

MALDIVES POTABLE WATER SECURITY OPERATION PLAN



MINISTRY OF ENVIRONMENT



GREEN
CLIMATE
FUND



MINISTRY OF ENVIRONMENT
WATER AND SANITATION DEPARTMENT

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ABBREVIATIONS

GCF	Green Climate Fund
ME	Ministry of Environment
MNPI	Ministry of National Planning and Infrastructure
NDMA	National Disaster Management Authority
STELCO	State Electric Company
MWSC	Male' Water Sewerage Company
NBS	National Bureau of Statistics
MMS	Maldives Meteorological Service
LGA	Local Government Authority
HPA	Health Protection Agency
EPA	Environmental Protection Agency
FENAKA	FENAKA Corporation Maldives
MNDF	Maldives National Defense Force
CSO	Civil Society Organization
NGO	Non-Government Organization
WDC	Women's Development Committee
IWRM	Integrated Water Resource Management
SME	Small to Medium Enterprises
CSR	Corporate Social Responsibility
RWHS	Rainwater Harvesting Systems
STO	State Trading Organization
HDC	Housing Development Corporation

SAP

Strategic Action Plan

APPENDIX

Appendix A	Diagram of recurring themes
Appendix B	Heat Maps of Water Shortage Area (2005 to 2018)
Appendix C	Water System map
Appendix D	Amount of Water Supplied in 2018
Appendix E	Effectuated island vs water systems map
Appendix F	Resorts vs affected islands map (2018)

ANNEXURE

Annexure A	MFDA National Standard for Bulk transportation and storage of Drinking Water
Annexure B	EPA Drinking Water Guidelines
Annexure C	MMS Weather Outlook Documents
Annexure D	NEC Product Documents

1. EXECUTIVE SUMMARY

The outer islands of the Maldives experiences drinking water shortages during the dry season. The Government of the Maldives, with the support of the UNDP received financing from the Green Climate Fund (GCF) to undertake the “Supporting Vulnerable Communities in Maldives to Manage Climate Change-Induced Water Shortages” Project. The project will support in reviewing existing procedures, documents, guidelines and regulations on water management and distribution. Carry out surveys and collect data. Based on attained information develop a Potable Water Security Operation Plan.

Potable Water Security Operation Plan proposes three types of strategies and systems to ensure safe and secure potable water to people in the islands of Maldives. Following are the recommended strategies;

1. Continuous Strategies
 - a. Develop and implement a rainfall alert system
 - b. Measurement of Potable Water levels
 - c. Education and Awareness Campaigns
2. Short Term Strategies (to be implemented within 1 to 3 years)
 - a. Increasing Community Water Reserve by increasing Catchment Areas
 - b. Increasing Participation of the Private Sector in Water Supply Services
 - c. Increasing Participation of Community Groups in Water Management Services
 - d. Packaging Filtered Potable Water
3. Long Term Strategy (to be implemented with 5 years) is development of a water network

In the situation where potable water runs out during dry season three types of emergency water supply systems are proposed. They are;

1. Decentralized Water Supply System: *supplying water in containers via decentralized hubs*
2. Supplying Bottled Potable Water: *supplying packaged filtered water bottles via decentralized hubs*
3. Portable RO Plant: *producing water onsite (recommended option)*

To ensure the quality of water supplied to the public, all parties responsible in implementing the Potable Water Security Plan especially Emergency Water Supply Systems should comply with the guideline and standard set by EPA and MFDA respectively. It is recommended to distribute Water quality kits to islands and also be readily available to buy at pharmacies for individual use.

Staff from island hospitals and health centers to be trained to conduct water quality checks via water quality kits.

The main stakeholders of effective implementation of this plan are Ministry of Environment, Island Councils, Utility Providers, Maldives National Defense Force, Maldives Food and Drug Authority, Environment Protection Agency, Maldives Food and Drug Authority and Maldives Meteorological Service.

2. INTRODUCTION

The outer islands of the Maldives experiences drinking water shortages during the dry season. The Government of the Maldives, with the support of the UNDP received financing from the Green Climate Fund (GCF) to undertake the “Supporting Vulnerable Communities in Maldives to Manage Climate Change-Induced Water Shortages” Project. This project will introduce decentralized and cost-effective dry season water supply systems, in which the proposed solution is to create additional, atoll level water hubs to improve timeliness and efficiency of water delivery during the periods of water shortages. Aim of the project is to deliver safe and secure freshwater to people in the islands of Maldives.

The project will support in reviewing existing procedures, documents, guidelines and regulations on water management and distribution. Carry out surveys and collect data. Based on attained information develop a Potable Water Security Operation Plan for effective execution.

2.1. Scope and Purpose

This report aims to achieve the following deliverables of the project:

1. Undertake a desk review of existing procedures and material on water production, water storage and demand in the islands; the existing dry-season water distribution operation; and the review of existing monitoring coordination mechanisms (including online portal) and regulatory and legal frameworks
2. Determination of the necessary operational arrangements/institutional arrangements, roles and responsibilities that ensure for organized and coordinated actions;
3. Appraise the existing decentralized, sub-national water production and distribution hubs (both in the North and South of Maldives) and create/determine the distribution hubs;
4. Determine a decentralized early warning strategy (to be further developed with the online portal) for water emergency alerts which is based on forecasted meteorological information and crowd-sourcing develop a framework for early warning system
5. Ensure adequate consultation and feedback from all national and island-level stakeholders (especially Women’s Development Committees (WDC), island councils and other community groups) in the process of identifying gaps and issues in current operations and in the consolidation of the Potable Water Security Operation Plan;
6. Consolidation and finalization of the Potable Water Security Operation Plan including the year-round Potable Water Management Operations and; the dry-season Water Distribution Operations

3. BACKGROUND

Since the conception of the project, many advancements have been made in the dry-season season response operations. As a consequence, the timeliness and effectiveness of water distribution and management is believed to have improved dramatically from the initial project baseline records.

Currently the Water and Sanitation Department (WATSAN Dept.) in the Ministry liaises with the utility company to supply potable water to the affected islands during the dry-period. There is a written Dry-season Procedure (please find attached under annexure A) guiding the water distribution process and a contractual agreement between WATSAN Dept. and the utility to enable execution of water distribution.

Once an island is in shortage of potable water, the island council lodges an application, via a standard water request form, to the utility services provider on the island requesting for potable water. If there is no local office for the utility provider on the island, the water request form will be sent to the utility head office.

Utility service provider assesses the applications from the island councils and operationalizes the transfer of potable water from the closest possible island(s) with sufficient water production capacity such as R/O facilities. HDPE tanks are filled with potable water and transported on sea-going vessels. Water Quality tests are conducted before transportation and after delivery to the beneficiary island. The water quality tests are required to comply with the MFDA regulations (please find attached under annexure B). Once the operation is completed, it will be verified and checked via a delivery receipt for record.

The Ministry plays a monitoring role, and keeps track of the operations and maintains records of the water shortage requests and the distribution of water. The already existing procedures are based on reduction of cost and time and long term sustainability of the operation. These operations also adhere to the points of reference set in the legal frameworks that has been developed.

In addition to the above mentioned government has been developing water networks and rain water harvesting systems through Public Sector Investment Projects (PSIP) via government budget, grants and funds. The current government target to develop water networks in all inhabited islands in the next 5 years. Following is a summary table of a water related projects.

Water Network Development		
#	Details	Number
1	Water network completed islands	39
2	Water network development ongoing islands	45
	Total islands with water network projects	84
Potable (Drinking) Water Projects		
#	Details	Number
1	Islands with RWHS completed (PSIP)	47
2	Islands with RWHS development ongoing (PSIP)	01
3	Islands with RWHS development ongoing (GCF)	25
	Total islands with Rainwater Harvesting Projects	73

Table 1 Summary of Table of Water Projects

4. RESEARCH FRAMEWORK

The following diagram summarizes the work carried out to arrive at a potable water security plan. Research methodology to achieve the main deliverables have been identified and presented during inception stage.

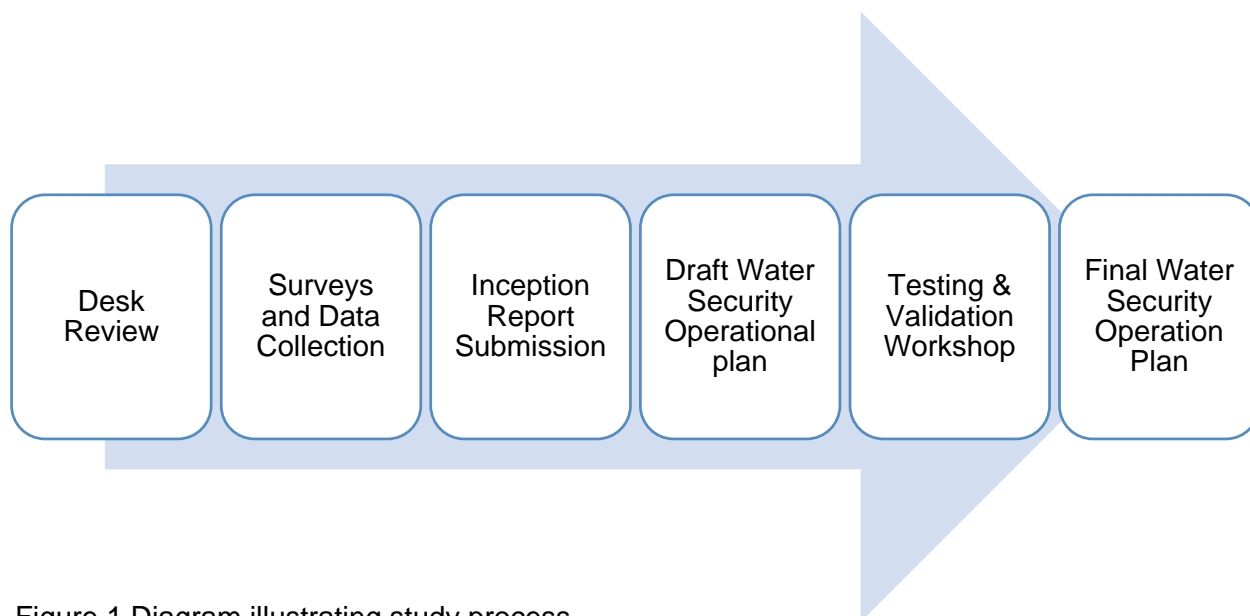


Figure 1 Diagram illustrating study process

4.1.Desk Review

A desk review on existing documents on water management in Maldives was conducted. The documents were provided by Ministry of Environment, National bureau of statistics (NBS), National Disaster Management Center (NDMC) and utility. The documents include written reports, population tables and generated maps. The Socio-economic reports (STC,DTM.2017) helped conclude the following points;

1. Public is satisfied with household rainwater
2. Islands have high demand to increase rainwater harvest
3. Majority of the people buy bottled drinking water
4. 40 to 50% people use public tanks in case of water shortage in some cases shortage and high demand for public water system
5. Average household storage capacity 2500 to 3500ltrs
6. More than 50% of people are willing to pay for better quality water

It was deemed most appropriate to build on this study by leading with a qualitative research approach. The next step taken was to identify islands facing potable water shortages. Dry report data (ME.2005 - 2017 ME) and Emergency Water Supply Report (NDMC.2016-2017) had listed the islands requesting water starting from year 2005.

To understand how the highlighted islands were spread out geographically and for the purpose of visualization the data was layered into tables and maps. Haa Alif, Haa Dhaal, Shaviyani and Noonu were identified atolls consisting of the most number of islands requesting for water (please refer to the annexure for the maps). These atolls which belongs to north and north central region of the country.

Information on existing potable water systems and dry season data was projected onto maps. This information included, islands with completed, ongoing and planned rainwater harvesting systems, desalination plants and water networks. It was highlighted that most of the completed water systems are located in north, north central atoll and Laamu atoll from south central provinces. This results were justified as number of islands requesting for emergency water was higher in the northern atolls. Laamu atoll's water systems were donor funded LecRED projects and government funded projects.

4.1.1. International Best Practice

In addition to the documents above, international practices from similar contexts to Maldives were briefly studied to get a better understanding of how a water security plan should be developed.

It is difficult to manage what is not measured (WSP,2015). A vision statement which was made in WSP toolkit. The output from the above documents were review and summarized into water security improvements (WSI) guiding principles for water security planning which could be applied to our context. Following are the principles (SWP);

1. Pragmatic focus on specific water risks
 - a. Translate priority water risks into specific goals
 - b. Explore and define possible water security activities
2. Engagement and mobilization of water users
3. A “systems thinking” approach to address causes and not just symptoms
4. Robust decision-making that considers uncertainties
5. Negotiated solutions that provide tangible benefits to different water user groups
 - a. Finalize and validate the action plan
6. Science-based actions that combine infrastructure development with water management, behavior change, and institutional improvements
7. Adaptive management and learning to improve over time and build the capacities of stakeholders
8. Sustainability through economic efficiency, environmental soundness, and social equity
 - a. Perform the funding “reality check”

The main reason for reviewing these documents during the inception stage to formulate a research framework for the water security plan and to define parameters for data collection. This would be detailed further in the following sections.

4.2. Government Policy Change

It is important to note that during the inception of this project governments policy direction is to link with population with type of water systems established in islands (WATSAN, 2018). This policy suggest population is an indicator for development.

Island Population	Type of Water System			
	Desalination Plant	Water Network with HH connections	Storage tanks	Rainwater harvesting systems
>2000	X	X	X	
1000 to 2000	X		X	
<1000				X

Table 1: Water systems classifications

However with the new government the policy has shifted to develop water and sewer network for all inhabited islands independent of population or island size. The aim of the research was amended to meet the new policy change.

4.3. Survey and Data Collection

Based on the information from above maps, islands for site visits were selected. Stakeholder engagement sessions were carried out during these site visits. Islands from north to south was selected identify if there were any correlations.

In selection of islands criteria were set to include islands with frequent and consistent request for emergency water requests, islands with completed water systems and community managed water systems (Sh. Komandoo). The island are color coded by their respective administrative regions of Maldives. Following is the information is tabulated form.

No:	Islands		Criteria under which islands have been selected for site visit							
		Population	Water requested from 2015 to 2018	High Frequency of water requested (2 to 3 times/ per year	Community managed water plant	RWH-GCF Project	HDPE - RWH	Water Network Completed	IWRM with network	LECRd
1	Hdh Kulhudhufushi	8,440						x		
2	Sh Komandoo	1,111			x			x		
3	R Fainu	318	x	x					x	
4	AA Maalhos	434	x	x						

5	AA Ukulhas	1,005						x	x	
6	Adh Kunburudhoo	462	x	x		x				
7	L Maamendhoo	896	x				x			x
8	L Fonadhoo	2,266					x			

Legend

	North
	Central
	South

Table 2: Island selected for survey

Based on the desk review, a qualitative semi-structured questionnaire was designed to collect data to understand the challenges with current operating procedures of water management. The following three groups were selected to administer the survey.

1. Stakeholders of the island
2. Island based water supply operators
3. Government Institutions and service providers

Survey was intended to be truth seeking and explorative to identify deeper recurring issues. The main objectives of the survey were:

1. Review of current operating procedures for water management for the whole island. This includes domestic household tanks, public storage tanks and water production center.
2. Identifying operational challenges for water management for the above mentioned areas.
3. Understanding island level and individual capacity to adapt water security procedures (willingness to adapt to the solutions proposed)
4. Attain an understanding for new baselines for cost and services population

4.4. Review of existing equipment used for water management

As shown in the table above in section 4.3, 4 out of the 8 islands visited experienced potable water shortage in dry season. Via a visual inspection of the water tanks, connection details and their location was identified. However it is important to note that this is insufficient data to make a conclusion.

Nonetheless, the water tanks are in good working condition and it located within 4000ft as per the 2017 guidelines by ME. Furthermore, it is important to note that no island had connection pipes with them. It was informed that the supplier brings the connection pipe (please refer to the cost and type of the pipe section 8.3).

No:	Islands	Water tanks/ roofs in working condition	Located with 4000ft from harbor
1	R Fainu	✓	✓
2	AA Maalhos	✓	✓
3	Adh Kunburudhoo	✓	✓
4	L Maamendhoo	✓	✓

Table 2 Condition Assessment



Figure 2 AA Maalhos RWHS

4.5. Updated Baseline Data

Analysis of the collected data helped to arrive at an updated baseline for the affected islands and population. The two graphs below show the figures.

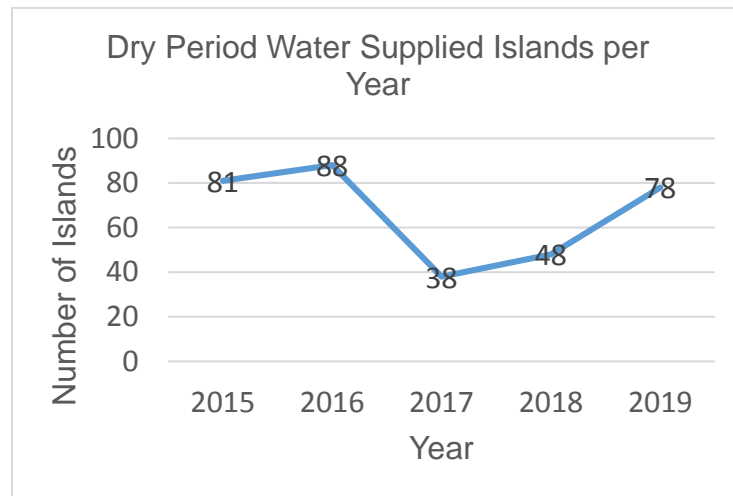


Figure 3 Dry Period Water Supplied Islands

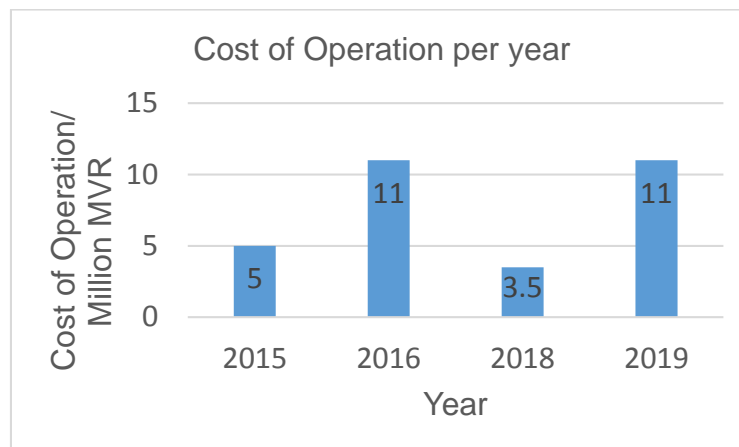


Figure 4 Cost of Operation per year

The graphs show steep decline in the number of serviced islands and cost of operation from year 2016 onwards to 2018. However in 2019 the numbers has risen back again. The exact reason behind the numbers are unknown as this plan making process is being carried out in 2019. Further information is required to make a conclusion for the 2019 results.

Please note that the above section has been summarized for the benefit of the readers and be advised to refer to the inception report of this project for further details of this section.

5. SITUATION ANALYSIS

Based on the research findings the following situation analysis table was compiled. This table has been split categorized into legislative, operational and behavioral challenges in potable water distribution and management. The intention of the Potable Water Security Plan is to address these challenges as per the objectives highlighted in this table.

Challenges	Causes	Effects	Objectives
Challenges due to lack of legal instruments			
1. Lack of potable water quality assurance	<ul style="list-style-type: none"> - Lack of resources; i.e. lack of accessibility to water quality kits (OR) testing facilities, lack of trained personnel - Incomplete guidelines assuring water quality - Missing SOP's for managing potable water 	<ul style="list-style-type: none"> - Loss of public trust for the quality of water and government institutions 	<ul style="list-style-type: none"> - Develop SOP to effectively implement EPA/MFDA guidelines - The guidelines need to address water quality check points; e.g. water quality is not checked when releasing public
2. Lack of clarity in defining functional roles in water management; e.g. who is going to carry out water quality checks after water has been supplied to tanks	<ul style="list-style-type: none"> - Delay in decision making 	<ul style="list-style-type: none"> - Effect quality of services delivered in water management 	<ul style="list-style-type: none"> - Developing detailed guidelines and SOP's outlining the process
3. Community water tanks are unregulated	<ul style="list-style-type: none"> - Lack of regulations and SOP's 	<ul style="list-style-type: none"> - Leads to water shortage during dry season - Loss of potential business opportunities to sell water 	<ul style="list-style-type: none"> - Developing detailed guidelines and SOP's outlining the process
4. Limited or no involvement of CSO's and WDC's in water management	<ul style="list-style-type: none"> - Lack of CSO's operating in islands - Lack of incentives for CSO's to be involved in water management 	<ul style="list-style-type: none"> - Limited or no technical, administrative and labor support - Little or no human capacity development 	<ul style="list-style-type: none"> - Utility companies can higher CSO's to sell water to businesses; e.g. fisherman, cargo ships etc. - Profit they generate can be used to assist in Water Management Activities; e.g. awareness campaigns.
5. Rising local tourism increases water demand strains the water production	<ul style="list-style-type: none"> - Unplanned developments 	<ul style="list-style-type: none"> - Inability to increase water storage 	<ul style="list-style-type: none"> - Development of long term land use plans as per the NDP

capacity and storage capacity			
Operational Challenges			
6. Lack of potable water quality assurance	- Lack of resources; i.e. lack of accessibility to water quality kits (OR) testing facilities, lack of trained personnel	- Loss of public trust for the quality of water and government institutions	- Develop a mechanism to test water. Both emergency supplied water and network water
7. Difficulty in transport and logistics; e.g. Water currently is being supplied in emergency situation from Male' and Kulhudhuffushi only	- Geography of scattered islands	- Delay in receiving potable water - High cost of the operation	- Developing a decentralized water supply system
8. Limited roof spaces for community rainwater catchment areas (this challenge is community water tanks only)	- Unutilized/underutilized roof spaces - Cleaning and maintenance difficulties	- Limited to no rainwater is harvested during dry season	- Amount of rainwater harvested can be increased by accessing additional roof space (this can be legal intervention)
9. Inability to collect rainwater from rooftops	- Cleaning and maintenance difficulties; i.e. too much of a burden for people to go up and clean the roof	- Limited to no rainwater is harvested during dry season	- Generation of a rainfall alert system
10. Lack of storage capacity	- Limited rainwater harvesting tanks - Land Scarcity of the Island	- Limited to no rainwater is harvested during dry season	- Introducing a loan scheme for councils and individuals to buy RWHS tanks
11. Lack of technical support	- Budget and Staffing restrictions	- Effect quality of services delivered in water management	- CSO's to be empowered to be more active in water services via incentives
Behavioral Challenges			
12. Preferences towards bottled water	- Lack of quality assurance in network supplied water - Taste of supplied water	- Lack of resources; i.e. lack of accessibility to water quality kits (OR) testing facilities, lack of trained personnel	- Water Quality Assurance - Water Quality Education

Table 3 Situation Analysis

6. POTABLE WATER SECURITY PLANNING

Aim of this Potable Water Security Operational Plan is proposed to reduce the need for dry season water supply. Nonetheless, as a nation we need to be disaster resilient. Hence emergency water supply procedure cannot be eliminated completely.

This plan consists of two parts. Part 1 is called Water Security Strategies. These strategies are designed to ensure potable water security via continuous, short and long term activities. Part 2 is dry season water supply procedure. Part 2 will be activated if potable water security is not ensured by Part 1 strategies.

7. PART 1: WATER SECURITY STRATEGIES

Water security strategies consists of three types of strategies. They are continuous, short and long term strategies. The following sections will present these strategies, activities and responsible parties respectively.

7.1. Continuous Strategies

Continuous strategies are year around strategies which needs to continue during both wet and dry season. These strategies are to be implemented independent of achievement of both short term and long term strategies.

7.1.1. Rainfall Alert System

Maldives Meteorological Service (MMS) is currently developing a Mobile Application and Common Alert Protocol (CAP) System for weather alerts. This strategy proposes rainfall alerts to be generated, shared and informed through necessary platforms such as instant messaging and social media. This alert will act as a reminder and encourage people start collecting water.

It is important to highlight here that these rainfall alerts may not be island specific, nonetheless can predict rainfall for atolls a week in advance. Further studies can also be carried out in weather modelling to more accurately predict weather.

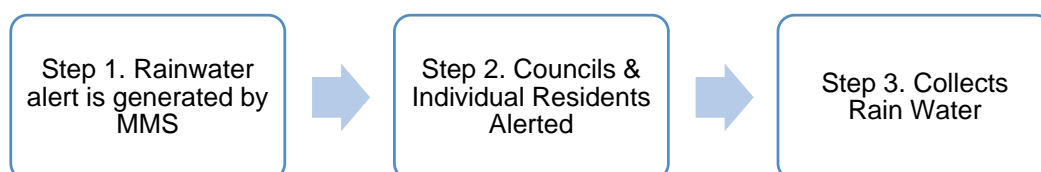


Figure 5 Rainfall Alert System Diagram

7.1.2. Measurement of Potable Water Levels

The intention of this strategy is to study year round potable water levels to understand whether the issue is with lack of storage or challenges in rainwater collection. From the information provided ¹by MMS we can conclude that Maldives get sufficient rainfall during wet season to cater to population requesting emergency potable water.

Furthermore, if existing water stock in islands can be monitored and managed well it can help avoid the need for emergency water supply by preparing for the situation in advance. This information would be essential to ensure water security. It is proposed to identify existing water levels through 2 options;

Option 1A: Manually Measuring Water Levels via Tapping

Council staff or with the help of NGO's water levels in existing water tanks need to be measured. The idea is crowd source information and work as much as possible. The manual process of collecting water proposed here is by tapping or via a measurement tape on the exterior tank wall to see whether it's full, half or empty. This information will suffice to generate number of liters as most community and household tanks are 2500 to 3000 liters.

The data collected needs to be updated to the Water Management Portal² by the council's administrative staff. It is advised to update the reading every quarter 3 months for minimum community tanks. For affected islands data should be update every month during dry season. Data can be collected in the following table format.

Island Name				
Tank Type	Tank Capacity/ Liters	No of tanks	Existing Water Level	Water Capacity/ Liters
Community	1500	5	Half	3750
	2500	3	full	7500
	3000	2	Empty	0
Household	1500			
	2500			
	3000			

Table 4 Potable Water Measurement Table

¹ Find document from MMS attached to annexure C

² Please find details of the Water Management Portal under section 8

Option 1B: Manually Measuring Water Levels via Water Level Indicators

Sight Tube

A sight tube is our most popular method of knowing how much water is in your tank. It features a high quality polyurethane tube that will resist sun light discoloration. We weld two $\frac{3}{4}$ inch fittings into your tank. One at the bottom and one at the top. A $\frac{3}{4}$ three-way valve is installed in the bottom. A 90 at the top. The $\frac{3}{4}$ tube runs between the two (Wright Tank & Steel Fabrication, 2019).

Target Gauge

Target gauge is the method for knowing the water level in your tank from a distance. The target gauge gives you the water level of the tank at all times. It works on a pulley system with a stainless steel float on the inside and a gauge board on the outside. The float and the gauge are attached with a stainless steel cable. Two stainless steel stringers are attached to the inside of the tank. These two stringers keep the float lined up with the gauge. All the parts and pieces that are attached on the inside of the tank are made out of stainless steel. The gauge board on the outside is made from galvanized steel (Wright Tank & Steel Fabrication, 2019).



Figure 6 Sight Tube



Figure 7 Target Gauge

Option 2: Measuring Water Levels via Smart Water Level Indicators

Smart Water Level Indicator to be connected to community water tanks. This information can be fed into the Water Management Portal in real time. Cost of an indicator is MVR 8,000 to 9000 (\$ 500 to 600). Assuming that we are providing 10 indicators for each island. Total cost for 48 islands (number of islands requested for water in 2018) would be MVR 4,032,200. Please note that it is assumed that this indicators can be operated with the existing internet packages in the islands. Furthermore this cost does not include any maintenance costs.

Two options can also be integrated where water levels from households can be measured using tapping method and smart water level indicators can be used for community water tanks.



Figure 8 Smart Water Level Indicator

7.1.3. Education and Awareness Campaigns

Educating the public on potable water security and safety is a continuous process where by local councils, ME, MFDA, CSO's, and NGO's needs to be actively engaged. Two focus areas of awareness campaigns is proposed for islands with potable water shortage.

1. Water Conservation

From existing socio economic reports³ it is evident that people are satisfied with household drinking water. With proper water quality assurance measures such as

³ Socio-economic reports prepared by STC and DTM

integrating tanks with carbon filters rainwater is once source of potable water to fight water shortage.

With sufficient rainfall during monsoon season, it is important to take measures to increase water storage. While the councils are working with government to increase community storage capacity, it is important to advocate to do the same at individual level as well. Unutilized or underutilized community water tanks should be identified via surveys. This includes tanks in households as well as public buildings such as mosques etc. Clean or repair these tanks to initiate rainwater collection from these tanks.

It is crucial to advocate for collecting rain water as it is a free potable water source. Local community should be encouraged to clean their roofs for dry season and increase their water storage capacity by purchasing additional household water tanks to prepare for dry season.

2. Water Quality Assurance

It has been identified through reports and surveys that most the people do not use the emergency supplied water for drinking. While there are many factors to why they do not use one of the main use is lack of water quality assurance.

Water quality should be checked via testing kits to give the assurance to the public. Once the public is informed of the testing parameters and (e.g. chemical and biological properties) and the outcome of the results is shared, general acceptance of emergency transported water will be more.

Furthermore water quality can be tested by individuals as well. For instance bacteriological H₂S field test bottle can be made available in pharmacies operated by State Trading Organization (STO). This would increase public confidence in supplied emergency water.

This will be important to shift the notion that states rainwater is always safer than desalinated water from networks. Currently, few people use desalinated water from networks for drinking due to heaviness although it is proven to be safer than rainwater.

7.2.Short Term Strategies

Short term strategies are strategies targeted to be achieved within 1 to 3 years. The aim of these strategies is to achieve water security at island level.

7.2.1. Increasing Community Water Reserve by increasing Catchment Areas

1. Rooftop Water Catchment Areas

The common practice in islands is to collect rainwater via a dedicated roof connected to community HDPE tanks. However, there are public buildings such as council building, health centers or hospitals, mosques and schools which own large roof areas.



Figure 9 R. Fainu Mosque

This strategy proposes to use all available roof spaces for rainwater collection independent of owner of these buildings. Currently, these roof spaces are unutilized as councils they are out of council's jurisdictions. It is important to look beyond institutional barriers and utilize these roof spaces as rainwater catchment areas. It is also important to highlight here that in most islands institutional buildings mentioned above are located in close proximity.

Roof spaces can be utilized in two methods. Method one is to connect the rainwater down pipes directly to the community tanks via an underground network. Although this method may be expensive the underground pipes can later be connected to IWRM systems.

Method two is directly connecting the rainwater down pipe to HDPE tanks. This would be easier and cheaper. However, will require additional land spaces. Nonetheless either of the two methods will help increase community water reserve.

2. Underground Water Reserve Tanks

Land scarcity is a challenge in many islands of the Maldives. Increasing water storage facilities at ground level is difficult. In order to find an alternative solution this strategy proposes new construction such as public buildings and parks to develop underground rainwater collection tanks.

This can be ensured by adding underground rainwater collection tanks as requirement in Planning and Development Guidelines or Building Code of the public buildings and parks. The primary use of the water reserve should be for potable uses. Other use may include firefighting and greening purposes. This can be a mandate of ME and MNPI to work together as a compliance code for public buildings in developing the Building Code.

3. Increasing the Number of Community Tanks

With Maldives, getting sufficient rainfall during monsoon season, a very straight forward answer to some islands maybe just increasing the number of community water tanks. This can be done by combining the unutilized tanks in household, mosques and other buildings already established on the island. Islands requesting 10 tons or lower every year can address their shortage with a few additional water tanks. However, this step should be taken after the studying the island's conditions to see if the problem is purely lack of storage capacity and not operational in nature. These tanks can be proposed as part of IWRM system which can be repurposed when the water network are built in the island.

7.2.2. Increasing Participation of the Private Sector in Water Supply Services

1. Encouraging Private Companies

It is important to take necessary step to encourage participation of private companies in providing water supply services. The current desalination plant regulation allows only large scale industrial operations or serving a population above 200 people. These conditions can be relaxed to make it more attractive to businesses.

Furthermore, through governments SME development initiatives, business proposals to supply water in effected islands can be priorities and incentivized. With

the development of more small business there is room for healthy competition to result in more quality services for the public.

2. Resort Sector Participation

Resorts operate in every atoll of the Maldives⁴. Through an organized manner, e.g. choosing resort in 50Km radius of affected islands, ME can advise resorts to supply desalinated water to affected islands within a selected service area. Resort produce water to cater for their development. Resort can systematically supply to affected islands when reserve reaches a certain threshold. This need not be limited to dry season, but can continue all year round till islands ensures water security. This can be part of their CSR program too. Legal instruments needs to be developed for resorts to take responsibility.

7.2.3. Increasing Participation of Community Groups in Water Management Services

The term community groups here is targeted at CSO's, NGO's and Women's Development Committees (WDC's). Currently none of these groups are involved in any water management services.

With the help of social service workers and start up grants, these groups can earn by helping out in water management services. For e.g. cleaning of the roof tops has been identified as a challenge for households to collect rainwater. The groups can provide cleaning services for a small charge. Moreover, councils lacking staff support is also in issue. These groups can be engaged in measuring potable rainwater levels in community tanks and households.

In islands with water networks operate kiosks at harbors. These kiosks sell water to fishing and passenger vessels. Currently these kiosks are operated by islands businesses.



Figure 10 A Water Kiosk in Sh. Komandoo

⁴ Refer to appendix D for map of resorts

Under this strategy it is recommended that instead of business, development of water standards/guidelines and reference tools to enable CSO's to be empowered to become more involved. The idea is that the profit they generate to be utilized in water management services mentioned above. With a strong transport network these groups can even extend their reach to neighboring islands. This activity will help increase water reserves in island acting as water supply hubs as well as help affected islands. Nevertheless, further details such as sustainability and profitability needs to be further studied in order to measure the success of this activity.

7.2.4. Packaging Filtered Potable Water

As mentioned previously most the people do not use the emergency supplied water for drinking. Mainly for two reasons. One lack of water quality assurance. Two is personal preference. Due to difference in taste of mineral water and desalinated water. Some people are more accustomed to bottled water. Which is adds to the plastic problem pertaining throughout the country.

This strategy proposes development activations of bottling factories in decentralized locations to produce reusable 5 gallon (19 liters) bottles. This is a more environment friendly approach which would eliminates single use plastic.

Furthermore, while packaged and sealed water 5 gallon bottles is equivalent to the market price for 5 liters bottles, it also gives people comfort of receiving quality uncontaminated water. Below is a cost comparison between 5 liters and 19 liter bottles;



- Assuming a person needs 10L per day;
for a 7 days = 70L
- 5 Liters x 14 Bottles (70 liters) = MVR 15 x 12 =
MVR 210
- 19 liters x 4 Bottles (76 litres) = MVR 53 x 4 =
MVR 212
- Cost a dispenser is MVR 800

Figure 11 Reusable 5 Gallon Water Bottle

7.3. Long Term Strategy

7.3.1. Development of a Water Network

Long term strategy is targeted to be achieved within 5 years. One strategy is proposed under this plan, development of water network the island. This strategy aligns with the government's pledge to ensure that no island come under shortage of drinking water, establish clean drinking water facilities in all islands, minimize cost and struggle for drinking water and reduce plastic bottles by ensuring that water provided by water companies is most suitable for drinking.

To ensure sustainability and reduce operational costs, it is recommended to develop IWRM systems where by water supplied to the household would be a combination of desalinated water and treated rainwater. This way the current Rainwater Harvesting Systems (RWHS) being developed under GCF project can be integrated into the water networks. Furthermore, all water supply network providers have to follow EPA guidelines which ensure that supplied water is sufficient for potable use.

7.4. Potable Water Security Strategies Action Plan Matrix

POTABLE WATER SECURITY STRATEGIES													
NO	STRATEGIES	ACTIVITIES	KPI'S	DURATION	2020	2021	2022	2023	2024	COMPLETION DATE	LEADING INSTITUTION	SAP 2019-2029	
CONTINUOUS STRATEGIES													
1	Develop and Activate a Rainfall Alert System	1. Location based Rainfall Alerts to be generated	Developing mobile app/portal (OR) Rainfall modelling established	3 years	X	X	X			2020	MMS, ME	Subsector 4.6 Strategy 1.3	
		2. Councils and individuals to be alerted to collect water via communication platform such as instant messaging or social media	Dissemination of rainfall alerts	continuous	X	X	X	X	X	continuous	Island Councils		
2	Measurement of Existing Potable Water Level Records	1. Exiting water levels in community tanks to be measure via tapping of the tank ³ or sensor	If the sensor option is explored, it should be established within one year	continuous	X	X	X	X	X	continuous	MMS,ME & Island Councils		Subsector 4.6 Strategy 4.1
		2. Water levels to be updated to water management portal	Activity to be carried out at every 4 months for next 5 years										
3	Awareness Campaigns	1. Water conservation (e.g. educating the public that rainwater is free water, it treated properly)	Increased usage of rainwater and less strain on community water tanks	continuous	X	X	X	X	X	continuous	Island councils, MFDA, ME, CSO's		
		2. Activating all unutilized tanks for community use ¹	All tanks should be utilized for rainwater harvesting										
		3. Water Quality Education (e.g. Application of water quality testing kits, and educating supply water is sufficient for drinking) ²	Less usage of plastic water bottles										
SHORT TERM STRATEGIES													
1	Increasing Community Water Reserve by increasing catchment areas	1. Identify, clean and maintain unutilized roof spaces to collect water (e.g. schools, hospitals, mosques)	Activate all roofs spaces for rainwater harvesting	2 years	X	X				2021	ME, MNPI, HDC, Island Councils	Subsector 4.6 Strategy 2.1	
		2. Increasing number of community water tanks	Make all unutilized tanks in households, mosques etc. usable as community water tanks	3 years	X	X	X			2022			
		3. Integrating all available catchment areas of the island into IWRM systems during development of infrastructure	Connect the rooftops to existing tanks	Continuous	X	X	X	X	X	Continuous			
		4. New construction such as public buildings and parks to develop underground rainwater collection tanks	Add as a prerequisite in Planning and Development Guidelines or as a compliance code for National Building Code	3 years	X	X	X			2022			
2	Increasing Participation of the Private Sector in Water Supply Services	1. Encouraging private companies ⁴ to provide water supply services	Introduce guidelines to engage with private developer to provide water services through island or city council	Continuous	X	X	X	X	X	Continuous	ME, Private Companies	Subsector 4.6 Strategy 2.2	
		2. Resort Sector Participation	Legal instruments to diverting CSR budget into water services	2 years	X	X				2021	ME,MOT, Resorts		
3	Increasing Participation of Community Groups in Water Management Services	1. Development of water standards/guidelines and reference tools to enable CSOs to be empowered to perform in this area	CSO's to be kiosk operators	Continuous	X	X	X	X	X	Continuous	Utility Service Providers, CSO's	Subsector 4.6 Strategy 2.2	
		2. CSO's to earn by selling water from kiosks to businesses and sea vessels	To develop standards and guidelines CSO's to be kiosk operator	2 years	X	X				2021			
		3. Portion of the profit generated from can be utilized for Water Security Activities	From third year onwards CSO's to be involved in water security activities	Continuous	X	X	X	X	X	Continuous			
4	Packaging Filtered Potable Water	1. Development (OR) activations of bottling factories in decentralized locations	Additional functioning bottling factories	3 years	X	X	X			2022	Utility Service Providers	Subsector 4.5 Strategy 1.1	
		2. Supply of packaged and sealed water in 5 gallon bottles or more cheaper than market price ²	Introduction of 5 gallon water bottles with selling water dispensers	3 years	X	X	X			2022			
		3. Supply of packaged and sealed water in 5 gallon bottles or more cheaper than market price ²	Introduction of 5 gallon water bottles with selling water dispensers	3 years	X	X	X			2022			
LONG TERM													
1	Development of a Water Network	1. Water networks to be laid with an established RO Plants	Completion of water networks in all islands	5 years	X	X	X	X	X	2024	ME	Subsector 4.6 Strategy 2.1	

Notes:

1. It is important to know some tanks are being unutilized in HH due to difficulty in maintenance of roofs and tanks
2. These activities can help reduce single use plastic
3. This activity is meant to help measure the Water Security Resilience level of the islands
4. Please refer to 2019 – 2023 Strategic Action Plan for details of the strategies under relevant subsectors

Table 5 Action Plan Matrix

8. PART 2: EMERGENCY WATER SUPPLY SYSTEM

Emergency water supply system will be activated when and if islands are faced with potable water shortages. This is usually a dry season procedure however if required will continue year round. This system will only be initiated if the islands do not achieve water security through the strategies mentioned in part 1. Three types of water supply systems are proposed in this plan.

8.1.Type 1: Decentralized Water Supply System

Presently when emergency water is requested, water is supplied from K.Male', Hdh. Kulhudhufushi and R.Dhuvaafaru only. This water is supplied by FENAKA, a State Owned Enterprise (SOE) working as a contractor. FENAKA buys water from other utility service providers (mainly MWSC) to supply to affected islands. Emergency water supply report (NDMC,2016) that the cost of 1 ton desalinated water is on average MVR 239. This system type proposes decentralized water hubs to supply to affected islands within a specified radius.

The following 15 islands are selected as water supply hubs under the following planning parameters. It is important to highlight here that preparation of a national spatial plan is in progress at this stage. Work has been done to align the hubs with the spatial plan as much as possible.

#	Atoll	Island	Service Radius/time			Land availability for expansion	Draft Maldives Spatial Plan		
			25km/ 1.5hrs	50km/ 3hrs	100km/ 6hrs		Regional Hub	Sub-Regional Hub	Water Reserve
1	Ha	Ihavandhoo		✓		✓		✓	✓
2	Hdh	Kulhudhufushi		✓		✓	✓		
3	Sh	Komandoo		✓		✓			
4	R	Dhuvaafaru		✓		x		✓	
5	Lh	Hinnavaru (OR) Naifaru	✓			✓	✓		
6	B	Eydhafushi		✓				✓	✓
7	AA	Thoddoo		✓		✓			
8	K	Male' city		✓	✓	x			
9	Adh	Mahibadhoo		✓		x		✓	
10	F	Nilandhoo		✓					
11	M	Mulah		✓	✓	✓			
12	Th	Thimarafushi		✓		✓		✓	
13	L	Fonadhoo		✓		✓			✓
14	Gdh	Thinadhoo		✓	✓	✓	✓		
15	S	Hithadhoo		✓		✓	✓		✓

Administrative Boundaries

- North
- North Central
- South
- South Central

Table 6 Decentralized Water Supply

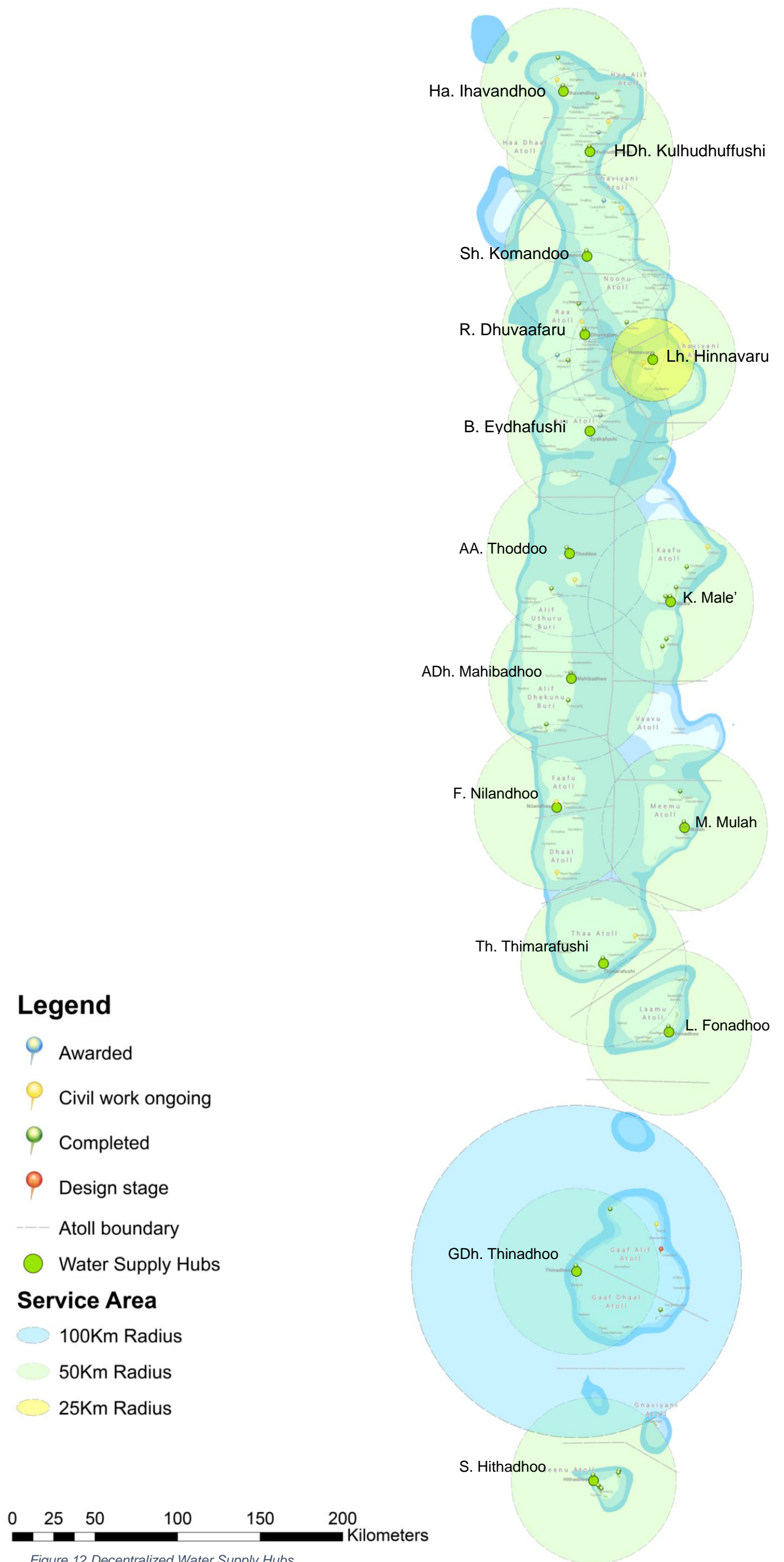


Figure 12 Decentralized Water Supply Hubs

The service radius of these hubs are chosen as 50km with a reach time of 3 hours as a basis. Some hubs may have to service longer distances while others for shorter one. Water is to be supplied via cargo vessels to the islands. It is targeted to do up and down trips within a day. Time of the trip is measure assuming the average travelling speed of a cargo vessel is 10 mile/hr (16km/hr).

Most frequently water is transported for Male' to islands with water shortages. Distance for Male' Atoll to Ha. Atoll (the northern most atoll) is roughly 300 km. Fuel cost comes up to MVR 21 per kilometer. With the proposed 50km service radius a cost saving of almost 83% is achieved from fuel costs alone. The table shows the estimated fuel costs for a round trip.

Service Radius/Km	Fuel Cost/MVR
25	1064
50	2128
100	4256

Table 7 Estimated Fuel Costs

Production capacity of RO plants and water consumption demand in HDh Kulhudhuffushi was studied. Assuming that a person requires 10 liters of potable water per day, current daily consumption and the daily consumption required was compared.

Population	Production Capacity/m3	Total Storage Capacity/m3	Current Daily Consumption/m3	Daily Consumption required/m3
12000	500	800	180	120

Table 8 Water Production and Usage Demand: Hdh Kulhuduffushi

Maximum amount of water supplied to an individual island in the year 2018 is 75 tons. From the above table it can be concluded that Kulhudhuffushi can supply up to 200 tons to affected islands per day without compromising required amount of water for the islands use.

Estimated investment costs of this type of water supply system is MVR 800,000 per hub. For 15 hubs MVR 12 Million. The main cost incurred is for a cargo vessel to carry water from the hubs to the islands. The following table provides a rough breakdown of the costs.

Type 1: Decentralized Water Supply System		
Details	Cost/MVR	Cost/USD
6" DIA Pipe Flexible Water Pipe (1200m/4000ft)	30,000	1,946
Vessel Price 40 ft vessel	750,954	48,700
Total Price per Hub	780,954	50,646
Total Price for 15 Hubs	11,714,310	759,682

Table 9 Decentralized Water Supply System: Investment Costs

8.2.Type 2: Supplying Bottled Potable Water

This type is very much similar to type 1 as it is also a decentralized service system. The idea behind proposing this system is not to add on to the widespread plastic issue but tackle the issue with a different approach.

From the findings of this project it is known that people do not drink emergency supplied potable water due to mainly lack of quality assurance. What this type is proposing is similar to the strategy proposed in part 1, i.e. supplying reusable 5 gallon water bottles to islands in case of emergency. Councils can procure water dispensers to distribute water to the public. If any household owns a dispenser, the water bottles can be supplied to the households directly.

The following table shows the selected islands with bottling factories developed by utility service providers and private companies, in strategic locations to supply bottled for in cases of emergency. Similar to type 1 these islands will have service radius of 50 to 100km. It is important to note that currently these factories do not have the required molds to produce 5 gallons reusable plastic bottles. They have to invest in such molds to produce the bottles.

#	Islands	Travelling Distance		Bottling Factory		Land Availability
		50km/3 hr	100km/6 hr	Completed	Planned	
1	HDh. Kulhudhuffushi	✓		✓		x
2	R. Dhuvaafaru	✓	✓	✓		x
3	B. Maalhos	✓		✓		✓
4	K. Male'\Hulhumale'	✓	✓	✓		✓
5	A.Dh Mahibadhoo	✓	✓	✓		x
6	L. Fonadhoo	✓	✓		✓	✓
7	G.Dh. Thinadhoo	✓	✓		✓	✓
8	S. Hithadhoo	✓	✓	✓		✓

Administrative Boundaries

- North
- North Central
- South
- South Central

Table 10 Island with Bottling Factories



Legend

- Emergency Water Requested in 2018
- Desalination Plant
- Rain Water Harvesting System
- Atoll boundary

Water Network

- Awarded
- Civil work ongoing
- Completed
- Design stage
- BottlingFactories

Status

- Completed
- Planned
- 100 Km radius

0 25 50 100 150 200 Kilometers

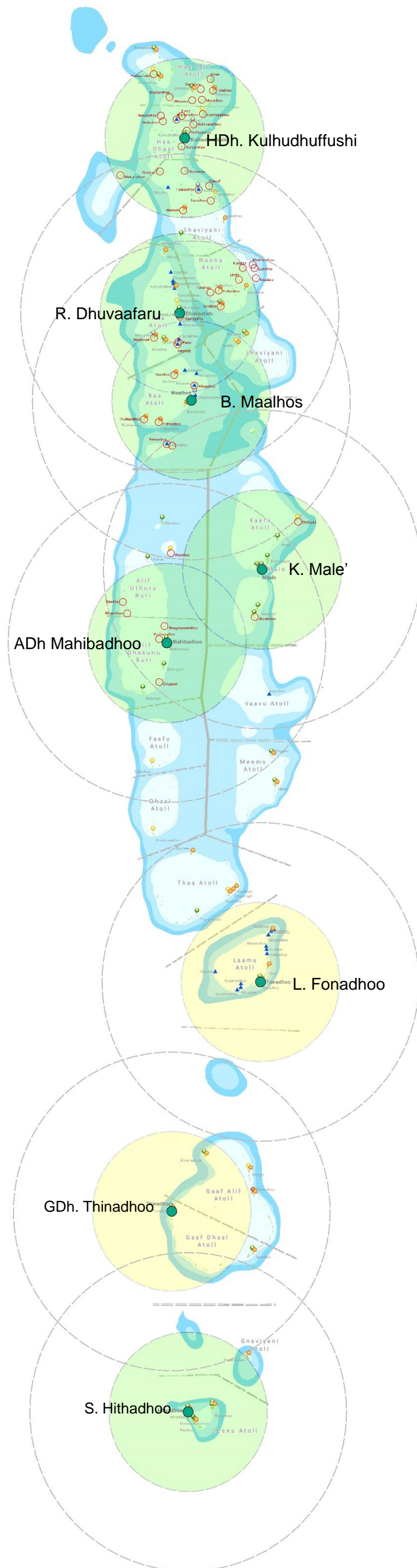


Figure 13 Island with Bottling Factories

The investment cost of equipping the bottling factories with molds was not investigated for this plan. However, the following costs have been taken into consideration for the cost comparison exercise in section 5.4. It has been assumed that 2 water dispensers have to be supplied to minimum 50 islands. The rate of a dispenser is MVR 800. The following table provides a rough breakdown of the known costs.

Type 2: Decentralized Supply of Bottled Water				
Details	Nos	Rate/MVR	Cost/MVR	Cost/USD
Dispenser	100	800	80,000	5,188
Vessel Price 40 ft vessel	8	750,954	6,007,632	389,600
Total Price for 8 Hubs			6,087,632	394,788

Table 11 Decentralised Supply of Bottled Water

8.3.Type 3: Portable RO Plant

The above two types include multiple steps and responsible parties⁵ before water can be supplied to affected islands. From the production stage to deliver more two parties are involved. Reducing responsible parties in one method to achieve greater operational efficiency.

In collaboration with NDMA, Maldives National Defense Force (MNDF) acts as the first responder to emergencies. MNDF coast guard services operates in strategic locations of the country. They can ensure that emergency water request prone areas highlighted in the heat maps⁶ already have their presence.

This type proposes to equip MNDF with a portable RO plant to supply desalinated water to affected islands during dry period. This RO plant should ideally be inbuilt into a sea vessel to acquire desalinated water for areas free from waste and garbage. In some cases shift is water current collects garbage in inner harbor areas. Current proposal is to have minimum one portable RO plant operating in each administrative boundary.

Furthermore, MNDF is mandated to produce sufficient water reserve for firefighting. After dry season passes, they can utilize the RO plants to increase water reserve for such tanks. Presently these tanks are located in islands with water networks and is filled with desalinated water. The designated service areas for the RO plants in 100km Radius. 5 portable RO plants are required to service the country. The following map highlights the service areas.

⁵ Refer to Water Security Plan Flowchart under section 6

⁶ Refer to appendix B

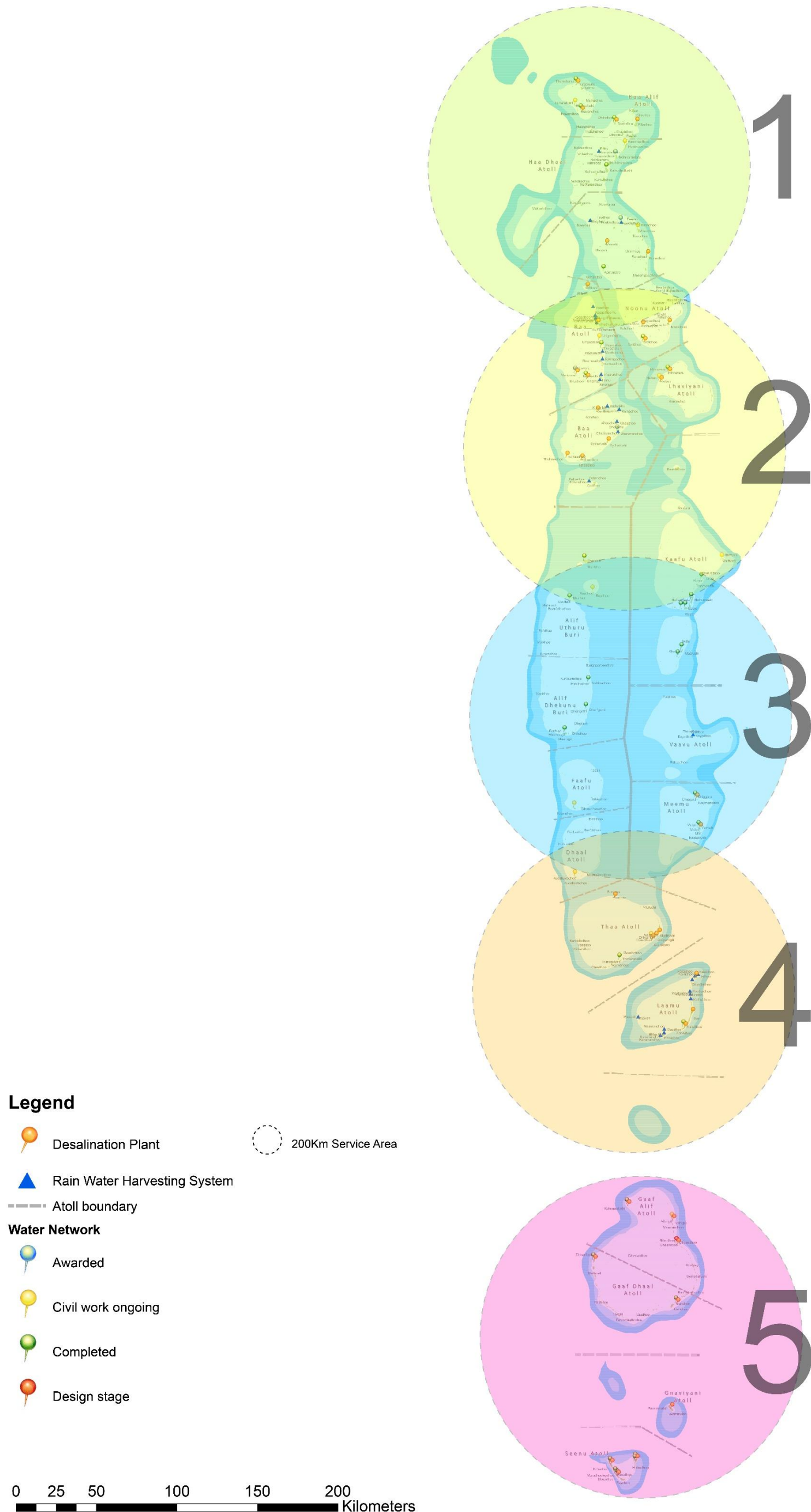


Figure 14 Portable RO Plant Service Areas

Two costing models have been studied for this type. One model is sourced from Japan while the other model can be produced locally. Two models produce 30 tons desalinated water daily. Following is a comparison of both models.

Model 1: Mobile Water Purification System by NEC

Specifications

NWPS Series		70		10*		
		Type-SS	Type-S	Type-1	Type-2	Type-3
Purification System		(DF+UF+RO)		(DF+UF+RO)	(CF+RO)	(RO)
Capacity (L/day)		70,000 (fresh water) 30,000 (sea water)		10,000 (fresh water) 10,000 (sea water)		
Design Water Temp		0°C 25°C		25°C		
Raw water condition	TDS (mg/L)	<46,200		<33,000		
	Turbidity (NTU)	<200		<200	**	-
	ph	4-9		6.5-8.5		
Raw water condition		Sodium Hypochlorite		Sodium Hypochlorite		
Power Source		220V 3Phase		220V 1Phase		
(KVA)		45	30KVA	3KVA	2KVA	2KVA
Operation		Automatic		Automatic	Manual	
Pre-filtration Backwash		Equipped		Equipped	None	-
Dimension (LxWxH)	(mm)	3,547x2,247x1,250		1,400x1,000x1,000	1,400x1,000x1,000	1,400x1,000x500
	Generator	1,870x860x1,250	-	-		
Weight	(Kg)	3300	3000	350	250	200
	Generator	1000	-	-		
Accessories	Generator	All included	Option	Option		
	Water Strage Tank					
	Raw Water Pump					
	Distribution Pump					
	Connecting Hoses					
	Raw Water Hose					
	Pure Water Hose					

Figure 15 NEC Mobile Water Purification Specifications

Product line









NWPS70	NWPS10		
Type-SS	Type-1	Type-2	Type-3
 <p>Raw Water Quality</p> <p>Turbidity High Turbidity</p> <p>TDS Very High</p>	<p>RO</p>  <p>+</p> <p>UF Auto Backwash</p>  <p>+</p> <p>DF Auto Backwash</p> 	<p>RO</p>  <p>+</p> <p>CF Manually Renew by brushing</p>  	<p>Protection Filter + RO</p>  <p>CF Ceramic Filter DF Disk Filter UF Ultra Filter RO Reverse Osmosis</p> <p>Clear</p> <p>Normal Sea</p>

Figure 16 NEC Mobile Water Purification Product Line

The NWPS 70 series by NEC comes produces 30 tons of fresh water from sea water. Furthermore, this model is supplied with the necessary accessories such as generator, water storage tank, pump etc. The following table provides a rough breakdown of the investment costs.

Model 1: Portable RO Plant (NEC)		
Details	Cost/MVR	Cost/USD
RO Plant	249,542	16,183
Shipping costs	77,100	5,000
6" DIA Pipe 100m (1200m required)	30,000	1,946
Vessel Price 40 ft vessel	750,954	48,700
Total Price per RO Plant	1,107,596	71,829
Total Price for 5 RO Plant	5,537,979	359,143

Table 12 Investment Cost of NEC Portable RO Plant

Model 2: Locally constructed Portable RO Plant

A RO plant of the same capacity can be produced locally. The following table provides a rough breakdown of the investment costs. However, accessories have to be combined to give a total solution in the local model.

Model 2: Portable RO Plant (Local Model)		
Details	Cost/MVR	Cost/USD
RO Plant (2x1x1.5)	616,800	40,000
Generator (40 KV) - MTCC Cost	200,000	12,970
Danfoss APP 5.1 Pump	131,070	8,500
6" DIA Pipe 100m (1200m required)	30,000	1,946
Vessel Price 40 ft vessel	750,954	48,700
Cartridge or Bag Filters (not acquired)	-	-
Total Price per RO Plant	1,728,824	112,116
Total Price for 5 RO Plant	8,644,120	560,578

Table 13 Portable RO Plant Local Model

Comparison shows that local model is slightly more expensive than the NEC model. However, in the local model accessories can be procured locally with ease compared to international brands. Furthermore, NEC models requirement trained workers to operate the system where as the local model can take advantage of existing institutional knowledge and promoted small businesses. Please note that these two models need to be studied further prior to concluding the most sustainable model.

8.4. Investment Costs Comparison of the Systems

The following table shows the costs of the systems proposed above. From the three types of systems, the system type with lowest investment cost is Portable RO Plant. However, it is important to note that operational costs of all the systems should be further studied to make a more accurate conclusion.

Emergency Water Supply System Types	Models	Cost/ MVR	Cost/ USD
1. Decentralized Water Supply System	-	11,714,310	759,682
2. Decentralized Supply of Bottled Water	-	6,087,632	394,788
3. Portable RO Plant	NEC	5,537,979	359,143
	Local	8,644,120	560,578

Table 14 Emergency System Cost Comparison

8.5. Systems Testing and Validation

Two-day stakeholder validation workshop was carried out among representatives from councils, utility service providers, MNDF, NDMA and MMS. The three system types were reviewed, analyzed and compared among the stakeholders.



Figure 17 Stakeholder Validation Workshop Image 1

The data from meeting was converted to strengths and weaknesses. The table bellows summarizes the strengths and weaknesses of every type discussed in the meeting.

Emergency Water Supply System			
#	Type	Strengths	Weaknesses
1	Decentralized Water Supply System	<ol style="list-style-type: none"> 1. Cost effective due to existing plants 2. Timely response 3. Easy to initiate process 4. Easy to maintain 5. One-time investment 6. Less investment cost per hub 7. Regulated by the government 8. Environment Friendly 	<ol style="list-style-type: none"> 1. Substandard carrier vessels 2. High operational costs 3. Lack of quality assurance 4. Dependency on network 5. Lack of public acceptance 6. Logistics and transport issues
2	Supplying Bottled Potable Water	<ol style="list-style-type: none"> 1. Safe and Secure 2. Reusable 3. Higher chance of public acceptance 4. Better quality 5. Convenient with household dispensers 	<ol style="list-style-type: none"> 1. Overall higher investment, transport and maintenance costs 2. Logistics and transport issues 3. Bottle maintenance challenges 4. Plastic pollution 5. Dependency on network
3	Portable RO Plant	<ol style="list-style-type: none"> 1. Reliable 2. Efficient 3. Cost Effective 4. Low transportation costs 5. Multipurpose use, e.g. fire emergencies 	<ol style="list-style-type: none"> 1. High maintenance and operations cost 2. Specialist training required

Table 15 Emergency Water Supply System Strengths and Weaknesses

From the table it can be concluded that, the type 3 Portable RO plant is the most preferred type by stakeholders, followed by Type 1. Type 2 is the least preferred as clearly observed from the table. Furthermore, key areas were defined and the systems were scored further through a rating scale. From both exercises it can be concluded that emergency water supply system type 3 acquiring Portable RO Plants is the best way forward. In addition, ME can choose to have mix of two types to give a more efficient service. For instance type 3 for northern atolls and type 1 for central and south.

Rating Scale: 1 – Low 2 – Medium 3 – High

Key Areas	Emergency Water Supply Systems		
	Type 1	Type 2	Type 3
Cost Effectiveness & Long term Sustainability	2	1	3
Time & Efficiency	2	2	3
Water Quality Assurance	1	3	2
Environment Sustainability	2	1	3
Total Point Scored	7	7	11

Table 16 Emergency Water Supply Type Scoring System

8.6. Emergency Water Supply System Operational Matrix

Each type of the Emergency Potable Supply System explain above is converted into step by step process. In order to enhance the coordination mechanism a water management portal ⁷should be developed to achieve systems integration. Each step is linked to a specific duration. Till the water management portal is established, councils can follow the current system. However based on the chosen system type, council may not have to report directly to the utility provider. In the proposed plan the responsibility is taken by ME. Nonetheless the first step for all system types are the same. For all the types to function effectively, existing water levels should be established (please refer to Water Management Portal under section 11).

Once the islands start updating the water levels every quarter and ideally every month during dry season, the water level trends can be identified. It is advised to report minimum 10 working days (2 weeks) prior depletion. The target is to supply water within 8 working days.

EMERGENCY WATER SUPPLY SYSTEM			
#	STEPS	TIMELINE/DURATION	LEADING INSTITUTION
TYPE 1: DECENTRALIZED WATER DISTRIBUTION			
1	Measuring Water Levels	Prior to 10 working days	ME/ Councils
2	Emergency Water Request	01 working day	Council
3	Verification Process	02 working days	ME
4	Alert relevant service providers	01 working day	ME
5	Activate Decentralized hubs	02 working days	Service Provider
6	Supply Water in tanks via Sea Vessels	02 working days	Service Provider
7	Supply to public via Community Tanks	-	Council
TYPE 2: SUPPLY OF BOTTLED POTABLE WATER			
1	Measuring Water Levels	Prior to 10 working days	ME/ Councils
2	Emergency Water Request	01 working day	Council
3	Verification Process	02 working days	ME
4	Alert relevant service providers	01 working day	ME
5	Activate decentralized bottling factories	02 working days	Service Provider
6	Supply Filtered Water Bottles via Sea Vessels	02 working days	Service Provider
7	Supply to public via Council Dispensers	-	Council
TYPE 3: PORTABLE RO PLANT			
1	Measuring Water Levels	Prior to 10 working days	ME/ Councils
2	Emergency Water Request	01 working day	Council
3	Verification Process	02 working days	ME
4	Alert MNDF as an Emergency Responder	01 working day	ME
5	Vessel to Supply Potable Water Requested Island	02 working days	MNDF
6	Produce Desalinated Water via a RO Plant(Inbuilt into Vessel/ Portable)	02 working days	MNDF
7	Supply to Public via Community Tanks	-	Council

Table 17 Emergency Water Supply System Operational Matrix

The following section presents a flowchart of the water security plan showing the step by step process.

⁷ Refer to section 8 for the details of the water management portal

9. POTABLE WATER SECURITY OPERATIONAL PLAN – YEAR AROUND FLOWCHART

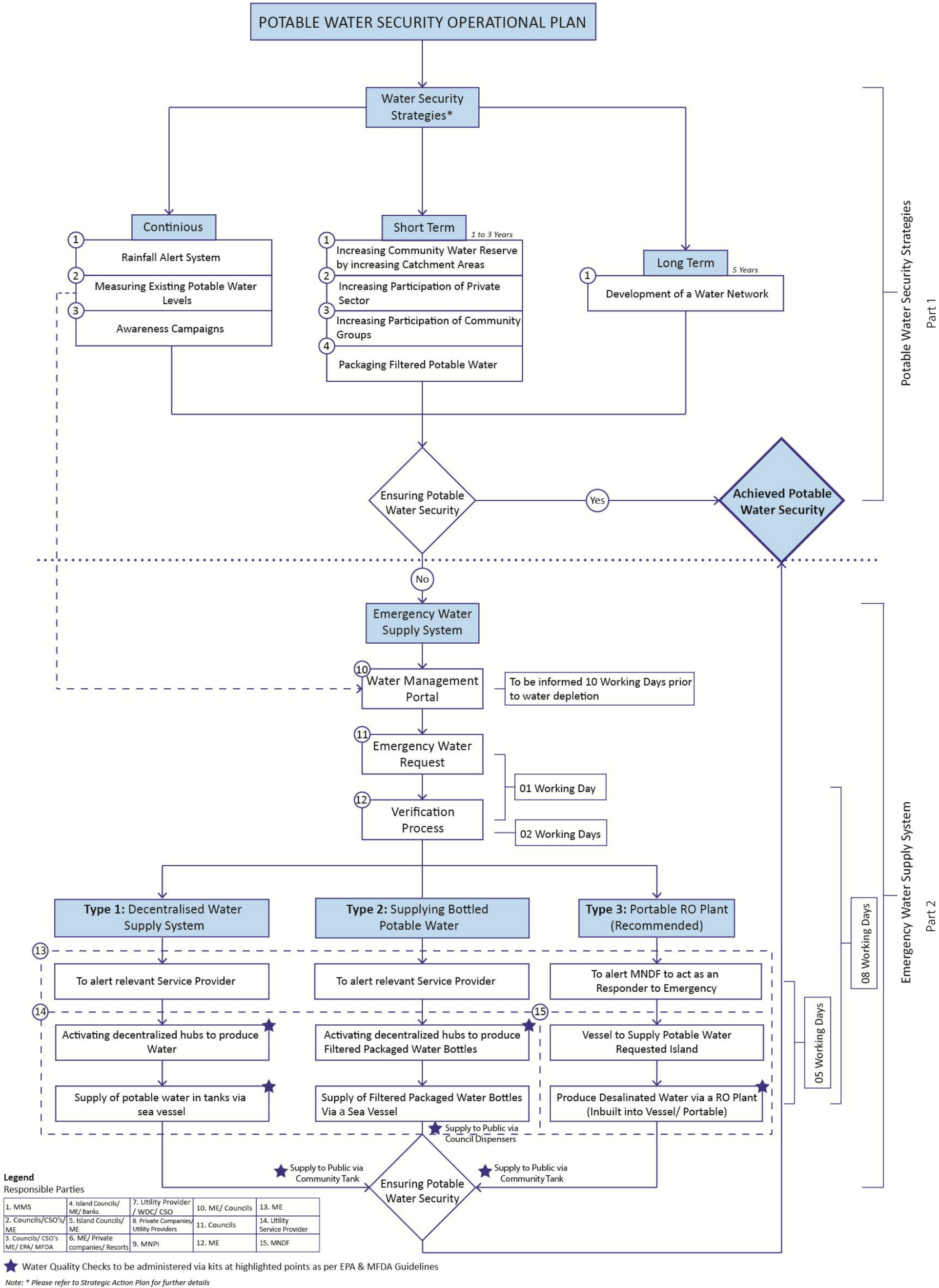


Figure 18 Water Security Operational Plan - Flowchart

9.1. Island level implementation

This section elaborates the responsibilities island councils. With reference to the above plan and section 7.4, all potable water security strategies with has councils as the responsible party should be implemented throughout the year. From those strategies following is a list of selected strategies where councils can lead at island level;

9. Measurement of Potable Water Levels (refer to section 7.1.2)
10. Education and Awareness Campaigns (refer to section 7.1.3)
11. Increasing Community Water Reserve by increasing Catchment Areas (refer to section 7.2.1)

9.1.1. Proposed dry season procedure during emergencies

The diagrams below underlines the actions of island councils during emergencies. This section aims to help mechanize and implement the plan at island level.

Type 1 & 3

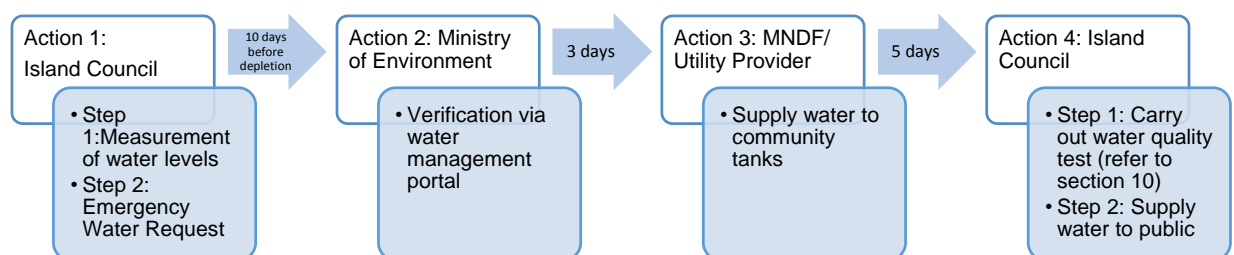


Figure 19 Dry Season Diagram - Type 1 & 3

Type 2

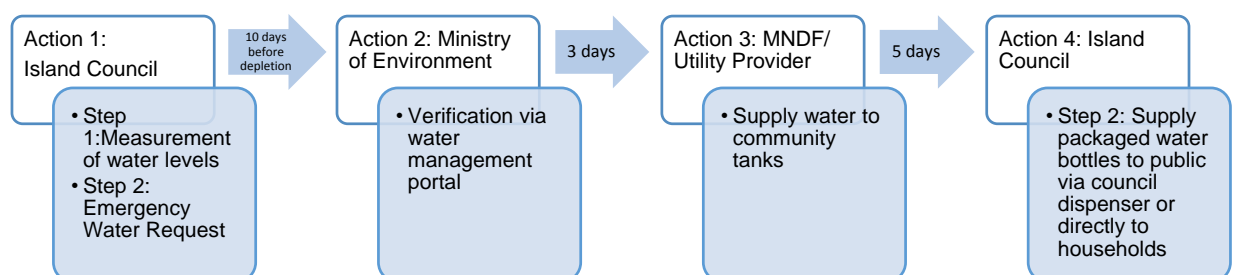


Figure 20 Dry Season Diagram - Type 2

10. MEASURES TO ENSURE WATER QUALITY

From the findings of the survey it is evident that water quality is a major concern among the public. A very important condition is implementing existing laws and regulations. Currently there are two legal documents⁸ ensuring water quality;

- Guidelines for drinking water (EPA)
- National Standard for Bulk transportation and storage of Drinking Water (MFDA)

EPA guidelines has clearly defined the water sample collection procedure as well as the testing parameters for drinking water. EPA conducts regular checks to ensure water supplied to the public fits their guidelines. However, EPA carries out this activity in islands where water networks are established and operational only. The quality of supplied water is not checked by EPA.

MFDA standard identifies the conditions of water carrying containers, fitting and vessels in detail. However, there have been challenges implementing the guidelines after NDMA handed over the emergency water supply operations to FENAKA. Quality tests are conducted at the source point by FENAKA during their emergency water supply operations. However, due to the limited resources, they are unable to verify the quality of water during the supply chain.

Throughout the course of preparing this plan measures to ensure water quality was discussed with the island level and government stakeholders. Such discussions and have been taken into consideration in the plan. The stars in the flowchart indicate water quality check points. Following are the recommendations proposed under this plan to implement such measures.

In addition to the above water quality can be tested by individuals as well. For instance bacteriological H2S field test bottle can be made available in pharmacies operated by State Trading Organization (STO). This would increase public confidence in supplied emergency water.

Cost Analysis of Bacteriological H2S Bottle

The calculations is made by taking the results of 2018 affected islands and population. As per the UNICEF website an indicative price for a kit is USD 1.53 (Bacteriological H2S field tst kit, 2019). It has been assumed that 4 kits will be required by each council or health center during dry season (1 kit per month). The cost incurred if a kit were to be bought by each household was also calculated. It was assumed that 4 people per household for the affected population. The kits for individual use can be sold from pharmacies.

⁸ Refer to annexure A and B for the document

Cost of Kits for 48 Islands	Cost/USD	Cost/MVR
Council/ Health post	294	4,530
Each Household	19,069	294,040

Figure 21 Cost of H2S Kits

10.1. Recommendations to ensure water quality

1. All parties responsible in implementing the Potable Water Security Plan especially Emergency Water Supply Systems should comply with the guideline and standard set by EPA and MFDA respectively
2. Staff from island hospitals and health centers to be trained to conduct water quality checks via water quality kits. For parameters reference can be made to the EPA guideline⁹
3. Water Quality Kits are to be distributed islands and should be readily available to buy at pharmacies for individual use
4. The trained personnel to check water quality at every check point indicated in the plan
5. Water quality checks to be carried out every month for community tanks carrying water for longer periods
6. STO can provide Bacteriological H2S field test bottles in island pharmacies for individuals to test water quality to increase water quality assurance
7. Councils to send water in community tanks to be checked by laboratories for extensive studies. ME or LGA to take responsibility in monitoring the council duties. Laboratories are located in the following locations;
 - K. Male' / Hulhumale'
 - Ga. Koodoo
 - K. Himmafushi
 - S. Hithadhoo

⁹ EPA can share specific parameters to check water quality

11. WATER MANAGEMENT PORTAL

The above Water Security Operational Plan is proposed to be implemented through an online portal. To ensure operational efficiency of the plan is important to integrate the steps in the plan with the portal.

Currently ME is in the process of developing an online portal called Emergency Water Supply Portal to manage the water supply and distribution process. However to address the strategies proposed in the plan in a more holistic manner the portal has been reviewed and certain changes are recommend.

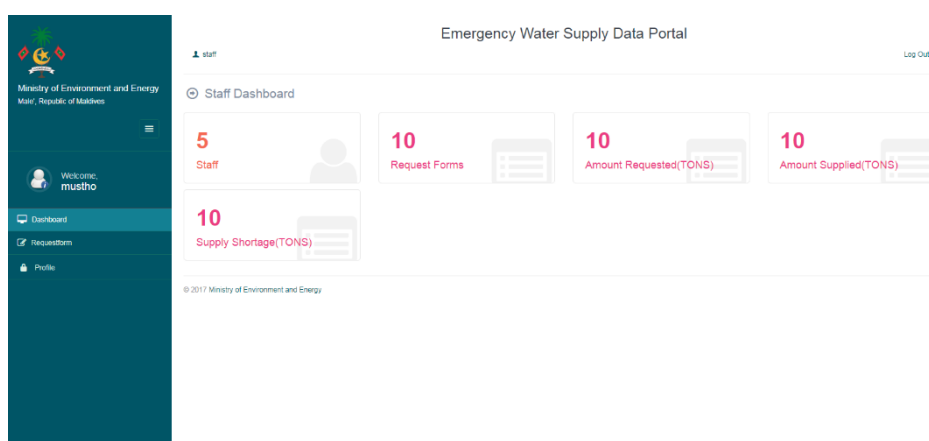


Figure 22 Screen Shot of the Emergency Water Supply Data Portal

11.1. Review of the Portal

Dashboard of the current water Emergency Water Supply Portal consists of the following tabs or categories:

- a. Number of request forms received
 - b. Amount of potable water requested
 - c. Amount of potable water supplied
 - d. Supply shortage (TONS)
1. Categories b. and c. needs to be enhanced to indicate the hub supplying the water and respective amount. A decentralized water distribution mechanism will have multiple hubs.
 2. Following are the categories to be introduced:
 - Potable water levels at community and household tanks in affected islands; as per the plan, the existing water levels measured in islands should be systematically fed into by portal by the councils
 - The above step is crucial for ME and service providers as a verification process
 - Daily water production and consumption of water supply hubs

11.2. Recommendations to enhance the portal

1. It is recommended to change the name of the existing portal from Emergency Water Supply Portal to Potable Water Management Portal. Proposed change is to address all aspects of Potable Water Management.
2. Rainfall alert system¹⁰ for early prediction needs to be integrated into the system to compare the water collection trends with weather patterns.
3. The portal should consider and map out all residential, industrial and resort islands. It is important to note here that resorts are included as they can be potential water suppliers.
4. To integrate a cross check to monitor whether council/health centers carry out water quality check (refer to section 7)
5. Information should be visible in the dashboard in the form of interactive maps, charts and graphs. The image below shows an example of a GIS maps ¹¹showing the information above.

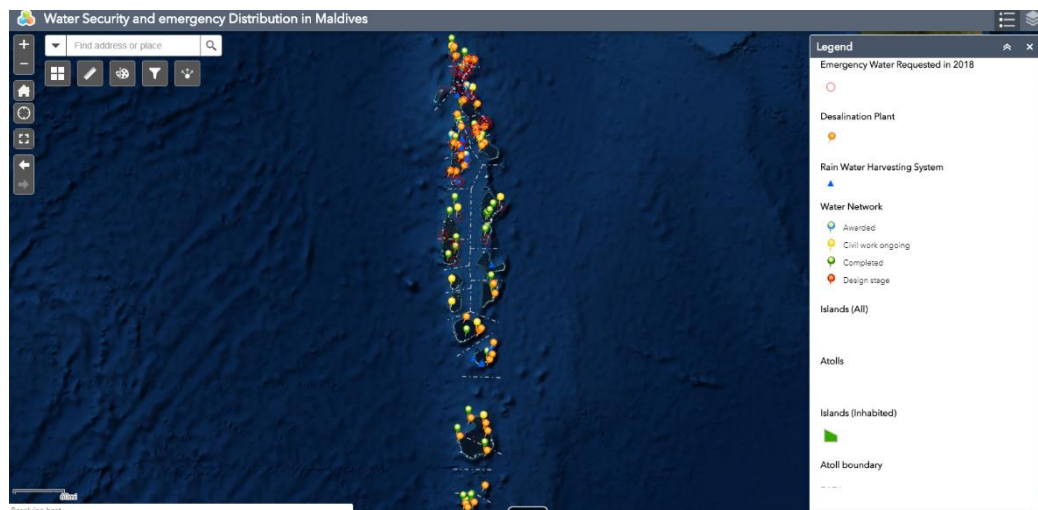


Figure 23 Screenshot of GIS maps

11.3. Verification Process

In the current practice, Emergency water supply requests are verified by a phone call or by staff for utility service branches from nearby islands physically visiting the island. With the setup of the water level measuring mechanism and regular updates to the portal, anomalies can be detected easily. If an anomaly arises a site visit can be carried out by a nearby hub to verify. If not the trends will not vary, in turn creating accountability for the councils and accurate data for ME to verify the entered data.

¹⁰ Refer to section 4.1.1 for Rainfall Alert System

¹¹ Reference; <https://accay.maps.arcgis.com/apps/webappviewer/index.html?id=d8a9472a6a4840caa59ad5db2e3c5b8d>

12. REGULATORY AND LEGAL FRAMEWORKS

Legal and operational instruments are essential to effectively implement the plan. Some guidelines need to be enforced for the plan to succeed. Existing documents were identified to find any gaps for implementation. Many laws and regulations are currently in draft stage, hence the possibility to incorporate comments is possible at this stage. Following table shows existing documents relevant to water categorized in their respective areas.

Aspect	Policies	Goals	Laws & Acts	Regulations	Guidelines & Standards
Legislative	National Water and Sewerage Policy	NWSP Goal 1: Ensure access to safe water supply and adequate sewerage services	Draft water and sewerage act (not acquired)	Draft Regulation of water service providers (registration and tariff)	National Standard for Bulk transportation and storage of Drinking Water (MFDA)
	National Development Plan (Draft Stage)			Draft Bottled water regulation	Guidelines for drinking water (EPA)
	Maldives Spatial Plan (Draft Stage)			Desalination plant regulation	
International agreements	Sustainable Development Goals (SDG's)	Goal 6: Clean water and sanitation Goal 10: Reduced Inequalities			
Unity Government Manifesto	Economy (Utility Services): Ensure that no island come by shortage of drinking water. Establish clean drinking water facilities in all islands.				
Operational	Dry period procedure				

Table 18 Existing documents relevant to water

12.1. Recommendations for regulatory and legal frameworks

After studying the existing documents, documents to be reviewed and new documents to be produced were recommended to support the Water Security Operational Plan. Please note these recommendation are not limited to the following only. These documents are proposed to be produced within 1 to 3 years.

#	Documents to be reviewed	Targeted Output	Objective
1	Desalination Plant Regulation	<ul style="list-style-type: none"> To encourage private sector participation To make it more accessible to SME's 	To support short term strategy 2; increase participation of the private sector
2	Guidelines for drinking water (EPA)	<ul style="list-style-type: none"> To ensure that the guidelines specifically is stated to apply for all type of drinking water 	To ensure water quality in all types of drinking water
3	National Standard for Bulk transportation and storage of Drinking Water (MFDA)	<ul style="list-style-type: none"> Make the standard more holistic Name of the standard is misleading, the standard does not address water storage conditions nor how to maintain quality. only addresses bulk transportation only 	<ul style="list-style-type: none"> To ensure water quality in all types of drinking water To accurately inform all relevant stakeholders
#	Documents to be produced	Targeted Output	Objective
1	Guidelines for measuring and updating potable water levels for local councils	<ul style="list-style-type: none"> Collecting Data and understanding water shortage trends Verification process for emergency potable water 	To support continuous strategy 2; Measurement of Potable Water Levels
2	Standard operating procedure to use Water Management Portal for all relevant parties	<ul style="list-style-type: none"> To provide an efficient emergency water supply service 	To ensure effective implementation of the plan
3	Guidelines to conduct water quality checks	<ul style="list-style-type: none"> To ensure water quality 	To achieve public confidence in water quality
4	Regulations to increase involvement of resort and tourism sector in water services	<ul style="list-style-type: none"> Resorts can provide desalinated water during emergencies for island within close proximities. 	To support short term strategy 2; increase participation of the private sector
5	Laws prohibiting/ minimizing single use plastic	<ul style="list-style-type: none"> To prohibit single use plastic Reduce dependency of plastic water bottles 	<ul style="list-style-type: none"> To support continuous strategy 3 education and awareness campaigns To support short term strategy 5; Reusable packaged filtered water in 5 gallon bottles
6	Guidelines to encourage CSO's/ WDC participation in water management services	<ul style="list-style-type: none"> Award contracts to CSO's to operate kiosks 	To support short term strategy 3; increase participation community groups
7	Regulation or guideline to use all available roof spaces in affected islands as water catchment areas	<ul style="list-style-type: none"> To remove the institutional barriers which limits roof use of public buildings 	To support short term strategy 1; increase community water reserve by increasing catchment areas
8	Planning act to reserve land for water storage	<ul style="list-style-type: none"> To increase disaster resiliency in islands 	To support short term strategy 1; increase community water reserve by increasing catchment areas
9	Planning and development guidelines or building act to include underground tanks in all public buildings and parks		

Table 19 Recommendations for the regulatory and legal framework

13. TRAINING REQUIREMENTS

The training requirements and responsible parties to implement Water Security Operational Plan and is highlighted in the table below. Some areas are cross cutting areas which falls under the responsibility of two or more parties.

Focus areas	Responsible Parties								Objectives
	Ministry of Environment	Island Councils	Island Health centers	Utility Service Providers	MNDF/ NDMA	MFDA/ EPA	MMS	CSO/NGO/WDC	
1. Software development/ engineering to develop the online portal. A GIS technician will required for this area to produce relevant maps	✓								To develop Water Management Portal
2. Software development/ engineering to develop rainfall alert system (and integrate to the portal)	✓						✓		To support continuous strategy 1; Rainfall alert system
3. Administrative training to operate and update online portal	✓	✓	✓	✓	✓	✓	✓		To ensure integrated operation of the portal
4. Administrative training measure and update the potable water levels		✓						✓	To support continuous strategy 2; Measurement of water levels
5. Technical training to operate a Portable RO plant				✓	✓				To implement Emergency Water Supply System type 3
6. Training to administer a Water Quality Check kit on site as per EPA parameters		✓	✓			✓		✓	To ensure quality of supplied water and gain public confidence
7. Training to operate water kiosks at harbors				✓				✓	To support short term strategy 4; Increase participation of community groups
8. Training individuals/ staff to conduct awareness campaign			✓					✓	To support continuous strategy 3; Awareness campaigns

Table 20 Training Requirements

14. CHALLENGES AND LIMITATIONS

Throughout the course of this planning exercise challenges were met and the above presents plan hold certain limitations. Following list summarizes the challenges and limitations of the Water Security Operational Plan;

- **Time constraint:** The total duration of the project limits research and the ability to dive deeper into underlying issues.
- **Lack of information sharing:** Information we receive from government stakeholders (e.g. utility companies) is limited in terms of costs of equipment and services
- **Lack of available data:** Existing data is limited, and if available incoherent.
- **Regulatory and legal framework under review:** During the course of preparation of this plan many of the documents (e.g. National development Plan, Maldives Spatial Plan) are in draft stage which only provided limited information

15. FURTHER STUDIES

In addition to the strategies and systems proposed in the Water Security Operational Plan, there is room for further or extended studies with regard to this topic. The following list highlight certain recommended areas;

- Potable Water Security Operation Plan should be published, shared with and linked to National Emergency Operations Plan (NEOP) updated by NDMC
- Review of the conditions of the island tanks, the locations, equipment and connection details required to transfer water if distributed from Hubs or RO produced during emergencies
- All resorts have desalinated water networks. After identification of resorts in water shortage areas initiating discussion to provide emergency water supply service. Resorts have been mapped under this plan. Please refer to appendix D.
- Study the characteristic of islands with water shortages individually and propose island specific solutions
- Exploration of how ground water can be used as a potable water source
- Developing compliance codes to include water reserve tanks in public buildings with ME, MNPI and city councils.

It is also important to highlight here retention of staff with a good understanding of the underlying ideas of this plan is important throughout the implementation stages to ensure success. This will help address any challenges which may arise in a timely and effective manner.

16. ACKNOWLEDGEMENT

The report was prepared by Mr. Hussain Ziyath, Planning Consultant supported by UNDP under financing from the Green Climate Fund (GCF). Immense support was received from Ahmed Fariz Nizar, Project Coordinator and Hassan Saeed M&E Officer, of GCF Project Management Unit. In addition to above, Mayriam Dheena, Project Officer, Afsal Hassan, Director, Mohamed Musthafa, Director General, and Shaheeda Adam Ibrahim, Project Manager of Water Sanitation Department, Ministry of Environment played a crucial role finalizing this report.

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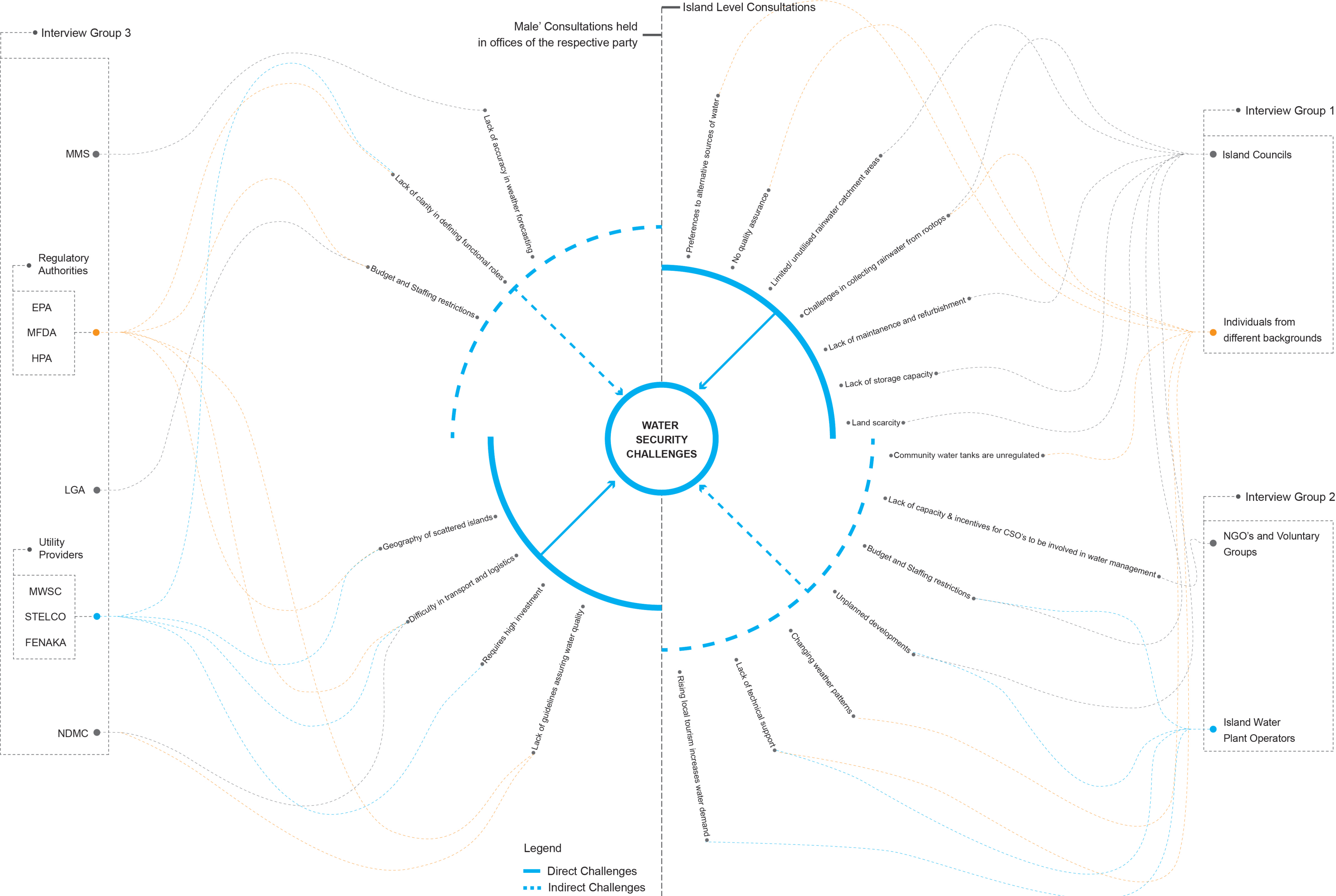
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Following are certain documents selected for (but not limited to) further analysis and have been used in preparation of this section of the methodology statement;

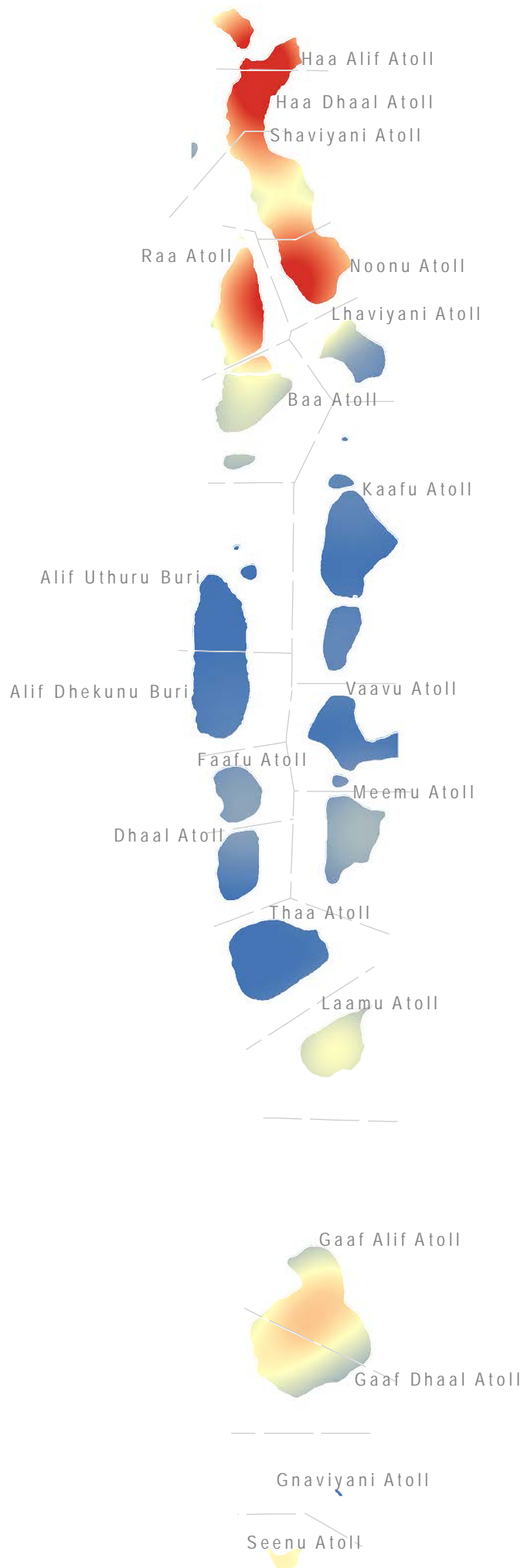
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APPENDIX A
DIAGRAM OF RECURRING THEMES

Recurring themes

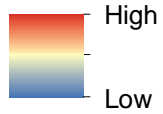


APPENDIX B
HEAT MAPS OF WATER SHORTAGE AREAS (2005 – 2018)

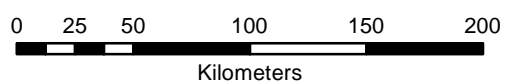


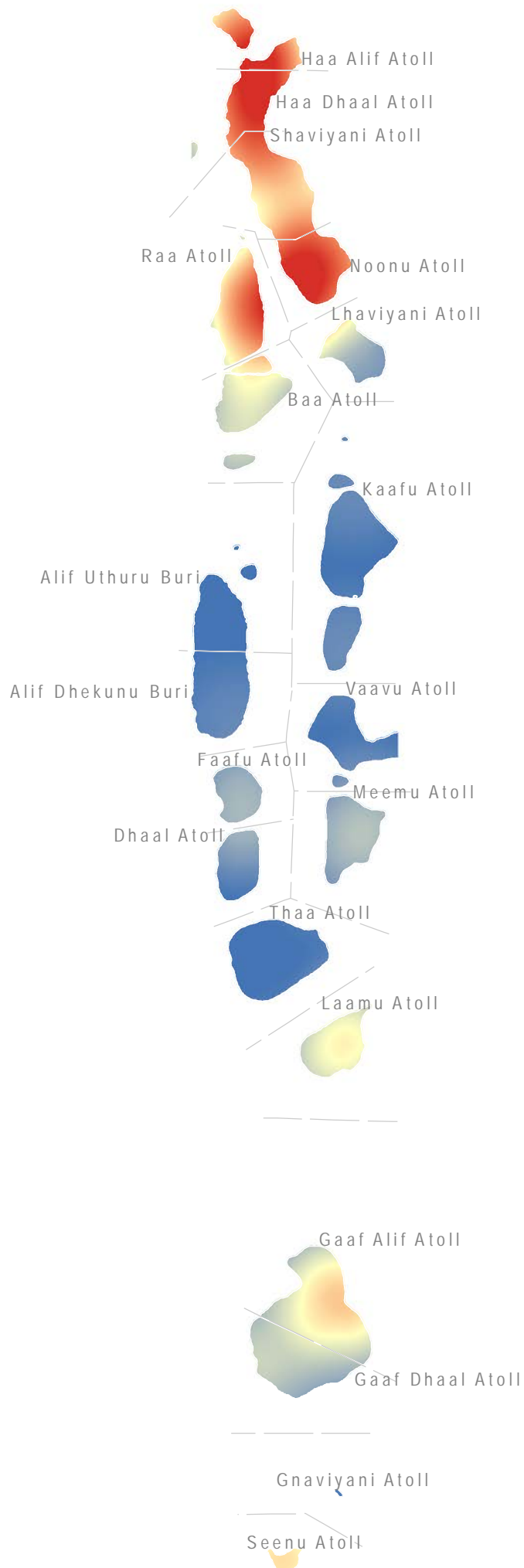
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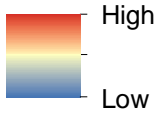
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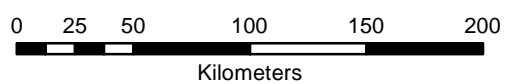


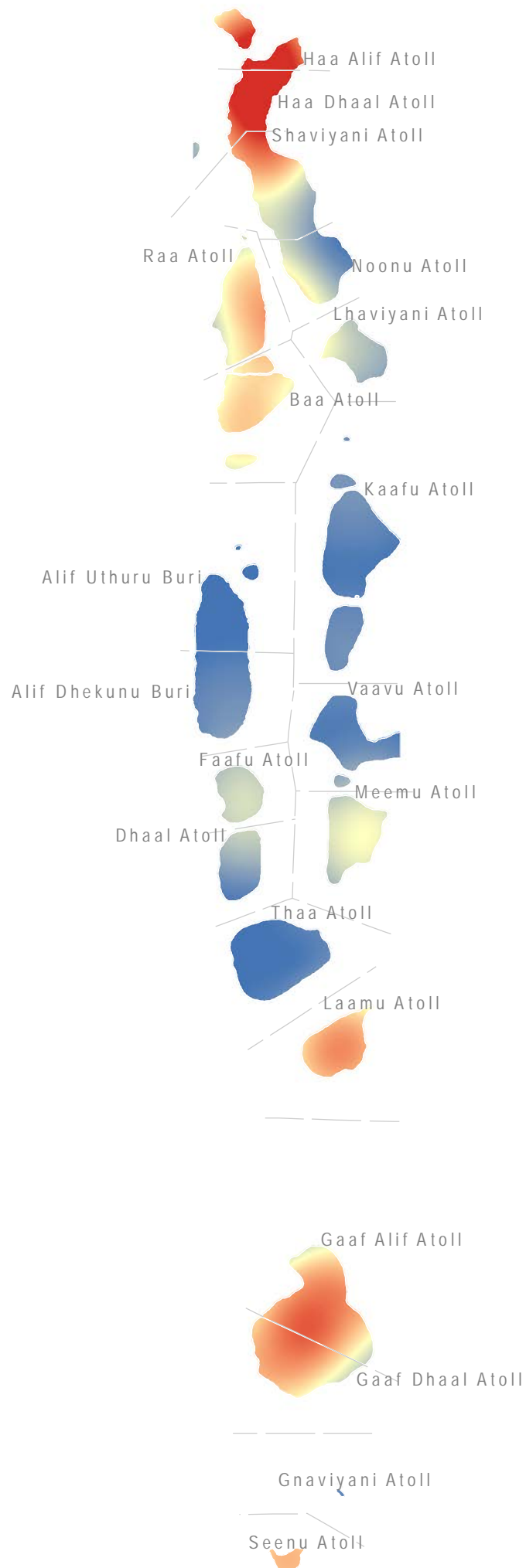
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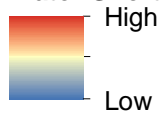
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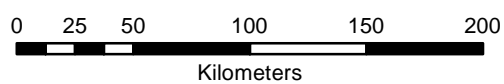


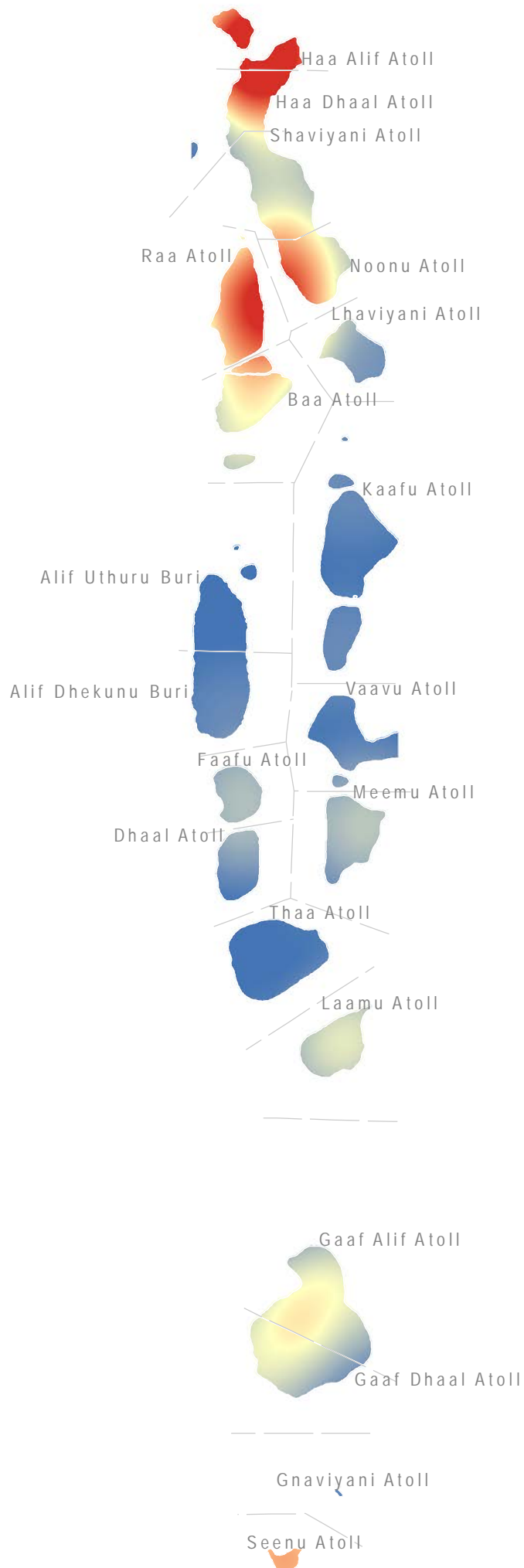
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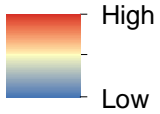
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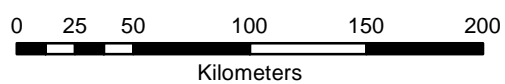


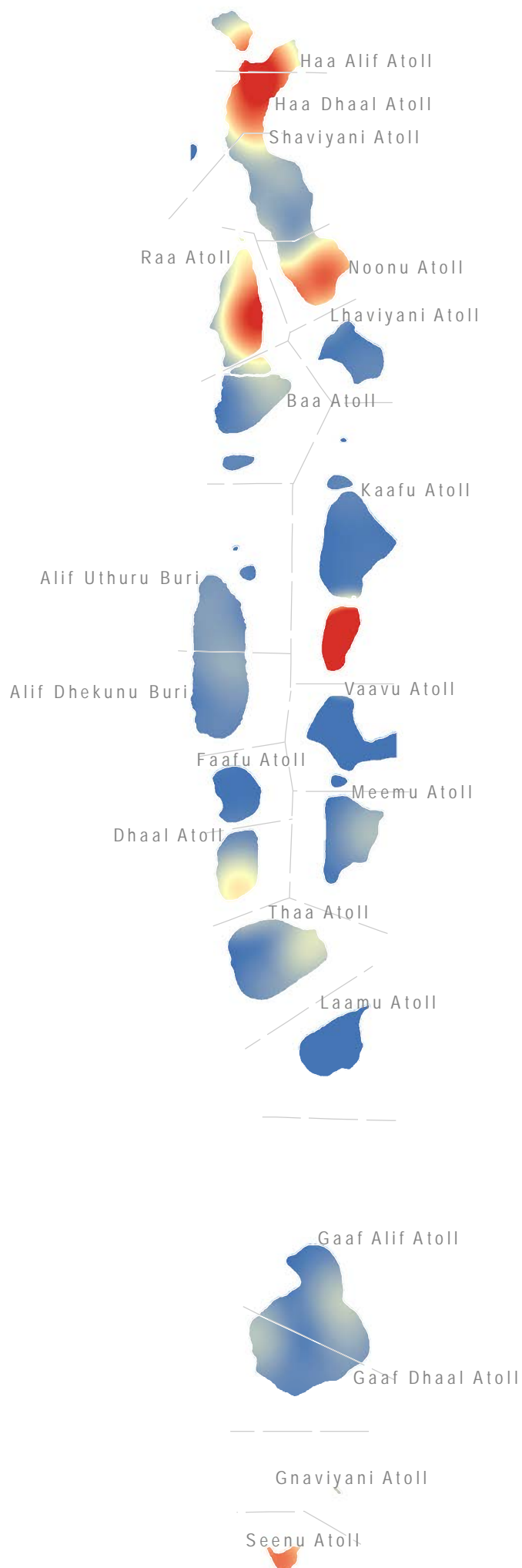
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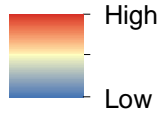
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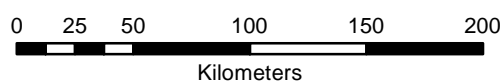


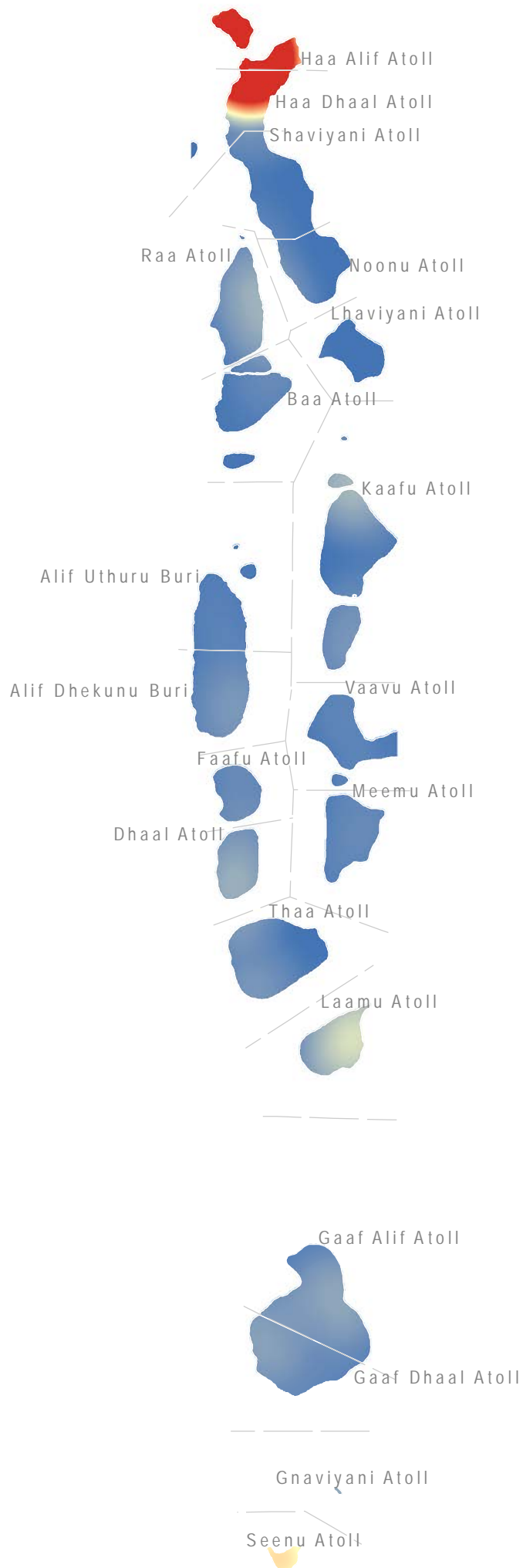
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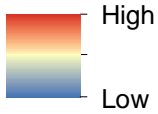
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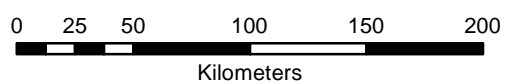


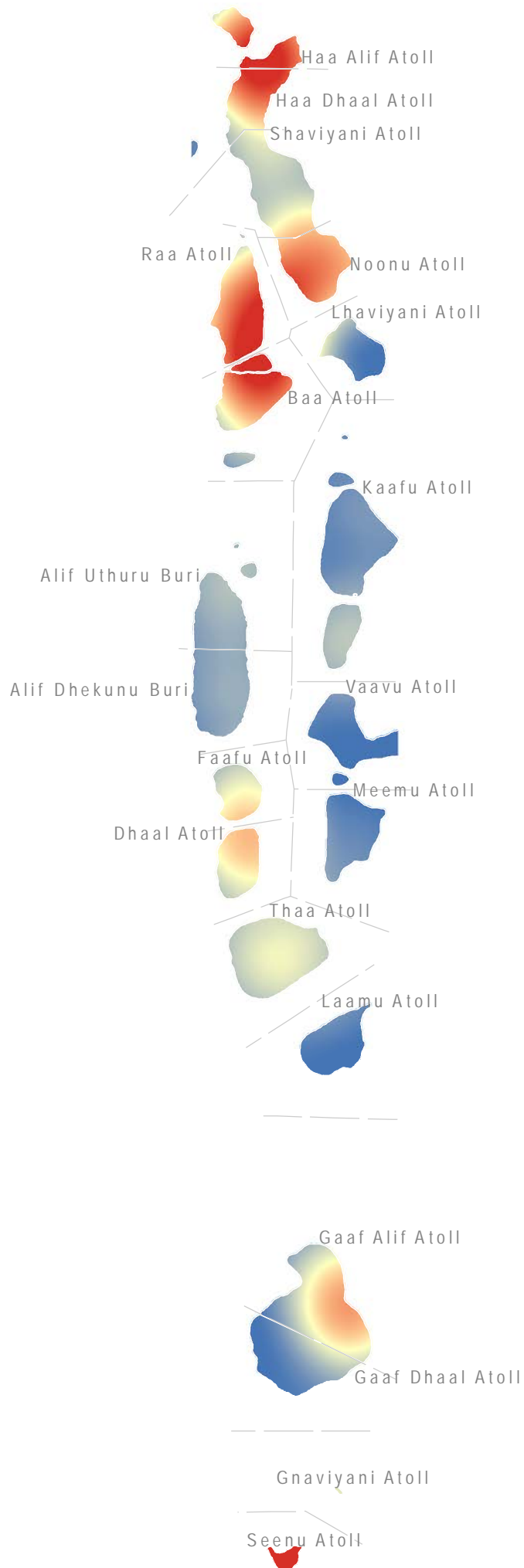
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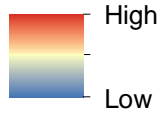
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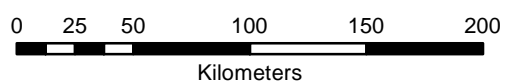


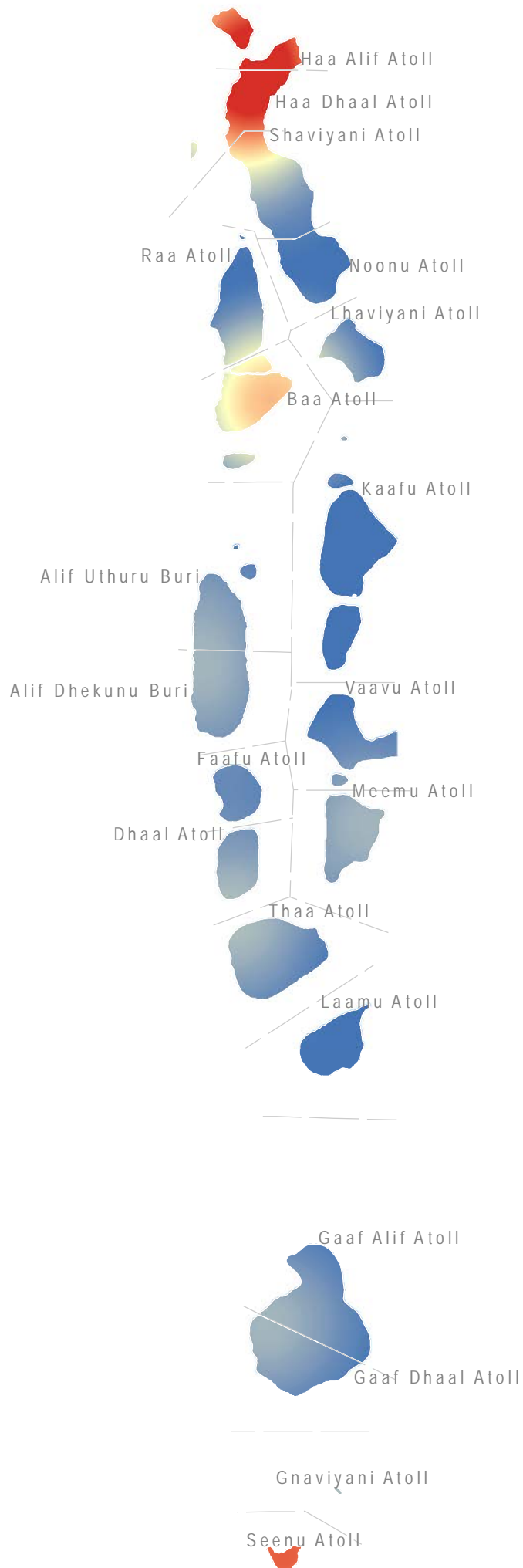
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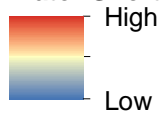
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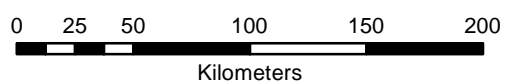


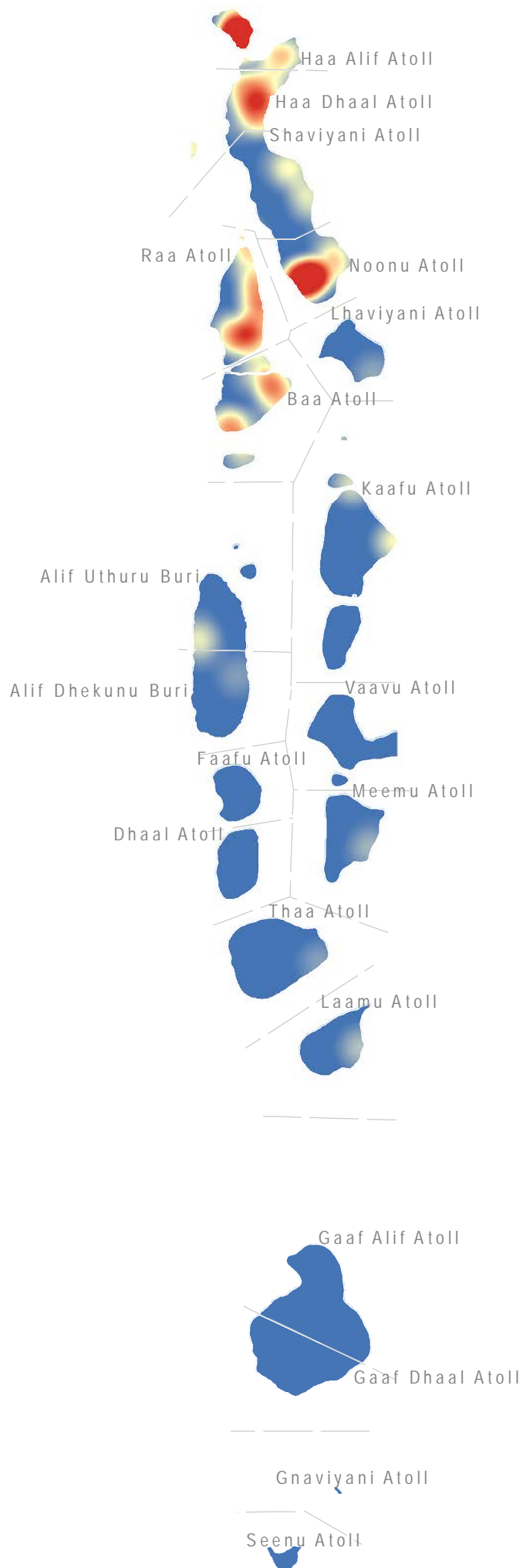
Legend

Water Shortage 2013



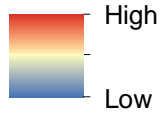
Atoll boundary



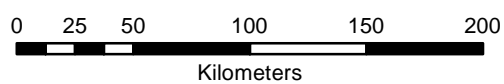


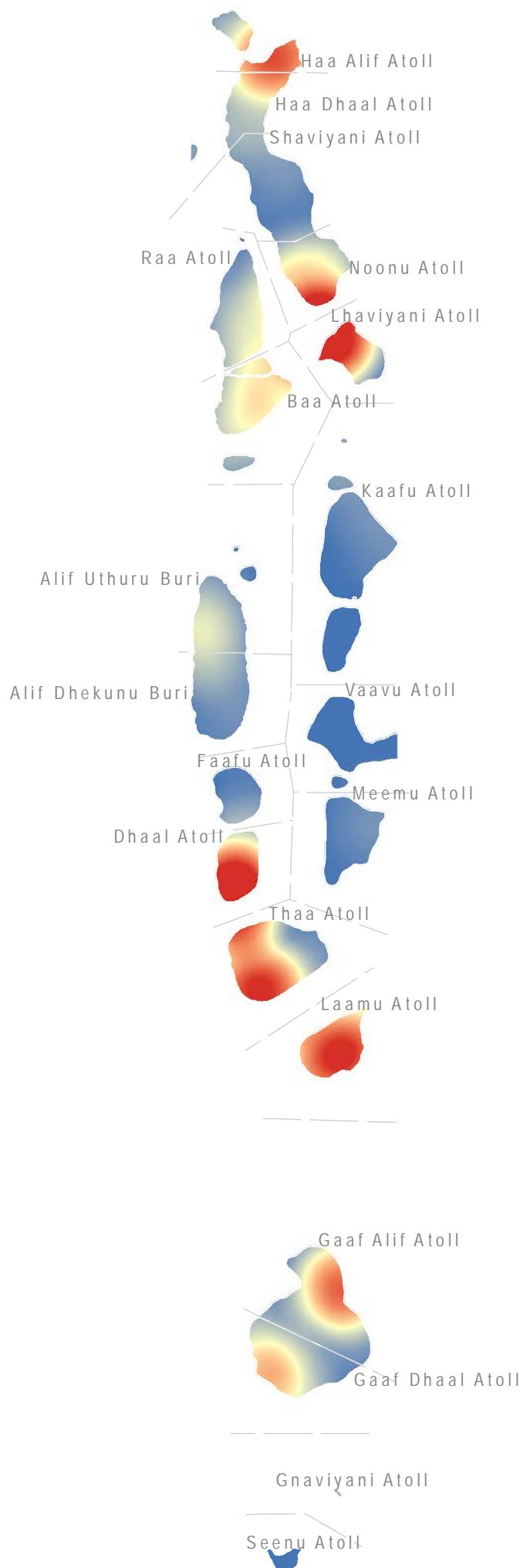
Legend

Water Shortage 2014



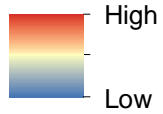
Atoll boundary



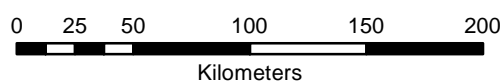


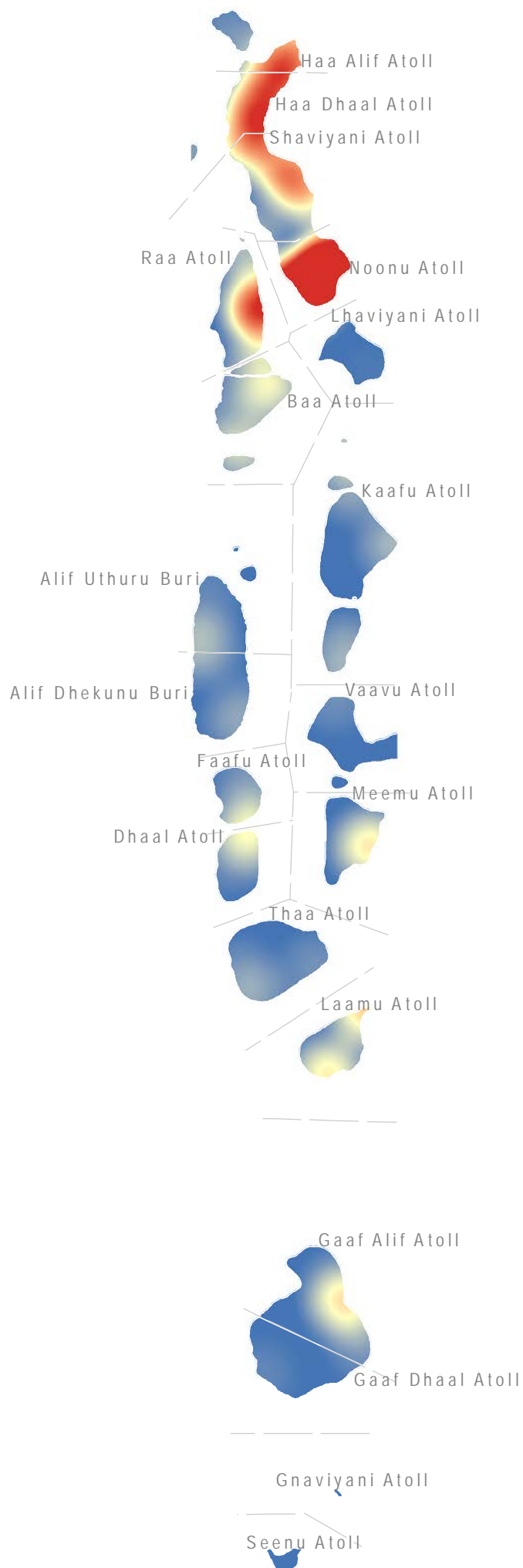
Legend

Water Shortage 2015



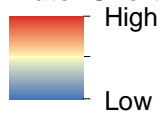
Atoll boundary



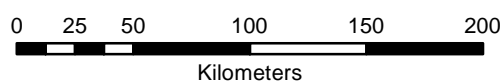


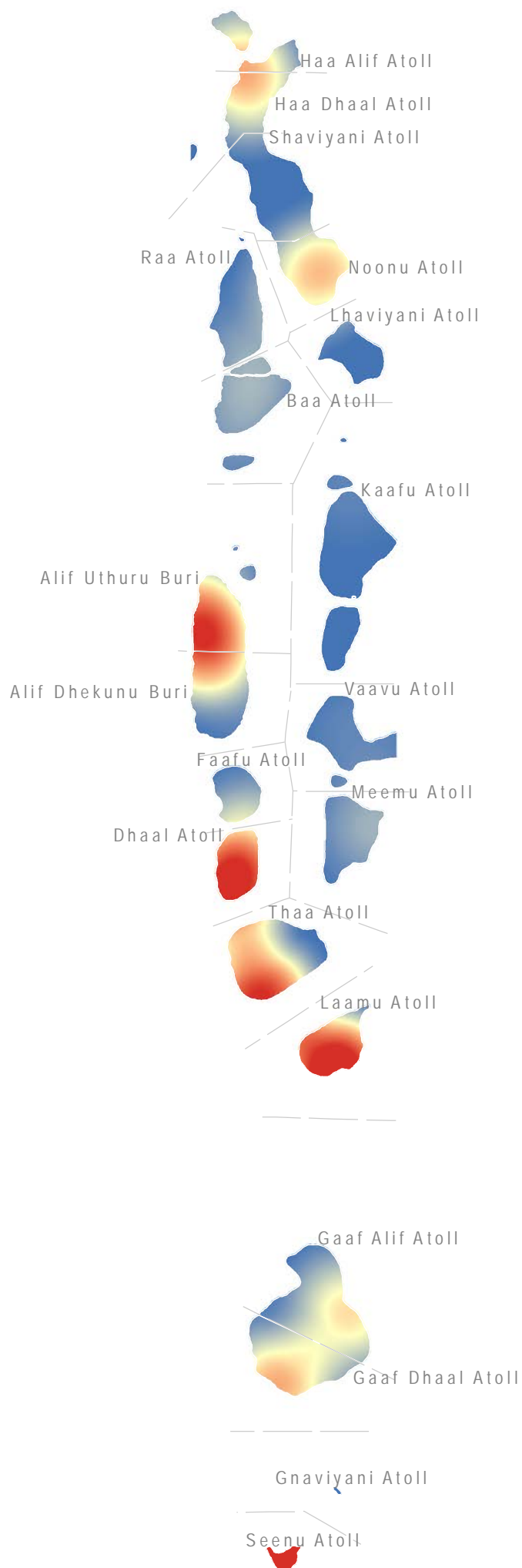
Legend

Water Shortage 2016



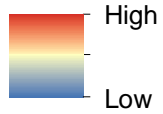
Atoll boundary



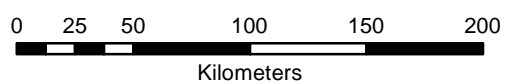


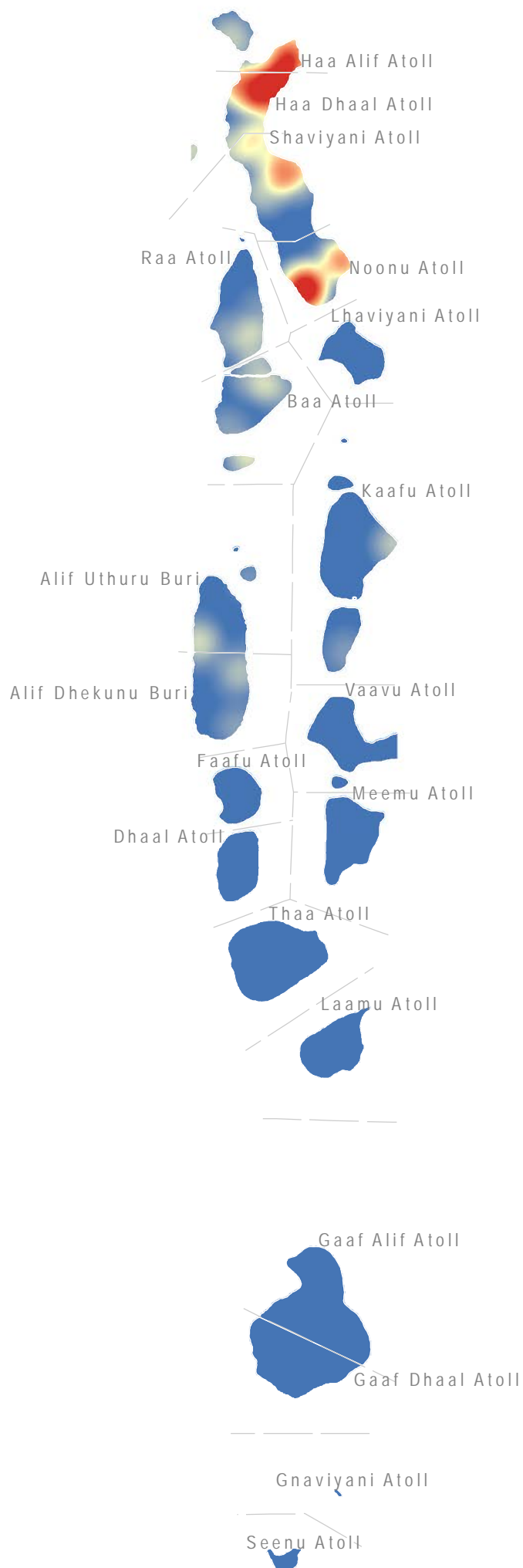
Legend

Water Shortage 2017



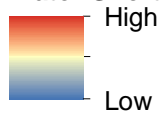
Atoll boundary



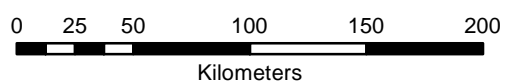


Legend

Water Shortage 2018



Atoll boundary








APPENDIX C
WATER SYSTEM MAPS



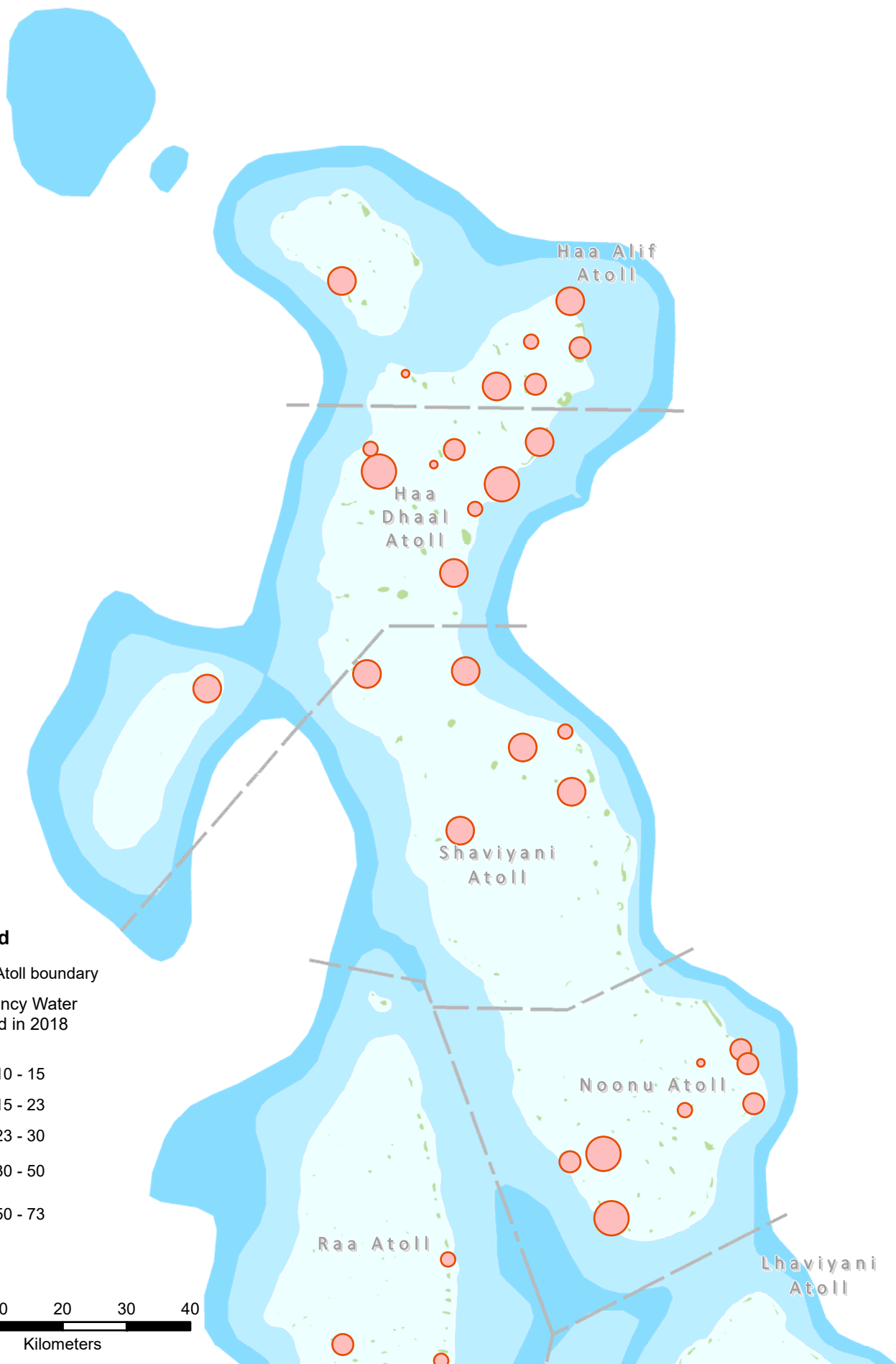
Legend

— Atoll boundary

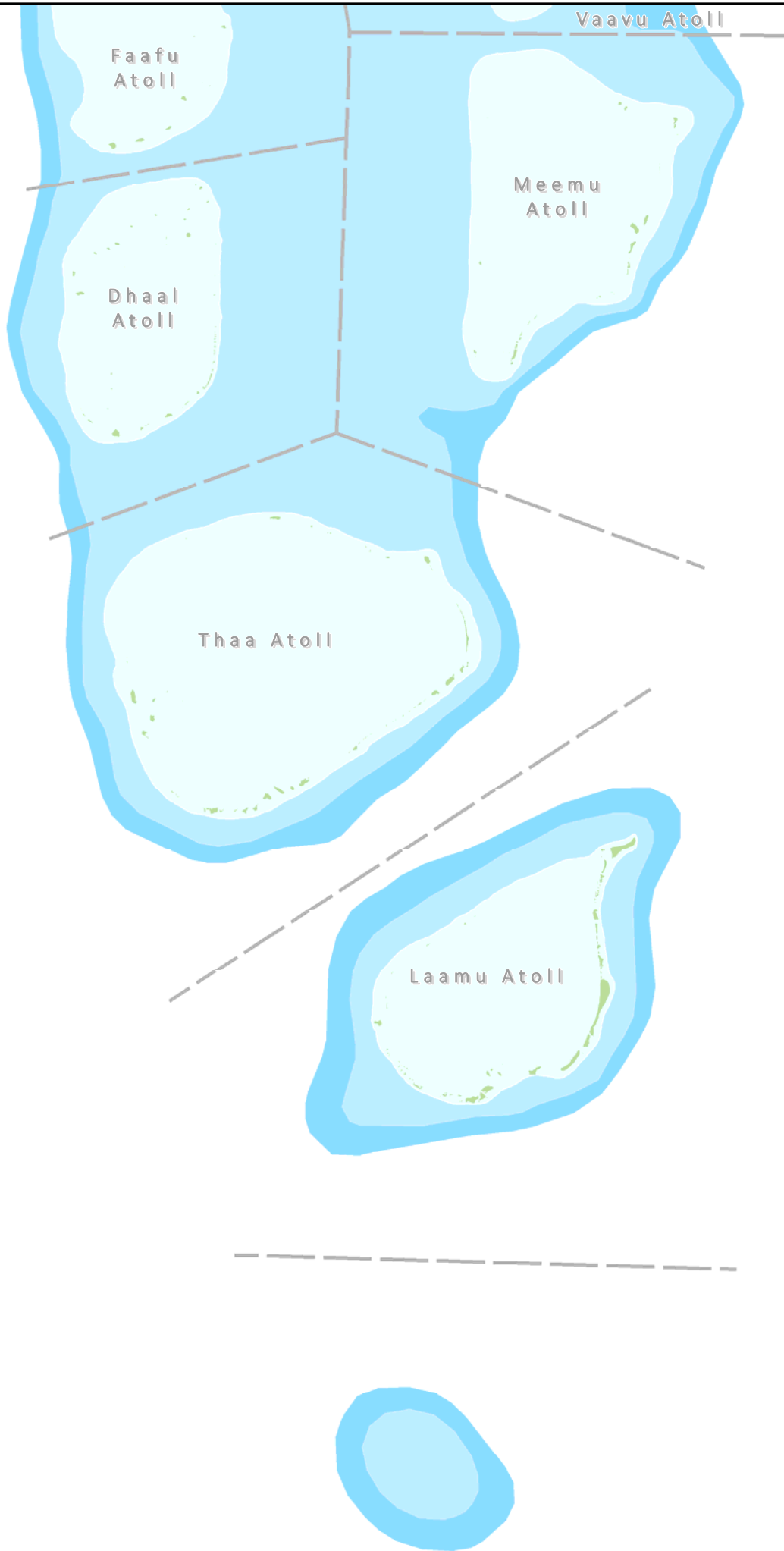
Emergency Water
Supplied in 2018
(Tons)

-  10 - 15
-  15 - 23
-  23 - 30
-  30 - 50
-  50 - 73

0 5 10 20 30 40
Kilometers





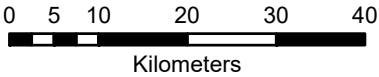


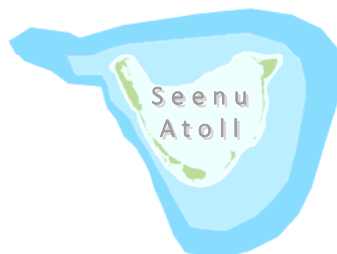
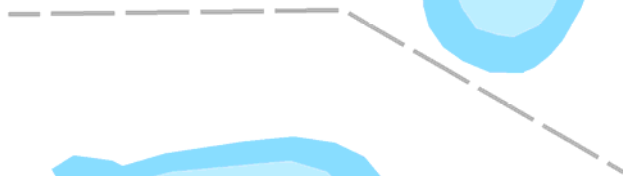
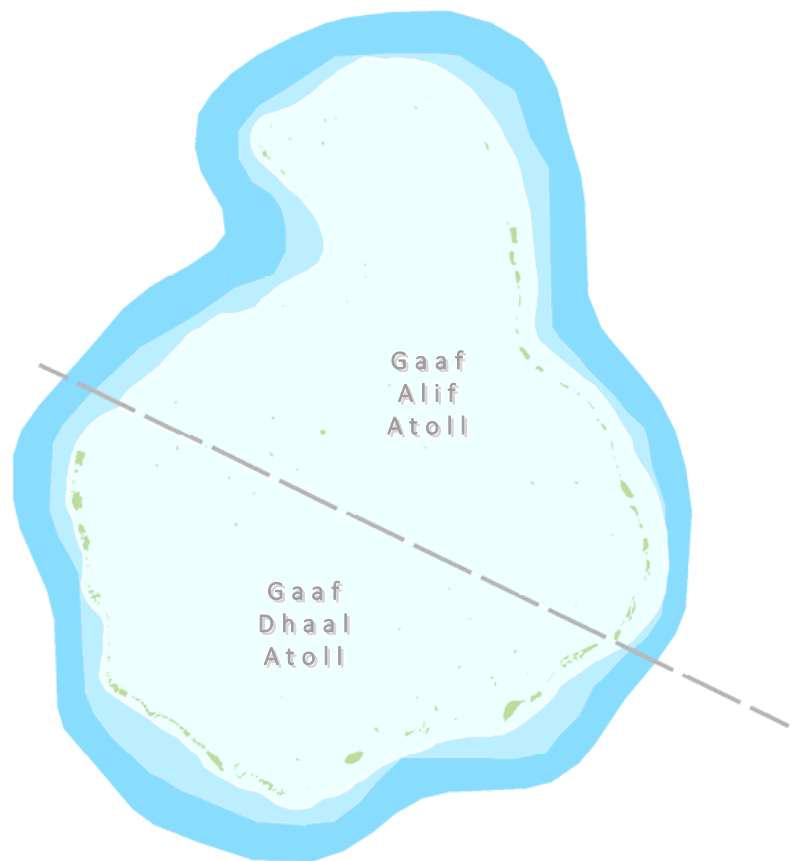
Legend

— Atoll boundary

Emergency Water
Supplied in 2018
(Tons)

- 10 - 15
- 15 - 23
- 23 - 30
- 30 - 50
- 50 - 73



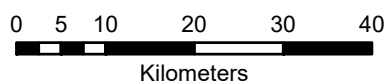


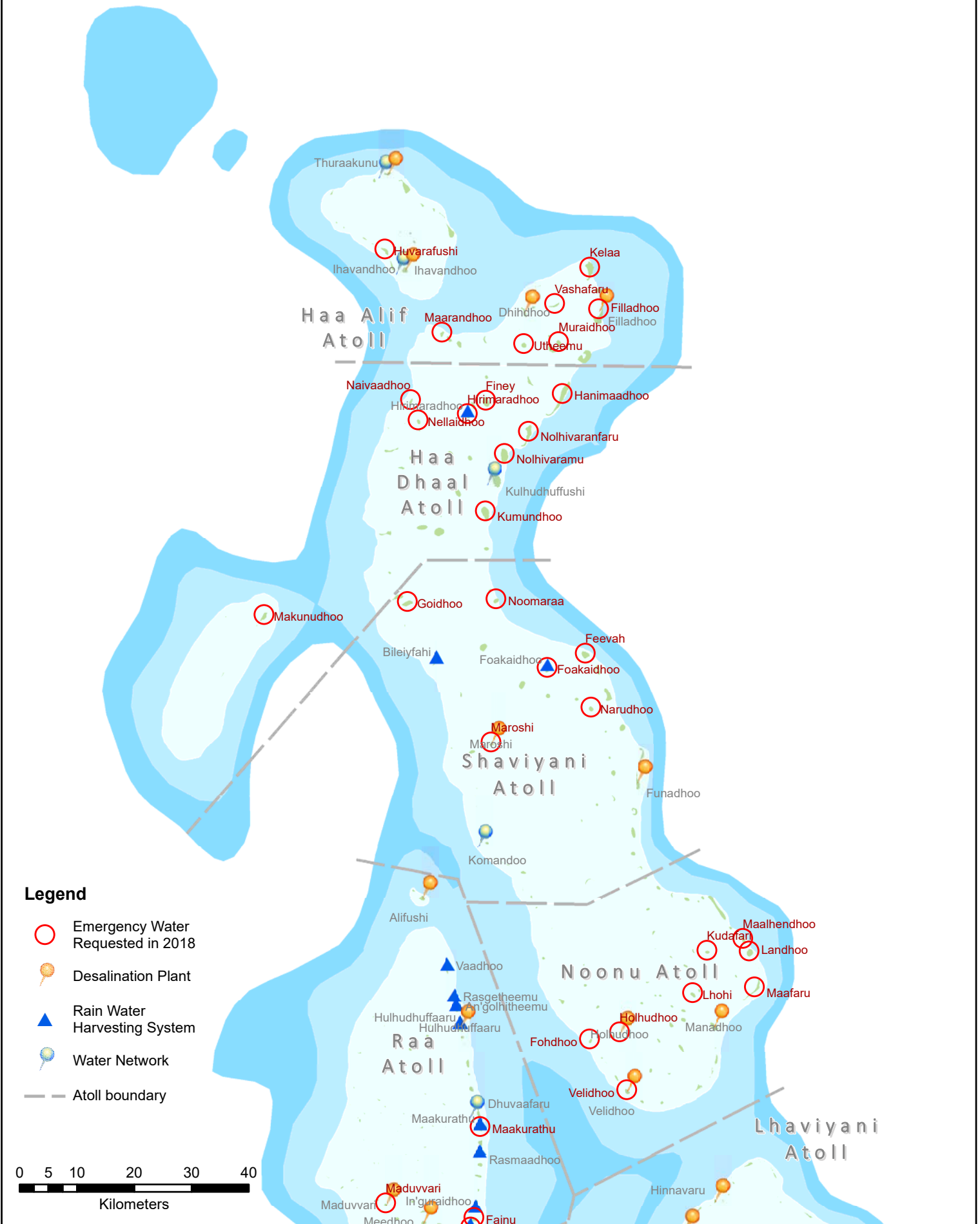
Legend

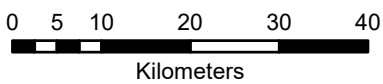
— Atoll boundary

Emergency Water
Supplied in 2018
(Tons)

- 10 - 15
- 15 - 23
- 23 - 30
- 30 - 50
- 50 - 73



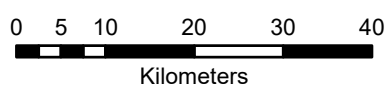
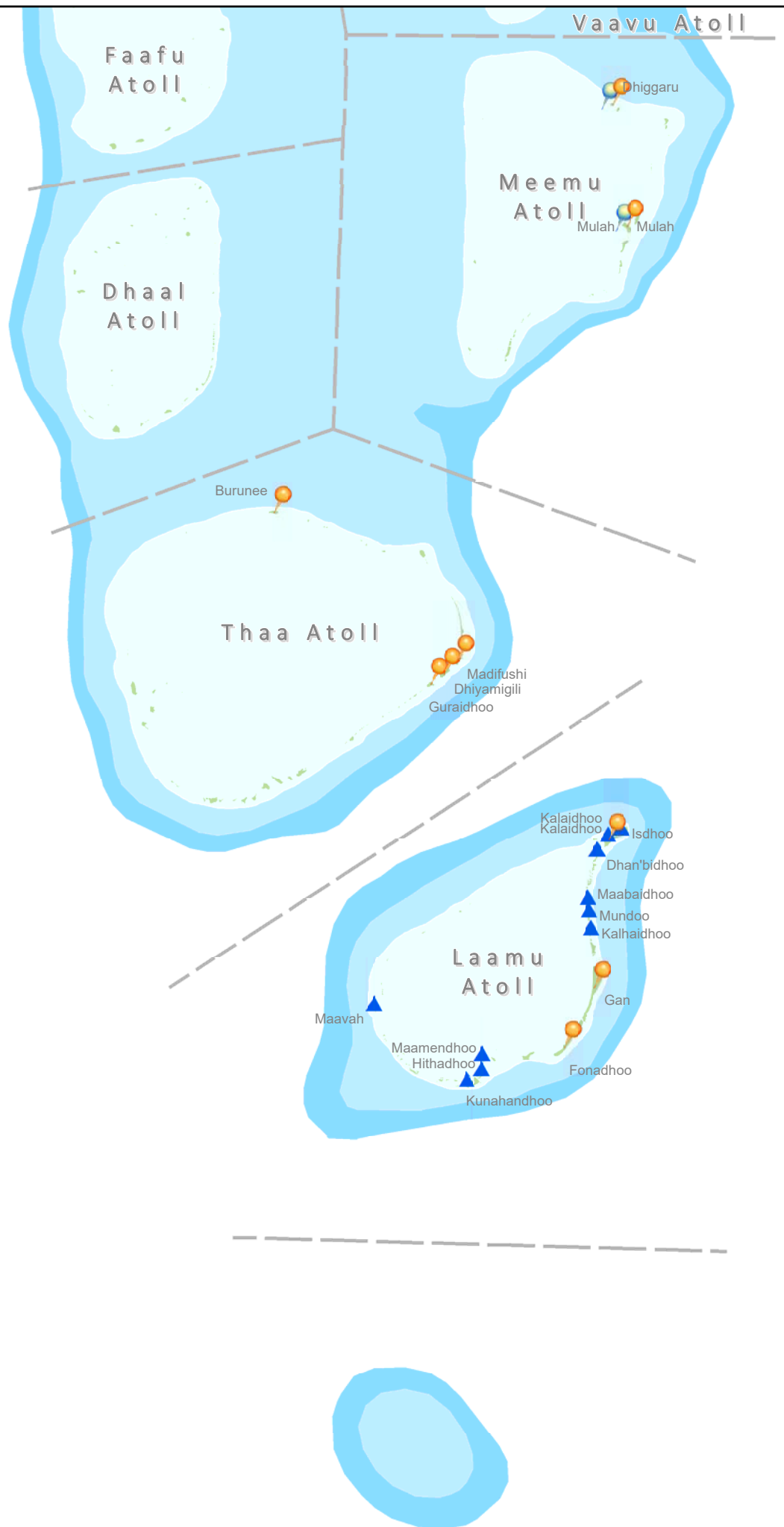


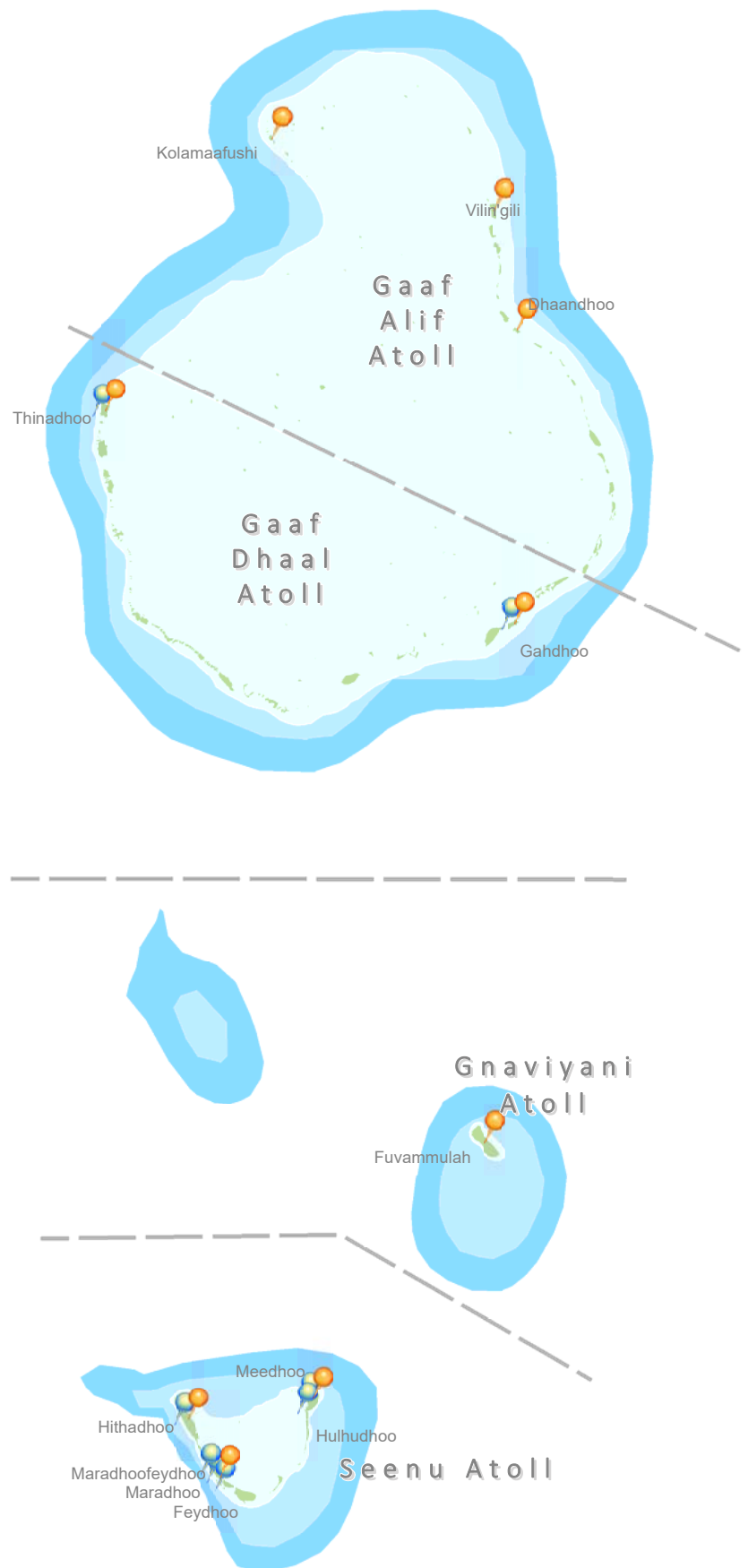


Legend

- Emergency Water Requested in 2018
- Desalination Plant
- Rain Water Harvesting System
- Water Network
- Atoll boundary





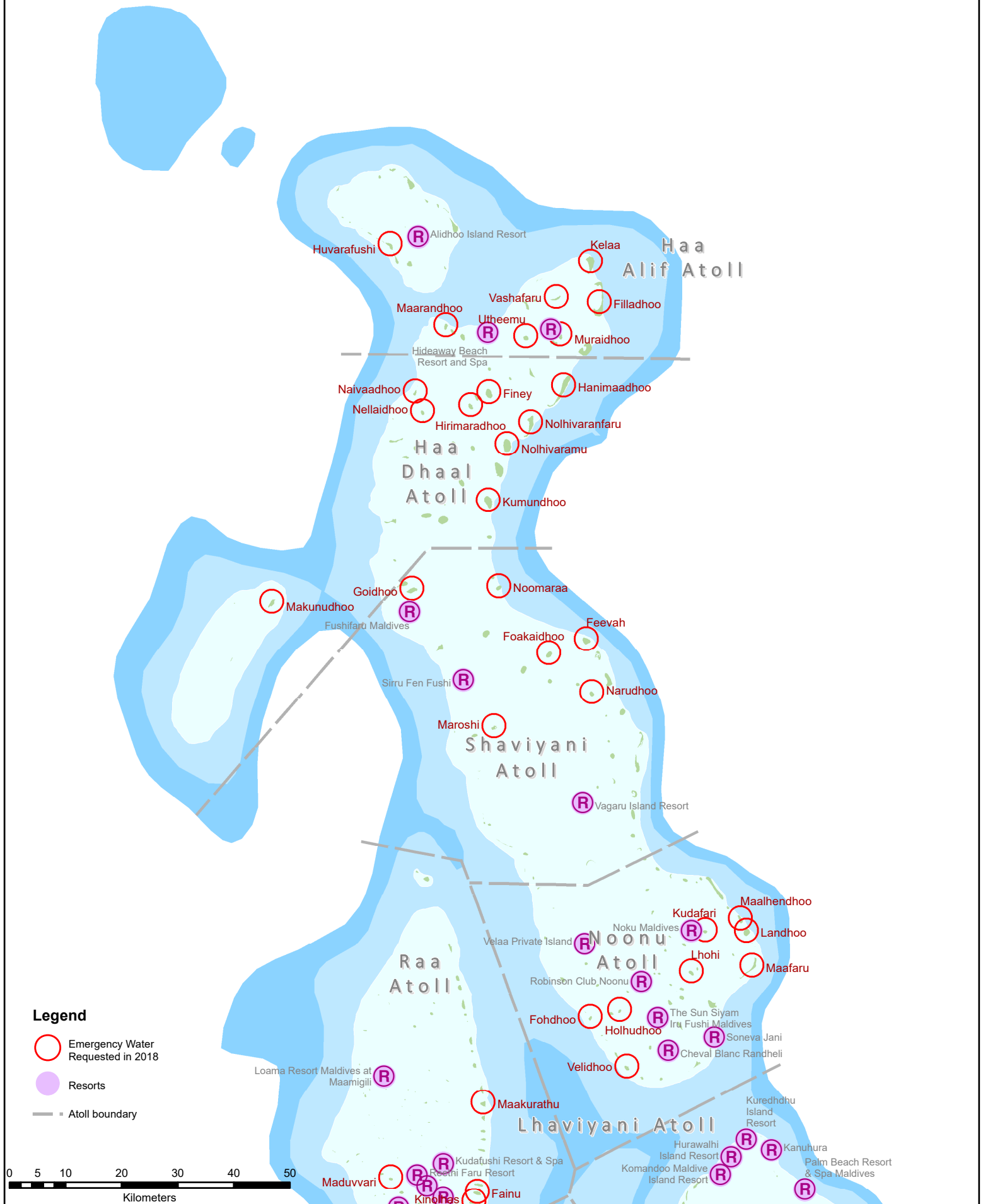


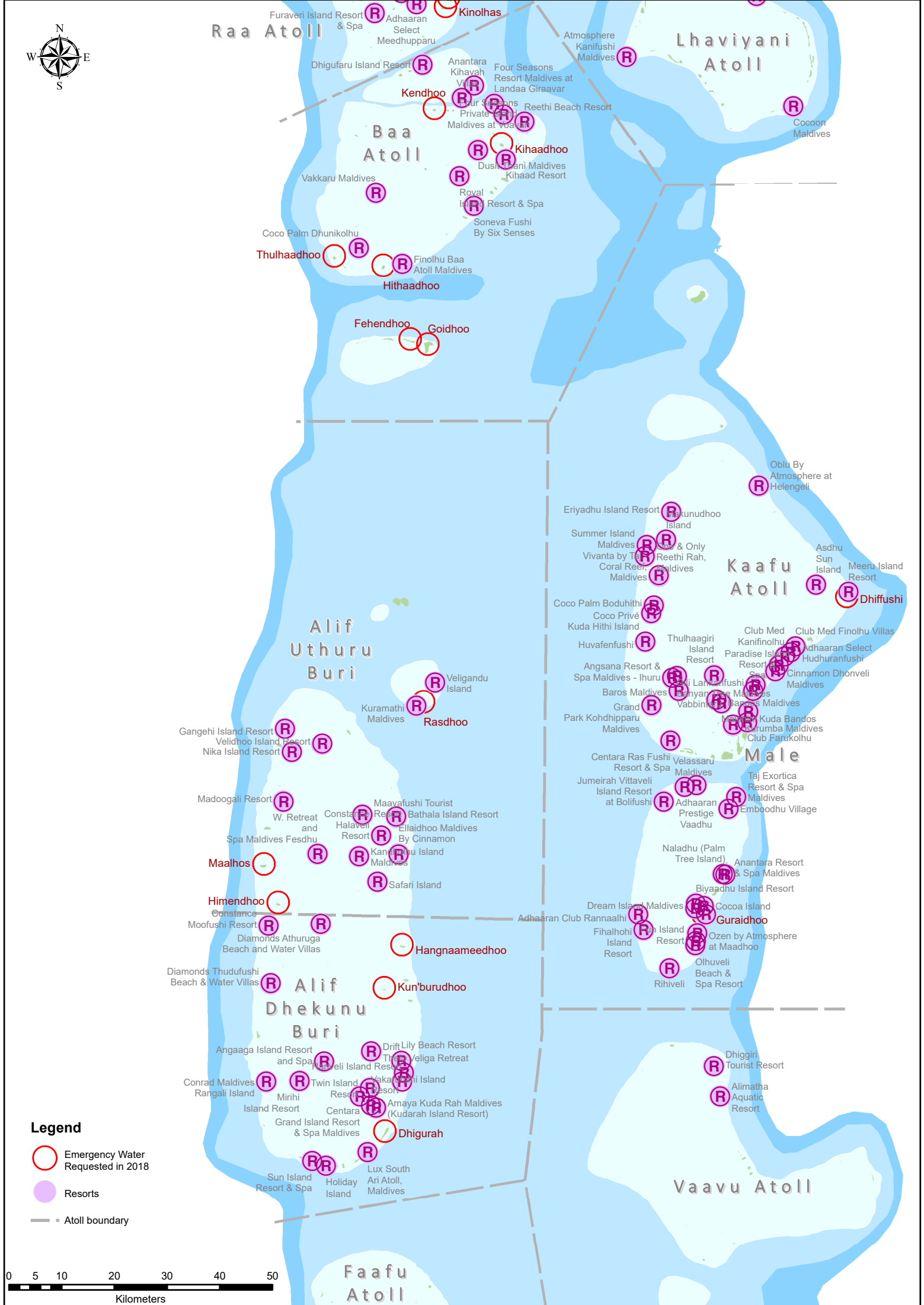
Legend

- Emergency Water Requested in 2018
- Desalination Plant
- Rain Water Harvesting System
- Water Network
- Atoll boundary

0 5 10 20 30 40
Kilometers

APPENDIX D
RESORTS VS AFFECTED ISLANDS MAP (2018)

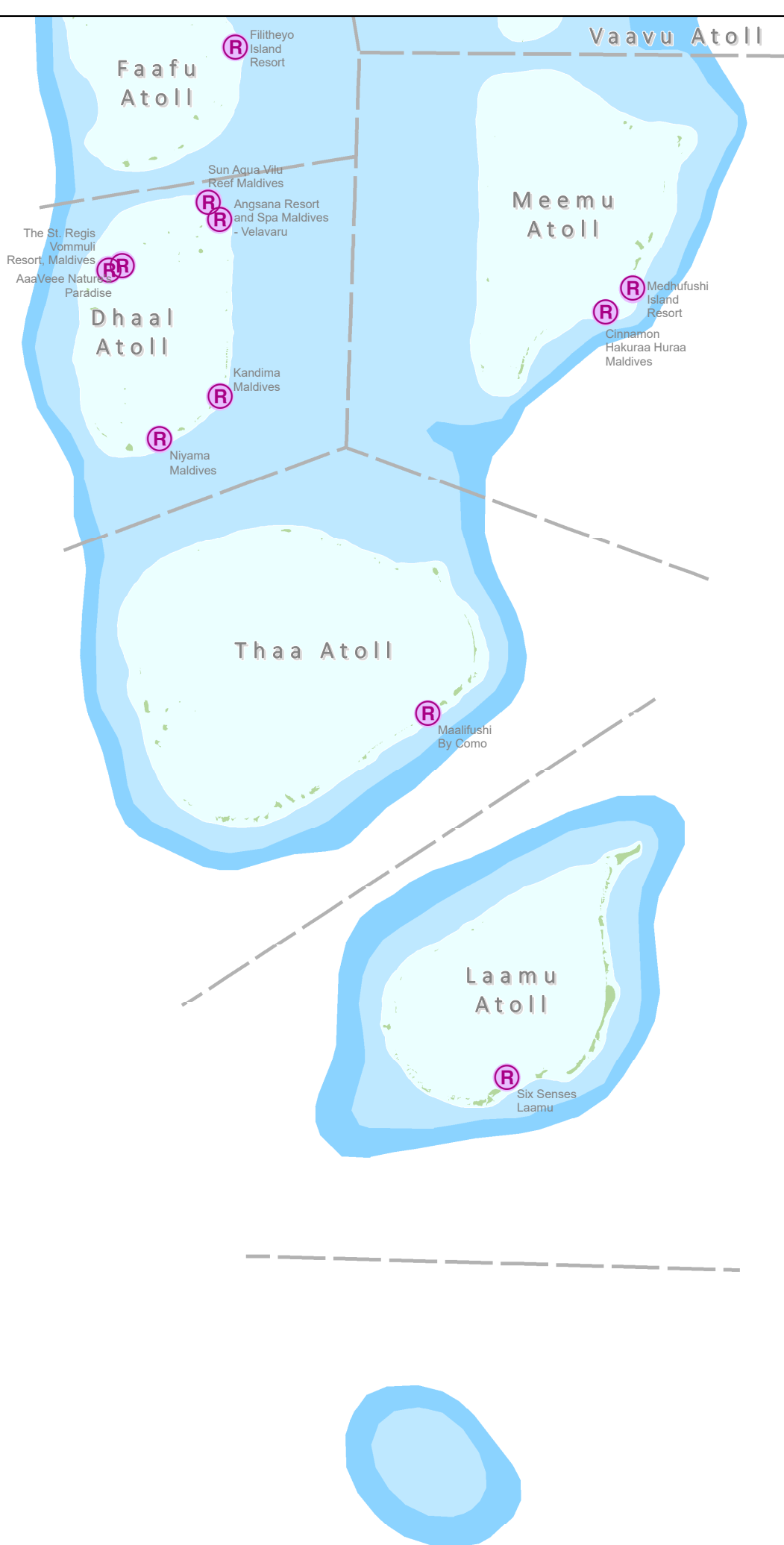







 Emergency Water Requested in 2018

— ■ Atoll boundary

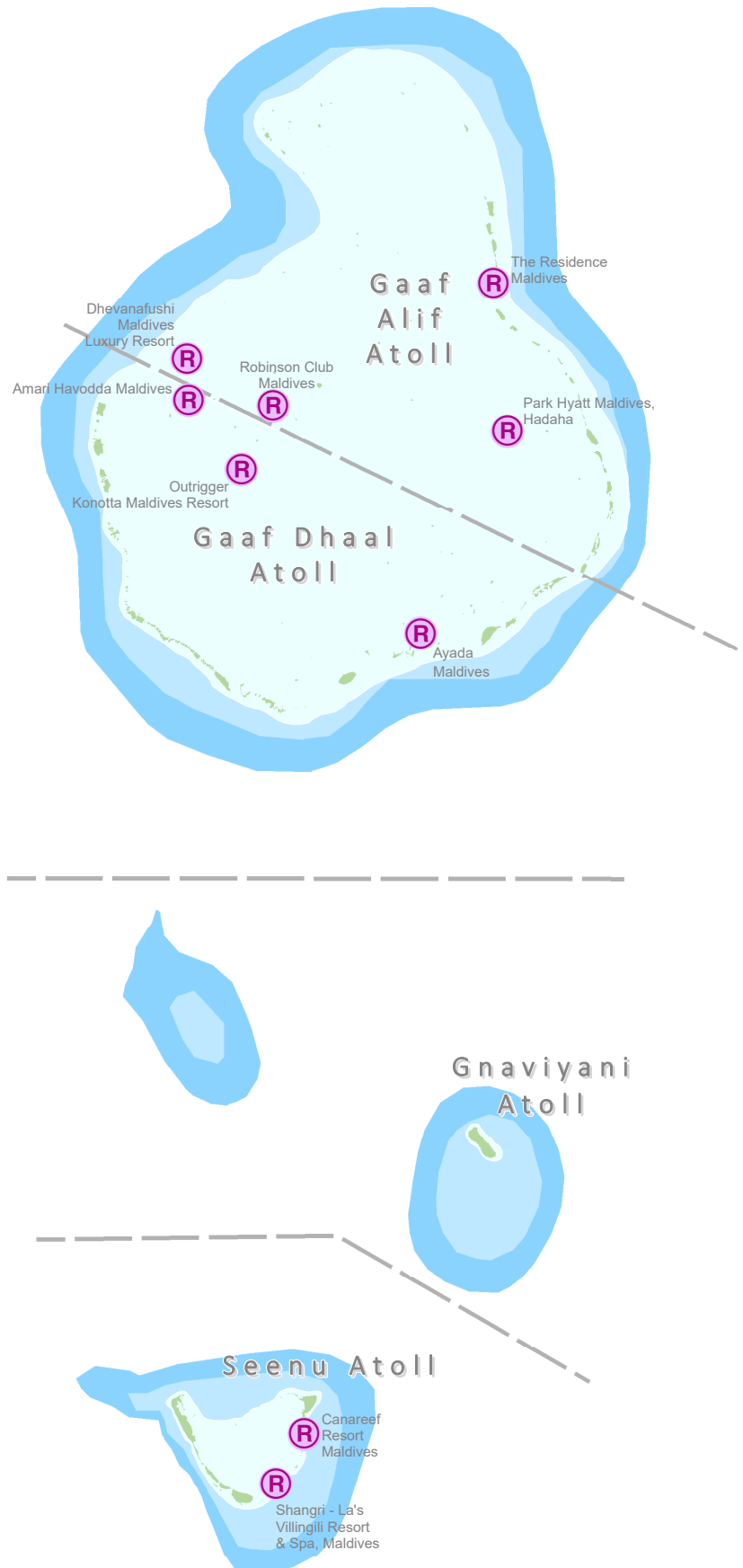




Legend

-  Emergency Water Requested in 2018
-  Resorts
-  Atoll boundary





Legend

-  Emergency Water Requested in 2018
-  Resorts
-  Atoll boundary



ANNEXURE A
MFDA NATIONAL STANDARD FOR BULK TRANSPORTATION AND
STORAGE OF DRINKING WATER



سندھ صحت اور خاندان وراثت کونسل دائرہ کار و سرکاری سرکاری

سرکاری: MFDA-FCD STAN 08-2018

سرکاری: 2018

دائرہ کار و سرکاری
سرکاری و سرکاری
سرکاری و سرکاری

مَدْرَسَةُ

1. *Handbook for the safe use of drinking water* (National Standard for Bulk transportation and storage of Drinking Water).
 The handbook provides information on the safe use of drinking water, including the importance of water quality, the role of water treatment, and the need for proper storage and distribution. It also includes information on the health benefits of drinking water and the risks of contaminated water.
2. *Handbook for the safe use of drinking water* (National Standard for Bulk transportation and storage of Drinking Water).
 The handbook provides information on the safe use of drinking water, including the importance of water quality, the role of water treatment, and the need for proper storage and distribution. It also includes information on the health benefits of drinking water and the risks of contaminated water.
3. *Handbook for the safe use of drinking water* (National Standard for Bulk transportation and storage of Drinking Water).
 The handbook provides information on the safe use of drinking water, including the importance of water quality, the role of water treatment, and the need for proper storage and distribution. It also includes information on the health benefits of drinking water and the risks of contaminated water.
4. *Handbook for the safe use of drinking water* (National Standard for Bulk transportation and storage of Drinking Water).
 The handbook provides information on the safe use of drinking water, including the importance of water quality, the role of water treatment, and the need for proper storage and distribution. It also includes information on the health benefits of drinking water and the risks of contaminated water.
5. *Handbook for the safe use of drinking water* (National Standard for Bulk transportation and storage of Drinking Water).
 The handbook provides information on the safe use of drinking water, including the importance of water quality, the role of water treatment, and the need for proper storage and distribution. It also includes information on the health benefits of drinking water and the risks of contaminated water.

3. $\frac{1}{x^2} = x^{-2}$ $\frac{d}{dx} x^{-2} = -2x^{-3} = -\frac{2}{x^3}$

[illegible][illegible][illegible]

(۱) ھُوَ ٱلَّذِى ٱرْسَلْنَا رُؤُوسَ بَنِي إِسْرَءِءَِلَ وَرُؤُوسَ ٱلْحَمْدِ ٱلْمُؤْمِنِينَ وَرُؤُوسَ ٱلْأَنْبِيَآءِ ٱلْمُرْسَلِينَ وَرُؤُوسَ ٱلْأَسْرَافِ ٱلْمُفْسِدِينَ وَرُؤُوسَ ٱلْمَلَائِكَةِ ٱلْمُرْسَلِينَ وَرُؤُوسَ ٱلْأَنْبِيَآءِ ٱلْمُرْسَلِينَ وَرُؤُوسَ ٱلْأَسْرَافِ ٱلْمُفْسِدِينَ وَرُؤُوسَ ٱلْمَلَائِكَةِ ٱلْمُرْسَلِينَ

[illegible]

(س) اُنسَرَقْدَرِ جَسْرَقْدَرِ قَبْرَسَرِ سَقْرَقْدَرِ قَرِ هَمَامِ دَسَرَقْدَرِ سَرَقْرَقْدَرِ. اَمِرِ حَرَقْرِ هَمَامِ اُنسَرَقْدَرِ اِنقَرَقْدَرِ
قُسَرِ سَرَقْرَقْدَرِ.

[illegible][illegible][illegible]

(v) $\frac{1}{\sqrt{\pi}} \int_{-\infty}^{\infty} f(x) e^{-x^2} dx = \frac{1}{\sqrt{\pi}} \int_{-\infty}^{\infty} f(x) e^{-x^2} dx$

(۱) کائنات کے ہر ذرہ اور ہر شے پر اللہ تعالیٰ کی قدرت کا اثر ہے۔ اس لیے ہر شے پر اللہ تعالیٰ کی قدرت کا اثر ہے۔ اس لیے ہر شے پر اللہ تعالیٰ کی قدرت کا اثر ہے۔

[illegible][illegible]

(۴) اَللّٰهُمَّ صَلِّ وَسَلِّمْ عَلٰى سَيِّدِنَا مُحَمَّدٍ وَعَلٰى اٰلِهِٖ وَاَصْحَابِهٖ وَسَلَّمَ

[illegible]

[illegible][illegible][illegible]

5. $\frac{1}{2} \times \frac{1}{3} = \frac{1}{6}$ $\frac{1}{4} \times \frac{1}{5} = \frac{1}{20}$ $\frac{1}{6} \times \frac{1}{7} = \frac{1}{42}$ $\frac{1}{8} \times \frac{1}{9} = \frac{1}{72}$ $\frac{1}{10} \times \frac{1}{11} = \frac{1}{110}$

[illegible]

$\frac{1}{x} = x^{-1}$

(1) $\frac{d}{dt} \left(\frac{\partial L}{\partial \dot{x}} \right) = \frac{\partial L}{\partial x}$

[illegible][illegible][illegible][illegible][illegible]

ANNEXURE B
EPA DRINKING WATER GUIDELINES

GUIDELINE FOR DRINKING WATER

Sample collection procedure

1. If the sampling tap is metallic, apply surgical spirit around mouth of the tap both from inside and its outside. Use flame to burn it to disinfect.
2. If the tap is plastic then avoid the first step
3. Let water run from the tap for a minute.
4. Do not touch or get contact with the opening of the tap after disinfection.
5. Disinfected 125ml glass bottles shall be used for sampling.
6. Remove the cap from the sterile collection bottle, being careful not to contaminate either the inside of the cap or bottle.
7. Grasp the bottle near its base and allow the bottle to be filled by the running tap.
8. Always keep the mouth of the bottle/container ahead of the hand so as not to contaminate the sample.
9. Replace the cap immediately after the fill.
10. Store the samples on ice immoderately for transport to the laboratory.
11. The date and time of the sample, the location of the sample, name of the island including Atoll (if the sample is to be taken to different island for testing) shall be labeled on the bottle.



The water produce for drinking purposes shall have the following parameters in given ranges. The following parameters needed to be tested and report to Environmental Protection Agency according to the timeframe given bellow

Table- 1 Weekly Tests

The following parameters must be tested weekly.

Parameters	Reference Range
• Free chlorine	0.2-0.5 mg/l
• PH	6.5-8.5
• Physical Appearance	Clear & Colorless
• Temperature	
• Electrical Conductivity	<1500 µs/cm
• Total Coliforms	0/100ml
• Faecal Coliforms	0/100ml

Table-2 Six monthly Tests

The following parameters must be tested every six months along with those given in table- 1 above.

Parameters	Reference Range
• Turbidity	<5NTU
• Total Dissolved Solids	<1000 mg/l
• Chloride	<250 mg/l
• Nitrates	<50 mg/l
• Ammonia	<1.5 mg/l
• Iron	<0.3 mg/l
• Total Coliforms (MF)	0/100ml
• Faecal Coliforms (MF)	0/100ml



Environmental Protection Agency

Min. of Housing & Environment Compound
Ameenee Magu

Male', Rep. of Maldives, 20392

Tel: 333 5949 / 333 5951

Fax: 333 5953

Environmental Protection Agency

Ameenee Magu

Male', Rep. of Maldives, 20392

ދިވެހިރާއްޖޭގެ ބިންދުވާލުގެ ދަށުން

މިނިސްޓްރީ އޮފް ހައުސިންގ އަދި ބިންދުވާލުގެ ދަށުން
އަމީނީ މާގު

މާލެ، ރިޕަބްލިކް އޮފް މާލްދިވެހި، 20392

އިމެއިލް: secretariat@epa.gov.mv

ވެބްސައިޓް: www.epa.gov.mv

ދިވެހިރާއްޖޭގެ ބިންދުވާލުގެ ދަށުން

އަމީނީ މާގު

މާލެ، ރިޕަބްލިކް އޮފް މާލްދިވެހި، 20392





Table- 3 Annual Tests

The Following parameters must be tested annually along with those given in Table- 1 and Table- 2.

Parameters	Reference Range
• Sulphate	<250mg/l
• Manganese	<0.1mg/l
• Total Petroleum Hydro Carbon	
• Sodium	<200mg/l
• Potassium	
• Calcium Hardness	
• Total Hardness	
• Bromine	
• Total Residual Chlorine	
• Hydrogen Sulphide	<0.05mg/l
• Mercury	<0.001mg/l
• Lead	<0.01mg/l
• Copper	<2mg/l
• Boron	<0.3mg/l
• Arsenic	<0.01mg/l
• Fluoride	<1.5mg/l
• Phenolic compounds	
• Anionic detergents	
• Cadmium	<0.003mg/l
• Chromium	<0.05mg/l
• Cyanide	<0.07mg/l

**In addition to this logs on pH and conductivity recordings from the plant should be kept on site*

Source: WHO Guideline for Drinking Water



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Male', Rep. of Maldives, 20392

ދިވެހިރާއްޖޭގެ ބިންގަނޑުގެ ބޭނުންކުރާ ފަރާތްތަކުގެ ތެރެއިން

މިނިސްޓްރީ އޮފް ހައުސިންގ އަދި ބިންގަނޑުގެ ބޭނުންކުރާ ފަރާތްތަކުގެ ތެރެއިން

މާލެ، ރިޕަބްލިކް އޮފް މާލިވެރިކަން، 20392

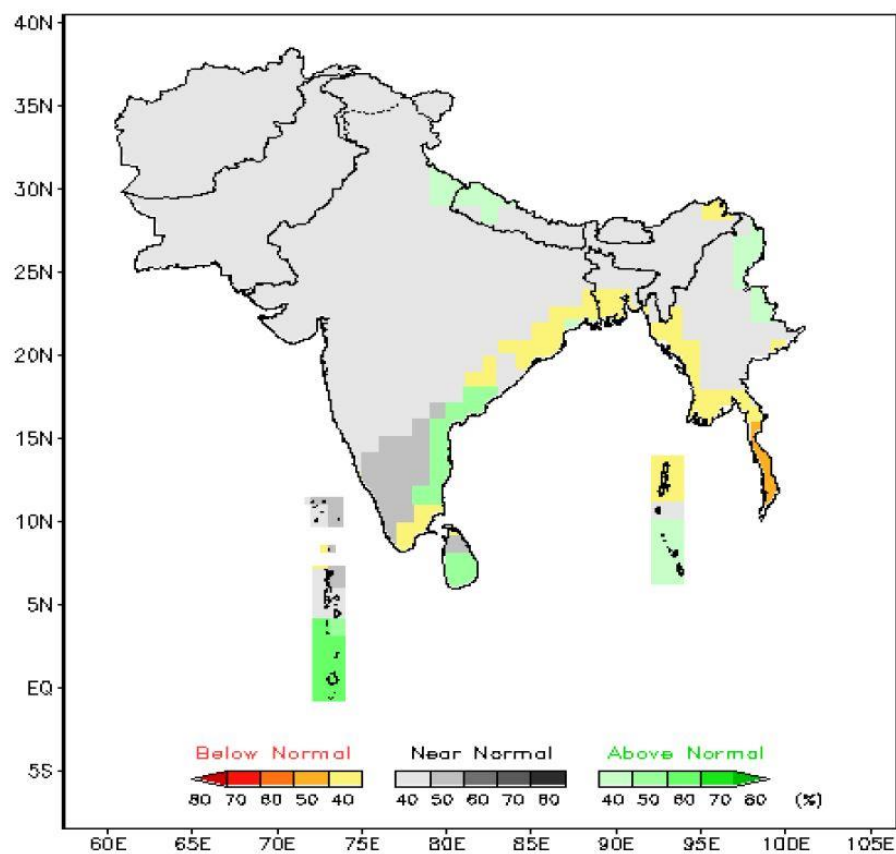
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Website: www.epa.gov.mv



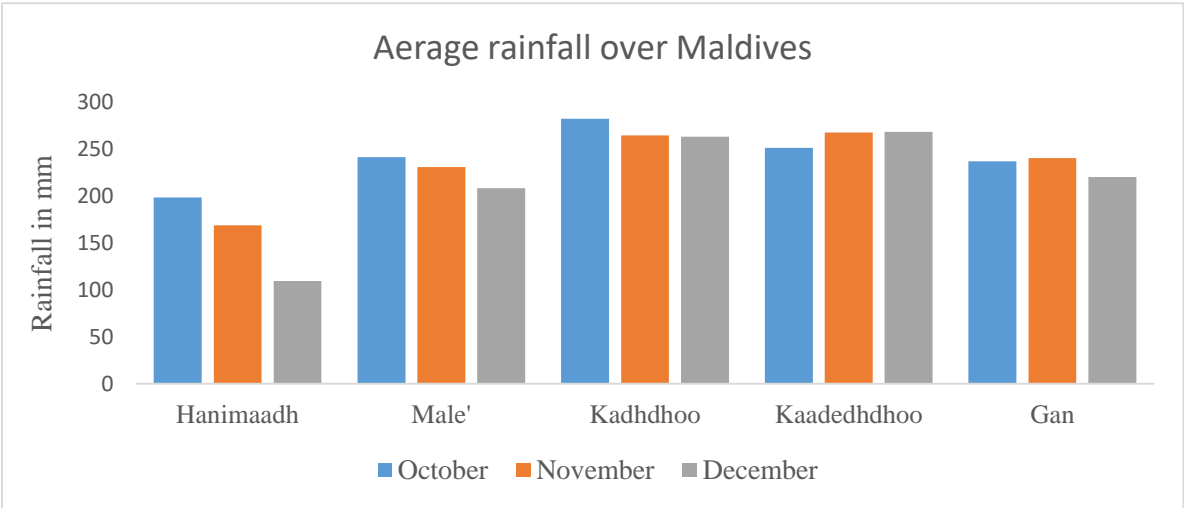
ANNEXURE C
MMS WEATHER OUTLOOK DOCUMENTS

Climate consensus outlook for October, November & December 2018 over Maldives



Consensus outlook for the 2018 OND season rainfall over South Asia.

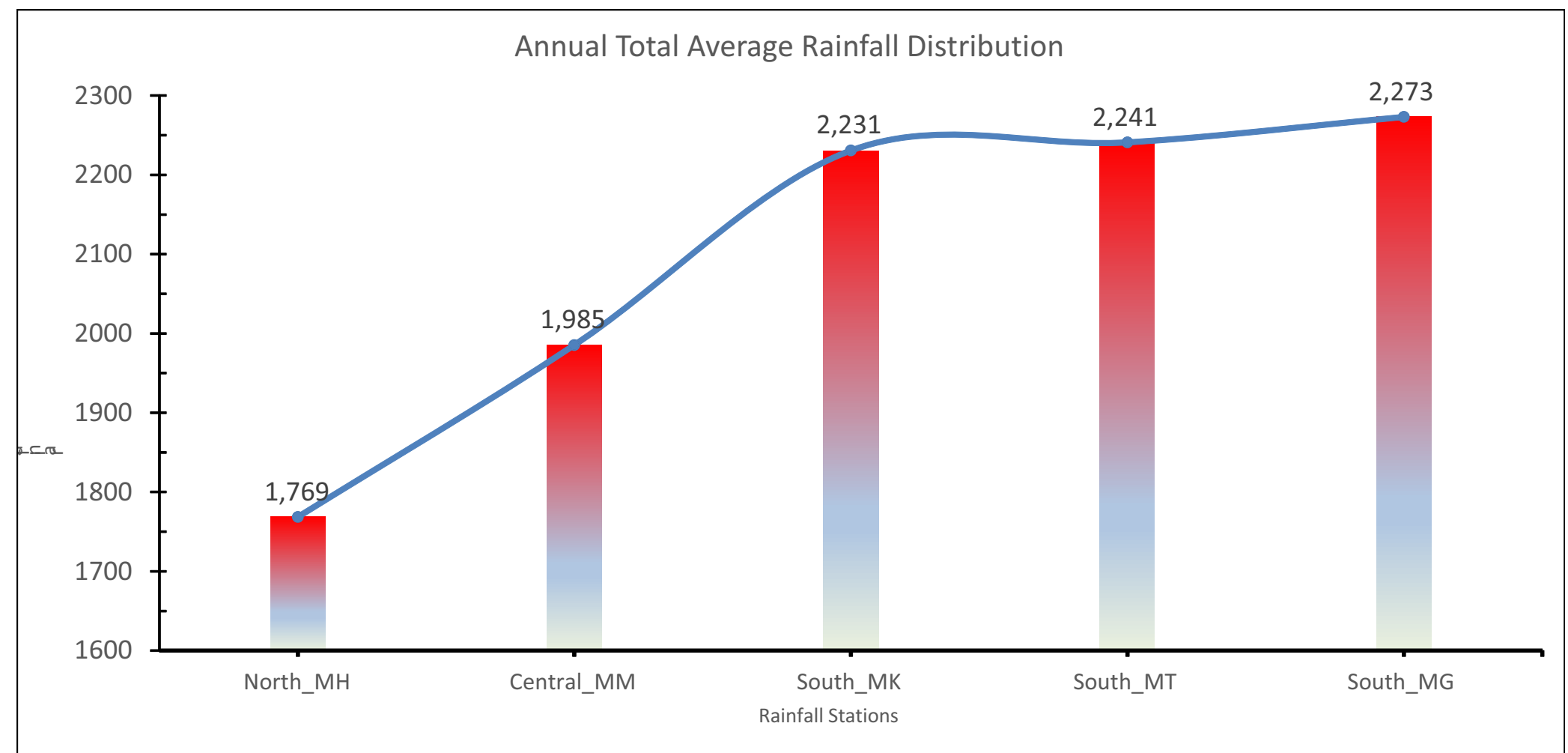
According to consensus outlook, atolls south of Kaafu atoll are likely to receive above normal rainfall while the rest of Maldives most likely to receive normal rainfall during October, November and December 2018. This consensus forecast outlook has been developed through an expert assessment of the prevailing global climate conditions and forecasts from different climate models from around the world.



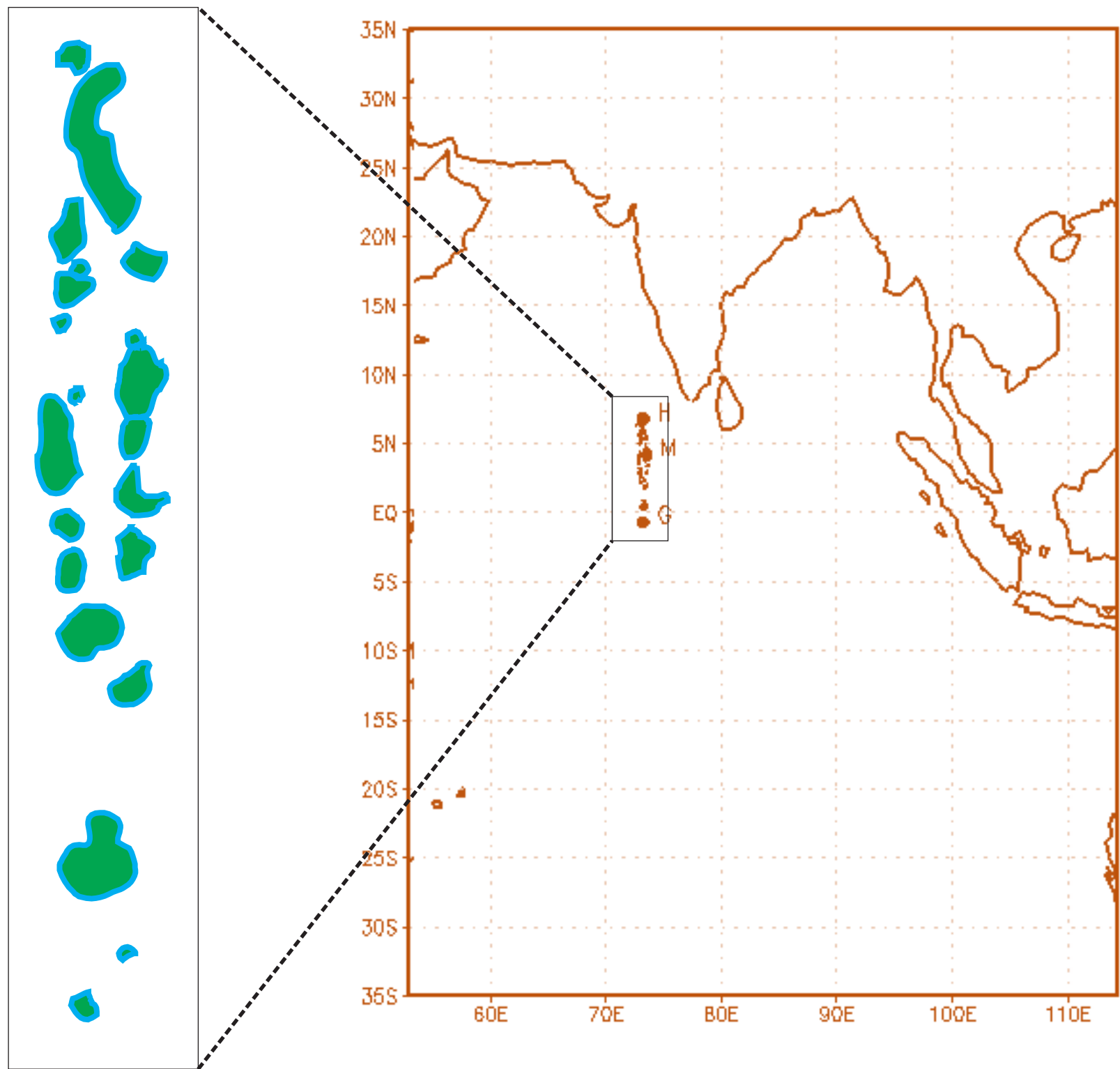
Weather and Climate Pattern over Maldives

Abstract

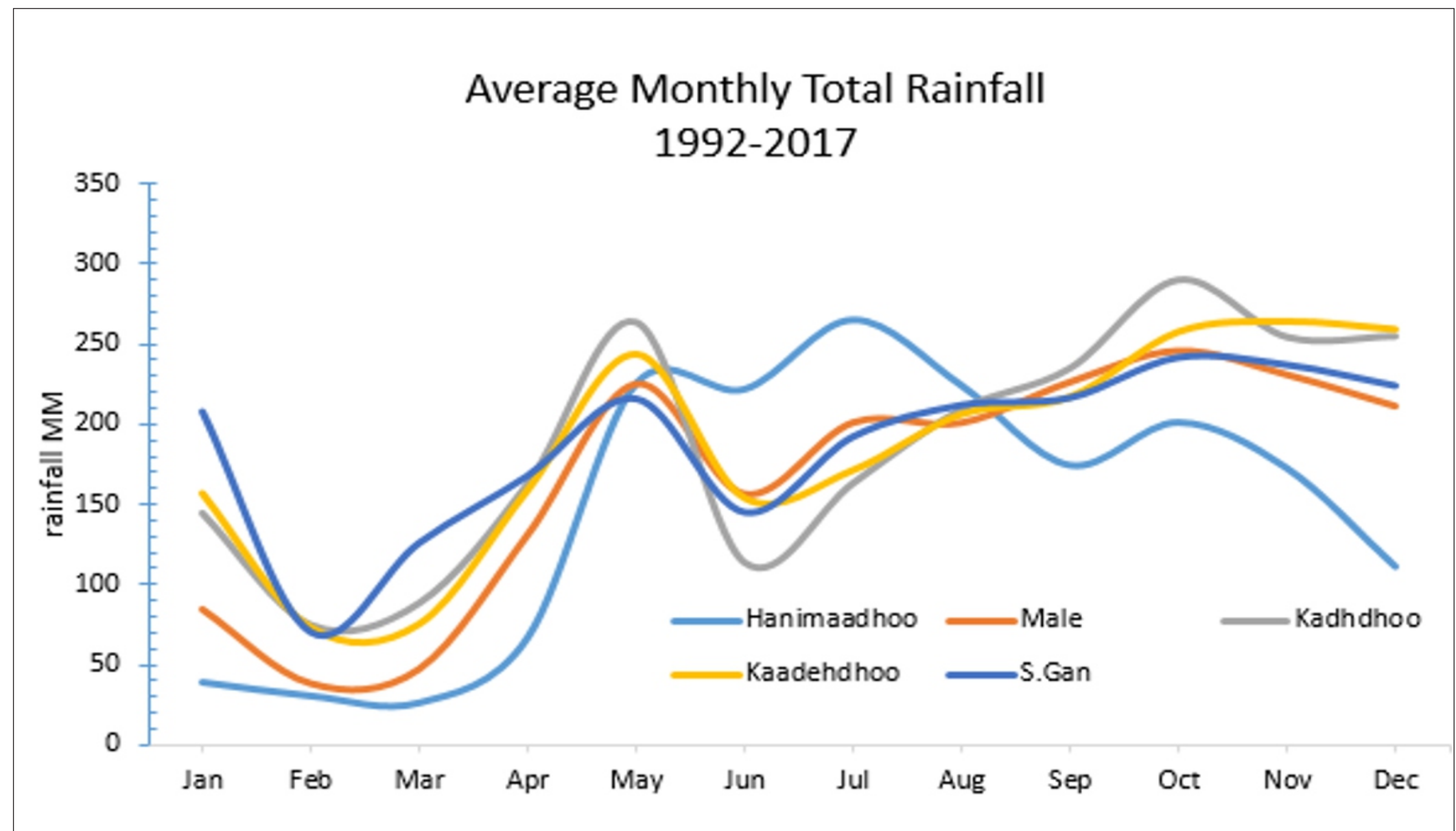
The Maldives is an archipelago of islands consists of about 1,192 small, low-lying coral islands. The Maldives enjoys a warm and humid tropical climate, with the weather mainly being dominated by two monsoons namely southwest monsoon and the northeast monsoon.



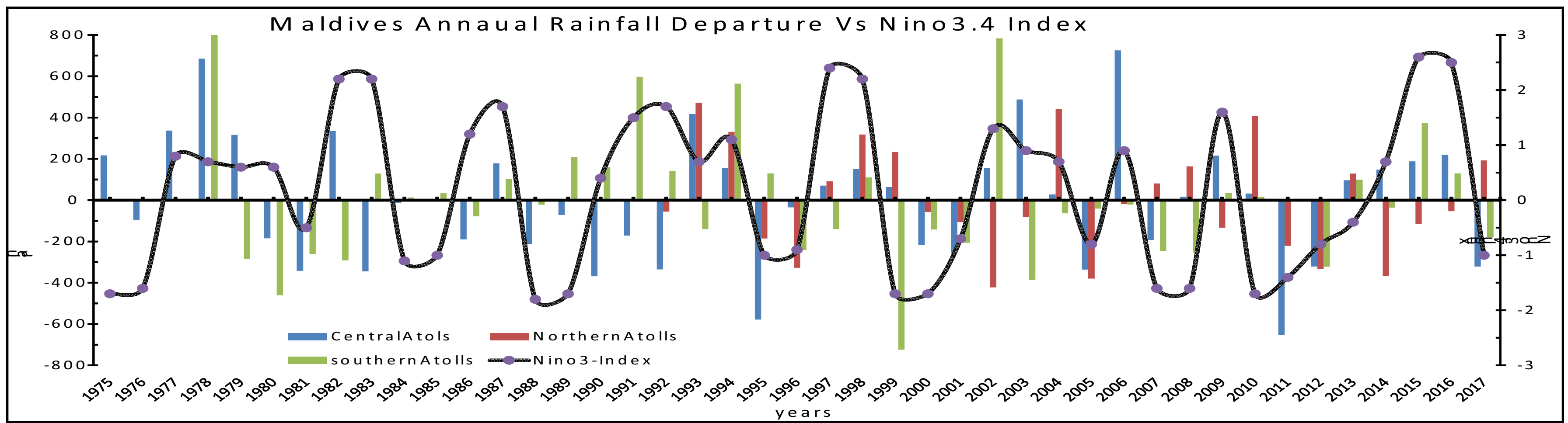
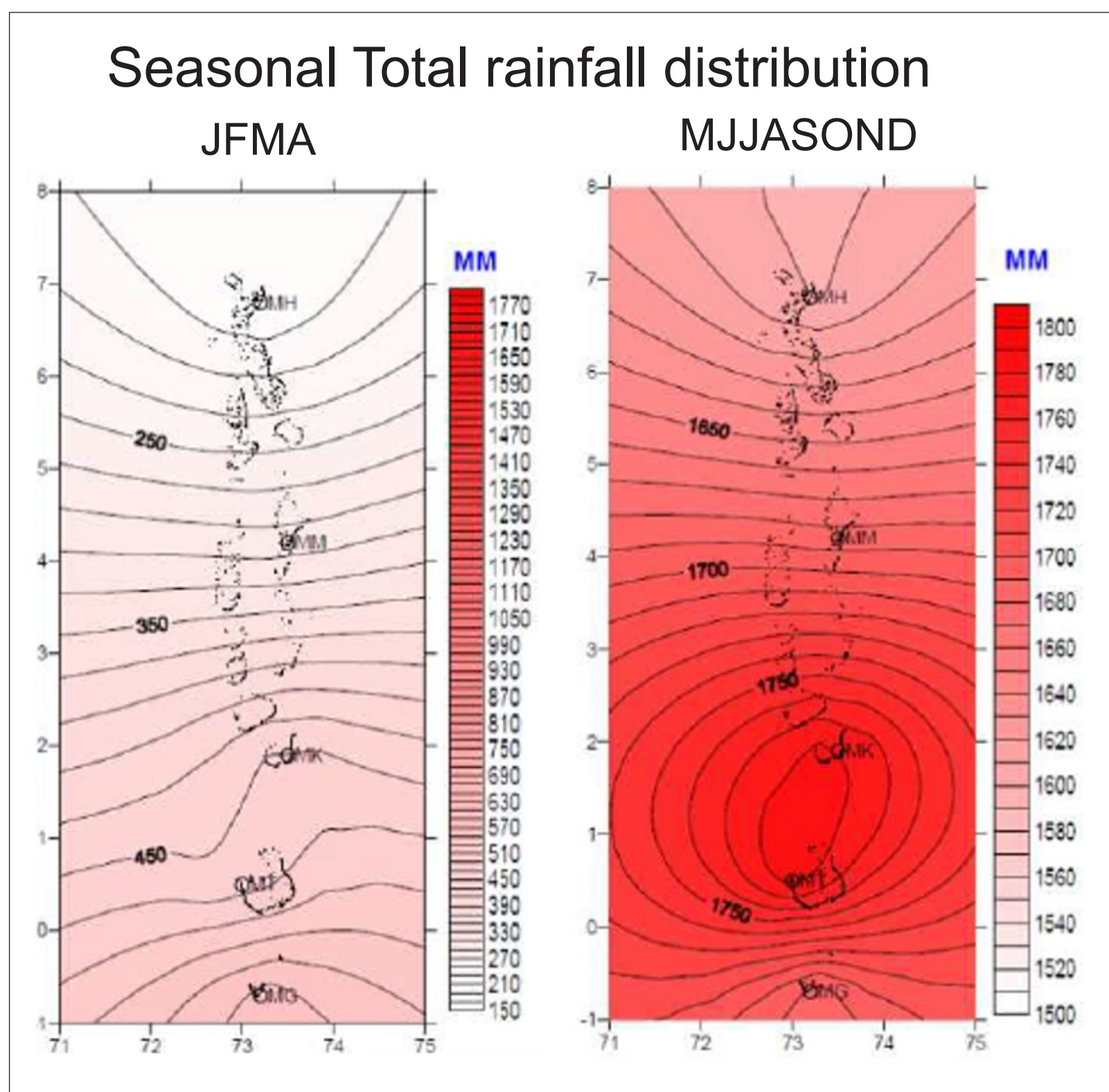
Annual rainfall over the country varies between 1760 - 2280 mm per year, while average temperatures range from 25°C to 31°C.



Fragile ecological profile, low elevation, combined with its economic dependence on limited sectors makes Maldives highly vulnerable to natural disasters and extreme climatic events.

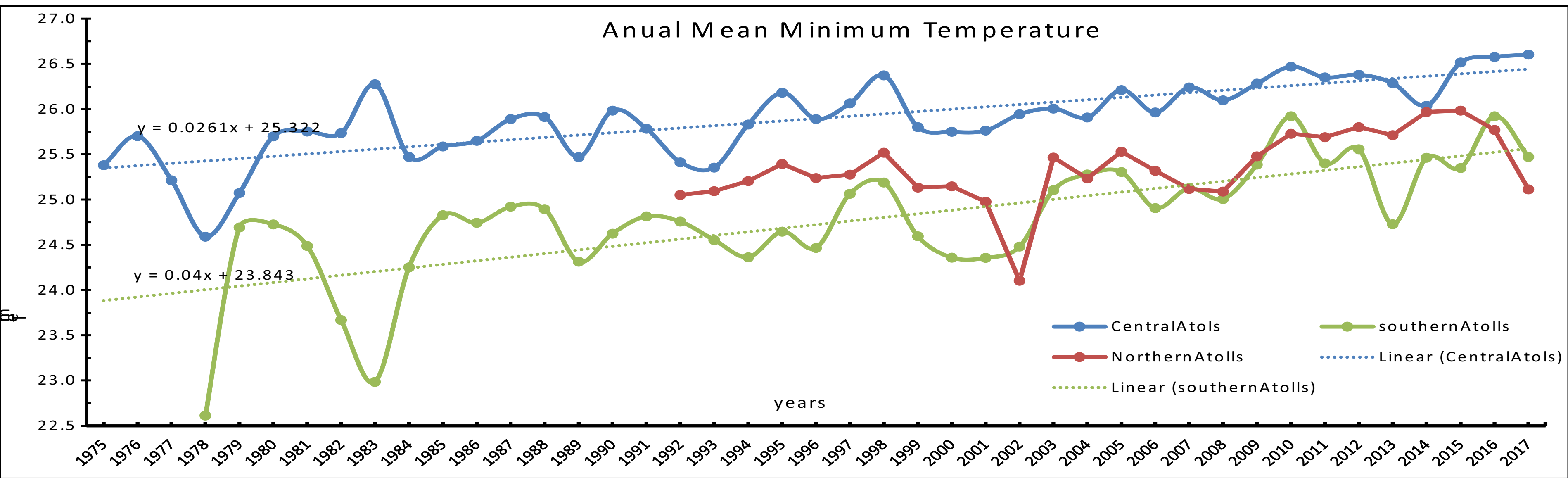
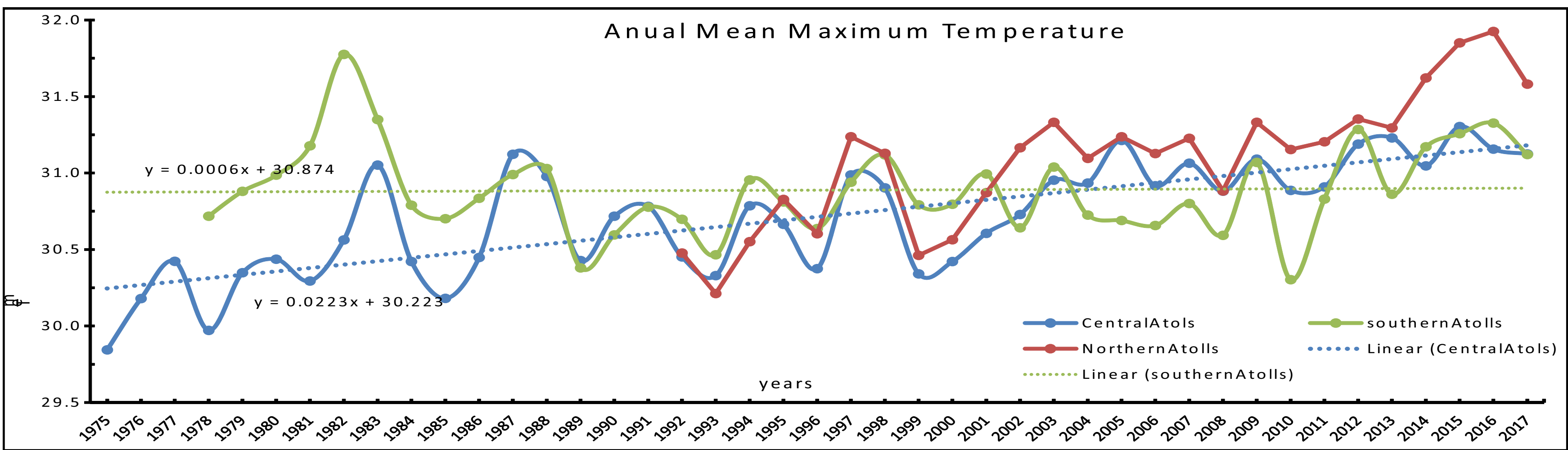


Maldives experiences two seasons
SW monsoon : mid-May to Dec
NE monsoon : Jan - April.
Most of the rainfall is received during SWmonsoon period.
NE monsoon period is relatively warm and dry.



Strong El-Nino years tend to be relative wet while strong La-Nina years tend to be relatively dry over Maldives. However weak or mild La-Nina or El-Nino events do not have much influence on the annual rainfall over Maldives

Annual Maximum temperature shows an increasing trend of 0.22 degree celsius per decade over central Maldives. The maximum temperature trend over Southern atolls is not significant.



Annual minimum temperature shows an increasing trend of 0.26 and 0.4 degree celsius per decade over central and southern atolls respectively.

TWAS Central & South Asia Regional Partner
Young Scientists Workshop on "Climate Change"
December 5-7, 2018
Divecha Centre for Climate Change,
Indian Institute of Science, Bengaluru-560012, India

By
Ahmed Rasheed and Ibrahim Humaid
Maldives Meteorological Service

ANNEXURE D
NEC PRODUCT DOCUMENTS

Introduction

Mobile Water Purification System

Durability & Low Energy

1. Solution Description

NEC Mobile Water Purification System

Any where, Any time, providing safe and clean drinking water

Disasters, remote areas, military use, those harsh and difficult circumstances, safe potable water is very valuable and difficult to obtain.

NEC Mobile Water Purification System could solve the task and provide the best solution for the hardships.

Beneficial Points

- ✓ Any surface water could be purified to potable *
 - high concentrated sea water, high level turbid water, very cold water
- ✓ Any where to be carried and obtain safe and clean water * **
 - Mobility, not only a truck but airplanes transportable
- ✓ Low energy required to be operating **
 - Saving fuel of generator or reasonable natural energy could be used

* NWPS 70SS
** NWPS 10 and 3

2. Our Experience

We are a supplier of water purification system to Japan Army (Japan Self Defense Force). The system is "NWPS-70SS" which is our flag ship military version and already 10 sets are actually deployed on army's key point camps.



Actually Deployed, 10sets

<2014>	Camp "A" 1set
	Camp "B" 1set
<2015>	Camp "C" 2sets
<2016>	Camp "C" 1set
	Camp "D" 2sets
<2018>	Camp "B" 2sets
	Camp "E" 1set

Back Orders

<2018>	Camp "D" 1set
<2019>	Camp "D" 1set

3. Solution Overview -1

We have 2 categories and 3 series of water purification system with it's own characters.

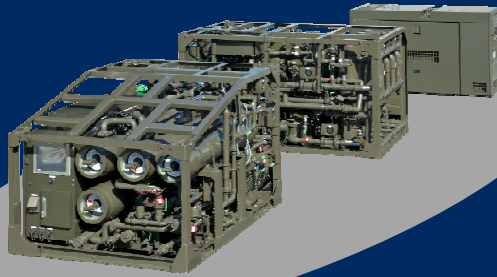
- High Specification

Toughness Model (Japan Army Model)

NWPS-70SS

30ton/day Sea water @0°C

70ton/day Fresh water @0°C



- Compact and Mobile Versatile
- Ecology

Compact, Low Energy Model

NWPS-10

10ton/day Sea water @25°C

10ton/day Fresh water @25°C

NWPS-3*

3ton/day Sea water @25°C

3ton/day Fresh water @25°C

* will be released on 2019



Photo : NWPS-10 Proto-type version
(Type-1)



3. Solution Overview -2

■ Toughness

- Various Water Source (Continuous Operation, Minimum Filter Replacing)



Sea water



Dirty Water, River, Marsh, Well ...

- Environmental Durability

Temperature (Air) -30 ~ +60°C (-22 ~140°F)*1
(Water) 0 ~ +40°C (32 ~104°F)*1

■ Energy Conscious

- Low Energy Consumption*2

1/3 elec. of conventional purifiers
=> Natural Energy Available

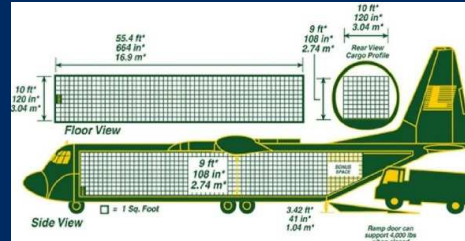


■ Mobility - Compact and Light Weight Design



NWPS-70 Series

Trucks



NWPS-10 Series

Aircrafts



By Hands*2

*1 NWRS-70SS
*2 NWPS-10 and 3

3. Solution Overview -3

- Product/Solutions
- Mobile Water Purification System
 - 1) NWPS-70 Series big size system for harsh condition
 - 2) NWPS-10 and 3* Series compact, versatile, solar power available

* will be released on 2019

- Product Information
- Provide drinking water from various water source
(Sea, Blackish and Fresh water even if it has Dirty matters)
 - Designed to be loaded on small or middle size trucks, or Aircrafts with its compact size and lightweight.
 - The compact model could be driven by very small energy
(Solar power, wind power, small generator are available to use)

- Business Matching
- Business Area
 - Remote Area
 - Military Defense
 - Plant Development
 - Disaster Measures
 - Human Aid etc.
 - Customers, Partners
 - Governments, Plant engineering company, Solar or wind power tool manufacturer, Body Work (Truck) manufacturer, Distributers

Business Matching



Customer
**Government
Plant Developer**

Remote Area
Plant Development
Disaster Measures
Military Defense etc.

Partner
**Distributor
Manufacturer**

Transportation Vehicles
(Body Work Manufacturer)
Packaging
Power Supply Tools etc.

 **Orchestrating** a brighter world

NEC

