologies are elaborated. Based on the analysis on the linkages of the barriers and possible solutions are suggested on how the barriers can be addressed, and what the resource required are discussed. Further, the enabling environment that will support the reduction or elimination of barriers confronting the technology is discussed.

3.1 Preliminary targets for technology transfer and diffusion of Integration of technologies (drone, satellite imagery and GIS) into existing land use planning processes

Small low-lying geographic nature of Maldives islands results in communities having to live in very close proximity to the shoreline and highly exposed to risks associated with coastal hazards such as sea swells, sea level rise and these impacts have increased many folds over the past few decades. Mapping is generally considered to be a basic necessity for the successful implementation of all other technologies for island dynamics and historical changes of shoreline extreme hydro meteorological events is a vital component for appropriate land use planning and to address climate change related vulnerabilities of islands. It creates easily-read, rapidly-accessible visual maps which facilitate the identification of areas at risk of erosion flooding etc., and also helps prioritise mitigation and response efforts. Such maps contribute to increase

awareness of the likelihood of climate risks among the public, local authorities and other organizations and serve as an indispensable resource for integrated planning. Understanding of coastal risk complements and strengthens other adaptation options, such as coastal erosion, island dynamics flood mitigation measures, emergency planning, provision and evacuation planning. As such, this approach could be applied almost universally, irrespective of the other adaptation technologies that are used.

The primary target for the diffusion of integrated technologies (drone, satellite imagery and GIS) into existing land use planning processes is to facilitate the identification of areas at risk of land loss, flooding etc., and to prioritise mitigation and response efforts to coastal risks and strengthens other adaptation options, such as coastal erosion, island dynamics flood mitigation measures, emergency planning, provision and evacuation planning. Integrated Land Use Planning (ILUP) Drone mapping, satellite imagery and GIS will employ combination of existing latest technologies such as Drones, DGPS high resolution satellite imageries as well as conventional methods for data collection surveying and mapping.

The objectives of integrated technologies (drone, satellite imagery and GIS) into existing land use planning processes is aligned with numerous strategies and national documents SNC, NDC, INDC. Specifically for the planning process where the allocation of land to different uses across a landscape in a way that balances economic, social and environmental values. This technology includes flood mapping, mapping of coastal ecosystems (using LIDAR and drones), bathymetry and current mapping to better understand waves dynamics in order to allow for better planning of coastal restoration and protection measures.

The overall aim is to practice evidence based informed decision-making process by optimizing land use with carrying capacity of small islands and adaptation to climate change is in mind. Establish, database, modeling and GIS platform for data analysis and integrated land use planning for decision support system and decision making to ensure that climate change is integrated into development planning and decision-making process.

Figure 4: Mapping technologies laser scan and UAV mapping 2

[2] https://www.water-solutions.com/uav-mapping

3.2 Barrier analysis and possible enabling measures integrated technologies (drone, satellite imagery and GIS) into existing land use planning processes.

3.2.1. General description of Integration of technologies (drone, satellite imagery and GIS) into existing land use planning processes

This technology includes many different methods to map for land use planning, terrestrial, coastal and marine developments and monitor coastal areas, both onshore and offshore for critical infrastructure developments economic and environmental projects related decision making. Mapping and monitoring of coastal processes is generally considered to be a basic necessity for the successful implementation of all other technologies used to protect the coast from the impacts of climate change.

Some of the mapping methods included in this technology are mapping of coastal ecosystems (using high resolution satellite imagery mainly but also ground-proofing with field studies drone photography and LIDAR data in GIS platforms), topography, bathymetry, and risk maps identifying key areas susceptible to flooding, erosion and other impacts of climate change. In terms of monitoring, periodic data collection and analysis is required to gauge changes over time due to climate change impacts, developments on the coast, and impact of coastal restoration measures.

The technology also includes ongoing studies of coastal dynamics to better understand island dynamics ocean and nearshore waves, currents and sand movement patterns in order to allow for better planning of islands, land reclamations harbour development and coastal protection measures, as well as inform other development projects such as water and sewerage networks, land cover and land use maps. By using up to date data, computer models can generate likely scenarios of how island developments and protection measures will affect hydrodynamics, sand movement and other coastal processes around the island.

While most of the inhabited islands, industrial and agricultural islands and all the resorts has already been mapped in Maldives, it is sporadic, fragmented, and much of the data is not accessible because it is owned by private developers or the Government. These maps and data is needed to be centrally stored and for producing maps for monitoring and decision making process. However, it would require several measures to be put in place for overcoming the financial and human capacity barriers (discussed below) that the technology faces. There is a need for better institutional coordination to guide decision-making about island coastal developments, or infrastructure such as roads water and sewerage networks, or how to restore a wetland allocated tourism and industrial zones in islands so as to better plan the islands for the future.

3.2.2. Technology category and market characteristics of Integration of technologies (drone, satellite imagery and GIS) into existing land use planning processes

Integration of technologies (drone, satellite imagery and GIS) into existing land use planning processes are from the following categories:

1- consumer goods

- Satellite images: resolution appropriate to the island scale of Maldives
- Drone, Photography LIDAR: Good for Shoreline mapping/ changes over time
- Hardware and Software
- Good Internet Speed

2- Capital goods

- Weather Data
- Establish GPS/GNSS network
- Capacity of analysing remotely sensing data, Drone and LIDAR images
- GIS platform

3- Publicly provided goods

- Permits and licenses (import/ export permits of technologies)
- Standards, certificates and regulation)
- Staff trainings
- Specialized computer hardware and software and numerical modelling platforms

4- Other non-market goods

- State level Investments in ICT and improvement of NCIT
- Center for data sharing and processing
- AI Outputs
- LUPs to consider social/community needs tied to climate change adaptation to resource use resilience

As shown above Integration of technologies (drone, satellite imagery and GIS) into existing land use planning processes components in different categories of technologies depending on the context and scale of the project.

A market supply chain analysis was carried out and it is shown in Figure 7 (Market Map for Integration of technologies (drone, LIDAR, satellite imagery and GIS) into existing land use planning processes). The supply chain includes importers of survey equipment, DGPS systems, retailers of measuring tools, local agents of equipment installers and maintenance contractors, and end users. The diffusion of integration of technologies (drone, satellite imagery and GIS) into existing land use planning processes requires an enabling environment for the demand-supply chain, and the services and inputs providers the technologies and skills. Such enabling environment should include a mapping and surveying, standards, policies, standards, license, data analysis guidelines, financial incentives and information and advisory services.

3.2.3. Identification of barriers to the diffusion of Integration of technologies (drone, satellite imagery and GIS) into existing land use planning processes

Stakeholders in the coastal and disaster management sector both at the policy and technical levels, and private and NGO partners in the sector, listed a series of barriers to consider in. Integration of technologies

(drone, satellite imagery and GIS) into existing land use planning processes barriers were identified in the demand-supply chain as illustrated by the Problem Tree (PT) in Figure *5*. The categories of barriers are as follow:

- Economic and financial
- Market conditions
- Legal and regulatory
- Institutional and organizational capacity
- Human skills:
- Information and Awareness
- Technical
- Social, cultural, and behavioral

Table 8. Barriers and measures for diffusion of Integration of technologies (drone, satellite imagery and GIS) into existing land use planning processes

Category	Barrier	Measure
Economic and financial	High capital cost Lack of state funds in the annual national budget Financial resources needed to train skilled staffs for maintenance of LIS Freelancers/private sector need financing Micro financing options for procurement of survey equipment.	invest in surveying, mapping and monitoring equipment, as well as computer hardware and software for storing and processing data Seek external grant funding from any of the climate adaptation funds Allocate Government budget capacity building and equipment maintenance Channel donor financial opportunities to the private sector and freelancers/SMEs Procure yearly country data sets of two monsoons
Market barriers	Unregulated expatriate involvement results in substandard maps and survey products; lack of technology means and tools available to aid LUP; High costs for purchasing, and low funding to achieve. Mapping projects are sporadically financed through project grants, private developments or in-kind support	Regulate foriegn farms involvement in professional and technical fields
Legal Institutional and organizational	Centralized GIS platform integrating MLSA) EPA, MNPHI, MECCT and several NGOs to a database is important for integrated LUP No data sharing mechanisms between institutions and organizations. Policy level mindsets on planning needs to improved and tailored on	centralized system to integrate existing databases Establish data sharing mechanisms between institutions Bottom-up approach in local level consultation

	case by case as two islands/locations will not be the same. Data used in policy level. Limited understanding of science-based decision-making Bottom-up approach and importance of local level consultation to make use of available data. Weak capacity; Lack of integration between institutions on common interests	
Human skill	lack of properly trained people with technical expertise in mapping, survey monitoring and modeling Lack of skilled surveyors and GIS technical personnel Lack of centralized institution, to compile and collate information about mapping and surveying	Alloate Govenment funding for staff development and training Enhance MNU Environmental and IT curculum to include GIS. mapping and data management Providing opportunities for Maldivian experts to work alongside international consultants Develop partnership with overseas universities and research institutions
Information, awareness and capacity measures	Lacking awareness on impacts of climate change on islands and reefs Lack of information dissemination and training, and limited coordination among key actors and institutions	awareness on climate change issues integration of surveying, mapping, monitoring and modeling technologies into LUP Awareness on CC linkages on Flooding, coastal erosion sensitive ecosystems and and adpatation conduct CC eduction programmes for decision makers media and developers contractors etc.
Technical Barriers	Political bias towards fulfillment of presidential campaign promises with quick solutions to life and infrastructure threatening problems eg: flooding or erosion need an in-depth climate change education programs for decision-makers Research and Development services both in private and public sector are la	Short-term training courses and TVET education programs for skill development in hydrography surveying Drone mapping imageanalyis LIDA Data Tertiary and higher diploma level Mapping and GIS professional and surveyors

Social, cultural, and behavioral barriers	lack incorporation or use of indigenous knowledge on island dynamics Engagement of foreign farms in island surveying and mapping project has reduced the availability of local professionals for competitive prices	IKLK use inisland dynamics terrestrial and marine environment assessment and LUP development Expetriate labour regulate encourage and create opportunity for local professionals

3.2.3.1 Economic and financial barriers

Major economic and financial barriers for the diffusion of Integration of technologies (drone, satellite imagery and GIS) into existing land use planning processes identified by the stakeholders are: High capital cost and lack of state funds in the annual national budget for related infrastructure and equipment. Financial resources are also needed to train skilled staffs for programing and maintenance of the existing Land Information System (LIS) for Maldives Land Survey Authority and MoECCT. Skilled freelancers and other private sector companies are facing lack of financing particularly unavailability of micro financing options for procurement of survey equipment.

Market barrier identified by the stakeholders to diffuse of Integration of technologies (drone, satellite imagery and GIS) into existing land use planning processes: Unregulated expatriate involvement in market chain which results in substandard maps and survey products; lack of technology means and tools available to aid LUP; high costs for purchasing, and low funding to achieve. Mapping projects are sporadically financed through project grants, private developments or in-kind support. Currently there is a hydrographic survey of the Maldives in partnership with Indian Navy. The end result is that because the Government of Maldives does not invest in mapping and surveying, it owns very little data, and the data are fragmented.

Some of the information, such as high-resolution satellite imagery can be purchased from international geospatial suppliers. At present the government relies on project grants to cover these costs and investments in the acquisition of images are sporadic. Ideally, the government should budget to invest in high resolution data set of the country at least twice per year (once for each monsoon season). These images can be used to track changes over time, both on land and in the shallow coastal seas.

Currently, the government is not providing any financial or economic incentives for promoting mapping and surveying technologies. At present the skill and training developments in the field are very much project based in Government offices. However, pooling drone, satellite imagery and GIS technologies together and connecting and integrating them to a database is necessary to integrate land use planning for various development purposes.

3.2.3.2 Non-financial barriers

The main non-financial barriers identified by stakeholders are; Institutional and organizational capacity; Human skills; Information and Awareness; Technical; Social, cultural, and behavioral illustrated in the Problem Tree (see PT in Figure *5*). These are discussed below:

Institutional and organizational barriers

Maldives Land Survey Authority (MLSA) already have a system in places and GIS platforms are also used in the relevant authorities eg EPA, MNPHI and MECCT and several NGOs as well as private companies have appropriate coastal mapping capacities. At present there is no one person authority or entity that has all these capacities and skills. etc. A centralized system integrating them to a database is important for

integrated land use planning and other development related decision support system. The barriers identified in this category can be summarized into:

- No data sharing mechanisms between institutions and organizations.
- Policy level mindsets on planning needs to improved and tailored on case by case as two islands/locations will not be the same. Data used in policy level.
- Limited understanding of science-based decision-making
- Bottom-up approach and importance of local level consultation to make use of available data.
- Weak capacity;
- Lack of integration between institutions on common interests

Human skill related barriers

Major barriers to diffuse technologies related to mapping and surveying is the lack of properly trained skilled people to engage and guide in the field. Recently increased the number of nationals with technical expertise in mapping, survey monitoring and modeling etc. these are handful of individuals generally interspersed among a wide range of Government and public institutions and some work as freelance consultants or for private companies. Generally, most of these experts are overstretched and none are focused on specific assignment and projects rarely engaged in compiling data from different sources, or generating models. The work is done on a case-by-case basis in response to developments or available funding for project of a particular island or development activity. As a result, while there is some technical expertise, it is not enough. There is a need for more training of local expertise, and also for building partnerships with overseas universities and research institutions that can bring in expertise and help train more Maldivian in the field of surveying, mapping and monitoring.

MLSA is the government institution responsible for surveying in mapping and they are more engaged in standardization and review of surveys as well as maintaining LIS. The institution is understaffed. There should be some committed technical experts housed in either MLSA or one centralised institution, devoted entirely to the task of compiling and collating information about mapping and surveying so that it is readily available for decision makers when planning island and measures for infrastructure developments. The barriers identified in this category can be summarized into:

- Lack of skilled surveyors and GIS technical personnel
- Lack of centralized institution, to compile and collate information about mapping and surveying

Information, awareness and capacity barriers

In order to ensure the success of any new technology or policy, awareness is important. Apart from an aggressive campaign on the particular technology on surveying and mapping, there will be a need to create the awareness of the impacts of climate change on islands and reefs in both the short and long term. Given the limited spaces in the islands available for development it is difficult to convince the public and the officials of the need and usefulness of proper scientific understating of the processes around the islands as this measure may appear to hinder to the overall development and livelihood of the island. There exists a knowledge gap between surveying, mapping and GIS related technical people who are practicing and engaged in private sector projects and the general agencies and authorities who have responsibility for approving and monitoring these activities. Therefore, there is usually a misinformation and misalignment of the process and way forward mapping and survey related activities. Information barriers may arise due

to poor extension services, lack of information dissemination and training, and limited coordination among key actors and institutions.

Technical Barriers

Not many policy makers understands that development activities can sometimes cause further problems if a systemic approach, including integrated planning and sound scientific knowledge, is not adopted. short political cycles favour short-term decision making at the detriment of sustainable development planning, including planning for the impacts of climate change and variability in general, and more specifically regarding impacts on coastal and marine environment. Consequently, there is a political bias towards fulfillment of presidential campaign promises with quick solutions to life and infrastructure threatening problems such as incidents of flooding or erosion, and mostly in a reactive way. Planning for the avoidance of potential future problems, and undertaking the scientific monitoring required for putting in place measures that will minimise damage from climate change impacts in islands, is not the norm, and not even a priority. In order to make informed decisions about tourism or infrastructure developments in reef islands, it is critical that decision-makers and planners have a very solid understanding of how dynamic our islands are changing as a result of climate change, and how they will change in the future, thereby affecting any developments or infrastructure built today.

There is an ongoing need for more in-depth and targeted climate change education programs to help decision-makers understand climate change impacts, and how they can be measured and modeled to inform effective long-term planning.

Maldives has very few skilled persons who has knowledge and can conduct properly surveys, monitor and collect data on the environment and compile them in GIS platforms. In Maldives, there are usually adhoc groups engaged in this field however qualified, trained and knowledgeable technical people are numbered. Research and Development services both in private and public sector are lacking.

Social, cultural, and behavioral barriers

Stakeholder discussion also identified some social cultural and behavioral barriers to diffuse Integration of technologies (drone, satellite imagery and GIS) into existing land use planning processes. One major barrier to the diffuse technology is lack incorporation or use of indigenous knowledge on island dynamics and changes that takes place in the terrestrial and marine environment. Understanding of those changing and taking them into account during the LUP preparation process is envisaged to be vital part of the planning and development. Another important cultural and social barrier was the involvement of foreign farms in island surveying and mapping project in the country. This has potentially reduced the availability of locals for competitive prices and created discontent among the professionals engaged in the field.

3.3. Identified measures

Based on the stakeholder consultations identified, measures that will enable diffusion Integration of technologies (drone, satellite imagery and GIS) into existing land use planning processes technologies are evaluated using objective tree (OT) method. Figure 6 This was done by identifying corresponding measures or interventions to address challenges and problems identified by the stakeholder to scale up the diffusion of technologies used for surveying, mapping and monitoring of developmental projects in islands

3.3.1 Economic and financial measures

There is need to provide funding to invest in surveying, mapping and monitoring equipment, as well as computer hardware and software for storing and processing data. The equipment can be owned by MLSA

or any other centralized agency/ institution designated by the Government Maldives to serve as the hub for providing necessary information for planning and development of islands.

The recommended strategy is for the Government is to apply for external grant funding from any of the climate adaptation funds to support for initial investment into equipment needed. A GCF project on climate change adaptation on the building climate resilient safer islands in the Maldives has already been initiated and can integrate the recommendations from the TNA process. The Government budget should allocate annual budgetary funds to support for the capacity developments and costs of the equipment to supplement the project.

Leveraging donor financing options- Government should provide and channel donor financial opportunities to the private sector and freelancers/SMEs technical people and interested groups to help to develop surveying monitoring and mapping technologies and try to develop dedicated need-based financing options

Also, the government should regulate and prevent unregulated foreign farms engagements in this kind of professional and technical fields in the Maldives without proper fulfilment of required legal procedures and documents.

3.3.2 Non-financial measures

Legal, Institutional and organizational measures

It is proposed that the institutional, policy and regulatory framework for promotion and Integration of technologies (drone, satellite imagery and GIS) into existing land use planning, to one centralised authority with existing capacity should be specifically designated as the hub for surveying monitoring and mapping onshore and offshore environment, and generating reports to guide decision-making. This could be either the MLSA, or the GIS unit of the MHPI. There would be a need for budget allocation and possible amendments to legislation regarding the mandate of the institution. The authority would be responsible for coordinating and harmonizing data between the different government and non-government stakeholders engaged in various studies of island and ecosystems throughout the country.

A legal framework might be required to mandate stakeholder Government agencies to share data and reports generated by all project with the centralised authority.

Human skill related measures

Skill development in coastal and disaster management sector in general Integration of technologies (drone, satellite imagery and GIS) into existing land use planning processes in particular is an important measure to diffuse related technologies in the Maldives. Implementation of laws and regulation on engagement of foreign firms in the field will encourage Maldivians to develop their skills in the sector. Also, the following measure will contribute to enhance human capacity in surveying, mapping and monitoring in the country:

- Allocate government funding for staffing and other operational costs to coordinate mapping and monitoring of islands on a national basis with all of the stakeholders
- Provide opportunities for student internships in government institutions and private sector organisations undertaking studies on surveying mapping and monitoring data collection in onshore and offshore areas of island;
- Enhance MNU environmental science and IT curricula related to GIS, mapping, data management, modeling, etc.;
- Providing opportunities for Maldivian experts to work alongside international consultants undertaking studies of islands at equivalent and fair pay rates; and

- Develop partnerships with overseas universities and research institutions engaged in data collection, mapping, monitoring and modeling related to small islands.

Information, awareness and capacity measure

Information and awareness campaign is needed to increase the awareness on climate change issues in general integration of surveying, mapping, monitoring and modeling technologies into existing land use planning processes in particular to provide practical information for infrastructure development projects. The objectives of such a campaign would be to touch different level of stakeholders including Government, public and private sector. Awareness campaign could further merge into a larger programme which aims at providing appropriate information with regards to climate change and issues like flooding, coastal erosion and other sensitive ecosystems to the stakeholders to explain how such measures can help in adaptation to climate change, and identifying alternatives that can be used and the benefits of the use of such technology that will have negative impacts on the surrounding environment.

There is a need for targeted climate change education programs to help decision-makers understand, island dynamic and climate change impacts, and how they can be measured and modeled to inform effective long-term planning. At the same time, improved media programs and climate information via social media can also provide a valuable source of information for the general public, potential developers, contractors and others to learn about how climate change and climate variability can impact the development projects in the long term.

Technical measures

Short-term training courses and TVET education can be provide to develop skilled people to undertake survey mapping and monitoring, short courses on hydrography levelling and survey set-out measuring, beach profiles, drone survey, analysis of satellite images, collecting and processing LIDAR data.

Tertiary and higher diploma level

Mapping and GIS professional and surveyors needs to be trained both in private and public sector. GIS and satellite image data analyst, and other professional groups/companies who can provide necessary data layers for the GIS platforms must be trained nationwide to guide and support the existing capacity in the usage of the new technology.

Social, cultural, and behavioral measures

Incorporation or use of indigenous knowledge and local knowledge on island dynamics and changes that takes place in the terrestrial and marine environment needs to be integrated into existing surveying, mapping and monitoring technologies used for land use planning processes. Understanding of the local context and environment and taking them into account during the LUP preparation process is envisaged to be vital part of the planning and development. Existing laws and regulations must be implemented to prevent unregulated professional involvement of foreign farms in island surveying and mapping project in the country. This will encourage and give opportunity for local professionals to engage in the field.

3.4 Linkages of the barriers identified

Technology selected for barrier analysis in coastal and disaster management sector is Integration of technologies (drone, satellite imagery and GIS) into existing land use planning processes. The title encompasses selected technologies involves and embedded to include many technological advancements

that are used in surveying, mapping and monitoring of land and marine environment for infrastructure development and land use planning process. Some of the mapping methods included in this technology are mapping of coastal ecosystems (using high resolution satellite imagery mainly but also ground-proofing with field studies drone photography and LIDAR data in GIS platforms), topography, bathymetry, and risk maps to identify key areas susceptible to flooding, erosion and other impacts of climate change. Monitoring technologies include periodic data collection and analysis required to gauge changes over time due to climate change impacts or land use, island dynamics ocean and nearshore waves, currents and sand movement patterns in order to allow for better planning of islands, land reclamations habrour development and coastal protection measures, as well as other development projects such as water and sewerage networks, land cover and land use maps etc. Different barriers common to the diffusion of integration of technologies (drone, satellite imagery and GIS) into existing land use planning processes are discussed below:

Budget and financing linkages

For all the technologies included in integration of (drone, satellite imagery and GIS) technologies into planning processes, there is very limited government investment on mapping and monitoring equipment, computer hardware and software for storing and processing data funding. Government budget support is necessary to sustain surveying, mapping and monitoring of land and marine environment for infrastructure development and land use planning process. Most of the available funding in this process is almost exclusively from project grants to government, and in some cases, limited budgetary support for salaries of civil servants working in the field.

Government support and financial assistance is needed for the private sector as well as for the local freelancers/SMEs surveying community to develop surveying mapping and monitoring technologies.

Regulatory institutional and organizational linkages

Climate change impact has to be considered in the planning process in island infrastructures development over the long term – over decades. It is very challenging given the current policy and legal framework, which lacks of political will (coupled with short political cycles of 5 years), limited knowledge of decision-makers about climate change, and the importance of science-based decision-making. This may be due to the unavailability of necessary information and data for decision making authorities in the government.

A designated centralised authority needs to be established as the hub for surveying monitoring and mapping onshore and offshore environment, and generating reports to guide decision-making, and land use planning process. A legal framework might be required to mandate stakeholder Government agencies to share data and reports generated by all the projects. The centralised authority responsible for coordinating and harmonizing and standardising data, compile and collate information from different government and non-government stakeholders

Technical skill and expertise

Climate change education programs are needed to help decision-makers understand climate change impacts, and how they can be measured and modeled to inform effective long-term planning. As decision-makers and planners must have a solid understanding of how dynamic of our islands are changing as a result of climate change, and how they will react in the future in response to developments or infrastructure built today. Maldives has very limited skilled persons who can conduct proper land and marine surveys, monitor and collect data on the environment and compile them in GIS platforms particularly in the government sector. Also, research and development services both in private and public sector are lacking in this field.

3.5 Enabling framework for overcoming the barriers in the Coastal and disaster management sector

Table 9. Measures and enabling framework for diffusion of Integration of technologies (drone, satellite imagery and GIS) into existing land use planning processes

Measure	Enabling framework
Financial	• Need to invest in surveying, mapping and monitoring equipment, as well as computer hardware and software for storing and processing data. External grant funding from any of the climate adaptation funds to support for initial investment into equipment could be considered. • Provide government budgetary support for the capacity developments and costs of the equipment maintance and training. • Channel donor financial opportunities to the private sector and freelancers/SMEs technical people and interested groups to help to develop surveying monitoring and mapping application of technologies and try to develop dedicated need-based financing options.
Legal, Institutional and organizational framework	• Promotion and Integration of technologies (drone, satellite imagery and GIS) into existing land use planning, to one centralised authority responsible for coordinating and harmonizing data between the different government and non-government stakeholders. • Establish a legal framework to mandate stakeholder Government agencies to share data and reports generated by all projects with the centralised authority. • Implementation of existing laws and regulations on engagement of foreign firms in the field to encourage Maldivians to develop their skills in the sector.
Technical social, cultural and skill related enabling framework	• Enhance MNU environmental science and IT curricula related to GIS, mapping, data management, modelling, etc., • Provide opportunities for Maldivian experts to work alongside international consultants undertaking studies of islands at equivalent and fair pay rates. • Develop partnerships with overseas universities and research institutions engaged in data collection, mapping, monitoring and modelling related to small islands. • Provide opportunities for student internships in government institutions and private sector organisations undertaking studies on surveying mapping and monitoring data collection in onshore and offshore areas of island • Increase awareness on climate change issues in general integration of surveying, mapping, monitoring and modelling technologies into existing land use planning processes in particular to provide practical information for infrastructure development projects.

	• Conduct climate change education programs to help decision-makers understand, island dynamic and climate change impacts, and how they can be measured and modelled to effective use in long-term planning. • Include survey mapping and monitoring, short courses on hydrography levelling and survey set-out measuring, beach profiles, drone survey, analysis of satellite images, collecting and processing LIDAR data in TVET education curriculum. • Include survey mapping and monitoring, short courses on hydrography levelling and survey set-out measuring, beach profiles, drone survey, analysis of satellite images, collecting and processing LIDAR data in TVET education curriculum. • Indigenous Knowledge and Local Knowledge (IKLK)should be integrated into LUP development process

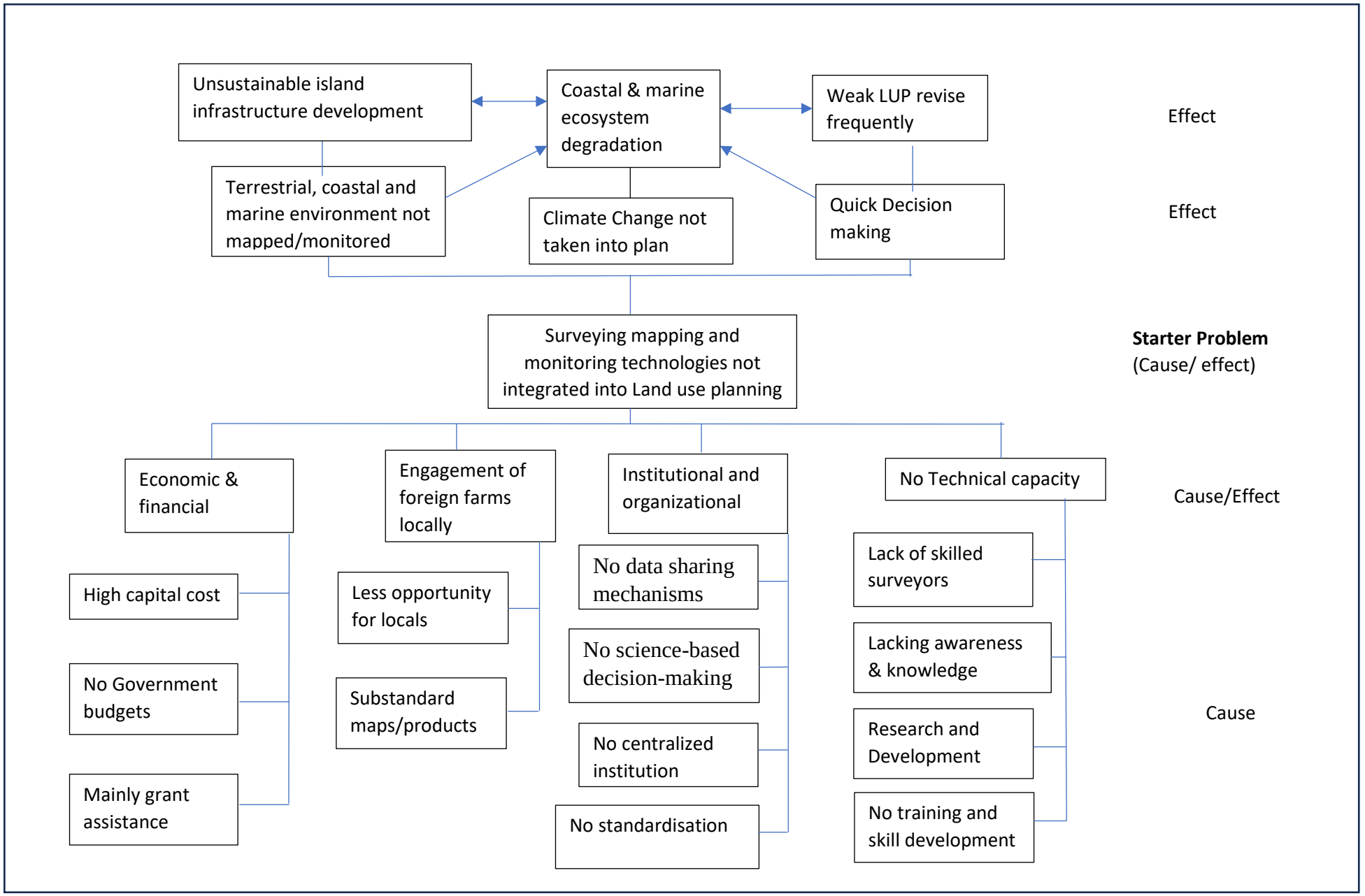

Figure 5:Problem tree; Coastal adaptation and disaster management, Integration of technologies (drone, satellite imagery and GIS) into existing land use planning processes

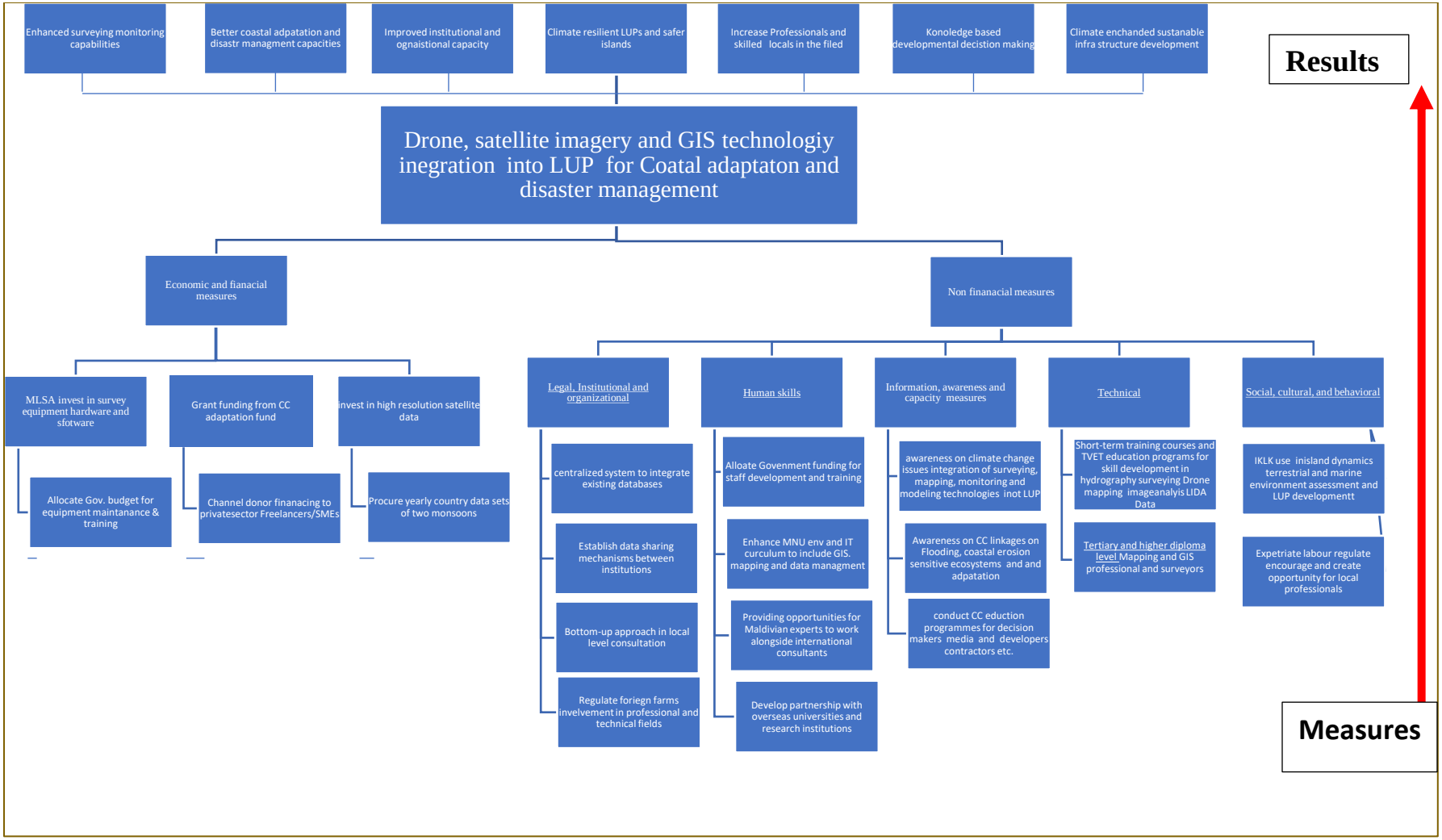

Figure 6: Objective tree Coastal adaptation and disaster management sector. Integration of technologies (drone, satellite imagery and GIS) into existing LUP processes

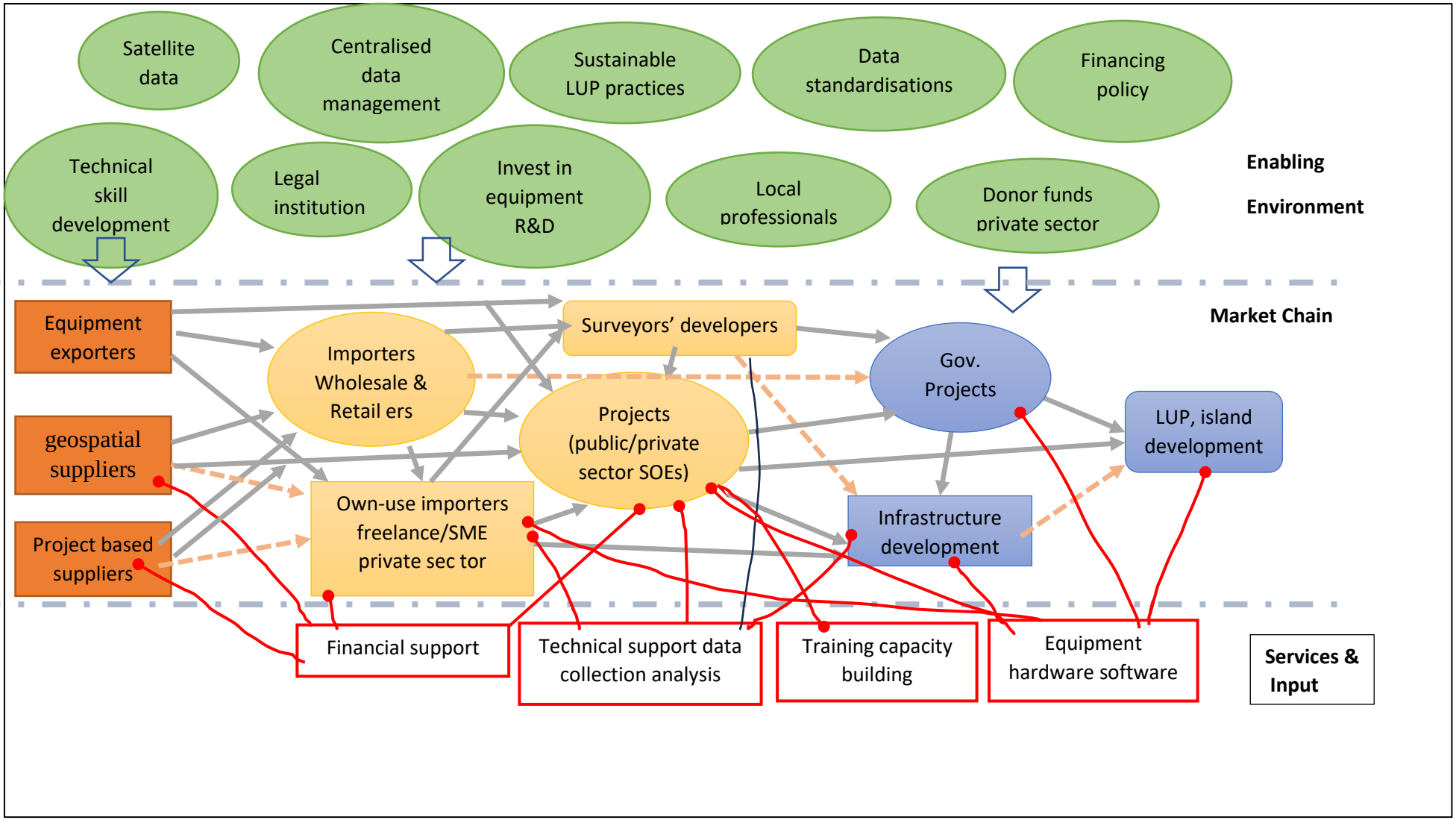

Figure 7: market chain actors and links Integration of technologies (drone, satellite imagery and GIS) into existing land use planning processes, coastal adaptation and disaster management sector

Chapter 4 Water Resource sector

Integrated water resource management is the policy adopted by the country to provide portable water for the islands and local community. IWRM involves combination of protection and conservation of fresh ground water lens, integration of rainwater for domestic consumption and aquifer recharge, inclusion of rainwater in public supply, demand management through use of efficient water fixtures and consumer practices, leakage control in the system at consumer level.

Based on extensive stakeholder discussions Maldives prioritized and selected promotion of rainwater integration into, irrigation, industrial purposes, building code technologies in the Technology Needs Assessment (TNA) as the resilience of natural environment is the key to coping with climate change in the water sector. Large number of inhabited islands in the Maldives are exposed to flooding from extreme precipitation events and Udha (storm surges, Tidal flooding). In general, nation-wide, over the past decade there has been a upward trend in the frequency and intensity of island flood incident associated with precipitation and Udha. Due to lack of proper flood and storm water management systems in most of the inhabited islands the impact of flood hazards risks with the climate change is predicted to be more severe and devastating in the Maldives. Therefore, artificial drainage facilities need to be constructed to discharge or infiltrate runoff collected on impervious land surfaces. Ministry of Environment (MoE, 2021) has recommended to adopt and promote sustainable infiltration drainage techniques in road drainage schemes in islands to maximise groundwater recharge. The idea of sustainable drainage is to intercept the hydrologic cycle, catch most of the rain before it reaches a piped drainage system and infiltrate it into the subsoil layer. Infiltration drainage systems (natural or artificial) are used in combination with underground piped system and conventional stormwater drainage system to prevent flooding and inundation. This method is suitable as on-site drainage solution for small-scale developments. The most important benefit of sustainable drainage methods is its potential for groundwater recharge when applied to urban road drainage schemes.

The institutional framework to address needs to integrate all the above measures in the national building code and required to develop capacity at the local level to promote technologies for water resource management in the country. Promotion of rainwater integration into, irrigation, industrial purposes, building code technologies in the climate adaptation in water sector is based on the actions identified in the, National water and Sewerage policy, National water and sewerage act (2020) and Water and Sewerage master plan (2021-2035) which include the following areas.

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

In this chapter, barriers hindering the acquisition and diffusion of promotion of rainwater integration into, irrigation, industrial purposes, building code technologies are identified and measures to overcome the barriers and facilitate the transfer, adoption and diffusion of these technologies are elaborated. Based on the analysis on the linkages of the barriers and possible solutions are suggested on how the barriers can be

addressed, and what the resource required are discussed. Further, the enabling environment that will support the reduction or elimination of barriers confronting the technology is discussed.

4.1 Preliminary targets for technology transfer and diffusion of rainwater integration into, irrigation, industrial purposes, building code technologies

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

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

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

The primary target for the diffusion of rainwater integration into, irrigation, industrial purposes, building code technologies is to facilitate community and household-based rainwater harvesting system integration into irrigation and industrial purposes to secure minimum water requirement in all situations. This will be in combination with sustainable drainage aimed to intercept the hydrologic cycle, catch most of the rain water instead of removing excess water from road surfaces and discharging to sea, use drainage infiltration techniques supports the replenishment of groundwater resources in urban road drainage schemes.

The objectives of promotion of rainwater integration into, irrigation, industrial purposes, building code technologies is aligned with numerous strategies and national documents SNC, NDC, INDC and, Water and Sewerage master plan (2021-2035). Establishment of rainwater integrated water network will improve the livelihood of the community and contribute health and wellbeing of the people and increase of economic activities Specifically for the water resource management where the groundwater resources are scarce and rain water storge capacity is limited in local islands. This technology is economically viable and environmentally friendly, involve cost-effectively sound capital investment and minimum affordable production, operation and maintenance cost to the end users.

4.2 Barrier analysis and possible enabling measures for Technology

4.2.1 General description of technology Promotion of rainwater integration into, irrigation, industrial purposes, building code technologies

The national water and sewerage strategic plane 2020-2025 have laid the overall policy for water resource management in the country to ensure equitable access to clean drinking water and improved sewerage facilities in all inhabited islands, through financially and environmentally sustainable technologies. Promotion of rainwater integration into, irrigation, industrial purposes, building code technologies includes many different methods for harvesting, storage and management of water resources in the Maldives. Rainwater and groundwater are the source of portable water to cater for water demand in the country. On average, the southern atolls receive about 2,218 mm of rainfall per year, while the annual rainfalls over central and northern atolls are 1,966 and 1,779 mm respectively. Flat topography and the porous sandy soil in the islands make the thin freshwater lens highly vulnerable to SLR subsequent increase in salinity level due to saltwater intrusion. Contamination from inappropriate waste disposal and sub-standard sanitation practices makes the groundwater unsuitable for human consumption in many of the islands.

Fresh water availability for human consumption is affected by both climate and non-climate drivers. The main nonclimate drivers in the water sector arise due to increasing demand from economic development, agriculture, industry, tourism and a growing urban population. These in turn result in heavy water consumption and also pollution of water resources.

Rainwater harvesting is being widely practiced and promoted especially in islands and urban areas where water supply networks (pipes) may be limited, and where collection is seen as a useful primary source for both potable and non-potable uses. Water is collected from rooftops of larger facilities (schools, Mosques, and Government buildings) and community catchments and stored in tanks as sources of primary and secondary water or to supplement other sources.

This includes many different technologies for rainwater integration into various types of, irrigation, industrial purposes in combination with sustainable drainage systems to use drainage infiltration techniques that supports the replenishment of groundwater resources in urban road drainage schemes.

The technology also includes harvesting and storage of rainwater to use in different types of micro-irrigation technologies such as the low-head, low-cost gravity-fed drip (GFD) irrigation kits, micro sprinklers, micro tube drip system suited for smallholder farmers to highly sophisticated, capital intensive pressurised commercial micro-irrigation systems. Micro irrigation technology is found to be more suitable for small scale farming that is being practiced in the Maldives the technologies will improves water use efficiency by 50-70 % under sprinkler and up to 90-95 % under drip irrigation (Peacock et al, 2007). Micro irrigation requires relatively lower investment cost but guarantee high economic impact due to strong local community governance and lower operation and maintenance costs and enhancement of crop yield and quality, water savings, expansion in areas under irrigation due to reduction in water requirement per unit area, increase cropping intensity. fertigation (application of fertilizer through irrigation system), enhanced land and water productivity, reduced non-beneficial evaporation loss, reduced labour cost and risk of crop failure, savings and advancement in produce harvest, all resulting in social benefits (Kumar et al, 2008).

Technologies discussed under industrial use includes waste water recovery and reuse which is widely practiced in some resorts and possibly some industrial island but not common in habited islands. Storm water recovery and reuse after filtration and treatment is also included in this category.

Technologies that will allow rainwater infiltrate into the subsoil layer during the road and drainage design is widely practices in inhabited islands where paved road network is established. Infiltration drainage systems (natural or artificial) are used in combination with underground piped system and conventional stormwater drainage system to prevent flooding and inundation. This method is suitable as on-site drainage solution for small-scale developments, thereby eliminating the need to build a piped stormwater drainage system to cater for the additional runoff. The system is designed to replenish and recharge the island freshwater aquifer through design enhanced infiltration techniques.

All the above-mentioned rainwater harvesting and related and integrated technologies have to be incorporated into the national building code to be effectively implemented and enforced throughout the country.

4.2.2 Technology category and market characteristics of Promotion of rainwater integration into, irrigation, industrial purposes, building code technologies

Promotion of rainwater integration into, irrigation, industrial purposes, building code technologies characterized by stakeholder as having the following categories:

1- consumer goods

- Household water filtration devices
- Household Storage tanks
- Conveyance system
- Network pipes and fittings
- Irrigations systems

2- Capital goods

- Weather Data
- Public rain water harvesting and storage tanks
- Rainwater harvesting public network
- Land area for public water filtration
- Roof top of public buildings for rainwater harvesting
- Filtration and bottling systems for commercial businesses
- Waste water and storm water treatment plants

3- Publicly provided goods

- Centralised rainwater harvesting and catchment systems at community level
- Storm water collection system
- Drainage systems
- Building code: rainwater collection through infrastructure design.
- Water quality sensors used or installed into rainwater catchment/storage systems.
- Stormwater diffusion designs (freshwater lens replenishment).
- Irrigation designs to suit for public use (eg: agriculture)

4- Other non-market goods

- IWRM

- Water quality control
- Water testing laboratories

As shown above Promotion of rainwater integration into, irrigation, industrial purposes, building code technologies components in different categories of technologies depending on the context and scale of the project.

A market supply chain analysis was carried out and it is shown in Figure 10 (Market Map for Promotion of rainwater integration into, irrigation, industrial purposes, building code technologies. The supply chain includes importers of equipment, fittings irrigations systems, retailers of rainwater filtration systems, local agents of equipment installers and maintenance contractors, and end users. The diffusion of Promotion of rainwater integration into, irrigation, industrial purposes, building code technologies requires an enabling environment for the demand-supply chain, and the services and inputs providers the technologies and skills. Such enabling environment should include a local standard and in the building code, policies, license, data analysis guidelines, financial incentives and information and advisory services.

4.2.3 Identification of barriers for Promotion of rainwater integration into, irrigation, industrial purposes, building code technologies

Stakeholders in the water resources Sector both at the policy and technical levels, and private and NGO partners in the sector, listed a series of barriers to consider in. Promotion of rainwater integration into, irrigation, industrial purposes, building code technologies and barriers were identified as illustrated by the Problem Tree (PT) in Figure *8*. They are as follow:

- Economic and financial
- Market conditions
- Legal and regulatory Institutional arrangements
- Information and Awareness
- Technical
- Social, cultural, and behavioral

Table 10. Barrier and measures for Promotion of rainwater integration into, irrigation, industrial purposes, building code technologies

Category	Barrier	Measure
Economic and financial	Lack of government funding for establishment of rainwater harvesting systems at household level. Lacks government budget allocation for system repair and maintenance. Lack of skilled staffs to undertake regular cleaning, repair and maintenance of the already existing rainwater harvesting systems. No financial resources for portable water quality control and testing in islands.	incentives for local households to invest in rainwater harvesting Agriculture sector to encourage small-scale farmers invest in rainwater harvesting Bank loans to promote rainwater based irrigation systems • Financila diincentives to

	No access to financial resources for Small and medium-sized farmers to purchase hardware required for establishment of appropriate irrigations systems	optimal use of harvested rainwater in micro irrigation systmes water price revision for water use in agricultural fields • Duty exception renewable energy & energy efficient rainwater harvesting systmes
Martket barriers	Lack of demand for/ tools and fittings; High costs for purchasing, and low funding to achieve	Promotion of water saving fittings and tools to create a market demand • Duty exception renewable energy & energy efficient rainwater harvesting systmes
Legal regulatory and Institutional	Lacking mandatory Monitoring of rooftop rainwater harvesting system at household/ community levels lack of legal regulatory and institutional arrangements to foster private sector investment in this sector. no overreaching national water institution with water committees at the local island level for promoting IWRM No building code regulations on regulations/ guidelines related to water efficiency for real estate development /household levels in local communities	IWRM systems compliance monitoring Building code regulations review Overarching national water institution for promotig IWRM & Rainwater harvesting Develop national standards and guideline for warnwater harvesting • includein Building code regulations related to rainwater harvesting and ground water infiltration • Establish institution to conduct research in water sector technologies

		relevant to small islands
Information, awareness and capacity	• lack of information and awareness in the general public of the adverse impact of climate change on water resources • lack knowledge on the long-term water savings at household level • awareness on how to maintain the cleanliness and hygiene of the water harvestin system • Limited knowledge on water efficiency technologies; • inadequate information on properly cleaning and maintaining; and • Lack of awareness about issues related to water -climate change and water efficiency • Regular testing of harvested rainwater to ensure the quality and maintain the standards •	awarenes on impct of CC on water resources household level water saving devices filteration and purification technology awareness • Awareness on maintiaing cleanliness, helath and hygiene for rainwater harvesting systems
Technical Barriers	Lacking technical details and knowhow on the safety, hygiene proper storage and maintenance Small and medium- sized farmers who lacks proper technical skills to setup and operate rainwater harvesting, sprinkler, and drip irrigation systems Technical capacity development treatment technologies, install and maintaince of systems for the efficient collection and use of water; optimizing production or implementing ground infiltration techniques.	Gov colloboration with Private sector research insttutions etc on viability of rainwater harvesting technologies Technical knowhow on collection maintanace health and hygiene of rainwater harvesting systems • chemical treatment of harvested rainwater for portable, industrial and agricultural use
Social, cultural, and behavioral barriers	Change in habit of general tendency to purchase bottled drinking water rather than harvested rainwater	Conduct large scale awareness campaigns Regular laboratory testing of harvested rainwater

	water resources are always envisaged as infinite consequently bad consumer habits are developed • Consumer preferences and social bases • Traditions, habits perceptions	• Filteration and treatment of Harvested rainwater to guranty safty

4.2.3.1 Economic and financial barriers

Major economic and financial barriers for the diffusion of promotion of rainwater integration into, irrigation, industrial purposes, building code technologies identified by the stakeholders are: Lack of government funding for establishment of rainwater harvesting systems for individual household level. Most of the Government resources and international grants are for establishment of community/ island level systems which often lacks government budget allocation for system repair and maintenance. Financial resources are also needed to train skilled staffs to undertake regular cleaning, repair and maintenance of the already existing rainwater harvesting systems in local islands. Quality of rainwater produced from the filtration systems that feeds into the existing IWRM based water networks in islands are not regularly tested due to budgetary constraints. Small and medium-sized farmers are unable to access financing for the initial capital to purchase the hardware required for establishment of appropriate irrigations systems

Market barrier identified by the stakeholders to diffuse of promotion of rainwater integration into, irrigation, industrial purposes, building code technologies: lack of demand for or low demand for water management equipment, tools and fittings; High costs for purchasing, and low funding to achieve.

Currently, the government is not providing any financial or economic incentives for promoting rainwater harvesting and storage for irrigation. At present such systems are promoted very much project based in Government offices. However, State Owned Enterprises (SOE) promotes initiative like rainwater integration into irrigation and industry uses etc can create a market demand and help both water and agriculture sector to grow sustainably. The diffusion of consumer goods is generally dominated by market decisions, whereas non-market goods are primarily diffused through political decisions. It is worth noting that the Government has a direct influence on the diffusion of non-market goods, but only indirect influence on consumer goods.

4.2.3.1 Non-financial barriers

Legal regulatory and institutional barriers:

The National Water and Sewerage Strategic Plan (NWSSP 2020-2025) provides the strategic framework for the development of the water and sanitation sector. Main target of the policy is to enhance water security across the country which is the key element to ensure island self-sufficiency. However, the as per the action plan strengthen operation, maintenance and management of water supply including harvested rainwater and water produced from IWRM systems through compliance monitoring and safety planning is yet to been established at island levels. Overall, the strategic policy lacks the government strong support to ensure its people achieve quality levels of safe and clean water at very minimum cost. The support refers to include implementation and monitoring of the types of rooftop rainwater harvesting system at household/ community levels. Also as mentioned in the action the standard mechanism to foster private sector investment in the water sector has not been established because lack of legal regulatory and institutional

arrangements to encourage such investments. Also, there is no overreaching national water institution with water committees at the local island level for promoting IWRM. Building code regulations should be revised to include regulations/guidelines related to water efficiency for new real estate development as well as at household levels in local communities.

Information and Awareness related barriers

There is a general lack of information and awareness in the general public of the adverse impact of climate change on water resources and how water efficiency could contribute to increase the resilience. of households and businesses. Households lack knowledge on the long-term water savings and water bill savings compared to the upfront investment costs. They may also lack knowledge on the technical performance of the devices to make a decision on investment. There is also need for raising awareness on how to maintain the cleanliness and hygiene of the system The following barriers have been identified under this category:

- Limited knowledge on water efficiency technologies;
- inadequate information on properly cleaning and maintaining; and
- Lack of awareness about issues related to water -climate change and water efficiency
- Regular testing of harvested rainwater to ensure the quality and maintain the standards

Technical barriers

Rainwater harvesting has been a common practice in the Maldives since early 1970s. Many communities in the outer islands of the Maldives heavily rely on rooftop harvested rainwater for potable needs A nationwide survey carried out in 2000 indicated that over 93% of the population were depending on rainwater for drinking. Therefore, Maldivians are familiar with techniques of establishing household level rainwater harvesting systems. However some of the technical details and knowhow on the safety, hygiene proper storage and maintenance etc ., are lacking in most of the island communities. Limited technical knowledge exists on rainwater harvesting related fields such as the small and medium- sized farmers who lacks proper technical skills to setup and operate rainwater harvesting, sprinkler, and drip irrigation systems. Many are unaware of the proper use of the technology; treatment technologies, how to install and maintain the systems for the efficient collection and use of water; and application for optimizing production or implementing ground infiltration techniques. The government must train locals to start installing these technologies across the island.

Social, cultural, and behavioral barriers

Habits and traditions have been identified as a main barrier likely to hinder the successful implementation and promotion of rainwater integration into, irrigation, industrial purposes, building code technologies. In Maldives there is a general tendency to purchase bottled drinking water rather than harvested rainwater. This may be due to prevailing safety, health and hygiene issues as well as the efforts to establish and maintain the collection systems and circumstances such as low incidence of rainfall, and limited space to store water. Collecting and using rainwater is generally seen as something only done by local communities and therefore, some individuals shun the idea that bottled water is more of a status symbol.

The general public is used to having water at a low cost and in abundance. Adapting to water scarcity is unimaginable and water resources are always envisaged as infinite consequently bad consumer habits are developed as far was water is concerned. The following barriers were identified under this category:

- Consumer preferences and social bases
- Traditions, habits perceptions

4.3 Identified measures

An OT was developed (see Objective Tree for promotion of rainwater integration into, irrigation, industrial purposes, building code technologies in Figure 9) to identify main measures to support diffusion promotion of rainwater integration into, irrigation, industrial purposes, building code technologies for harvesting, storage and management of water resources in the Maldives. This was done by identifying corresponding measures or interventions to address challenges and problems identified by the TNA project to scale up the diffusion of promotion of rainwater integration into, irrigation, industrial purposes, building code technologies. As shown in the OT Figure 9, the proposed measures are articulated around the following components:

Creating financial or economic incentives for promotion of rainwater integration into, irrigation, industrial purposes

Policy legal regulatory and institutional strengthening

Improving information and awareness

Developing technical capacity

Improving Social, cultural, and behavioral perception

4.3.1 Economic and financial measures

Taking into consideration the main barriers hindering the promotion of rainwater integration into, irrigation, industrial purposes, building code technologies for harvesting, storage and management of water resources in the Maldives explored using the objective tree developed for this technology, the main economic and financial measures identified in this study include:

- Provision financial support mechanism or economic incentives as an instrument to motivate and encourage local households/ community to invest in basic equipment for rainwater harvesting and storage systems.
- Provision of financial support mechanism for the agriculture sector to encourage small-scale farmers to invest in harvested rainwater-based irrigation system, storage facility, pump and tanks. particularly youth and women who engage in small scale farming activities, where promotion of such technologies will result in water and energy saving and maximize socio-economic impacts.
- Review water pricing so as it reflects its long-term marginal cost taking care of agriculture sector and to consider cost of making the water available in the field and for use
- Seek external funding and provision of bank loan to establish rainwater harvesting infrastructure and improving micro- irrigation system
- Financial disincentives to encourage optimal use of harvested rainwater water using water efficient micro-irrigation system
- Customs import duty exemption from components of renewable energy-based and energy efficient rainwater harvesting system to make the technology more affordable to the general public.

4.3.2 Non-financial measures

Policy legal regulatory and institutional strengthening

It is proposed that the institutional framework for water is strengthened with the establishment of an overreaching national water institution with water committees at the island level for promoting IWRM and rainwater harvesting.

Development of national standards and guidelines for rainwater harvesting. This should be done with the required agencies responsible for water management including local councils in the islands.

Building code regulations should be revised to include regulations related to rainwater harvesting for new real estate development, with provision for ground water infiltration in road construction and infrastructure development.

Establish an institution to conduct research in water sector technologies relevant to small islands. It is recognized that limited collaboration between government agencies and research institutions at national level have often led to duplication of efforts and a loss of resources. Hence the need for a clear policy or high-level coordination mechanism for cross-sectoral cooperation to promote collaboration between public and private sectors to conduct advanced research with greater mobilisation of resources and exchange of information.

Improving information and awareness

There is a need to create awareness in the general public and the local communities on adverse impact of climate change on water resources and how water efficiency could contribute to increase the resilience. of households and businesses.

Knowledge and awareness campaign has to be conducted at household level on water savings and technical performance of the devices used for water filtration purification available in the markets. Also raising awareness on how to maintain the cleanliness and hygiene of the rainwater harvesting systems and regular testing of harvested rainwater to ensure the quality has been identified as an important measure to promote rainwater harvesting and storage technologies in local communities.

Developing technical capacity

The government must collaborate with private sector, research institutes and universities to undertake studies on available options and viability of rainwater harvesting technologies that could withstand extreme weather and climate change.

Technical knowledge and knowhow are needed to safe collection and to maintain the health and hygiene of rainwater collection systems. Technically skilled people are needed to setup, operate and maintain harvested rainwater-based irrigation systems such as sprinkler, and drip irrigation systems

Technical expertise is needed chemical treatment of harvested rainwater various uses including portable use and agriculture and industrial uses.

Improving Social, cultural, and behavioral perception

To improve habits and traditions large-scale awareness campaigns are needed in local islands. Regular laboratory testing of harvested rainwater to confirm the quality and safety of the water is required to make

it trustworthy for portable uses. This can only be achieved by ensuring the that the whole process of collection network, storage equipment is regularly checked against established local and international standards to guarantee the safety, health and hygiene of the water.

Establish a mechanism for proper filtering and treatment of harvested rainwater to ensure the safety and guarantee the standard and quality of the harvested rainwater.

4.4 Linkages of the barriers identified

Technology selected for barrier analysis in water resources sector is rainwater integration into, irrigation, industrial purposes, building code technologies. For the adaptation technologies discussed in the water resources sector, it has been noted that there are common barriers. These are:

- Establish institutional, regulatory framework for strengthen operation, maintenance and management of water supply, IWRM systems through compliance monitoring and safety planning
- Limited awareness on climate issues related to water resources, and appropriate adaptation technologies;
- Limited technical expertise; and
- High costs of the adaptation technologies.

This creates synergies between the technologies related to the linked barriers. Therefore, these linkages provide an opportunity for scaling up climate adaptation through the promotion of rainwater harvesting technologies in water resource sector. For instance, establishing an overreaching institution in the water sector, developing an integrated water resource management technologies into national building code and the regulatory framework could be shared between the implementation of all technologies. The awareness campaign of climate issues related to the water sector can be done conjunctly for all the adaptation technologies, while bearing in mind the different target audiences. Financing, customs import duty exemption and other incentives needed for the adoption of climate change adaptation technologies for the water sector could be managed jointly with other sectors. Technical capacity building at vocational level required for these climate adaptation technologies could be a module within the curriculum of MNU.

4.5 Enabling framework for overcoming the barriers in the water sector

In order to implement promotion of rainwater integration into, irrigation, industrial purposes, building code related technologies at the residential, local and national level for harvesting, storage and management of water resources, agricultural sector and industrial sector the following elements of an enabling framework is recommended for consideration.

Table 11. Measures and enabling framework for Promotion of rainwater integration into, irrigation, industrial purposes, building code technologies

Measure	Enabling framework
Institutional strengthening	Establishment of an overreaching national water institution with water committees at the island level for promoting IWRM and rainwater harvesting •
Policy framework	• Although there is an existing national policy on water, National Water and Sewerage Strategic Plan (NWSSP 2020-2025), targeted to enhance water security across the country and self-sufficiency, strengthening operation, maintenance and

	management of water supply including harvested rainwater and water produced from IWRM systems need implementation of compliance monitoring and safety planning at island levels. • Private sector investment in the water sector has to be encouraged through establishment of appropriate legal regulatory and institutional arrangements and incentives. • Overall, the strategic policy needs government support to ensure its people achieve quality levels of safe and clean water at very minimum cost. • Promote agriculture policy that supports small and medium farms to operate sprinkler, and drip irrigation systems etc.to use of harvested rainwater.
Regulatory framework	• Standards for safety health and hygiene, storage maintance, treatment and filtration of harvested rainwater needs to be established and regular testing machenism should be established at local island level. • Building code regulations should be revised to include regulations related to rainwater harvesting for new real estate development, with provision for ground water infiltration in road construction and infrastructure development. • A labelling system for water efficiency appliances should introduced to inform and certify consumers of volume of water saved by technology type •
Economic and Financial instruments	• Financial incentives to motivate local households/ communities to invest in basic equipment for rainwater harvesting and storage systems. • Low interest loan scheme to encourage agriculture sector small-scale farmers to invest in water and energy saving technologies for harvested rainwater-based irrigation system, storage facility, pump and tanks. • Financial disincentives to encourage optimal use of harvested rainwater-based technologies in irrigations system • Customs import duty exemption from components of renewable energy-based and energy efficient rainwater harvesting technologies
Information awareness and technical skills	• collaborate with private sector, research institutes and universities to undertake studies research on rainwater harvesting technologies as a climate change adaptation measure • Training for locals on setup, operate, safe collection and maintenance of health and hygiene, chemical treatment, of rainwater collection systems. •

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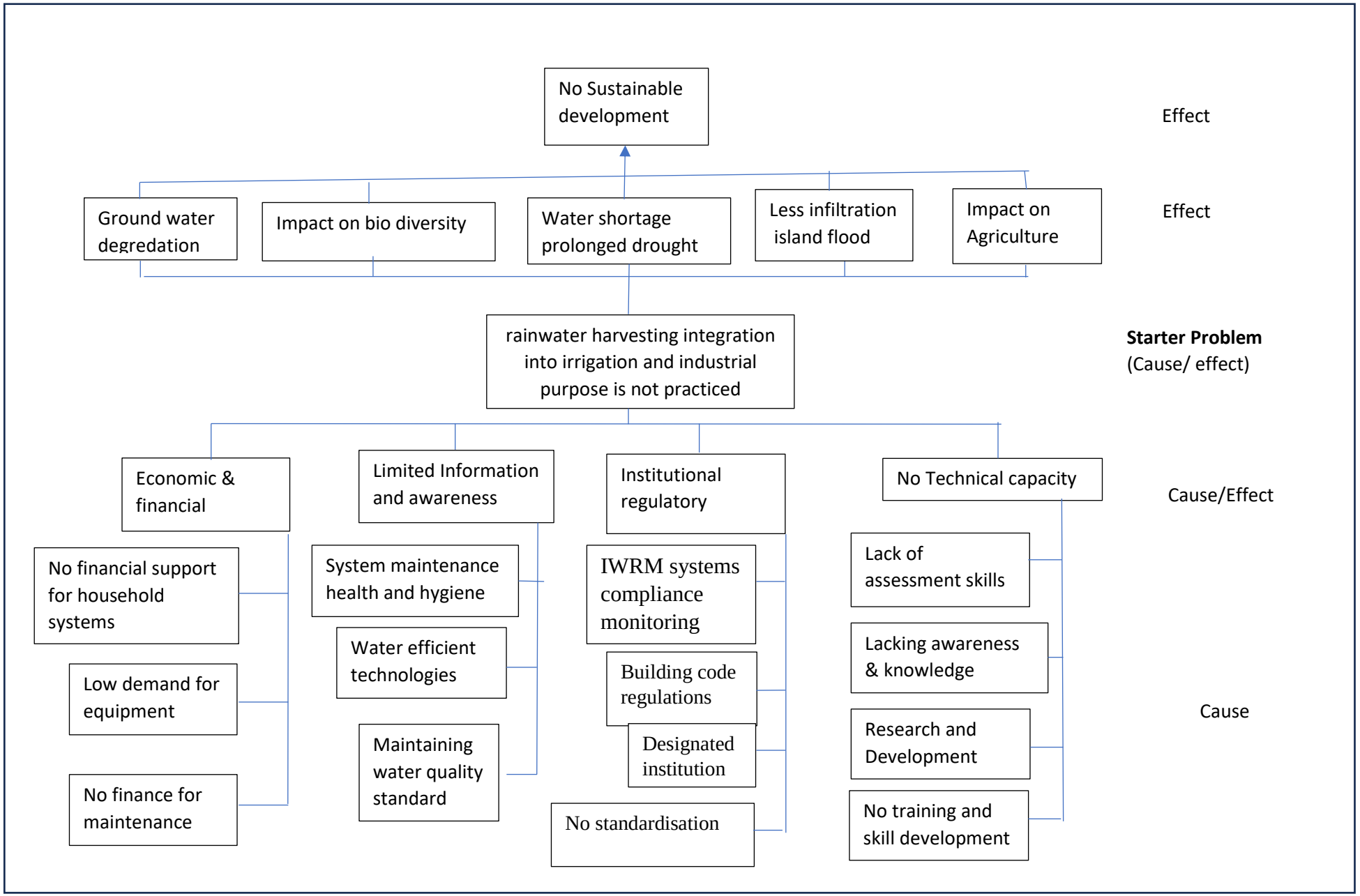

Figure 8: problem tree; rainwater integration into, irrigation, industrial purposes, building code water resource sector

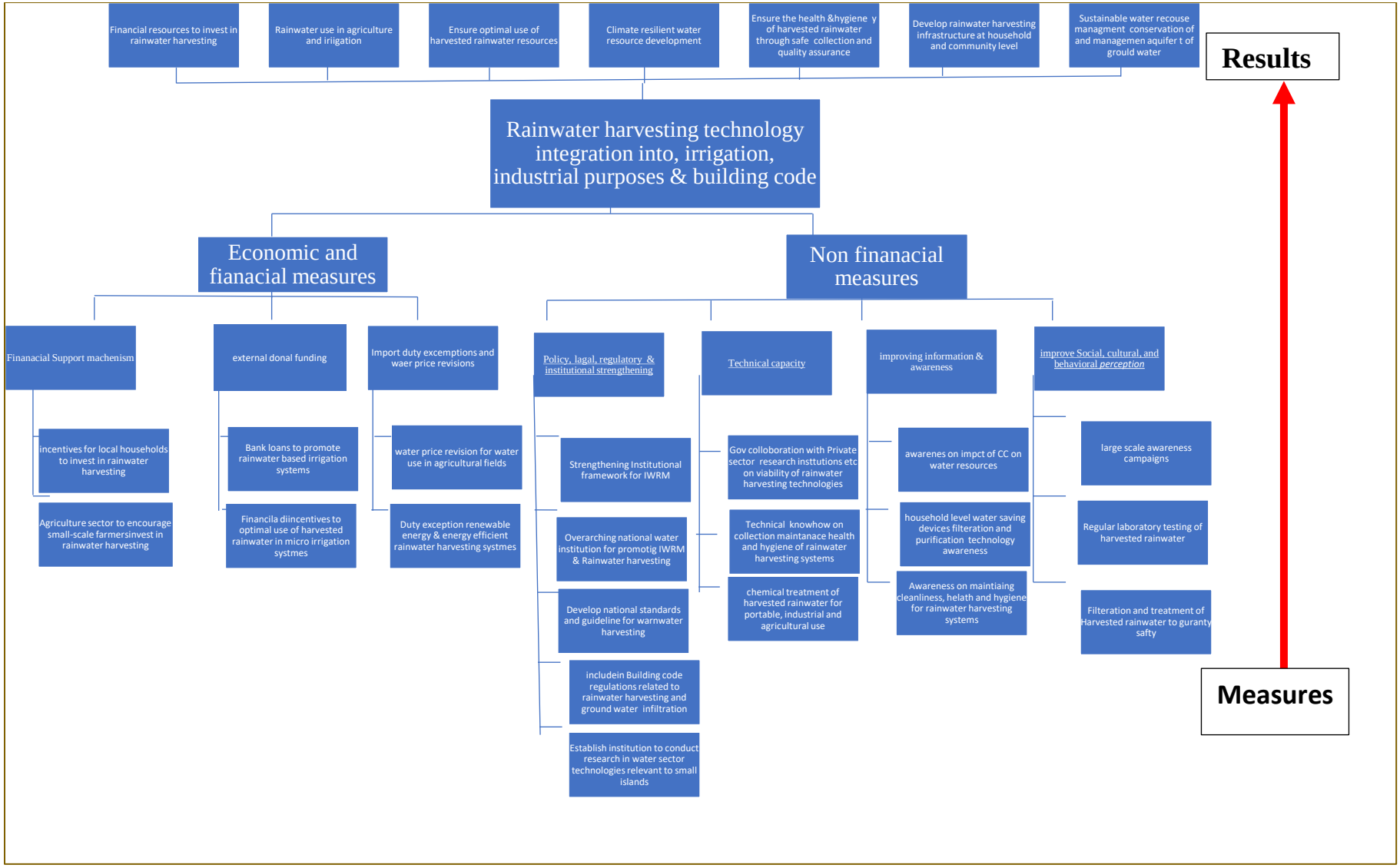

Figure 9: Objective tree for rainwater integration into, irrigation, industrial purposes, building code technologies; water resource management sector

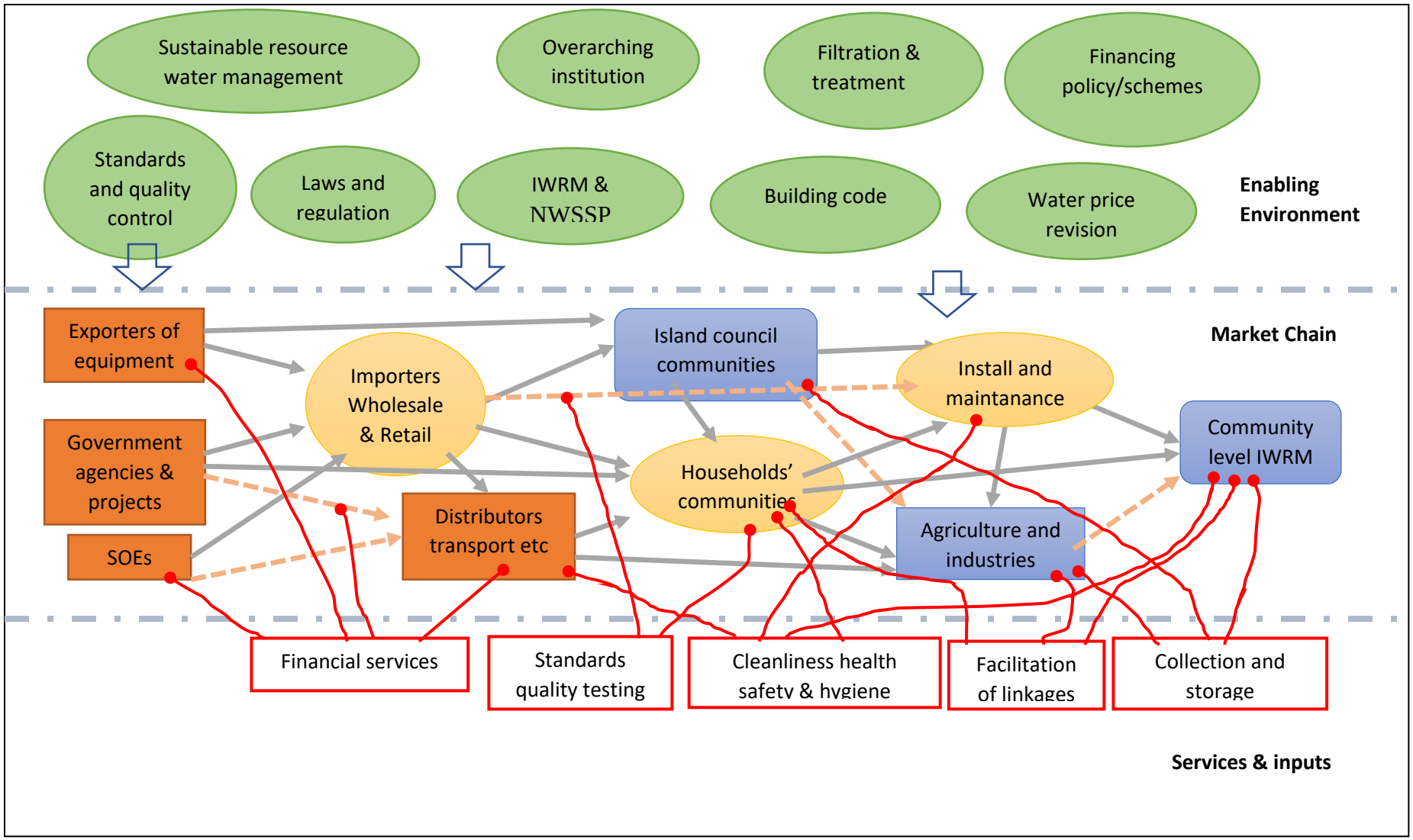

Figure 10: market chain actors and links rainwater integration into, irrigation, industrial purposes, building code water resource sector

Chapter 5. Conclusions

The Barrier Analysis and Enabling Framework (BAEF) presented in the report reflect the result of valuable contributions of many and diverse, extensive stakeholders consultations in each of the three sectors selected and prioritized for adaptation technologies in the context of the Maldives. As successful technology transfer requires participation and building on indigenous knowledge. Social, economic and environmental indicators, clearly selected and measurable, should reveal if goals and objectives are being achieved or were achieved.

BAEF process identified several interrelated barriers among broader adaptation technologies selected from the prioritized sectors, and it is noteworthy that lack of finance has emerged as the biggest barrier to the transfer of adaptation technologies. There is need to mobilise greater financing for environmentally sound technologies not just for related R&D but also for the early stages of commercialisation and for sharing risks.

Other barriers and associated enabling measures included: institutional strengthening; Government policy and regulatory framework; economic and financial instruments; information awareness and technical skills; integrated approaches for technology defussion; knowledge gaps, research and knowledge transfer mechanisms; technical capacity and practical approaches to introduce change ; political decision-making and social factors.

This assessment has allowed for a better understanding of the economic, social and environmental benefits of the proposed technologies. The identified barriers for technology difussion are not insurmountable although the challenge now is to integrate the relevant technologies into a Technology Action Plan of the Country, which actually will be prepared and presented as bankable project concepts. The resulting technology diffusion projects if implemented will contribute to the country's resilience to climate change adaptation and influence to the livelihood security of many Maldivians in the in the face of impending threats of climate change.

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