

# MALDIVES IMPACT-BASED FORECASTING PROGRAM

2024









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# Abbreviations & Acronyms

AR5	Fifth Assessment Report
AWS	Automatic Weather Stations
CBDRM	Community Based for Disaster Risk Management
DSS	Decision Support System
ECMWF	European Centre for Medium-Range Weather Forecasts
EPA	Environment Protection Agency
FENKA	FENAKA Cooperation
GIS	Geographic Information System
HPC	High-Performance Computer
IBF	Impact-Based Forecasting
IPCC	Intergovernmental Panel on Climate Change
LDCs	Least Developed Countries
MBS	Maldives Bureau of Statistics
MCI	Ministry of Construction and Infrastructure
MED	Ministry of Economic Development and Trade
MHEWS	Multi-Hazard Early Warning System
MHLUD	Ministry of Housing, Land and Urban Development
MLSA	Maldives Land and Survey Authority
MMS	Maldives Meteorological Services
MNDF	Maldives National Defense Force
MOAAW	Ministry of Agriculture and Animal Welfare
MCCEE	Ministry of Climate Change, Environment and Energy
MoE	Ministry of Education
MOFOR	Ministry of Fisheries and Ocean Resources
MoH	Ministry of Health
MoHELS	Ministry of Higher Education, Labour and Skills Development
MoSFD	Ministry of Social and Family Development
MOT	Ministry of Tourism
MoTCA	Ministry of Transport and Civil Aviation
MOUs	Memorandum of Understanding
MPL	Maldives Ports Limited
MPS	Maldives Police Services
MRC	Maldives Red Crescent
MTCC	Maldives Transport and Contracting Company
NDC	Nationally Determined Contribution
NDMA	National Disaster Management Authority
NGOs	Non-Governmental Organizations
RDC	Road Development Cooperation
SIDS	Small Island Developing States
SOEs	State-Owned Enterprises
SOFF	Systematic Observations Financing Facility
SOPs	Standard Operating Procedures
STELCO	State Electric Company Limited
URA	Utility Regulatory Authority



FOREWORD



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# Foreword



Maldives is a nation that thrives on its natural environment and strategic geographical position. The country comprises 1,190 small islands. Maldives as a nation is calling on the international community to increase efforts to address climate change through provision of sustained and adequate implementation means.

Access to better and improved climate information is often lacking in countries like Maldives. There is a need to ensure that the climate information available to policymakers and local community is meaningful and impactful. Over the last fifty years, Maldives Meteorological Services has made a significant contribution in predicting the-likelihood of climate-related hazards. This has enabled communities to better adapt to climate-induced disasters and allowed response agencies, including the National Disaster Management Authority, to swiftly manage situations.

Climate change results in increasing intensity and frequency of disasters; hence, communities, response agencies, and policymakers need to be provided with new and updated information on the level of impact that may be associated with these events. A shift from hazard-based to impact-based forecasting is more important than ever as we make the transformation to climate-resilient development pathways.

Impact-based forecasting (IBF), which aims to predict the consequences associated with a climate hazard, will provide communities and response agencies with lead time to act in disaster situations. It will transform weather forecasting in the Maldives and increase the country's ability to better respond to disasters. The improved information available through IBF will also contribute to overall implementation of our Nationally Determined Contribution and its associated actions.

On behalf of the Government of Maldives, I reaffirm our country's commitment to implementing policies based on evidence and scientific knowledge. Such policies will be durable and beneficial to the island communities. Thus, I would like to express my sincere gratitude and warm con-

gratulations to all the stakeholders who have worked diligently to make the program realistic and attainable.

I wish to express my heartfelt appreciation to the United States Agency for International Development Climate Adaptation Project for their kind assistance in formulating this action plan and in kickstarting its implementation through provision of the required computational capacity and demonstration of IBF in one of the islands of Maldives.

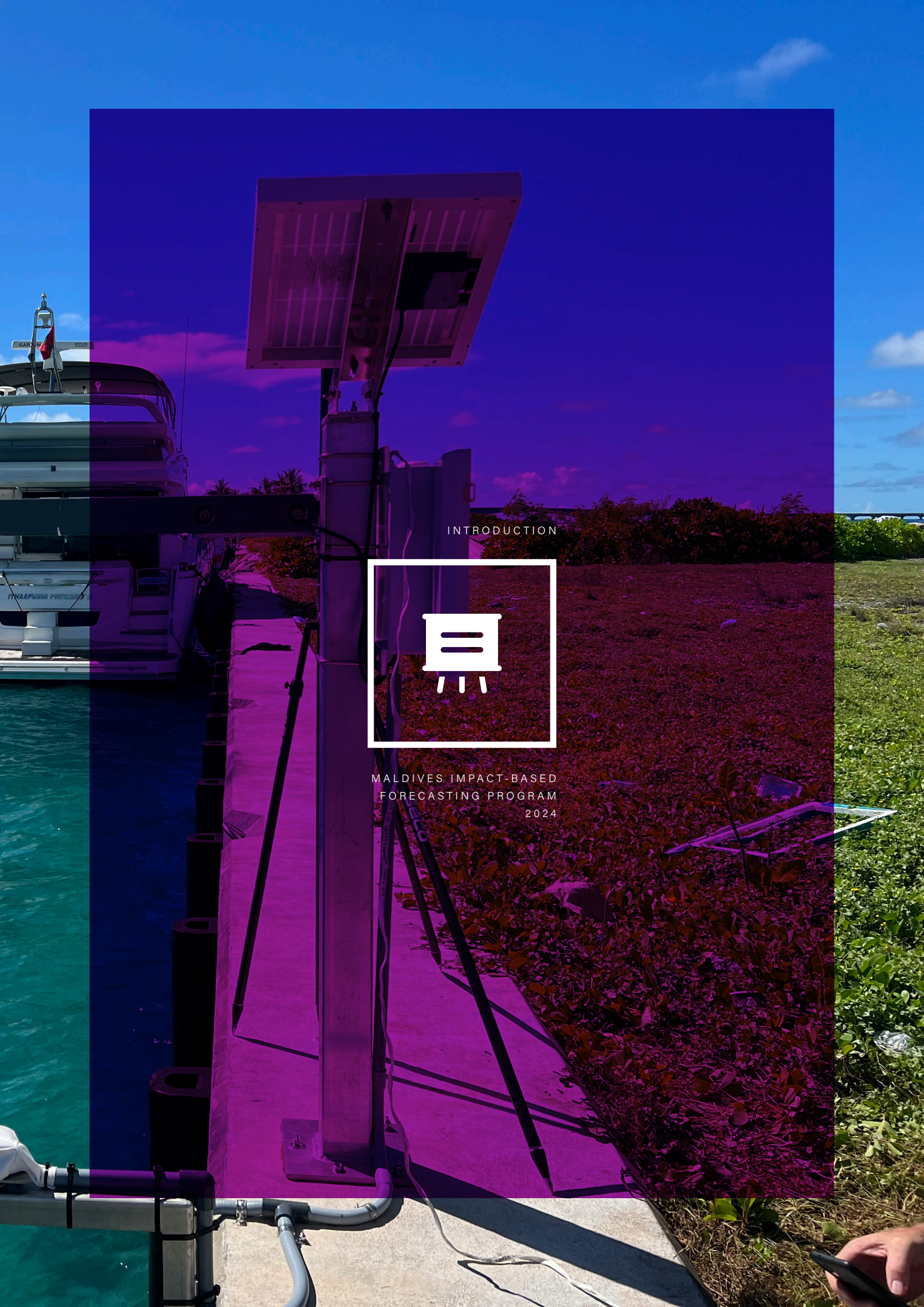
I am confident that this program will provide our communities with reliable, people-centric weather messages and alerts, transforming forecasting in the Maldives.

**H.E Thoriq Ibrahim**

**Minister of Climate Change, Environment and Energy**







## INTRODUCTION



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# 1. Introduction



Maldives is a small, low-lying island nation with a dispersed geography and is highly susceptible to the impacts of climate change. Severe weather, including droughts, storms, heavy monsoonal rains, cyclones, storm swells, and coastal erosion, frequently impacts the country. Climate change exacerbates the intensity and frequency of many of these hydrometeorological hazards. When combined, they significantly threaten the livelihood and well-being of the people (NDC, 2020).

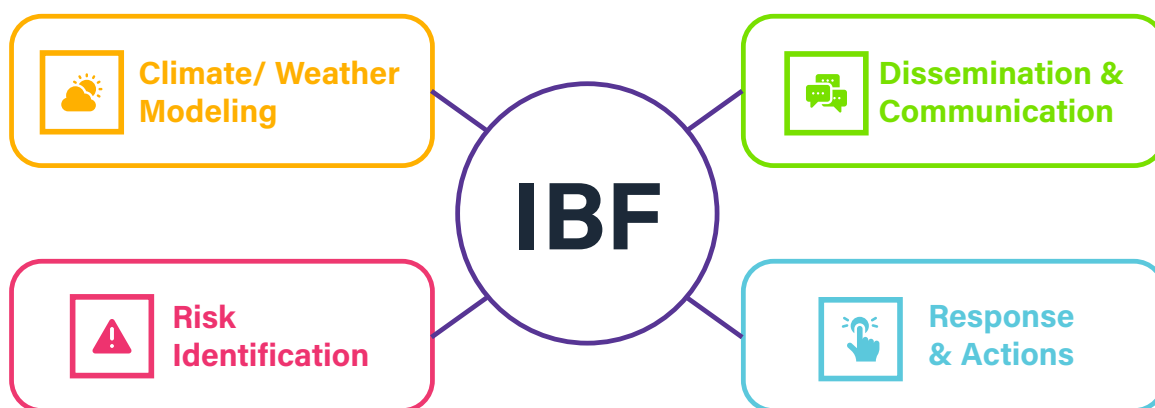
Climate and weather-related information in the Maldives is provided by Maldives Meteorological Services (MMS). Currently, MMS provides hazard forecasts, providing the public and end users with information on the duration, geographical location, and intensity of the rainfall. The potential impact from the climate event is not forecasted. Improving forecasting and availability of the climate information is priority of the Government of Maldives. Thus, MMS is taking measures to transform their current weather forecasting from hazard-based to impact-based forecasting. Progressing from weather forecasts and warnings to multi-hazard

impact-based forecast and warning services represents a paradigm shift in climate service delivery for the organization.

Impact-Based Forecasting (IBF) is a structured approach for combining hazard, exposure, and vulnerability data to identify risk and support decision-making, with the ultimate objective of encouraging early actions that reduce damages and loss of life from natural hazards or climate risks. This will enhance MMS forecasting capacity and access to high quality information to move from what the weather will be to what the weather will do. This approach would provide improved information on the level of impact and its geographic boundaries that could be used by the public and/or emergency response planners and other potential users to prepare for, and minimize loss and damage from, hazards.

The Maldives IBF Program aims to develop a quality service improvement program for MMS, transforming the availability of and access to high-quality information for decision making to reduce vulnerability to climate change.

The plan comprises four elements.



**GOAL**

Provision of accurate and people-centric weather messages and alerts by transformative forecasting in the Maldives



RISK IDENTIFICATION



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## 2. Risk Identification



Small Island Developing States (SIDS) are often recognized as countries that are at the forefront of climate change. The low-lying nature of the islands make exposure to climate-related hazards such as sea level rise, saltwater intrusion, coral reef degradation, and ocean acidification more severe (IPCC, 2018). The Intergovernmental Panel on Climate Change's (IPCC) Fifth Assessment Report (AR5) formulated a clear linkage between the climate element and the socioeconomic process in establishing a risk framework. The associated climate risk is defined as a product that emerges due to interaction between climate-related hazard, vulnerability, and exposure.

Maldives climate risks are categorized into the four major types (Hay, 2006). These risks are influenced by climate and non-climatic factors (Figure 1). These climate factors include change in precipitation, temperature, wind direction and speed. Most of the non-climatic factors are not only due to natural processes but also due to unsustainable management of resources and lack of adequate levels of planning.

CLIMATE	COASTAL EROSION	SWELL SURGE STROM WATER FLOODING UDHA	CYCLONES /THUNDERSTORMS HEAVY RAINFALL DROUGHTS	CHANGES IN SEA LEVEL CHANGES IN SEA SURFACE TEMPERATURE CHANGES IN MONSOON
NON-CLIMATE	EARTHQUAKES COASTAL EROSION	TSUNAMIS		
	GEOLOGICAL	METROLOGICAL	HYDROLOGICAL	CLIMATE RELATED

Figure 1 Classification of natural risks in the Maldives. adapted from (DNP, 2008; Hay, 2006).

The climate risks mentioned above must to be well understood to pave the way for comprehensive risk assessment, which remains a key consideration for IBF implementation. The strategic actions that contribute to overall risk assessment are (a) data collection; (b) data storage and management; and (c) vulnerability assessment.

### Data Collection

Climate-related data are collected by several government and non-government agencies in the Maldives, but often for a time-specific reason or objective. Thus, there is often a lack of consistent data collection, though MMS collects information on the weather daily through its outpost offices and some of the Automatic Weather Stations (AWS); this information is now available for the last three decades. Economic, and non-economic data are not frequently collected, leading to insufficient availability of the data required for robust policy formulation and decision-making. Since several types of climate and socioeconomic data, and the geophysical settings of the islands, are needed for island-level risk assessment or analysis, strategic actions must be adopted to ensure the availability of continuous data.

1. **Increase AWS coverage in the Maldives (especially on the western side).** There are currently 40 AWSs across the country in addition to MMS's five main outposts. These AWSs collect general weather data and share them in real time.
2. **Establish protocol for collection of data during and after climate events.** This information will be used in the future in preparation for climate-related events.







3. **Strengthen and enhance existing meteorological observation data collection and integration system.** The system will bring together observation data gathered from different collection points: meteorological stations, AWS, satellite, and radar. With a special focus on maintenance, upgrading and calibration the existing system in operation.
4. **Expand the meteorological forecasting capacity by installation of Doppler radar.** There is currently a single radar system that does not cover the entire archipelago; therefore there is a need to establish additional Doppler systems.
5. **Support line agencies in collecting a socioeconomic and geophysical dataset to be used in the generation of IBF in the Maldives.** Enhance transparency and data sharing between the line agencies.

## Data Storage and Management

Climate data sharing is not a common practice. Often these data are managed by stakeholders with limited avenues for sharing among themselves—data are only shared with other stakeholders through required agreements or understandings. However, some data, including weather information from MMS and statistical data collected by Maldives Bureau of Statistics (MBS), are available. In addition to the public data, private sectors also collect, store, and manage their own. Since IBF requires sharing of data, including geophysical conditions of the islands, in addition to the historical and weather information, a holistic mechanism needs to be developed to effectively manage these (Table 1).

6. **Establish Memorandums of Understanding with sectors for providing climate-sensitive data within those sectors.** These sectors include, but are not limited to, transport; fisheries; agriculture; tourism; health and education; governance and policymakers; local councils/islands; the National Disaster Management Authority (NDMA); Maldives Police Services (MPS); the Maldives National Defense Force (MNDF); Maldives Red Crescent (MRC); NGOs; the public; media; and the private sector. weather data and share them in real time.
7. **Establish data sharing protocols and guidelines with relevant stakeholders.** These guidelines will ensure that the MMS, as the key institution tasked with issuing IBF warnings, has up-to-date information such as bathymetry, topography, demographic characteristics, and land-use plans to better inform the impact area for early actions.
8. **Strengthen the National Geographic Information System (GIS).** The GIS mechanism will allow sharing of data across the sectors with different levels of information.



Table 1 Data layers required for implementation of IBF

DATA REQUIRED	DATA SOURCE
<b>Meteorological:</b> This is the basic data required for IBF. Most of these are available within government agencies and State-Owned Enterprises (SOEs)	
<ul style="list-style-type: none"> <li>• Historic and real-time hydro-meteorological data</li> <li>• Vector and raster cartographic, geological, and geographic spatial data</li> <li>• Historical natural disaster and damage data</li> <li>• Risk assessment data</li> <li>• Hydrometeorological conditions</li> <li>• Climate Model</li> <li>• Hazard Forecast</li> <li>• Probability of the weather or climate hazard occurring (used as the basis to calculate the level of impact and the likelihood of impacts occurring)</li> </ul>	<ul style="list-style-type: none"> <li>• MoCCEE</li> <li>• MMS</li> <li>• NDMA</li> <li>• MCI</li> <li>• MBS</li> <li>• EPA</li> </ul>
<b>Island Reef:</b> Bathymetry data of all the island might not be available; also, the data standards must be established by a government authority such as MLSA.	
<ul style="list-style-type: none"> <li>• Geographic location</li> <li>• Island type (inhabited, resort/industrial/agriculture, etc.)</li> <li>• Topography</li> <li>• Bathymetry</li> <li>• Hydrometeorological characteristics</li> <li>• Climate Model</li> </ul>	<ul style="list-style-type: none"> <li>• MLSA</li> <li>• MoCCEE</li> <li>• MOT</li> <li>• RDC</li> <li>• MTCC</li> <li>• EPA</li> <li>• MHLUD</li> </ul>
<b>Island Physical and socioeconomic structures:</b> This data will aid understanding of the socioeconomic environment that will be affected by an event and define the event's socioeconomic significance.	
<ul style="list-style-type: none"> <li>• Coastal protection structures</li> <li>• Important/critical infrastructures</li> <li>• Proximity to the shoreline</li> <li>• Commercial, agriculture, industry, and transport infrastructures</li> <li>• Building: number of stories, roof, and foundation</li> </ul>	<ul style="list-style-type: none"> <li>• MoCCEE</li> <li>• MMS</li> <li>• MLSA</li> <li>• MCI</li> <li>• MBS</li> <li>• EPA</li> <li>• MHLUD</li> </ul>
<b>Land use:</b> This data can be used to understand the infrastructure, type of land, and ecology exposed to the event.	
<ul style="list-style-type: none"> <li>• Land use types (residential commercial, waste etc)</li> <li>• Type of land cover vegetation and soil type)</li> <li>• Ecology (wetland/ Kulhi/Mangrove etc)</li> <li>• Commercial, agriculture, industry, and transport infrastructures</li> <li>• Building: number of stories, roof, and foundation</li> </ul>	<ul style="list-style-type: none"> <li>• MBS</li> <li>• NSPA</li> <li>• MoSFD</li> </ul>
<b>Critical infrastructure locations:</b> This information will aid understanding of the important and critical infrastructure that will potentially be affected by the event.	
<ul style="list-style-type: none"> <li>• Energy infrastructure: Power generation plants, transmission substations, distribution stations, and transmission lines and poles</li> <li>• Water desalination plants pump stations</li> <li>• ransportation links and hubs (e.g., highways, airports, ports/harbors)</li> </ul>	<ul style="list-style-type: none"> <li>• URA</li> <li>• FENAKA</li> <li>• STELCO</li> <li>• MBS</li> <li>• MoTCA</li> <li>• MWSC</li> <li>• MCI</li> <li>• RDC</li> <li>• MTCC</li> <li>• MPL</li> <li>• Regional Airports</li> </ul>
<b>Public health system:</b> This data is particularly useful for evacuation and rescue operations during the event.	
<ul style="list-style-type: none"> <li>• Number and locations of health establishments: hospitals, clinics, pharmacies, etc.)</li> <li>• Bed capacity</li> <li>• Doctors/nurses per capita</li> <li>• Incidence of disease</li> </ul>	<ul style="list-style-type: none"> <li>• MoH</li> <li>• MBS</li> <li>• Island/atoll and City Council</li> <li>• MLSA</li> </ul>
<b>Economic system:</b> This will be useful in understanding the event's impact on trade, economic, and business activities.	
<ul style="list-style-type: none"> <li>• Type of economic activity</li> <li>• Size of labor force</li> <li>• Assets</li> <li>• Capital investment values</li> <li>• Annual average capital of businesses</li> </ul>	<ul style="list-style-type: none"> <li>• MED</li> <li>• MBS</li> </ul>

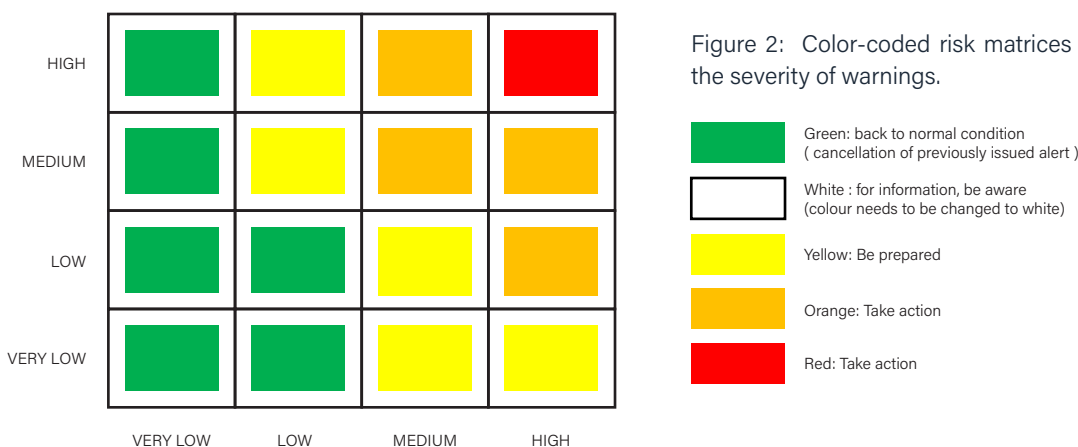
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<b>Education system:</b> This will be useful in understanding the impact of the event on education systems in the affected area. (SOEs)	
<ul style="list-style-type: none"> <li>• Number or location of schools</li> <li>• Number of students and teachers</li> <li>• Number of female students</li> <li>• Physical structure of the school</li> </ul>	<ul style="list-style-type: none"> <li>• MoE</li> <li>• MoHELSD</li> <li>• MBS</li> </ul>
<b>Fisheries sector:</b> This is useful for understanding the fisheries sector and how it can be used to reduce the impact of an extreme event.	
<ul style="list-style-type: none"> <li>• Number of boats operating in the area</li> <li>• Type of fisheries</li> <li>• Number of fishermen</li> <li>• Safety equipment and capacity of fishing vessels</li> <li>• Tracking systems</li> </ul>	<ul style="list-style-type: none"> <li>• MOFOR</li> <li>• MoTAC</li> <li>• MBS</li> </ul>

## Vulnerability Assessment

Risk assessments are the keystone of IBF and require information on hazard, exposure, and vulnerability (including coping and adaptive capacity). They use a combination of objective and subjective methods; consequently, data on different risk dimensions often begins as qualitative and develops iteratively. Producing an objective assessment of risk will be challenging due to factors that affect the quality and robustness of information used throughout the process, including how data is collated; what data is available; how data is processed; and what assumptions have been made in weather and climate models.

Risk matrices are the basic tool of an impact-based forecasting system. A matrix will show the likelihood of occurrence of the hazard. The likelihood is determined from weather forecasting techniques, and the level of the impact is determined from knowledge of vulnerability and exposure. The matrices determine the severity of the warning using a four-color system: green, yellow, orange, and red (Figure 2).

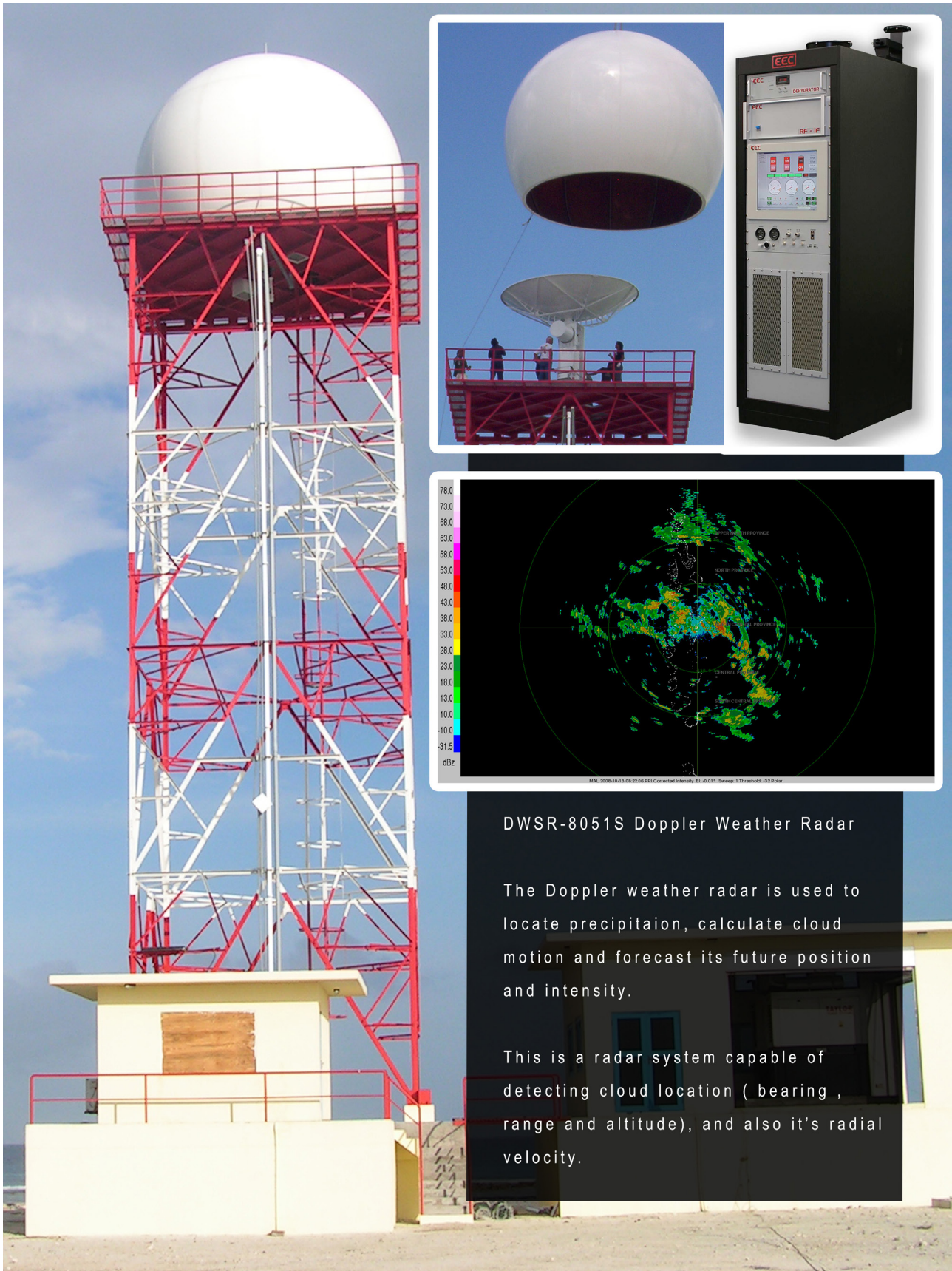


To determine hazard exposure, data is combined with exposed population datasets. Return periods can be calculated from climatology data (probability of an extreme event of a certain magnitude happening in a given year). Vulnerability and exposure data are required to provide an objective assessment of risk in impact-based forecasting. Data layers required for this process is listed in Table 1. Once vulnerability and exposure data are gathered and processed, the data can be analyzed alongside the hazard information to produce a risk matrix.

9. **Develop guidelines and methodologies for island specific vulnerability assessment.** Most of the vulnerability assessments are conducted through different methods; however, comparative assessment can only be done with use of a similar approach to both vulnerability assessment and hazard mapping. Some vulnerability and hazard assessments are undertaken by the government, especially within a project-specific context. With the IBF in place, assessments similar to the Detailed Island Risk Assessment conducted for Hdh. Kulhudhufushi and Gdh. Thinadhoo need to be undertaken for each island.



10. **Prepare Risks, Vulnerability, and Hazard mapping for selected islands.** Based on the guidelines developed to assess all physical and socioeconomic vulnerability settings, islands where the IBF will be demonstrated shall undertake a detailed vulnerability assessment. This assessment will identify potential locations within the islands that are exposed to several climate-induced hazards.





WEATHER AND  
CLIMATE MODELING



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### 3. Weather and Climate Modeling



MMS currently issues climate products, such as daily forecasting products. These are available as 24-hour and 5-day forecasts. However, the quality and frequency of these products is low due to the limited information available for their preparation. Stakeholders consultation identified that more frequent products (hourly or at least 3-hour weather information) should be available. However, the current limited data and computational resources must be enhanced for such products to be prepared.

#### Enhance Computational Power for Forecasting

Climate-related data are collected by several government and non-government agencies in the Maldives, but often for a time-specific reason or objective. Thus, there is often a lack of consistent data collection, though MMS collects information on the weather daily through its outpost offices and some of the Automatic Weather Stations (AWS); this information is now available for the last three decades. Economic, and non-economic data are not frequently collected, leading to insufficient availability of the data required for robust policy formulation and decision-making. Since several types of climate and socioeconomic data, and the geophysical settings of the islands, are needed for island-level risk assessment or analysis, strategic actions must be adopted to ensure the availability of continuous data.

11. **Improve WRF forecasting and integrate WAVE4M for enhanced forecasting and hazard warning.** This will require investment in a High-Performance Computer (HPC) system to transfer and run the WAVE4M model (for sea state forecast) locally and enhance the current weather forecasting resolution.



## Develop Risk Indices

Vulnerability, exposure, and hazard indices must be established on island levels for broader IBF implementation in the Maldives, and a methodology should be developed for establishing the indices. Below are some potential indices for climate-related hazards that can be further discussed with the stakeholder prior to adoption. Table 2 Indices can be used for implementation of IBF. The IBF products focus on addressing climate risks and are tied into the necessary and adequate indices.

12. **Improve WRF forecasting and integrate WAVE4M for enhanced forecasting and hazard warning.** Maldives currently have weather alert levels for climate events. Given the level of information required for issuance of the IBF alert, a significant level of data—such as topographical, hydrological, bathymetrical, and socioeconomic conditions—is required. This data would be used to analyze and design thresholds for the island. Since the development of the thresholds requires multiple disciplines, an integrated methodology shall be designed for collection, management, and integration of data to formulate the indices.

Figure 3 Major data required for the preparation of the several indices.



13. **Identify and develop hazard indices.** Hazard indices will be based on the priorities identified by MMS and other stakeholders. Information on past historical climate, extreme weather events, social and economic data will be used to formulate the indices. The level of impact will be measured using available vulnerability data.



Table 2 Indices that can be used for implementation of IBF.

CLIMATE HAZARD	THRESHOLD	HAZARD INDICES	HAZARD EXPOSURE INDICATORS	RATIONAL	POTENTIAL DATA SOURCES
HEAVY RAIN	Percentage of land/population exposed to n number of days when the total daily precipitation amount is above the (threshold level)	More than a certain threshold level of water inundation of the land	Exposed population in the island or part of an island	Heavy rain extremes are risk factors that can cause sudden flooding, impacting various sectors.	Hourly or daily records of rainfall from MMS
		Low Visibility	Exposed agricultural land Low visibility	Extreme rainfall is vital for policymaking (e.g., disaster preparedness or investment decision-making).	Historical data from NDMA
		Very short duration	Disrupt socioeconomic activities (schools, transport, business)		Population block data from MBS
		Localized flooding in low-lying areas	Stranded students/workers		Land use plans from MLSA
		Isolated damage to Vegetation			
		Traffic Jam			
		Sporadic accumulation of water (compounds)			
		Disrupt outdoor activities Small area affected			
TIDAL WAVES	Historical data on exposure of atolls/islands to	Percentage of land exposed to waves, swell;	Percentage of island/ population exposed to and affected	Violent tidal waves, swell surgea are defined using prevailing tide height at	Historical data on the impact's damages available from NDMA
SWELL SURGE	tidal waves, swell surges at a certain threshold level	surge, proximity of buildings and other infrastructure to the sea	by tidal waves, swell surge	highest tide and swell conditions in the region	Occurrence and frequency data available from MMS
			Percentage of built-up area exposed (per year) to tidal waves, swell surge		MBS also has statistics of damage
FLOOD	Rain-induced flood as well as swell-induced coastal flood has to be distinguished, and threshold levels should be defined.	Percentage of land/population exposed to both types of flooding with 10-, 20-, 50-, and 100-year return periods	Percentage of population/islands exposed to rain-induced and swell-induced flooding with 10-, 20-, 50-, and 100-year return periods	Both rain-induced and swell-induced flooding can cause huge economic losses, impacting people, property, and important infrastructure.	Flood areas in islands are in the CBDRM plans. This data is available from NDMA.
			Percentage of built-up area exposed to rain-induced and swell-induced flooding with 10-, 20-, 50-, and 100-year return periods		Histories of both types of floods are available from MMS.
			Percentage of Agriculture land exposed to rain-induced and swell-induced flooding with 10-, 20-, 50-, and 100-year return periods		Damage data from floods are available from NDMA and NBS
WIND	Historical data on wind threats and the speed intensity direction thresholds need to be established.	Percentage of land/population exposed to violent wind threats per year	Percentage of island population exposed to wind storms per year	Strong windstorms are defined using wind gust, as most damages occur in extreme wind speeds during gusts	Flood areas in islands are in the CBDRM plans. This data is available from NDMA.
			Percentage of built-up area exposed to wind-storms per year	Cyclone wind threats are direct risks to humans through flying debris and falling trees or damage to built-up areas.	

## Scenario Development

The damage caused by climate-related events needs to be predicted, with the development of several scenarios. The outcome of climate events depends on several factors, including the strength of the hazard, the resilience of the exposure area, and socioeconomic conditions within communities. Predicting the likely outcome from any hazard is often complex and often developed with the assistance of high computational capacity. These scenario generations are also time consuming. An adequate level of input data should be managed to ensure the most reliable and accurate outcomes.

14. **Enhance weather and climate modeling mechanism.** Climate modeling requires installing, managing, and troubleshooting modeling softwares that generate possible pathways for a likelihood of events or series of events. This software needs to be monitored, and system integration is required throughout the IBF implementation phase.
15. **Prepare of data management tool.** Climate data, and other non-climate and long-term data, is required as input to the modeling process. Even though data collection and sharing guidelines and protocols are established (under the Risk Identification component), the data needs to be further processed prior to inputting into the system.
16. **Develop Decision Support System (DSS).** This web-based platform allows incorporation of different components required in the IBF to generate automatic sector-specific information providing likely impact associated with a risk. The platform has three major components—vulnerability, hazard, and exposure—to accurately provide the likely outcome from potential risks.

## Risk Matrix

Hazard impact levels are determined based on impact tables developed for each sector in close collaboration with relevant stakeholders through stakeholder workshops. The level of impact requires combining information from modeling, past events, and risk analysis. Modeling combines forecast hazard magnitude with vulnerability and exposure data to determine the potential severity of the impact. Past-event analysis correlates information from past events with the magnitude of the hazards that occurred during the same event. For forecast events, these correlations can provide an estimate of potential impact. Estimates of impact must be adjustable based on known population vulnerability and exposure information within the forecast area. Impact tables at their most basic would rely on expert knowledge rather than quantitative data.

Data from observation networks, modeling, or socioeconomic datasets are important to develop impact tables; however, their limited availability will not prevent the development of impact-based forecasts and warnings. Limited data will affect the certainty level in any impact-based forecast and warning, but there are ways to generate impact-based forecasts and warnings even where data and infrastructure are scarce. The basic questions an IBF impact table should answer are shown in Table 3 below.





Table 3: Key questions IBF impact table should answer.

KEY QUESTIONS	INFORMATION REQUIRED.	
	HAZARD SPECIFIC DETAILS	IMPACT INDIVIDUALS/MEMBERS OF PUBLIC
What is going to happen?	<ul style="list-style-type: none"> <li>Summary of the hazard</li> <li>Summary with detail of the weather/climate parameter, such as magnitude of the hazard; probability/likelihood of event</li> <li>What are the potential impacts?</li> </ul>	<ul style="list-style-type: none"> <li>Summary of the hazard impacts,</li> <li>Must be understandable to laymen</li> </ul>
When will it happen?	<ul style="list-style-type: none"> <li>When will impacts begin?</li> <li>When will impacts stop occurring?</li> <li>Timing and location</li> </ul>	<ul style="list-style-type: none"> <li>When will impacts begin?</li> <li>When will impacts stop occurring?</li> <li>Timing and location</li> </ul>
How bad will it be and where?	<ul style="list-style-type: none"> <li>Assessment of the risk</li> <li>Risk matrices, risk maps/intervention maps</li> <li>Where will impacts take place?</li> <li>How severe will the impacts be?</li> </ul>	<ul style="list-style-type: none"> <li>Clear explanation of risk, free from technical terms and focused on impacts.</li> <li>Severity expressed as, Very Low, Low, Medium, and High</li> </ul>
What can be done to reduce impacts?	<ul style="list-style-type: none"> <li>Possible response plans</li> <li>Issuance of the impact-based warning</li> <li>Where will impacts take place?</li> <li>How severe will the impacts be?</li> </ul>	<ul style="list-style-type: none"> <li>Advice and guidance on what actions can be taken to prepare</li> </ul>

17. **Harmonize metrological alert and response level.** Harmonize metrological alert and response level. The Multi-Hazard Early Warning System (MHEWS) in the Maldives is currently based on standard operating procedures established at four color-coded alert levels and hazard risk thresholds in accordance with the indices developed in the section above. The system is structured in such a way that decisions are optimized to minimize delays in communication and effective action. On its own, however, this system does not guarantee that those threatened by a natural hazard understand the warning, their vulnerability and exposure, or, consequently, the risk they face. Often, users and affected groups have difficulties in understanding and taking appropriate response action as the interpretation of warning messages, advisories and alerts has different meanings for different communities.

18. **Strengthen impact advisory mechanism.** The likelihood of impact is an important tool for decision-makers. Providing an assessment of likelihood of impact enables agencies/organizations that activate before a weather or climate event occurs to assess the socioeconomic costs and benefits associated with acting early against the cost of doing nothing. Developing an advisory message table based on the likelihood of impact, with potential actions to take, is the final step of an IBF warning system. The warning messages have to be tailored to the specific needs of the country and each stakeholder/user group.



DISSEMINATION AND  
COMMUNICATIONS



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## 4. Dissemination and Communications



IBF and warning services should inform about the cascading threats (e.g., causing subsequent impacts like heavy rainfall leading to flooding, health risk, property damage, and loss of lives) and compounding threats caused by meteorological and hydrological events to prevent the hazards from becoming human disasters. This requires the capacity to predict the onset of specific meteorological and hydrological hazards and the subsequent impact based on the vulnerability of society to those hazards; the ability to communicate and inform; and community capacity to understand the threats and take appropriate mitigating actions.

### Mainstreaming Awareness of IBF

MMS has established links for communicating with local, regional, and international centers by using 256kbps VSAT, 10mbps internet connection and satellite phones. MMS has its own weather studio, recording daily and airing during the prime time of three local TV channels, including Public Service Media. Daily forecasts and warnings are issued through hotlines; fax; mass media (TV and radio); Public Alert (cell broadcast and landline phones); SMS to selected users; email; and social media (Twitter and Facebook). With IBF, the communication and outreach of the products needs to be strengthened.

19. **Develop and activate a media communication strategy/plan.** Outreach is currently limited to a few channels and platforms, and members or followers are expected to grow organically. To further strengthen visibility, active promotion of IBF activities needs to be conducted regularly via multiple, multilingual platforms including mass and social media phase.
20. **Develop sector- and community-specific communication plans.** This would enable provision of information on sectorial plans, which is crucial for meeting the customized needs of user and enhancing preparedness and response efforts.
21. **Conduct a nationwide awareness campaign on IBF.** Design a comprehensive awareness campaign, on-site and digital, to raise knowledge of the IBF. Awareness sessions will be conducted for both end users and policy decision-makers on the importance and usage of IBF. These sessions also

need to be tailored to younger people to ensure that future generations recognize the importance of such forecasting. Targeted awareness sessions will make participants aware of the interpretation of the IBF results and what they mean to the community, individuals and their livelihood.

### Stakeholder Engagement

Collaboration with user sectors such as disaster risk management, energy, health, agriculture, and water management are vital for effective IBF. Collaboration enables agencies to leverage the experience and expertise of other non-weather-related agencies in defining impact thresholds, exposure, and vulnerabilities. Collaborative actions should include data collection and sharing, consultation involving the selection of indicators and impact thresholds, and interpretation of results. This directly supports the development of meaningful targeted warnings that assist those organizations in decision-making and management of their activities.

However, in producing accurate and effective IBF, several challenges need to be addressed. These challenges include limitations related to data quality and availability, lack of capacity and resources, and the complexity of the forecasting process. These challenges can be addressed by improving data quality and availability, increasing resources and capacity, and developing appropriate tools and techniques to manage the complexity of the forecasting process.







RESPONSE AND  
EARLY ACTIONS



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## 5. Response and Early Actions



Effective communication of forecasts and warnings is crucial for impact-based forecasting. By focusing on the needs of the target audience and ensuring that the design, communication, and delivery of forecasts align with these needs, the effectiveness of communication and response can be improved. Understanding the needs of the users and tailoring the communication accordingly is essential for timely and appropriate actions to minimize impacts.

Sector-specific users, including disaster risk management agencies, government departments, and humanitarian organizations, have specific needs for impact-based forecast services to inform their contingency plans and early action strategies. Incorporating impact-based forecasts and warnings into these plans is crucial for meeting the needs of these users and enhancing preparedness and response efforts.

In addition to MMS and disaster responding organizations such as NDMA, MNDF, and Marine Police, industries such as the tourism and fisheries sector also have needs for weather information and early warnings. These forecasts enable them to manage logistics, plan for climate risks, and reduce the impact of hazardous weather or climate events on their operations, supply chains, and employees. Addressing the needs of businesses aligns with corporate social responsibility priorities and fosters resilience in the face of climate-related challenges.

### Early Action Mechanism and Protocols

Due to lack of adequate coordination among the key stakeholders, often the response to climate risk is ad hoc. Since the information provided by IBF products will be detailed on the level of impacts to the community, including providing the location of impact, a comprehensive plan or protocols can be developed. Stakeholder consultations indicate that information currently provided to the end users is often inadequate; thus, they are dependent on global platforms.

22. **Develop Climate Risk Response Protocols.** Protocols to address any climate- or non-climate-related disasters are general and broad. Therefore, there is a need to develop climate risk specific response protocols recognized at the national level. These protocols will ensure management of the event and reduce its level of impact.
23. **Strengthen the Climate Information Network.** A strong collaborative approach brings together the producers of weather, climate, and risk information with those who use the information to make decisions. Through an appropriate coordination process, partners contribute their expertise and insights—strengthening the learning design and process. Partnership developed between the stakeholders should be continuous through design, development and implementation stages of impact-based forecasting services. Within the context of risk assessment, with a multi-sectoral, multi-hazard approach for meteorological, hydrological and climate-related hazards, strengthen national and regional institutional capacities and cooperation among MMS; disaster response agencies (NDMA, MPS, MNDF); Island Councils; and other IBF stakeholders.







SUSTAINING IBF



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## 6. Sustaining IBF



### Capacity Building and Training

Improved infrastructure for data collection and processing should come with the necessary capacity building to use and maintain those infrastructures. Technicians need to be prepared to handle the equipment for troubleshooting and maintenance. Human resources need to be trained among all the service providers, as do the human resources in MMS. Specialists in forecasting, climatology, GIS, and data analysis will be needed. This will require training of experts for both the short and long term. Long-term training could be provided via institutions abroad, while short-term training could be done in-house with the help of external experts. Capacity building of human resources will require financial resources and investment in time.

24. **Enhance the capacity for IBF implementation.** Conduct a capacity needs assessment for IBF implementation in order to Improve human resource and technical capacities of MMS in the following areas: (1) increase technical capacity for weather forecasting and service delivery as well as for maintenance of equipment; (2) build capacity in satellite and radar meteorology; (3) establish marine observation capacities particularly tidal/swell waves; (4) enhance Doppler weather radar coverage in the country; and (5) establish lightning detectors to enable thunderstorm and lightning forecasting.
25. **Develop a comprehensive IBF training plan.** A sustainable training program is crucial for MMS to enhance its technical capacity and deliver accurate weather and climate services. To achieve the sustainability of a permanent training facility, MMS should develop a comprehensive plan that includes identifying potential funding sources, engaging stakeholders, and building internal capacity. Leveraging partnerships with local and international agencies can help overcome budget constraints and ensure training continuity.



## Governance Instruments

Improved infrastructure for data collection and processing should come with the necessary capacity building to use and maintain those infrastructures. Technicians need to be prepared to handle the equipment for troubleshooting and maintenance. Human resources need to be trained among all the service providers, as do the human resources in MMS. Specialists in forecasting, climatology, GIS, and data analysis will be needed. This will require training of experts for both the short and long term. Long-term training could be provided via institutions abroad, while short-term training could be done in-house with the help of external experts. Capacity building of human resources will require financial resources and investment in time.

26. **Formalize multi-stakeholder partnerships and collaboration.** Strengthening national and regional institutional capacities and cooperation among MMS, disaster response agencies (NDMA, MPS, MNDF), Island Councils, and other IBF stakeholders through formal MOU/agreements and effective Standard Operating Procedures (SOPs) will be a critical element for the smooth functioning of IBF. Consultation with partner stakeholders is necessary for the development of impact and advisory tables for IBF warning systems.
27. **Enhance civil society engagement.** Develop an inclusive engagement plan for IBF implementation with civil society organizations such as the Maldives Red Crescent. They play a crucial role in advocating for the policies, governance, and finance necessary for implementing early warning systems. They bridge the gap between technical scientific agencies and communities, ensuring that warning information is customized, disseminated, understood, and acted upon.
28. **Incorporate IBF into the legal framework.** Ensure integration of IBF needs into the forthcoming Meteorological Act of Maldives. This will strengthen IBF as a core function of MMS and holistically support climate risk reduction in Maldives.

## Donor Engagement and Complementarity Among Donors

The prospect for sustainability of the impact-based forecasting system in the Maldives faces a significant challenge in terms of finance. However, the government's commitment to improving the sector and the potential support from international cooperation offer opportunities for progress. Maldives is a party to many of the global initiatives and is benefited continuously. The UN Global Early Warning initiative provides a framework for targeted investments to address deficiencies and scale up financial instruments such as the Systematic Observation Financing Facility and the Climate Risk and Early Warning Systems initiative. Through the Systematic Observations Financing Facility (SOFF), countries with the largest capacity gaps, particularly Least Developed Countries (LDCs) and SIDS, can enhance their climate and weather observations to achieve the adaptation and observation goals of the Paris Agreement. SOFF offers financial assistance and technical support to improve hydromet networks, data collection, processing, and sharing.

29. **Streamline IBF into the climate risk reduction funding pipeline of Maldives.** IBF is an important tool for effective evidence-based policy in the country. Hence, meaningful consideration needs to be considered in interactions with the donors.
30. **Avoid duplication of efforts to maximize resources.** Develop donor engagement plans to lead consultations and interactions among donors to ensure harmonization to achieve strategic goals of IBF in the Maldives.







# PROPOSED IBF IMPLEMENTATION PLAN



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## 7. Proposed IBF Implementation Plan



Institutionalization of the above strategies with clear roles and responsibilities within specific timeframes is essential for the implementation of IBF in the Maldives. This would enable the transformational changes expected with the launch of IBF. Table 4, shows the proposed strategic actions and its implementing partners with timeframes.

#	STRATEGIC ACTION	LEAD AGENCY	SUPPORTING AGENCY	TIME FRAME
<b>RISK IDENTIFICATION – DATA COLLECTION</b>				
0 1	Increase AWS coverage in the Maldives	MMS	MoCCEE, Island Councils	Medium-term
0 2	Establish protocol for collection of impact data during and after weather/ climate events	NDMA	MoCCEE, MMS, MNDF, MPS, Island Councils	Short-term
0 3	Strengthen and enhance existing meteorological observation data integration system	MMS	MoCCEE, MNBS	Short-term, Medium-term
0 4	Expand the meteorological forecasting capacity through installation of doppler radar	MMS	MoCCEE, MNDF, MPS	Medium-term
0 5	Support line agencies in collecting a socio-economic and geophysical dataset to be used in the generation of IBF in the Maldives	MMS	MoCCEE, MNBS, Island Councils, NDMA, MPS, MNDF	Short-term, Medium-term
0 6	Establish Memorandums of Understanding with sectors for providing climate sensitive data within those sectors	MMS	MoCCEE, NDMA, MNDF, MPS, MRC, MOFOR, MOAAW, Civil Society	Short-term, Medium-term
0 7	Establish data sharing protocols and guidelines with relevant stakeholders	MMS	MoCCEE, NDMA, MNDF, MPS, MRC, MOFOR, MOAAW, Civil Society	Short-term, Medium-term
0 8	Strengthen the national Geographic Information System	MLSA	MMS, MNDF, NDMA	Short-term, Medium-term
0 9	Develop guidelines and methodologies for island specific vulnerability assessment	MoCCEE	MMS, MNDF, NDMA	Medium-term
1 0	Prepare Risks, Vulnerability and Hazard mapping for selected islands	MoCCEE	NDMA, MMS, MNDF, MPS, MNBS, Development Partners	Medium-term
1 1	Improve WRF forecasting and integrate WAVE4M for enhanced forecasting and hazard warning.	MMS	NDMA, MoCCEE, Development Partners	Short-term
1 2	Prepare methodologies for development of hazard indices	MMS	NDMA, MoCCEE, Development Partners	Short-term
1 3	Identify and develop hazard indices	MMS	NDMA, MoCCEE, Development Partners	Short-term
1 4	Enhance weather and climate modeling mechanism	MMS	NDMA, MoCCEE, Development Partners	Short-term
1 5	Prepare data management tool	MMS	NDMA, MoCCEE, Development Partners	Short-term
1 6	Develop Decision Support System	MMS	NDMA, MoCCEE, Development Partners	Short-term
1 7	Harmonize meteorological alert and response level.	MMS, NDMA	NDMA, MoCCEE, Development Partners	Short-term, Medium-term
1 8	Strengthen impact advisory mechanism	MMS, NDMA	NDMA, MoCCEE, Development Partners	Short-term, Medium-term
1 9	Develop and activate a media communication strategy/pla	MMS, NDMA	NDMA, MoCCEE, Development Partners	Short-term, Medium-term

Continued on next page..

2 0	Develop sector- and community-specific communication plans	MMS, NDMA	MoEECC, MOT, MOAAW, MOFOR, Media, Development Partners	Short to Medium-term
2 1	Conduct a nationwide awareness campaign on IBF	MMS, NDMA, Island Councils	MoEECC, MRC, Media, Development Partners	Short to Medium-term
2 2	Develop Climate Risk Response Protocols	MMS	MMS, MoCCEE, MRC, MOT, MOFOR, MOAAW, Development Partners	Short to Medium-term
2 3	Strengthen the Climate Information Network	MMS	NDMA, Media, Development Partners	Short to Medium-term
2 4	Enhance the capacity for IBF implementation	MMS	NDMA, Development Partners	Short to Medium-term
2 5	Develop a comprehensive IBF training plan	MMS	NDMA, Development Partners	Short to Medium-term
2 6	Formalize multi-stakeholder partnerships and collaboration	MoCCEE	MMS, NDMA, MNDF, MPS, Island Councils, MRC, Development Partners	Short to Medium-term
2 7	Enhance civil society engagement	MMS	MMS, NDMA, MNDF, MPS, Island Councils, MRC, Development Partners	Short to Medium-term
2 8	Incorporate IBF into the legal framework	MoCCEE	AGO, MoCCEE, NDMA, MNDF, MPS, Island Councils, MRC, Development Partners	Short to Medium-term
2 9	Streamline IBF into the climate risk reduction funding pipeline of Maldives	MoCCEE	MMS, NDMA, Development Partners	Short to Medium-term
3 0	Avoid duplication of efforts to maximize resources	MoCCEE	MMS, NDMA, Development Partners	Short to Medium-term



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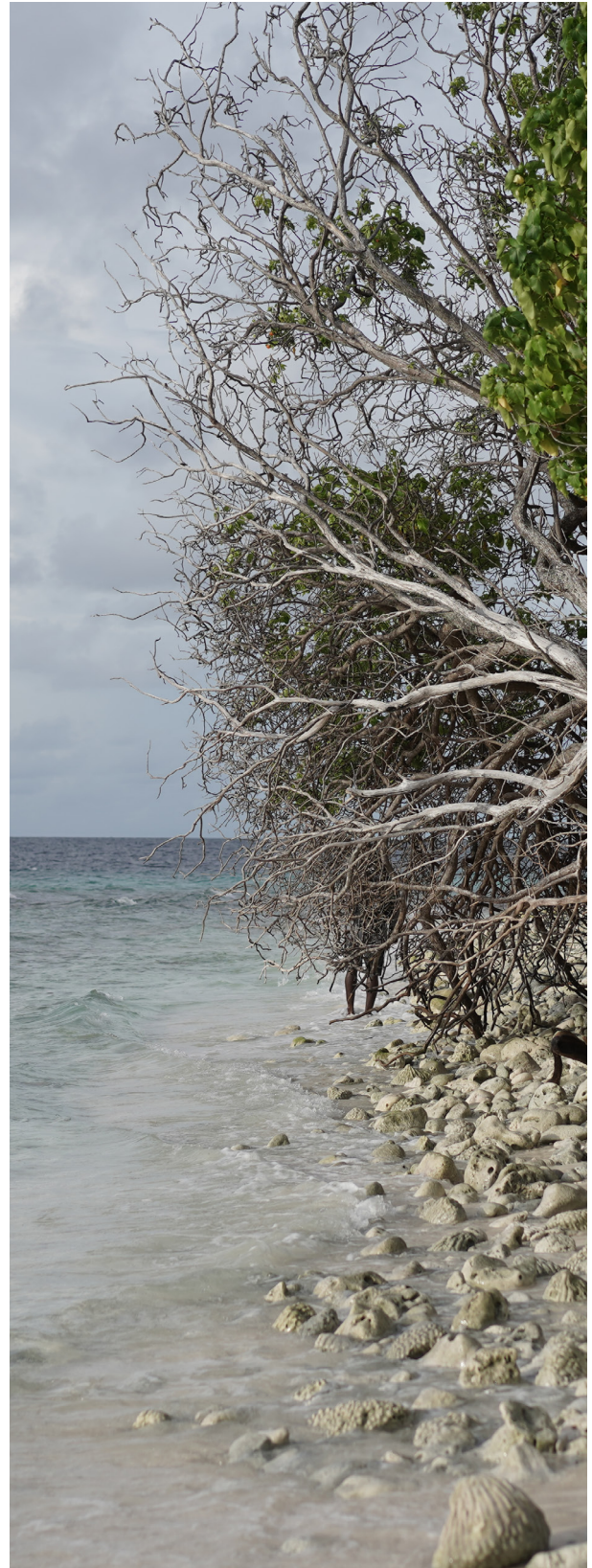
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