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COUNTRY CLIMATE AND DEVELOPMENT REPORT

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Table of Contents

Figures, Tables, and Boxes

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Abbreviations

ASPIRE	Accelerating Sustainable Private Investments in Renewable Energy
BAU	Business-As-Usual
CCDR	Country Climate and Development Report
CoTS	Crown-of-Thorns Starfish
CTF	Conservation Trust Fund
DAPP	Dynamic Adapive Policy Pathway
EEZ	Exclusive Economic Zone
ENSO	El Niño–Southern Oscillation
EPA	Environmental Protection Agency
ESG	Environmental, Social, and Governance
EV	Electric Vehicle
EWS	Early Warning System
FCCL	Fiscal Commitments and Contingent Liabilities
FDI	Foreign Direct Investment
GDP	Gross Domestic Product
GHG	Greenhouse Gas
IPP	Independent Power Producer
IWRMC	Island Waste and Resource Management Center
MIFCO	Maldives Industrial Fishing Company
MMA	Maldives Monetary Authority
MMRI	Maldives Marine Research Institute
MMS	Maldives Meteorological Services
MoCCEE	Ministry of Climate Change, Environment and Energy
MoF	Ministry of Finance
MPA	Marine Protected Area
MSMEs	Micro, Small, and Medium Enterprises
MSP	Marine Spatial Planning
NAP	National Adaptation Plan
NbS	Nature-Based Solution(s)
NDC	Nationally Determined Contribution
NDMA	National Disaster Management Authority
PIM	Public Investment Management
PPP	Public-Private Partnership
PSIP	Public Sector Investment Program
PV	Photovoltaic
RCP	Representative Concentration Pathway
RE	Renewable Energy
SAP	Strategic Action Plan
SIDS	Small Island Developing State
SLR	Sea Level Rise
SMEs	Small and Medium Enterprises
SOE	State-Owned Enterprise
SPIS	Social Protection Information System
SSP	Shared Socioeconomic Pathway
TCO	Total Cost of Ownership
UNFCCC	United Nations Framework Convention on Climate Change

Executive Summary

Maldives' development success is facing headwinds

Maldives has achieved remarkable economic success in the last couple of decades. In 2023, the country achieved the highest gross domestic product (GDP) per capita in South Asia and human capital (health and education) indicators that are on par with high-income economies**.** Since the early 2000s, Maldives has doubled its real income per capita, transitioned from low- to middle-income status, and substantially reduced poverty. Human capital has also seen marked progress. Life expectancy more than doubled from 1960 to 2020, child and maternal mortality decreased drastically, and educational attainment significantly increased. The government has made infrastructure investment a priority, with construction of over 200 artificial harbors since 2002, six major seaports/terminals, 17 airports, and numerous seawalls and jetties (to name but a few examples).

Tourism and fisheries, both reliant on the country's natural capital, have been instrumental in Maldives' economic transition. Tourism and fisheries account for about half of the value-add to GDP and jobs, with their success intimately linked to the country's natural capital. While 8 out of 10 visitors report being attracted by the beaches, 6 out of 10 are drawn to the marine life. Beaches and marine life are maintained by the extensive coral ecosystem, which is critical for the islands' climate resilience.

High public spending, particularly driven by infrastructure investments, has led to a rising debt stock and concerns about the ability to service the debt. Public debt increased to an estimated 123 percent of GDP in 2023, compared to 77 percent in 2019. The twin deficits in fiscal and current accounts have increased the risk of debt distress and there are almost no fiscal or external buffers in place. High fiscal deficits and growing external liquidity pressures contribute to concerns over short-term liquidity and solvency. According to the debt sustainability analysis carried out by the World Bank and the International Monetary Fund in March 2024, increasingly higher repayment requirements would negatively affect several debt indicators, rendering debt unsustainable. As a result, Maldives is at a high risk of external and overall debt distress. Failure to implement planned fiscal reforms, while obtaining new external debt at expensive terms, could lead to a macro-financial shock. This would have significant negative impacts on the country's growth and debt profile and undermine the ability to finance urgent reconstruction and climate adaptation investments.

Climate change will have unprecedented impacts on the economy

Maldives is renowned for its unique island geography and rich biodiversity. With only 298 km² land surface, the country comprises 1,192 coral islands dispersed across 26 atolls over roughly 90,000 km². This makes it one of the most geographically dispersed countries on the planet. The country is distinguished by its extraordinary marine ecosystems, including extensive coral reefs that support natural island growth and a wide array of marine life that forms the foundation for economy and climate resilience. The land area has an average elevation of just 1.5 m, with 80 percent elevated less than 1 m. This fact renders Maldivians and their assets particularly vulnerable to sea level rise (SLR) and flooding, among other climate impacts.

SLR and related flooding is a major concern. Between 1992 and 2015, annual SLR averaged just under 4 mm. However, projections carried out by this Country Climate and Development Report (CCDR) suggest the rate could increase to between 6 and 12 mm per year, under severe warming scenarios, potentially leading to a rise of anywhere from 0.5 to 0.9 m by 2100. Without adaptation, coastal flooding could damage up to 3.3 percent of total assets by 2050 during typical 10-year floods. For rare, more intense events, damage to natural assets could reach up to 3.8 percent (for century-level floods) and 4.4 percent (for millennium-level floods).

Maldivian islands have adapted to SLR naturally in the past, but climate change impacts make their future natural adaptation potential highly uncertain. The physical foundation of atoll islands largely comes from the sand produced by marine ecosystems. This has historically enabled them to adapt to SLR. Despite SLR of 3–4 mm per year in recent decades, only 3 percent of the islands experienced net land loss from 2004

to 2016, while 59 percent saw increases in land area and 38 percent remained stable, owing to natural accretion and strategic land reclamation. However, the degradation of coral reefs compromises the islands' ability to sustain this vital sand production. More than economic loss, this represents a substantial reduction in the ecosystem services that coral reefs provide. The flood protection service of coral reefs alone is valued at US$442 million or 8 percent of GDP per year.

This CCDR estimates that SLR impacts would cause an almost 11 percentage point reduction of GDP by 2050 under a high-emission scenario—this impact, however, can be reduced to less than 6 percentage points with sustained reconstruction and adaptation investments. The macroeconomic modeling conducted for this CCDR assesses the impact of SLR on economic growth and the debt trajectory. It is based on scenarios with different considerations of reconstruction, adaptation investments, and fiscal consolidation. This reflects the critical role of fiscal reforms in improving the debt profile and boosting the government's ability to finance reconstruction and adaptation.

Almost all coral cover could be lost if global temperatures exceed 2°C. Ocean warming—resulting in coral bleaching events—is a major climate concern. Past ocean heating events in Maldives led to significant coral mortality. The severe 1998 coral bleaching event, for instance, resulted in a reduction of coral coverage from more than 70 percent to less than 10 percent. Fortunately, corals recovered to nearly pre-shock levels, until the next bleaching event occurred in 2016. Coral bleaching is cyclical, and corals can recover if they have the necessary time. However, climate change shortens the duration between ocean heatwaves and intensifies them. Modeling conducted for this CCDR estimates that almost all coral cover could be lost if global temperatures exceed 2°C. Even under a low-emission scenario, heatwave intensity will increase two to five times. Despite significant impacts, under the low-emission scenario, reefs would retain substantial coral cover. In addition to lowering global emissions, reducing impacts from local stressors such as coastal development and pollution will be key to preserving the country's vital coral reefs.

Severe climate-induced impacts are expected to begin in the second part of this century. The projections prepared for this CCDR on the climate change impacts on coral reefs, fish stocks, land, and infrastructure, all indicate that up until mid-century the negative impacts are expected to be incremental only. However, by around 2050, negative impacts are expected to escalate quickly, especially under the medium- to high-emission scenarios. Ocean heating, for instance, could cause an almost entire collapse of coral reefs and fish stocks. It is critical to use the decades leading up to these projected impacts to plan and build adaptative capacity for high-impact scenarios and, with the support of the international community, prevent them to the extent possible.

Impact of climate change on key sectors of the Maldivian economy

The tourism sector urgently requires accelerated climate adaptation efforts across its resort islands and guesthouses. A survey conducted for this CCDR across 55 resorts indicates that over 90 percent are grappling with moderate to severe beach erosion, while around 60 percent report considerable infrastructure damage due to climate-related events. However, many of the problems reported are not solely attributable to climate change. Islands naturally change (eroding in one area, while gaining land elsewhere) as a reaction to seasonal oceanographic patterns. Tourism infrastructure is often not designed with this changing environment in mind, requiring interventions to prevent naturally occurring erosion. Yet, as climate change alters natural oceanographic processes, often exacerbating their impacts, stepping up the climate resilience of the tourism sector is key. The sector also faces climate transition risks, including those related to the high carbon intensity of air travel.

Climate change is also anticipated to have a severe impact on the fisheries sector with analysis conducted for this CCDR projecting a dramatic decrease of almost 100 percent in fish catch potential by the end of the twenty-first century under a high-emission scenario. If no adaptation action is taken, such impacts could translate to almost 99 percent revenue reduction from fisheries. About 91 percent of key species are at very high risk from increased ocean temperatures and acidification. The Maldives' northern exclusive economic zone (EEZ) is particularly at risk of high rates of local species' extinction due to accelerated warming, whereas

the southern EEZ is expected to witness increased species' invasion rates alongside more intense marine heatwaves. In contrast, low-emission scenarios show inconsequential impacts on fish catch and revenue, reemphasizing the need for the international community to reduce emissions globally.

Importance of island-driven adaptation approach

There are five broad categories of adaptation options for making atoll islands more climate resilient: (a) protection infrastructure (using hard/gray measures to reduce SLR and flooding); (b) accommodation measures (building resiliently, such as on stilts or floating); (c) nature-based solutions (NbS), using natural practices such as restoring coral reefs or planting mangroves for flood protection); (d) island raising and land reclamation; and (e) relocation and migration. Underpinning these adaptation options are climate, disaster, and environmental monitoring and modeling as well as early warning systems (EWSs), serving as crucial tools to facilitate effective implementation.

These climate adaptation options must be tailored to the needs of each island. This CCDR develops an island typology and four archetypical Dynamic Adaptive Policy Pathways (DAPPs) that aim to guide island-level SLR adaptation strategies. The four pathways identified are (a) protection, (b) transition to protection, (c) transition to accommodation with nature-based measures, and (d) pure accommodation with nature-based measures. These generic pathways offer a starting point for developing more detailed adaptation strategies for individual islands and recommend solutions for various situations and points in time.

Choosing the right island adaptation measures

Currently, the most prevalent coastal adaptation measures are land reclamation and hard/gray coastal protection infrastructure. More than three-quarters of the 188 inhabited islands have seen some form of island or sandbank widening (and in selected cases also raising) or a seawall, breakwater, or groyne erected on its shores. Between 2000 and 2016, a total area of 10 km^2 was reclaimed (about 3 percent of the total land area). In the past, reclamation has primarily been done to create additional space for housing and economic development and not for climate adaptation, with most of the reclaimed areas not raised higher than the original surface area. However, climate adaptation is likely to become a more prominent objective for choosing land reclamation going forward.

While gray-engineered measures currently dominate adaptation efforts on both inhabited islands and resort islands, several resort islands have experimented with NbS. From 2004 to 2016, 47 inhabited islands implemented coastal protection interventions and 45 of them chose gray interventions. Very few inhabited islands have implemented NbS such as mangrove planting or coral restoration. Resort islands also report a predominant use of gray solutions although to a smaller degree. About 40 percent of resort islands reported application of beach nourishment, more than 15 percent mangrove plantation, and about 5 percent coral restoration.

Island raising and reclamation can address risks from SLR but can also exacerbate vulnerabilities. Hulhumalé, for instance, was designed and developed with future SLR in mind and features extensive island augmentation. The land was raised to approximately 1.8 m above mean sea level to reduce flood risks. However, land reclamation often affects lagoons and coral reefs, which are instrumental in natural island formation and growth, by disrupting natural sediment transport processes. The removal and redistribution of sand and sediment can also damage coral structures that protect against coastal erosion and flooding.

Gray infrastructure can have tangible coastal protection benefits in some cases but also detriments in other cases. Depending on the island type, coastal protection with gray infrastructure may be the right-fit approach to coastal protection. That said, there are also maladaptive examples—islands locked into hard protection pathways lead to destruction of protective coral reefs, which has negative impacts on the tourism and fisheries sectors that rely on healthy coral ecosystems. On inhabited islands, gray coastal protection measures are often a solution to the consequences of past island development choices, including infrastructure placement and type, rather than to climate change impacts. These coastal modifications have

had impacts in the form of coastal erosion down current. Consequently, efforts are being made to mitigate these erosion effects through coastal protection measures. This highlights the complexity of coastal protection in the face of economic imperatives such as tourism as well as the urgent need for a nuanced approach that combines engineered and nature-based measures. Such a balanced strategy aims to protect island communities while preserving ecological integrity and adaptive capabilities.

Maldives' commitment to climate change adaptation

The government has established a comprehensive policy framework to address climate change, but implementation is hampered by inadequate inter-agency coordination, translation of policies into action, and tracking of commitments. The lack of a detailed National Adaptation Plan (NAP) as well as weaknesses in project planning, preparation, and selection exacerbate effective public investments in climate adaptation. The 2020 Nationally Determined Contribution (NDC) targets a 26 percent reduction in emissions by 2030, with aspirations for net zero emissions, contingent on international support. However, policy implementation is hampered by coordination challenges among institutions with partly overlapping mandates and disjointed activities. Local island councils also struggle to manage climate impacts and disaster response, and central agencies face challenges in monitoring and forecasting.

Transitioning to a green economy

Maldives can reap significant development benefits from a green transition in key sectors, particularly energy. The country is heavily dependent on imported diesel fuel for electricity production which accounts for over 90 percent of its energy needs. The fuel import bill was US$507 million (8 percent of GDP) in 2022, with US$61 million paid in subsidies. The potential fiscal and foreign exchange savings from switching to cheaper solar energy could help facilitate investments in climate resilience and other development objectives over the medium to long term. In addition, creating its own energy would reduce vulnerability to global energy shocks and create quality jobs for the local population. There are also significant development benefits from transitioning transport, housing, and waste management to a greener pathway. However, large investments in the green transition need to be planned carefully and implemented sequentially considering the current macro-fiscal limitations.

Enhancing social protection and skills development is crucial for building the resilience of people and communities and fostering sustainable growth. Poor and vulnerable households in Maldives report higher incidences of floods and droughts. Remote atolls face increased risks of coastal flooding and extreme sea levels and have more difficulty accessing post-disaster support. There is a foundation for a responsive social protection delivery system, but it requires improved digital infrastructure, data, financing, and institutional strengthening. Existing social and social protection programs need to be more adaptive, scalable, and targeted to reach the poorest households. Skill development and unemployment insurance could help mitigate risks from green transition policies, which must be designed carefully, as they could also further add strain to public finance. A robust social protection system, digitization, and smart policy design can shield the poor from the impacts of decarbonization reforms, such as energy subsidy removal.

How to finance climate action in Maldives

The financing requirements for Maldives' climate change adaptation to SLR and flooding alone range between US$2 billion and US$4 billion. This estimate is based on selecting bespoke coastal protection solutions to cater to the physical characteristics of each island (which contrasts with previous estimates based on the costliest measures). It does not include other adaptation costs such as those related to ocean warming, which will significantly threaten tourism and fisheries. Similarly, it also does not include the financing gap for mitigation, which has been estimated at US$1 billion.

Restoring fiscal space, building external buffers, and ensuring macroeconomic stability will be a prerequisite to mobilizing the required financing for climate action. Major policy reforms are urgently needed, including significant expenditure adjustments via reforms in subsidies, the health sector, public investment, asset and debt management, and state-owned enterprises (SOEs) and private sector support.

In addition, structural reforms are needed to diversify the economy over a longer term. Revenue-side measures such as the Green Tax and airport development fees could be increased to finance urgently needed climate action.

The financing gap cannot be met by domestic public finance alone. A variety of external financing sources should be explored. Grants and concessional financing totaling around US$500 million have contributed to financing climate projects in the past. For adaptation investments that are not commercially viable, grants will continue to be crucial but will not be sufficient to fill the significant financing gap. New sources of concessional funds may be tapped, which could be facilitated by establishing dedicated conservation and climate adaptation trust funds. Related to that, the government could consider other debt-neutral instruments such as debt-for-nature swaps or donor outcome-based bond structures. The country can also tap into carbon markets, including for blue carbon projects, and develop climate-related risk management financial products such as insurance and instruments for disaster risk financing.

Mobilizing private sector finance will be critical but might require de-risking instruments to attract investors. Maldives needs an updated public investment management (PIM) framework and could expand public-private partnerships (PPPs) to mobilize green finance. Once the existing fiscal and external vulnerabilities are addressed and the appropriate regulatory frameworks are in place, more projects can be bid out to the private sector. The small project size and lack of capacity might require the use of de-risking instruments to attract more private capital and foreign direct investment (FDI) to meet climate adaptation and mitigation financing needs. A fiscal commitments and contingent liabilities (FCCL) framework for PPP projects can help manage the associated fiscal risks and enhance coordination between institutions.

Structure of the main report and recommendations

Figure ES.1: Conceptual framework for climate change and development in Maldives

The main report analyzes the climate resilience and green transitions as well as the enablers to address critical climate hazards and reap development benefits in more detail. Figure ES.1 presents the report's conceptual framework. After an introduction to the Maldives' development trajectory, the CCDR discusses the main climate hazards—SLR and ocean warming—based on several pieces of original modeling work conducted for this report (Chapter 1). At the core of the report is the discussion of the key resilience

transitions for climate-resilient ecosystems (Chapter 3), islands and infrastructure (Chapter 4), and livelihoods (Chapter 5), focusing on tourism (5.1) and fisheries (5.2) as the main sectors of the economy as well as social protection and people (5.3). The need for a green transition is discussed in Chapter 6 and focuses on energy (6.1), mobility (6.2), and waste (6.3). The CCDR identifies four key enablers for the resilience and green transitions: macro and fiscal stability as well as finance (Chapter 7), policies and institutions (Chapter 2), and adaptation planning (Section 4.2).

Based on the findings from this analysis, this CCDR presents a set of Key Recommendations that are structured along six High-Level Objectives. The High-Level Objectives are aligned with the report's conceptual framework. The Key Recommendations build on a longer list of technical recommendations identified throughout the report at the end of the individual chapters and sections. Table ES1 provides a snapshot of the Key Recommendations with those considered *urgent* (as defined in the main report) marked with a ★ symbol. The Key Recommendations are further elaborated (including in terms of the time frame for implementation, synergies and trade-offs with other development objectives, implementation barriers, and progress indicators) in Chapter 8 of the main report.

Table ES1: High-level objectives and snapshot of key recommendations

High-Level Objective 1: Improve macroeconomic stability and fiscal space to finance climate action	
★ ✓	(**1.1**) Reduce expenditure related to subsidies, infrastructure, expensive health care options, and SOEs to return public spending to sustainable levels; address fiscal vulnerabilities; create space for climate-related spending over the medium term; and increase private sector participation.
★ ✓	(**1.2**) Implement revenue mobilization measures including tax reforms such as raising the Green Tax and dedicating proceeds to environmental- and climate-resilient interventions.
★ ✓	(**1.3**) Pass a new Public Debt Management Bill and a revised Fiscal Responsibility Act to address debt vulnerabilities.
★ ✓	(**1.4**) Limit the sovereign-bank nexus to allocate more resources to the private sector for climate adaptation investments and enhance banking regulation and supervision to ensure financial stability.
High-Level Objective 2: Mobilize climate finance	
★ ✓	(**2.1**) Operationalize the Climate Finance Hub and develop a climate investment plan with bankable projects.
✓	(**2.2**) Set up a conservation and climate adaptation trust fund with appropriate governance structures to help attract additional concessional finance for climate adaptation and environmental protection.
✓	(**2.3**) Develop a national carbon market strategy and infrastructure and promote the development of robust carbon crediting systems to tap into finance from voluntary and compliance markets.
✓	(**2.4**) Introduce climate budget tagging to improve climate-related spending and decision-making and facilitate the engagement with green investors.
High-Level Objective 3: Enhance the climate resilience of islands and infrastructure	
★ ✓	(**3.1**) Develop an NAP and related island/regional development plans that explicitly integrate SLR, flooding, and ocean heating scenarios to guide future spatial and development planning.
★ ✓	(**3.2**) Develop guidelines for island raising and land reclamation to optimize their use and, when used, increase the resilience and sustainability of newly developed land and limit negative environmental impacts.
★ ✓	(**3.3**) Systematically study the feasibility and unintended side effects of hard/gray protection infrastructure and preserve natural island processes to avoid maladaptation and lock-in effects.
✓	(**3.4**) Update building codes and practices to increase the resilience and sustainability of infrastructure.
✓	(**3.5**) Further assess the feasibility and effectiveness of NbS to support their scale-up.

High-Level Objective 4: Enhance the climate resilience of ecosystems	
	(**4.1**) Develop a coral management and funding plan with a time horizon until 2050 to scale up coral reef restoration, including exploring emerging restoration technologies.
	(**4.2**) Improve waste management and coastal infrastructure development to reduce local stressors on coral reefs.
	(**4.3**) Systematically develop and implement marine protected areas (MPAs) to conserve high-biodiversity marine and coastal ecosystems.
	(**4.4**) Establish a coral reef management decision support system to guide the targeting of conservation and restoration interventions.
High-Level Objective 5: Enhance the climate resilience of livelihoods (fishers and tourism)	
	(**5.1**) Research pelagic and reef fish migration and impacts under different climate scenarios to inform fisheries planning.
	(**5.2**) Assess alternative livelihood opportunities for fishers such as diversification of deep-sea fisheries and mariculture development to improve the resilience of fishing communities.
	(**5.3**) Strengthen the regulatory framework to ensure that new resorts and guesthouses are being developed using climate-resilient and green infrastructure, existing resorts and guesthouses receive advice on and support for upgrades/retrofits, and minor repair and climate resilience upgrade works can proceed without lengthy approval processes.
High-Level Objective 6: Unlock the development benefits from green transitions in the energy, mobility, and waste sectors	
	(**6.1**) Phase out fossil fuel subsidies and reduce public expenditure while mitigating the impacts on poor and vulnerable households.
	(**6.2**) Promote risk-sharing frameworks and increased private sector participation and PPPs to increase renewable energy adoption and improve waste management.
	(**6.3**) Introduce a renewable energy mandate for resorts to increase the share of renewable energy.
	(**6.4**) Develop a strategy and action plan to promote green mobility, including non-motorized transport, e-scooters, e-buses, e-ferries, and charging infrastructure.

1. Maldives' Intertwined Development and Climate Change Challenges

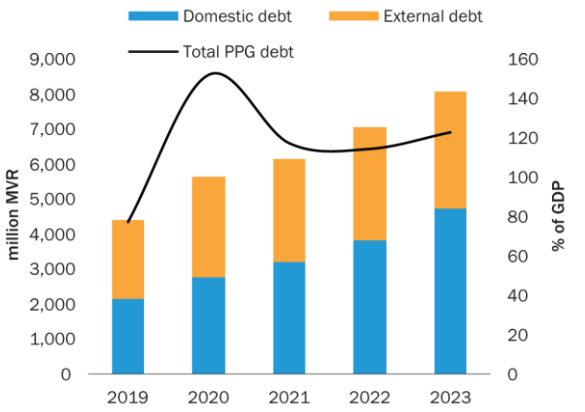
1.1. Overview of Maldives' development trajectory in a changing climate

Maldives, an archipelago state in the Indian Ocean, is renowned for its unique geography and abundant biodiversity and marine resources. Spanning a mere 298 km² of land across 1,192 coral islands scattered over 26 atolls in an area of about 90,000 km², Maldives' territory is 99 percent water with one of the world's most dispersed landmasses. The country is noted for its remarkable marine ecosystems, which include vast coral reefs that contribute to the natural formation of islands and a diverse range of sea life that underpins the nation's economic prosperity and resilience to climate change. With an average elevation of only 1.5 m above sea level—the lowest globally—about 80 percent of its territory is less than 1 m above sea level.[1] Consequently, the Maldivian people and their property are especially susceptible to the consequences of rising sea levels and other climate-related challenges.

Maldives has been a development success story over the past two decades, capitalizing on its natural capital to transition from a low-income to a middle-income country. Real gross domestic product (GDP) per capita has doubled between 1990 and 2021 (to almost US$11,000 per year in constant 2021 US$). In 2023, Maldives could boast of the highest GDP per capita in South Asia. The population living on less than US$3.65 a day decreased from 7.2 percent in 2002 to virtually zero in 2019. Many human capital indicators are on par with high-income economies. Near-universal primary education and universal access to electricity were achieved and life expectancy rose to 78 years, while child and maternal mortality drastically decreased. Educational attainment has significantly increased over the last few decades. Nearly 100 percent of the population has access to water supply and basic sanitation services, with significant improvements, particularly in rural areas.[2] The number of broadband internet connections increased from 190 in 2002 to more than 63,000 in 2020.[3] However, these achievements have come at the cost of fiscal imbalances, driven by highly expansionary infrastructure spending, rising recurrent spending including subsidies and health, and interest payments.

High public debt is a key concern; limited fiscal and external buffers constrain the ability to finance its climate-related spending and attract foreign and private investment. Total public and publicly guaranteed debt stood at US$8.1 billion or around 123 percent of GDP in 2023 (see Figure 1). The overall fiscal and current account deficits averaged at 13 percent and 16.2 percent of GDP, respectively, between 2021 and 2023. Moreover, fiscal risks were estimated at US$2.5 billion or 45 percent of GDP in 2019. A sharp spike in external debt repayments leading up to 2026 heightens the fiscal and external vulnerabilities. The country is projected to pay, on average, about US$512 million annually as external debt servicing over 2024–2025, which is expected to jump to US$1.1 billion in 2026.

Figure 1: Maldives' public debt has reached unsustainable levels



Source: Ministry of Finance. 2024. "Quarterly Public Debt Bulletin for 2024 (Q1)." GDP figures are World Bank Staff calculations.

[1] Dauphin, L., and A. Voiland. 2021. "Preparing for Rising Seas in the Maldives." NASA Earth Observatory.
[2] WHO, and UNICEF. 2022. "Joint Monitoring Program Estimates on WASH."
[3] World Bank. 2022. World Development Indicators.

Tourism and fisheries, drivers of the country's transformation, contribute to about half of the value-add to GDP and jobs. The tourism sector alone accounts for almost 30 percent of GDP, more than 60 percent of foreign exchange receipts, and almost 50 percent of public revenues.[4] One-quarter of all women and one-third of men work directly or indirectly in tourism,[5] with direct employment in resorts dominated by male and foreign workers (in 2019, resorts employed 45,000 people, of which foreign male and local male employees accounted for 45 percent each, foreign females for 7 percent, and local females only for 3 percent).[6] The second-largest economic sector is fisheries, which contributes around 4.5 percent of nominal GDP and 50 percent of merchandise exports; it provides direct or indirect income to more than 20 percent of the population.[7]

The success of the tourism and fisheries sectors is closely linked to the health of natural capital, which is under threat from climate change. The tourism sector, drawing visitors for its pristine beaches and vibrant marine life, reports that 80 percent of tourists are attracted by the beaches and over 60 percent by underwater activities.[8] This demonstrates the importance of coral reef health, upon which 3 in 10 fish species depend. The fisheries sector's profitability, particularly in tuna fisheries, also hinges on the health of coral reefs and marine ecosystems. However, economic and tourism growth has not always been sustainable and in part undermined the natural capital foundation. For example, ocean pollution from significant amounts of per capita waste and coastal infrastructure development has been found to negatively affect island and marine ecosystems, which are already stressed by sea level rise (SLR) and higher ocean temperatures.[9]

The government has formulated an extensive framework for development and climate action, but the economic situation is very fragile. Key policies include the Strategic Action Plan (SAP) 2019–2023,[10] 2021 Climate Emergency Act, and 2020 updated Nationally Determined Contribution (NDC). These policies focus on fostering interconnectivity across the archipelago and promoting inclusive growth. Central to the SAP is the advancement of the blue economy, with specific goals to boost tourism and fisheries, conserve coral reefs, and develop infrastructure to attract international events. Despite these ambitious objectives, the country's fragile economic situation, marked by slow growth, high public debt, and a precarious macroeconomic outlook, poses substantial challenges. GDP saw a sharp decline of 32.9 percent in 2020 due to the COVID-19 pandemic, followed by a recovery with growth rates of 37.7 percent in 2021 and 13.9 percent in 2022, surpassing pre-pandemic levels. This recovery, however, has begun to falter, with GDP growth slowing to 4 percent in 2023, even as tourist arrivals hit a record high of 1.88 million, marking a 12.1 percent increase over 2022.

A climate-resilient development path is not just a strategic response to climate and environmental challenges, it is fundamentally the most sustainable and beneficial trajectory for the nation's economic and social development. Maldives has begun to seize the opportunities of a blue and green economy. However, much more needs to be done to preserve the natural capital on which its economy is based and to unlock additional areas for green, resilient, and inclusive growth. Green transitions in the energy, mobility, waste, and housing sectors can build resilience, reduce harmful climate and environmental impacts, and save fiscal space in the longer term. Clean ocean water and waste management are key for tourism, fisheries, and people. Recent investments and policy reforms such as the upgrade of regional waste management facilities, the single-use plastics phase-out plan, and new regulations requiring waste segregation are encouraging but need to be sustained and expanded to additional areas. Maintaining environmental sustainability and establishing appropriate links to value chains will be critical in developing high-value products supplied to the local tourism industry or niche international markets.

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[4] World Bank Group. 2023. *Maldives Country Partnership Framework*.

[5] Ibid.

[6] National Bureau of Statistics. 2019. "Employment in Tourist Resorts 2019." Government of the Maldives.

[7] World Bank. 2020. *Maldives Systematic Country Diagnostic*.

[8] World Bank. 2024. *Maldives: Country Environmental Analysis. Towards a More Sustainable and Resilient Blue Economy*. Washington, DC: World Bank Group.

[9] Ibid.

[10] A new SAP was being developed at the time of finalizing this report.

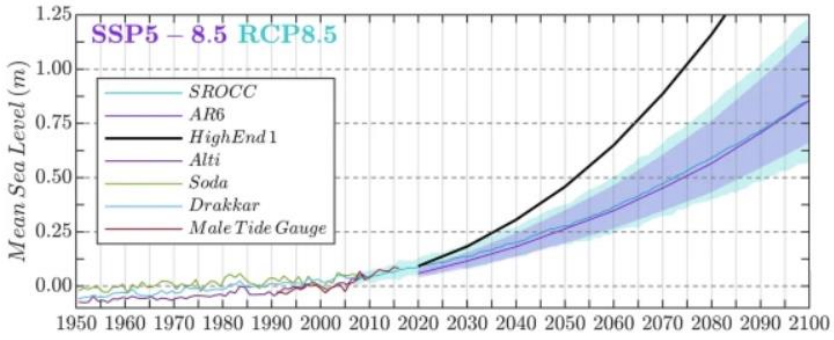
1.2. Climate change impacts in Maldives

This Country Climate and Development Report (CCDR) focuses on the two main climate risks in Maldives: (1) SLR, flooding, and coastal erosion and (2) ocean warming and acidification.

1.2.1. Impacts from SLR, flooding, and coastal erosion

SLR is the first and foremost climate change threat and has the potential to be existential. At least 80 percent of the landmass lies less than 1 m above mean sea level, and over 40 percent of the population resides within 100 m of the coastline.[11] Malé, for instance, has an average elevation of only 3 m above sea level and Hulhumalé is, on average, 2 m above sea level. Most of the islands' population and economic activity is concentrated near the shoreline; 36 percent of all buildings are located within 100 m from the shoreline, while 71 percent of buildings are located within 200 m.[12] From 1992 to 2015, the average annual SLR was just below 4 mm.[13] However, in a strong warming scenario (Representative Concentration Pathway [RCP] 8.5), the rate of SLR could escalate to 6–12 mm per year. This acceleration could result in a cumulative SLR of 0.2–0.5 m by 2050 and up to 1 m by 2100 compared to the 1995–2014 mean (see Figure 2). For Maldives, such levels of SLR are possibly an existential threat, given its low-lying terrain and erodible landforms. SLR could lead to frequent inundation or even submersion of islands, significantly reducing the already limited land available.

Figure 2: Projected acceleration in mean sea level in Maldives



Source: Amores, et al. 2022. "Coastal Flooding and Mean Sea-Level Rise Allowances in Atoll Islands." Scientific Reports 12: 1281.
Note: The figure shows sea levels relative to the mean of 1995–2014; SROCC, AR6, and HighEnd1 refer to different estimates of SLR based on different underlying scientific methods and physical models.

Maldivian islands have historically adapted to SLR naturally, but their future natural adaptation potential is now highly uncertain. Atoll islands have greater geomorphic resilience than commonly recognized due to their continual morphological adjustment in response to natural variations in climate at seasonal to decadal timescales, global climate change, and anthropogenic factors. These islands have persisted for millennia since their formation, although their configuration has changed. Many Maldivian atolls were established during the mid-Holocene epoch under slightly higher than current sea levels. Despite SLR over the past two decades, the land area of most islands has remained either stable (38 percent) or increased (59 percent), with only 3 percent (or five islands) reducing in size.[14] A key factor in island formation is the natural accumulation of sediments from corals and algae. In theory, coral reefs could keep pace with significant future SLR, as they have in historical periods. For example, between 4,000 and 2,100 years ago, when SLR was 0.5 m above current levels, Maldivian islands also rose in elevation. However, rising ocean temperatures pose a

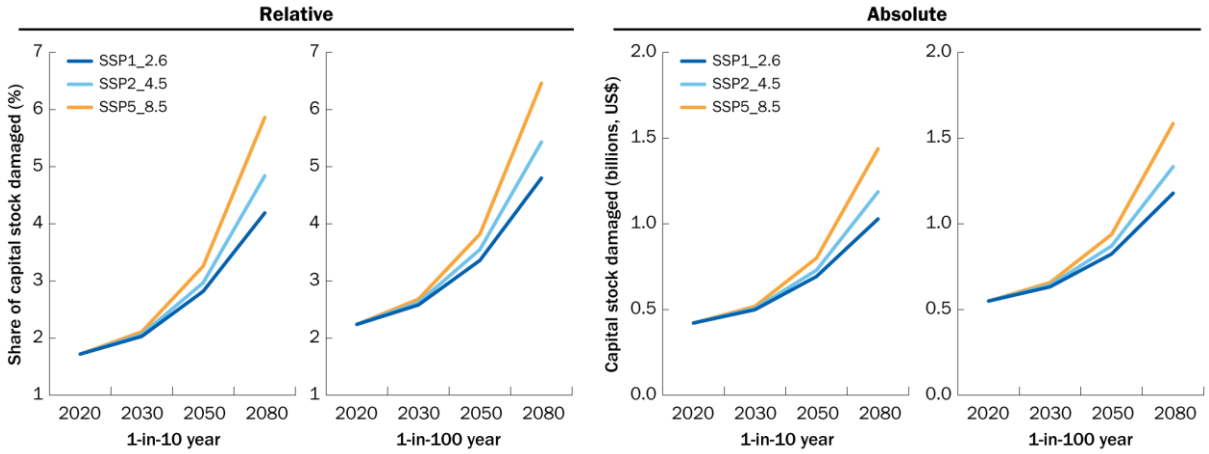
[11] World Bank. 2024. *Maldives: Country Environmental Analysis. Towards a More Sustainable and Resilient Blue Economy*. Washington, DC: World Bank Group.
[12] World Bank staff calculation.
[13] World Bank. 2024. *Maldives: Country Environmental Analysis. Towards a More Sustainable and Resilient Blue Economy*. Washington, DC: World Bank Group.
[14] Duvat, V. K. 2020. "Human-Driven Atoll Island Expansion in the Maldives." *Anthropocene* 32: 100265.

significant threat to corals, potentially exceeding past rates of change. In addition, human interventions on the coastline are a recent phenomenon, the implications of which are not yet fully understood.

Despite a clear understanding of the historical impacts of SLR, the islands' capacity to adapt to future impacts remains largely unknown. This is particularly true given the expected heterogeneity of future SLR impacts on the more than 180 inhabited islands and the more than 160 resort islands. The limitation lies in the absence of local models for planning and data on locally measured sea levels, bathymetry, or topography. Global models, on the other hand, often fail to capture local SLR and wave dynamics, and typically only consider sea levels rising without accounting for the potential growth of the islands. This lack of meaningful information on likely local SLR projections and resulting inundation hinders Maldives from fully considering the looming threat of SLR in spatial and investment planning.

The most significant risk from SLR is increased flooding. This risk is not just about the gradual encroachment of water but also the heightened magnitude and frequency of extreme water level events leading to more frequent and severe flooding. At present, coastal flooding resulting from extreme storm surges could already pose significant damage to buildings and infrastructure.[15] Under a 1-in-10-year event,[16] storm surge-induced coastal flooding could affect assets valued up to 2 percent of the total asset stock[17] (approximately US$421 million). Under a more extreme 1-in-1000-year event, the affected assets are valued at about 3 percent of the total asset stock[18] (around US$675 million). The annual expected damages amount to around US$200 million[19] but depend critically on existing flood protection standards, which is not accounted for in the abovementioned estimated damages.[20]

Figure 3: Capital stock damaged from coastal flooding in relative (share of total capital stock) and absolute (US$) terms, under different climate change scenarios



Source: World Bank staff calculation using coastal flood layers from FATHOM 3.0.

Without any adaptation to SLR, more valuable land and productive capital essential for the economy will be exposed to and damaged by coastal flooding. Depending on the climate scenarios, in 2050, coastal flooding can result in damages of up to 2.8–3.3 percent of the total asset stock in a 1-in-10-year event, 3.4–3.8 percent in a 1-in-100-year event (see Figure 3), and 3.9–4.4 percent in a 1-in-1000-year event (not

[15] The analysis presented in this paragraph is based on World Bank staff calculation using coastal flood layers from FATHOM 3.0.

[16] A 1-in-10-year event refers to an event whose severity and/or magnitude is expected to be equaled or exceeded on average once in 10 years.

[17] The analysis considers buildings, roads, ferry terminals, airports, education facilities, health facilities, and hospitals.

[18] The relatively small increase of impacts from 1-in-10 to 1-in-1000-year events is likely due to the absence of long swell wave dynamics in the underlying flood model, which could result in temporary overtopping and overwash.

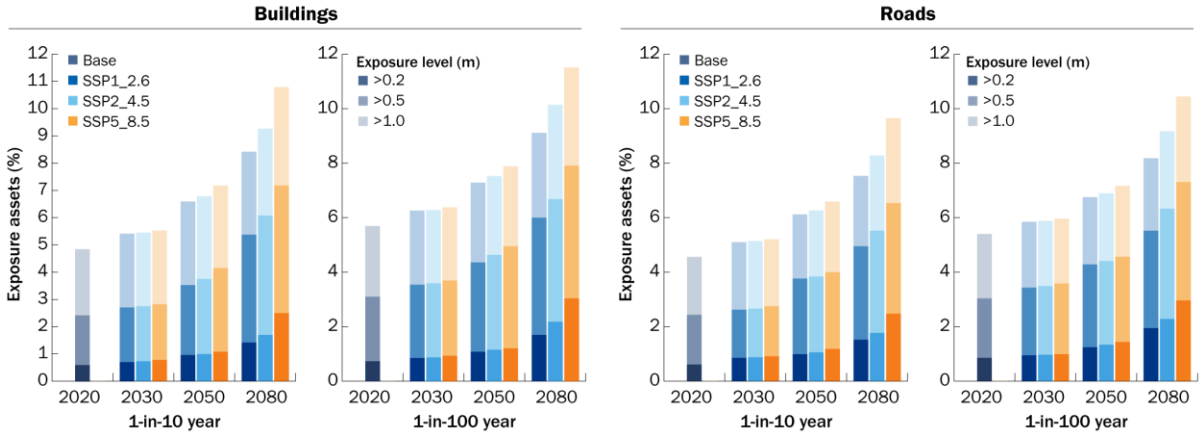
[19] The flood risk assessment assumes that flooding takes place across all islands simultaneously, which is highly unlikely. The storm conditions that drive extreme water levels differ across atolls (Indian monsoon, swell waves, and so on), making it unlikely that extreme water levels occur at all islands at once.

[20] Coastal flood protection is not physically accounted for in the flood model. However, the risk estimates are sensitive for the level of protection assumed. For instance, using a protection level of two years lowers the risk estimates by 30 percent, whereas assuming a protection level of five years lowers the risk by more than 50 percent.

shown). These damages are equivalent to US$0.7–1.1 billion or between 11.3 and 17.7 percent of GDP. Toward 2080, the damage rises as high as US$1.6 billion even under a 1-in-100-year event. This is without accounting for the expected socioeconomic growth over the decades to come, which might further increase the amount of capital and assets located in areas at risk of coastal flooding. For instance, the population growth is projected to reach almost 1 million by 2054,[21] further increasing the capital stock required to serve these residents.

While the total potential damages from coastal flooding are relatively large, the number of exposed assets is relatively low. Currently, under an extreme 1-in-100-year event, approximately 6.0 percent, 3.0 percent, and 0.7 percent of all buildings are exposed to at least 20 cm, 50 cm, and 100 cm of flooding, respectively (see Figure 4).[22] Toward the end of the century, under a mild climate change scenario of RCP4.5, the numbers would go up to around 10.5 percent, 7.0 percent, and 2.4 percent for the same flood depth thresholds. The pattern is relatively similar for road infrastructure, with approximately 9.0 percent, 6.5 percent, and 2.4 percent of the total road length exposed to at least 20 cm, 50 cm, and 100 cm of flooding, respectively, under a 1-in-100-year event in 2080. The relatively low number of exposed assets highlights the need for a more detailed assessment using higher resolution models so that adaptation investments can be better targeted to assets that are actually exposed to flooding.

Figure 4: Assets exposed to inundation from coastal flooding under different climate scenarios



Source: World Bank staff calculation using coastal flood layers from FATHOM 3.0.

Note: 'Buildings' category refers to all buildings as identified by the Google Building Footprints, which include residential, commercial, industry, health care facilities, education facilities, and other critical facilities.

Alongside SLR impacts on the overall capital stock, the tourism sectors will face increasing pressure from rising water levels. The resort islands will be challenged by the risk of permanent inundation, increasing storm surges leading to flooding and erosion, and less reliable services of supportive infrastructure for tourism (for example, ferries, airports, and health facilities). At present, 3.6–3.9 percent (1-in-10 to 1-in-100-year event) of the resort island landmass, equivalent to around 1.3–1.4 km^2, is affected (more than 0.5 m of inundation) by coastal flooding (see Figure 5). In 2050, the additional landmass affected is 0.17–0.22 km^2 for a 1-in-10-year event and 0.14–0.24 km^2 for a 1-in-100-year event.

SLR will further exacerbate water security. Maldives does not have suitable surface water sources. The demand for freshwater is met by a combination of shallow groundwater, rainwater harvesting, and desalination. The country faces a challenging water future, with the lowest internal renewable water resources per capita compared to regional peers, significantly lower than the average of Small island developing states (SIDS).[23] Per capita renewable water resources have decreased from nearly 300 cubic

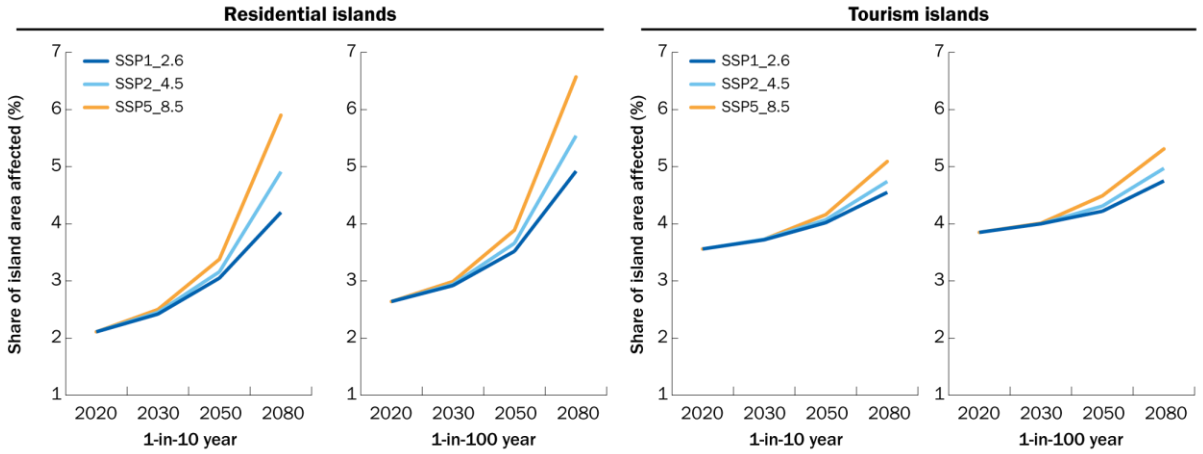
[21] National Bureau of Statistics, Government of the Republic of Maldives. 2018. "Maldives Population Projections 2014-54: Assumptions and Result Analysis."

[22] The analysis presented in this paragraph is based on World Bank staff calculation using coastal flood layers from FATHOM 3.0.

[23] FAO. 2020. "AQUASTAT data." Food and Agriculture Organization of the United Nations.

meters in 1964 to 55 cubic meters in 2020, largely due to population growth, which will continue to stress existing sources as the country develops.[24] Groundwater in atoll islands is found in a layer of freshwater known as a freshwater lens, which is located 1–1.5 m below the surface, making it particularly prone to pollution from saltwater intrusion and human activities.[25] The freshwater lenses are recharged through rainfall and are therefore vulnerable to seasonal rainfall variability in the short term and changes in precipitation resulting from climate change in the long term.[26] Agriculture and food production are limited due to the small size of the islands, land scarcity, poor soil conditions, and limited water resources. However, the sector is crucial in terms of national development goals, food security, poverty alleviation, and employment.[27] Despite a lack of assessments, increased salinity of groundwater is likely to negatively affect agricultural productivity.

Figure 5: Share of island areas exposed to at least 0.5 m of inundation from coastal flooding



Source: World Bank staff calculation using coastal flood layers from FATHOM 3.0.

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[24] Ibid.

[25] World Bank, and Australian Aid. 2013. "Combating Water Insecurity in the Maldives: An Integrated Water Management Approach."

[26] Bailey, R. C., A. F. Khalil, and V. Chatikavanij. 2014. "Estimating Transient Freshwater Lens Dynamics for Atoll Islands of the Maldives." *Journal of Hydrology* 515: 247–256. https://doi.org/10. 1016/j. jhydrol. 2014. 04. 060.

[27] Ministry of Environment, Republic of Maldives. 2020. "Updated Nationally Determined Contribution 2020." United Nations Framework Convention on Climate Change.

World Bank, and Asian Development Bank. 2021. "Maldives Climate Risk Country Profile."

[28] FAO. 2020. "AQUASTAT data." Food and Agriculture Organization of the United Nations.

[29] Ibid.

[30] World Bank, and Australian Aid. 2013. "Combating Water Insecurity in the Maldives: An Integrated Water Management Approach."

[31] Bailey, R. C., A. F. Khalil, and V. Chatikavanij. 2014. "Estimating Transient Freshwater Lens Dynamics for Atoll Islands of the Maldives." *Journal of Hydrology* 515: 247–256. https://doi.org/10. 1016/j. jhydrol. 2014. 04. 060.

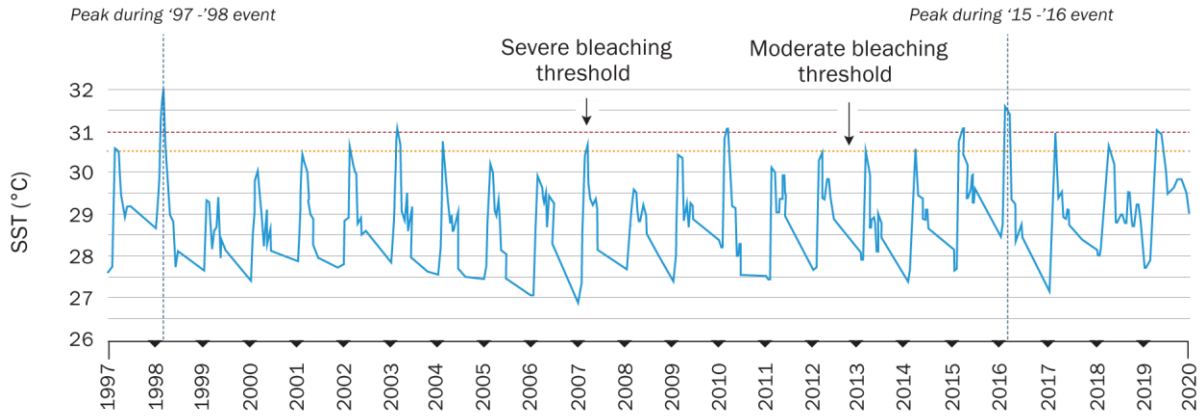
employment.[32] Despite a lack of assessments, increased salinity of groundwater is likely to negatively affect agricultural productivity.

1.2.2. Impacts from ocean heating

Ocean heating and its impacts on coral reefs and fish stocks are the other major climate change threats. Maldives is home to unique coastal and marine ecosystems, which are rich in biodiversity and crucial for its economy. Particularly its coral reef assets stand out in terms of their extent and the ecosystem services they provide, covering up to 4,510 km^2 and considered the fifth richest in the world.[33] The tourism and fisheries industries are critically dependent on these ecosystems.[34] Ocean heating driven by climate change is expected to negatively affect coral reefs and the distribution of fish species, placing pressure on both industries and the economy overall.

Maldives has experienced significant coral bleaching events in the past, resulting in the loss of up to 60 percentage points of coral cover. Ocean temperatures fluctuate naturally, partly driven by the El Niño–Southern Oscillation (ENSO) phenomenon. The higher-than-average ocean temperatures during ENSO cause heat stress for corals. Bleaching events occur when temperatures rise too quickly or too high. There have already been significant coral bleaching events in the past, for example, in 1998 and 2016 (see Figure 6), leading to the destruction of up to 40–60 percentage points of coral cover. Corals have recovered after past bleaching events, although not fully, and the recovery took several years. In the case of the 1998 bleaching event, it took 16 years to reach 65 percent of cover (see Figure 7). At the time of finalizing this report, Maldives was on the verge of another bleaching event with high levels of bleaching alerts throughout May 2024.[35]

Figure 6: Sea surface temperature and severe coral bleaching thresholds (1997 and 2020)



Source: Montefalcone, M., C. Morri, and C. N. Bianchi. 2020. "Influence of Local Pressures on Maldivian Coral Reef Resilience Following Repeated Bleaching Events, and Recovery Perspectives." Frontiers in Marine Science 7: 587.

Climate change is expected to increase the intensity and frequency of bleaching events, placing coral reefs at significant risk. Marine heatwaves are projected to further increase in frequency and intensity in the twenty-first century.[36] Original work carried out for this CCDR finds that, in a low greenhouse gas (GHG)

[32] Ministry of Environment, Republic of Maldives. 2020. "Updated Nationally Determined Contribution 2020." United Nations Framework Convention on Climate Change.

World Bank, and Asian Development Bank. 2021. "Maldives Climate Risk Country Profile."

[33] International Coral Reef Initiative. 2022. Maldives, ICRI.

IUCN. 2022. "Maldives Launches Assessments of 39 Coral Species."

[34] World Bank. 2024. *Maldives: Country Environmental Analysis. Towards a More Sustainable and Resilient Blue Economy*. Washington DC: The World Bank Group.

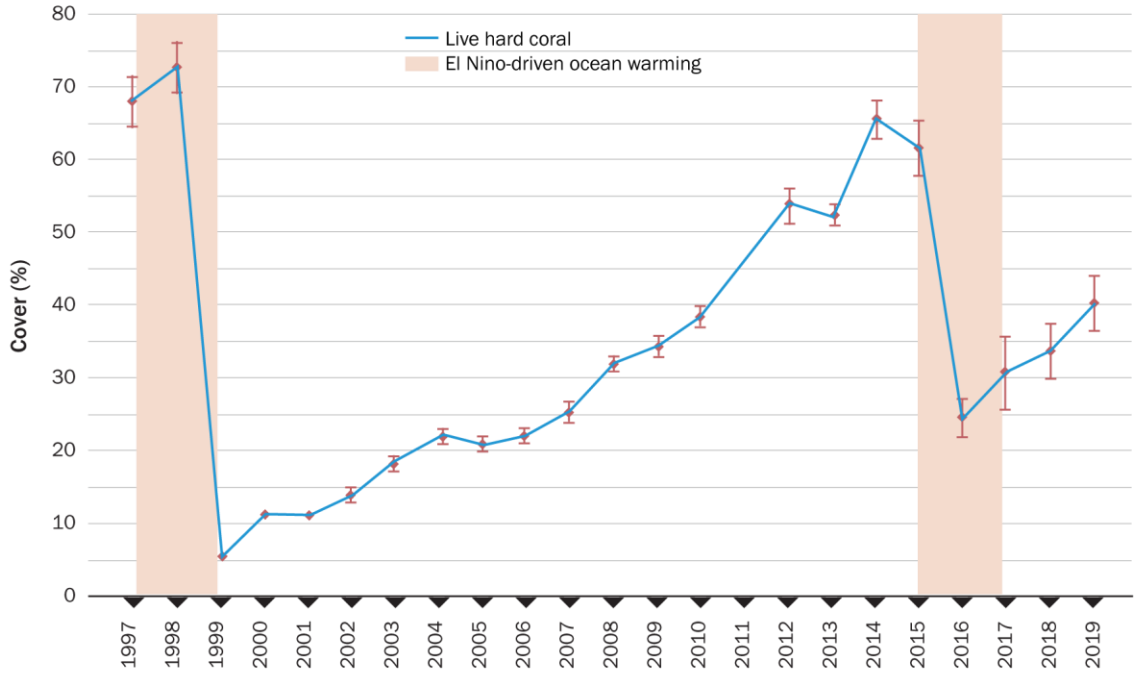
[35] NOAA. 2024. "Maldives 5 km Regional Bleaching Heat Stress Maps and Gauges (Version 3.1)."

The extent of bleaching and whether mass coral bleaching occurred could not be assessed by May 2024, when this report was being finalized, as events were still unfolding.

[36] University of British Columbia. 2024. *The Impact of Climate Change on Fisheries, Coastal Ecosystems and Coastal Communities in Maldives*. (Background research report for this report).

emissions scenario (Shared Socioeconomic Pathway [SSP]1–2.6), the intensity of marine heatwaves is projected to increase by two to five times by the end of the century.[37] Under a high GHG emissions scenario (SSP5–8.5), the entire exclusive economic zone (EEZ) is projected to experience year-round marine heat waves every year toward the second half of the century. In this pessimistic scenario, the intensity of marine heatwaves will increase by 18 to 70 times. Likewise, sea surface temperature is projected to be 0.8–1.2°C higher mid-century under low and high GHG emissions scenarios, respectively. The increasing frequency and severity of coral bleaching events will diminish the recovery capacity and resilience of coral ecosystems. The full extent to which coral reefs recover and whether they will be able to do so if bleaching events become more intense and frequent is not yet fully understood.[38]

Figure 7: Coral mortality due to ocean warming shocks in previous years



Source: Montefalcone, M., C. Morri, and C. N. Bianchi. 2020. "Influence of Local Pressures on Maldivian Coral Reef Resilience Following Repeated Bleaching Events, and Recovery Perspectives." Frontiers in Marine Science 7: 587.

The extent to which coral reefs are affected will be defined by the degree of warming with a risk that almost all coral cover will be lost if global warming exceeds 2°C. Simulations of climate scenarios carried out for this report indicate that the risk of exceeding Paris Agreement targets (meaning SSP2–4.5 and above) may be a dramatic coral decline by 2050–2060, with almost no scope for natural adaptation and long-term persistence (see Figure 8).[39] If global warming is limited to 1.5°C (SSP1–1.9), coral populations tend to recover in the second half of the century and the share of reefs with a high coral cover is expected to increase after a mid-century decline (see Figure 9). This is driven by the combination of progressively reduced rates of warming and natural selection toward more heat-tolerant corals.[40] For a 2°C scenario (SSP1–2.6), the projections indicate that reefs with high coral cover endure particularly in the central region. However, the overall share of reefs with high coral cover falls below 20 percent (see Figure 9) and almost 50 percent of reefs risk lose their full coral cover (see Figure 8). The results are representative of reefs at 5–10 m depth. Shallow reefs (3–5 m) are expected to see even greater impacts. Deeper reefs (10–15 m) are likely to see fewer impacts. Although the

[37] Ibid.

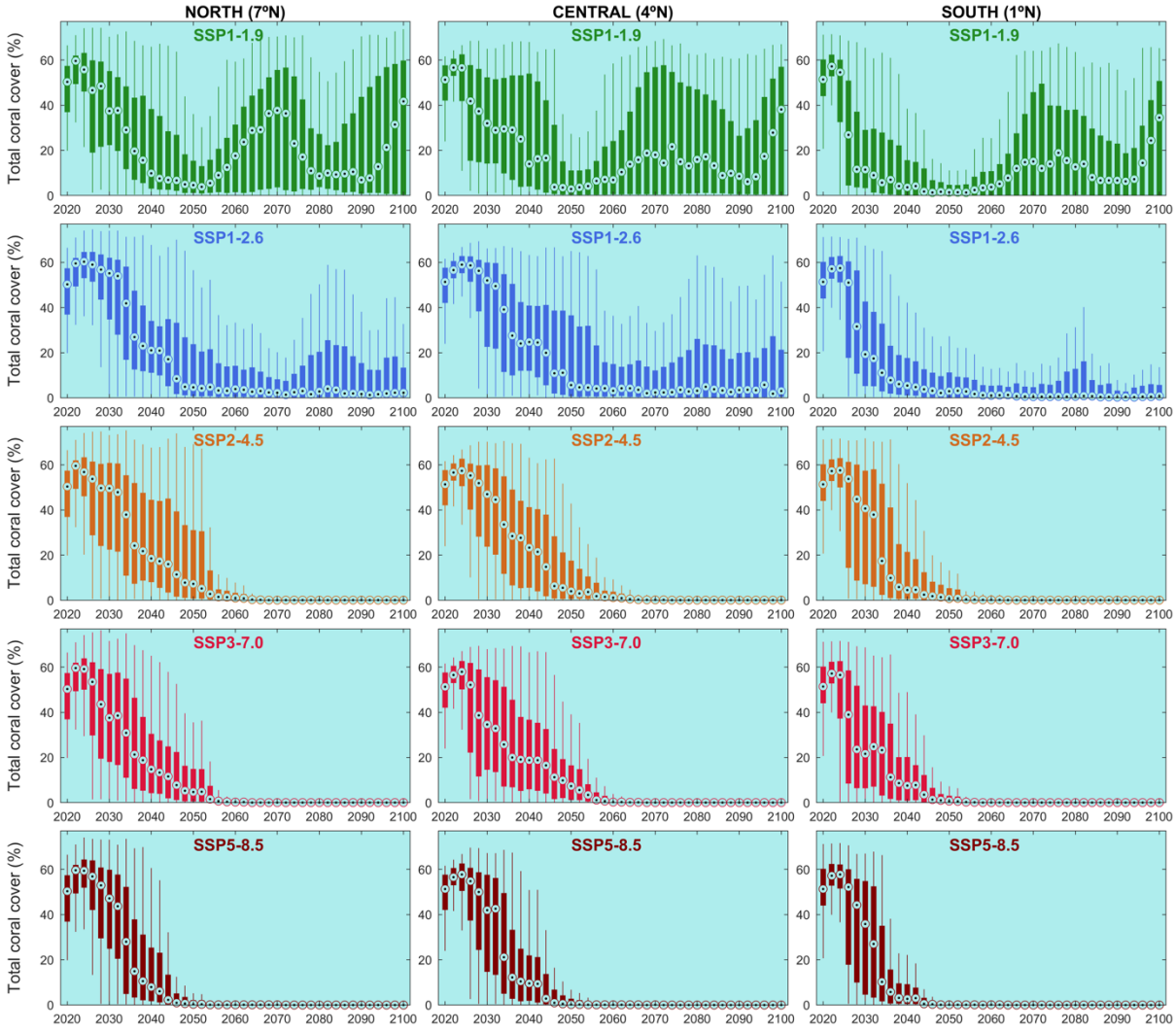
[38] Bang, et al. 2021. "Quantifying Coral Reef Resilience to Climate Change and Human Development: An Evaluation of Multiple Empirical Frameworks." *Frontiers in Marine Science* 7: 610306.

[39] Mumby, and Bozec. 2024. *Roadmap for Fostering Coral Reef Resilience in the Maldives*. (Background paper to this report).

[40] Ibid.

projections are associated with uncertainties and there is a need for a deeper understanding of adaptive capacities, the outlook for coral reefs dramatically diminishes with higher degrees of warming.

Figure 8: Development of the distribution of coral cover among reefs till 2100 under different climate scenarios



Source: Mumby, and Bozec. 2024. Roadmap for Fostering Coral Reef Resilience in the Maldives. (Background paper to this report).

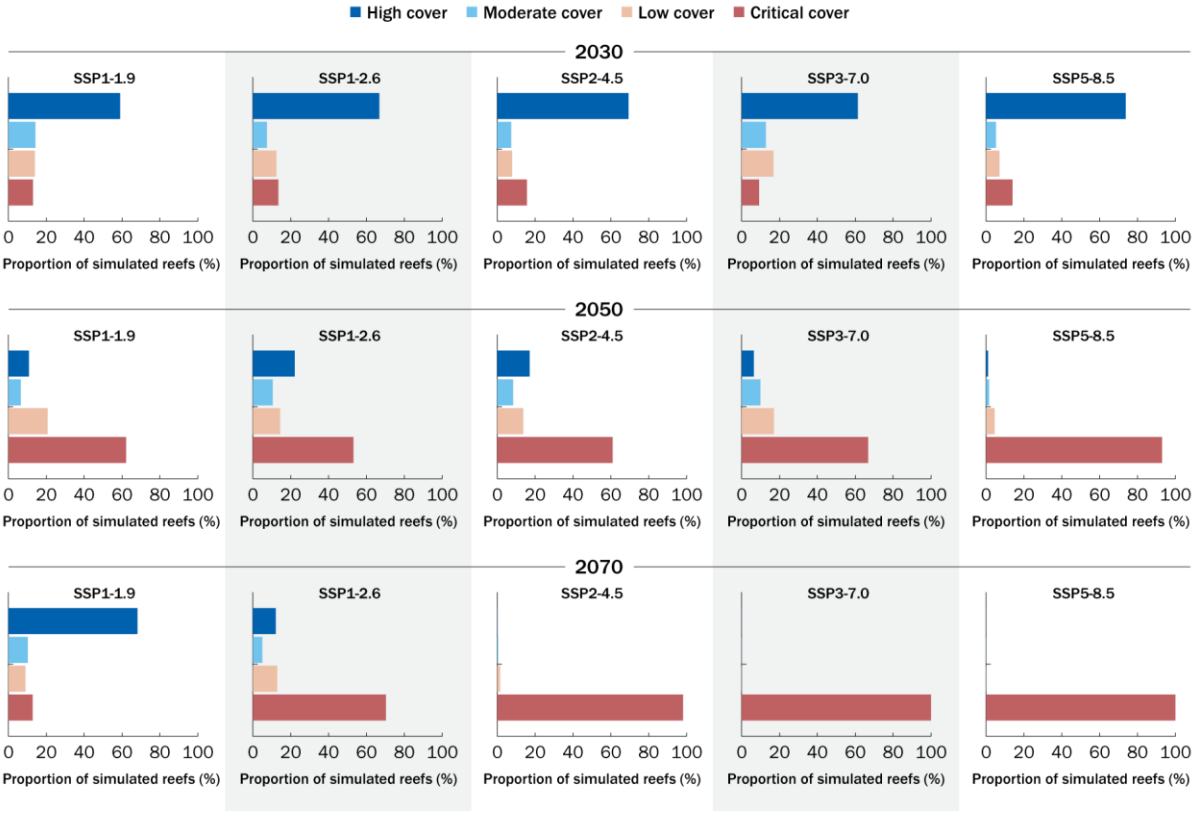
Note: Distribution of predicted values of total coral cover captured every two years with all geophysical coral reef mappings combined for the 'North' (left), 'Central' (middle) and 'South' regions (right) for a model with no crown-of-thorns starfish (CoTS) outbreaks. For every selected year, N = 120 values for SSP1-1.9 and N = 200 values for all the other scenarios of carbon emission. The boxes show the interquartile range which visualizes the spread of reef states between the 25th and 75th percentile. From each box, whiskers are drawn up and down to 1 time the interquartile range, which covers around 85–90 percent of reef states. The central mark indicates the median.

Degrading coral reefs have follow-on impacts on the climate resilience of islands and the tourism and fisheries industries. Coral reefs are a main attraction that tourists come to see in Maldives. They are also crucial for fish spawning and nesting and as a food source for many species. This supports the reef and live bait fishery which is a vital component of the tuna fishery. It is expected that the productivity of reef fisheries would at least halve once corals are lost.[41] More importantly, coral reefs protect islands against SLR and flooding. The loss of coral reefs is tantamount to losing the first line of defense in the struggle to fight climate change and increases its vulnerability to climate-related coastal hazards. Without coral reefs, Maldives would

[41] Rogers, A., J. L. Blanchard, and P. J. Mumby. 2018. "Fisheries Productivity under Progressive Coral Reef Degradation." *Journal of Applied Ecology* 55: 1041–1049.

incur additional annual flood damages amounting to US$442 million per year which is about 8 percent of GDP.[42]

Figure 9: Predicted coral cover categories among reefs (2030, 2050, and 2070)



Source: Mumby, and Bozec. 2024. Roadmap for Fostering Coral Reef Resilience in the Maldives. (Background paper to this report).

Note: Distribution of predicted reef state categories captured in 2030, 2050, and 2070 for all geophysical coral reef mappings and regions combined in the absence of CoTS outbreaks. Reef state categories are defined by the following limits of total coral cover: 'High cover': ≥30 percent; 'Moderate cover': 20–30 percent; 'Low cover': 10–20 percent; 'Critical cover': <10 percent.

Ocean heating also directly affects fish species and fishery regions, with varying impacts across the country, with the northern waters projected to be most affected by local extinction of fish species. Past declines in fish catch have been partially attributed to increases in sea surface temperature, and future changes may have the potential to drive skipjack and yellowfin tuna out of the EEZ. The marine waters of the northern and central regions are warming at a faster rate than those of the southern region, while marine heatwaves are projected to intensify more rapidly in the southern part of the EEZ. Based on this, the northern and central ecosystems are projected to experience more impacts from slow-onset risks. The northern part of the EEZ will be most affected by the local extinction of fish species in the mid- and end-century. The southern part of the EEZ will have comparably higher invasion rates as new species are expected to occur in the area.[43]

1.2.3. Other hazards and climate change impacts on people and communities

Other hazards are relatively low risk in aggregated terms, and major sudden-onset disasters have been rare.[44] Major disasters have included the Indian Ocean tsunami in 2004 and a major storm in 1991. While tsunamis are unrelated to climate change, climate-related SLR increases the country's vulnerability to

[42] World Bank. 2024. *Maldives: Country Environmental Analysis. Towards a More Sustainable and Resilient Blue Economy*. Washington, DC: World Bank Group.

[43] University of British Columbia. 2024. *The Impact of Climate Change on Fisheries, Coastal Ecosystems and Coastal Communities in Maldives*. (Background paper to this report).

[44] World Bank. 2024. *Crisis Preparedness Gap Analysis: Maldives Briefing Note (English)*. Washington, DC: World Bank Group.

tsunamis. Floods have been the most frequent sudden-onset hazard—three major events have been recorded over the past decades in 1987, 2007, and 2019—but have created modest aggregate losses to date.[45] Maldives lies outside the tropical cyclone zone, but experiences, though rarely, cyclonic disturbances during the southwest monsoon season (specifically from October to January). There have been only 11 cyclones between 1877 and 2004.[46] There is a clear pattern of northern Maldives being exposed to more frequent freak storms than the south.[47] Gusts reaching 50 miles per hour occur nearly every year throughout Maldives, while 60-mile-per-hour winds recur every two to three years in the central areas and every four to seven years in the southern regions.[48] The highest recorded storm surge of 1.32 m has a recurrence interval of 500 years.[49] Historical data indicate more variability in annual rainfall in central regions compared to the south, with relatively stable temperatures nationwide.[50]

On the local level, however, small-scale and recurrent hazards significantly affect people and communities.[51] Most of Malé sees about 0.40 m of flooding after 4, 8, and 12 hours of rain events, creating large-scale traffic disruptions, property losses, risks to public health, and disruption of business activities.[52] Other small-scale and recurrent hazards include increased rainfall variability (with the north and central regions expected to face increased and the southern region decreased rainfall), strong winds, storm surges, saltwater intrusion, and coastal floods.[53]

Climate change and disaster risks have a crucial poverty, social, and people dimension, where the atolls outside of the capital, Malé, are particularly vulnerable. More than 90 percent of the poor (as per the national poverty line of MVR 71.4 [US$4.65] per person per day) live on atolls outside of the capital island.[54] They are particularly vulnerable to climate change impacts because of their (a) dependence on climate-sensitive livelihoods such as fishing and agriculture, with limited options for diversification and access to other jobs, particularly for women; (b) limited access to resources to reduce exposure to climate pressures; and (c) limited access to resources to cope with climate impacts, including access to basic services such as food (90 percent of which is imported),[55] health care, water, transportation, and disaster relief as well as to information including early warnings. Solar-powered cold storages have been established on nine islands, but in many places, food storage infrastructure continues to be limited to key population centers[56] and food security remains a challenge, especially on remote islands. Climate change also heightens the risk of vector-borne diseases, heat-related illnesses, and waterborne infections and severe weather occurrences can potentially interrupt medical services and damage health infrastructure,[57] with particular impacts on poor and remote communities due to the distance to alternative infrastructure and service provision. Women are particularly vulnerable, as they largely work in low-growth informal sectors such as domestic, education, social work, and manufacturing linked to the fishery sector, all of which are susceptible to the impacts of climate change. Moreover, due to male outmigration in search of better economic opportunities, there is a growing share of female-headed households who face the triple burden of productive, household, and care

[45] D. Guha-Sapir, R. Below, and Ph. Hoyois. "EM-DAT: The CRED/OFDA International Disaster Database." Université Catholique de Louvain, Brussels, Belgium.

[46] Ministry of Environment and Energy. 2016. "Second National Communication of Maldives to the United Nations Framework Convention on Climate Change."

UNDP. 2006. "Developing a Disaster Risk Profile for Maldives."

[47] UNDP. 2006. "Developing a Disaster Risk Profile for Maldives."

[48] Ministry of Environment and Energy. 2016. "Second National Communication of Maldives to the United Nations Framework Convention on Climate Change."

[49] UNDP. 2006. "Developing a Disaster Risk Profile for Maldives."

[50] IFRC. 2021. "Climate Change Impacts on Health and Livelihoods: Maldives Assessment."

[51] UNDRR. 2019. "Disaster Risk Reduction in Republic of Maldives."

[52] Royal Haskoning DHV. 2024. *Draft Final Report, Detailed Design for the Drainage Management System of Malé*. Report prepared for the World Bank.

[53] UNDRR. 2019. "Disaster Risk Reduction in the Republic of Maldives."

[54] World Bank Group. 2023. *Maldives Country Partnership Framework*. Based on data from the Household Income & Expenditure Survey 2019.

[55] Maldives Ministry of Environment and Energy. 2016. "Second National Communication of Maldives to the United Nations Framework Convention on Climate Change."

[56] "President: Solar-Powered Cold Storage Facilities in Nine Islands will be Operationalized Soon" [online]. *Sun*, October 16, 2022.

[57] IFRC. 2021. "Climate Change Impacts on Health and Livelihoods: Maldives Assessment."

work and tend to have limited access to resources and decision-making.[58] Likewise, the vulnerability of migrants is heightened by systemic challenges such as lack of medical insurance, challenging labor conditions, and difficulties in accessing support during emergencies. This vulnerability is compounded by high rates of undocumented migration and the pressures of climate change, which exacerbate displacement and health risks.[59]

Lower-income households are more likely to be exposed to climate risks. In 2019, 7.8 percent of households in the bottom 40 percent of income reported having experienced a flood in the past 12 months, against more than 6.1 percent of households in the top 60 percent. Similarly, 4.3 percent of households in the bottom 40 percent report having experienced a drought against 1.7 percent for households in the top 60 percent.[60] This is because there are pockets of poverty across the country while extreme sea levels are higher in Southern Atolls and in islands distant from Malé. More remote atolls in the southern region are at higher risk of extreme sea levels. Remoteness could represent a vulnerability on its own if it translates into higher barriers to climate adaptation strategies (for example, migration) or to policy interventions in the aftermath of a climate event.

[58] FAO. 2019. "Country Gender Assessment of Agriculture and the Rural Sector in Maldives." Food and Agriculture Organization of the United Nations, Malé, Maldives.

[59] IFRC. 2021. "Climate Change Impacts on Health and Livelihoods: Maldives Assessment."

[60] Maldives 2019 Household Income and Expenditure Survey.

2. Institutions and Policies for Climate Change

2.1. Climate change commitments and policies

Maldives is committed to a holistic development agenda, supported by a suite of environmental and climate policies to foster a sustainable, resilient future. As per the SAP 2019–2023, the development trajectory is focused on enhancing the blue economy, fostering a caring state, ensuring dignity for families, promoting sustainable island life, and implementing good governance.[61] These areas are critical for addressing climate change impacts and supporting ecosystem resilience. To further this vision, Maldives has established a robust climate policy framework, including key legislations and plans such as the Climate Change Policy Framework (2015), NDC implementation plan (2018),[62] updated NDC (2020),[63] Climate Emergency Act (2021),[64] Maldives Energy Act (2021),[65] and a national roadmap for Early Warnings for All (2024),[66] among others. In addition, work on a National Adaptation Plan (NAP) and the next NDC update for 2025 has been initiated.[67] The Climate Change Policy Framework was developed with broad stakeholder engagement and sets forth five key policy goals: to secure sustainable financing, promote low-emission development, enhance adaptation efforts, lead in climate advocacy, and foster overall sustainable development.[68] Underpinning all these efforts is the Environment Protection and Preservation Act of 1993, which sets the legislative foundation for environmental governance, including protected area management, environmental impact assessment, and waste management. Despite the absence of a post-2013 National Environmental Action Plan, the Ministry of Climate Change, Environment, and Energy (MoCCEE) has advanced various policies and strategies to further national energy goals, solid waste management, and environmental conservation.[69]

In terms of adaptation commitments, the 2016 NDC and the updated 2020 NDC identify several priority areas including infrastructure resilience, coastal protection, coral reef biodiversity, tourism, fisheries, early warning and observation, and disaster risk reduction and management; finance, climate governance, and capacity building are cross-cutting issues. To ensure infrastructure resilience, the 2020 NDC calls for the establishment of (a) a national building code to guide planners, architects, and engineers to integrate climate and weather-related factors into the design of buildings and facilities; (b) a National Development Act to facilitate integration of climate change into development planning, considering the economies of scale for public services, land use planning, and population consolidation; and (c) a mechanism to mainstream climate resilience into public sector investment programs and projects, which the Ministry of Finance (MoF) is already working toward.[70] The NDCs emphasize nature-based solutions (NbS) for adaptation, particularly focusing on the protection of marine ecosystems and biodiversity of coral reefs. However, they do not present specific, measurable indicators to assess their efficacy. Under the Disaster Management Act, the government has moved from a relief-focused to a more holistic approach for mainstreaming disaster risk reduction and preparedness.[71]

In terms of mitigation, the 2020 NDC commits to a emissions reduction by 26 percent by 2030 and strives to achieve net zero emissions by 2030, both subject to international support.[72] In its 2015 NDC submission to the United Nations Framework Convention on Climate Change (UNFCCC), the government expressed its

[61] Government of Maldives. 2019. "Strategic Action Plan 2019–2023."

[62] Ministry of Environment, Republic of Maldives. 2018. "Nationally Determined Contribution Implementation Plan." United Nations Framework Convention on Climate Change.

[63] Ministry of Environment, Republic of Maldives. 2020. "Updated Nationally Determined Contribution 2020." United Nations Framework Convention on Climate Change.

[64] Government of Maldives. 2021. "Climate Emergency Act. Act no. 9/2021."

[65] Government of Maldives. 2021. "Maldives Energy Act. Act no. 4/96."

[66] Ministry of Climate Change, Environment and Energy. 2024. "Scaling Up Early Warning Systems: Implementation Roadmap 2023–2027."

[67] UNEP. 2024. "Maldives Rests Hope on New National Adaptation Plan to Tackle Climate Change". Press release [online].

[68] Maldives Ministry of Environment and Energy. 2015. "Climate Change Policy Framework (2015–25)."

[69] World Bank. 2024. *Maldives: Country Environmental Analysis. Towards a More Sustainable and Resilient Blue Economy*. Washington, DC: World Bank Group.

[70] Ministry of Environment, Republic of Maldives. 2020. "Updated Nationally Determined Contribution 2020." United Nations Framework Convention on Climate Change.

[71] Republic of Maldives. 2007. "Disaster Management Act 2006." Revised on October 3, 2007.

[72] Ministry of Environment, Republic of Maldives. 2020. "Updated Nationally Determined Contribution 2020." United Nations Framework Convention on Climate Change.

intention to unconditionally reduce its GHG emissions by 10 percent below a business-as-usual (BAU) scenario by 2030, with the potential to increase this reduction to 24 percent conditionally, dependent on international support. The updated 2020 NDC is more ambitious, committing to a conditional 26 percent reduction in emissions by 2030 relative to a 2011 BAU scenario. Furthermore, Maldives set an aspirational goal of reaching net zero emissions by 2030, contingent upon extensive international assistance. The shift from the 2015 to the 2020 NDC shows a move from setting unconditional and conditional targets to relying entirely on external support for both enhanced emissions reductions and the ambitious net zero goal (see Chapter 6 for a more detailed discussion of mitigation commitments in key sectors).

The NDC targets, while ambitious, present areas for enhancement, notably in specifying a carbon budget, detailing mitigation strategies, and emphasizing domestic resource mobilization. Expanding the vision beyond 2030 with a long-term strategy and specifying the support needed for conditional commitments could facilitate more effective international collaboration, which is crucial for achieving the ambitious aim of net zero emissions by 2030.[73] Despite the ambitious net zero target, the NDCs emphasize economywide cuts primarily in the energy and waste sectors without specifying a carbon budget. A more explicit carbon budget, which is under preparation, would aid in tracking progress toward emission reduction targets. Elaborating mitigation strategies, especially in the energy and waste sectors, could also enhance the targets' clarity and feasibility. Augmenting the NDC with a clear domestic funding strategy and specifying conditions of international support could streamline the necessary resource mobilization for climate action.[74] Additionally, aligning climate actions with Sustainable Development Goals could help ensure that efforts contribute to broader development objectives.

Private sector climate and sustainability commitments are growing, particularly in the tourism sector. Resorts across Maldives are actively engaging in coral restoration projects to both meet tourist expectations and contribute to environmental conservation. These projects typically involve attaching coral fragments to artificial frames, which can lead to continuous coral cover. However, these efforts currently only contribute to an additional 0.03 km² of coral cover—a fraction of Maldives' extensive 8,900 km² coral ecosystem.[75] Closer engagements between the private and public sectors on coral reef conservation are an important opportunity to better integrate measures, reach scale, and ensure effectiveness. Individual resorts have also committed to greening their operations, including through renewable energy (RE) and on-site waste processing, waste reduction, and recycling targets.[76]

2.2. Climate change institutions and governance

Maldives has developed a comprehensive institutional framework to tackle climate change. The MoCCEE has a broad mandate for implementing climate change-related policies and programs at the national level and supervises the Maldives Meteorological Services (MMS) and the Environmental Protection Agency (EPA), among other entities. The National Disaster Management Authority (NDMA) is responsible for mainstreaming disaster risk management at the national level. Other entities with relevant responsibilities for climate change include the Maldives Marine Research Institute (MMRI); President's Office; MoF; Ministry of Housing, Land and Urban Development; Ministry of Construction and Infrastructure; and sectoral entities including the Ministries of Tourism, Fisheries and Ocean Resources, Agriculture and Animal Welfare, and Transport and Civil Aviation.

This institutional framework grapples with challenges such as governance integration, decentralization, and constrained state capacity, which collectively impede effective policy execution and stakeholder engagement. The lack of an inter-sectoral coordination and management structure across these entities creates challenges of overlapping mandates and exacerbates coordinated policy formulation and

[73] Ibid.

[74] Ministry of Environment, Republic of Maldives. 2020. "National Strategic Framework to Mobilize International Climate Finance to Address Climate Change in the Maldives 2020-24."

[75] Many resorts collaborate with a marine consultancy firm Reefscapers, which has so far been involved in placing 8,500 coral frames in Maldives. The data are reported on https://reefscapers.com.

Reefscapers. n.d. https://reefscapers.com/. Accessed April 3, 2024.

[76] "These Maldives Resorts Are Leading the Charge on Sustainability." [online]. *CNN*, September 30, 2022.

implementation.[77] This is evident in the absence of detailed plans that specify concrete steps and fix institutional responsibility for each, to translate climate adaptation policies into action. The framework's effectiveness is further weakened by the partially unclear division of responsibilities among stakeholders, which often operate with overlapping mandates without a unified direction. Local authorities at the city/atoll/island councils, while empowered by the Decentralization Act of 2010, suffer from a lack of resources and authority, leading to uneven policy enforcement across regions. Environmental impact assessments are sometimes bypassed, and regulations aimed at protecting coral reefs are inadequately enforced. Moreover, the extensive network of institutions, including NDMA and sectoral ministries, faces coordination hurdles in the absence of an inter-sectoral framework or a comprehensive Climate Action Plan. More effective coordination is also needed between MMRI and other stakeholders as well as initiatives monitoring reefs. This underscores an urgent need for integrated, forward-looking policies that acknowledge the dynamic nature of climate change impacts and streamline the governance mechanisms for more coherent action. Efforts at mainstreaming climate concerns into local policy planning, particularly through embedding climate change risks into island planning processes, have had limited success.[78]

These challenges are exemplified in ocean management, where, despite a robust legal framework, the country does not have a formal marine spatial planning (MSP) system that could facilitate the holistic management of the vast EEZ.[79] MSP provides a functional framework to achieve policy coherence and address challenges in sustainable resource management, environmental protection, economic diversification, and climate change adaptation.[80] It is cross-sectoral, necessitating collaboration across various government departments, including fisheries, tourism, and the environment. Crucially, MSP needs to align with other strategic frameworks, such as the Strategic Environmental Assessment and the Fifth Tourism Master Plan, to ensure a cohesive approach. By considering the collective impact of diverse activities, MSP provides a holistic perspective, avoiding the pitfalls of fragmented development.[81] Though Maldives has made a start with a draft MSP for offshore areas, it is important to continue the process, including for nearshore areas, where most competing seascape use is occurring.

There is currently no comprehensive system to transparently track the implementation of climate commitments. The 2016 NDC mandated the MoCCEE with the responsibility for monitoring, reporting, and verification to ensure accountability and progress tracking.[82] However, the updated NDC highlights significant challenges in information and data availability due to the wide geographic dispersion, capacity constraints, and insufficient resources, which hinder the expansion of observation networks. Commitments are made to enhance information gathering for early warning systems (EWSs) and to develop mechanisms for tracking both public and private climate finance flows. Despite these efforts to improve data collection and financial tracking, the updated NDC lacks explicit mention of a comprehensive system to monitor the overall implementation of climate actions.[83]

The government has recently transferred spending responsibilities for addressing climate impacts to Atoll and Island Councils, but these local bodies are facing implementation challenges. The councils are now responsible for local development activities, service provision, waste management, and promotion of climate-smart livelihoods and food production. However, they are encountering implementation challenges as their capacity to address climate change impacts and respond to disasters is often limited. The government's ability to respond to disasters is therefore constrained, without significant improvements in SLR monitoring,

[77] UNEP. 2021. "Readiness Proposal for the Advancing the National Adaptation Plan for the Maldives."

[78] Maldives Institute of Local Governance. 2023. "Decentralization Framework in the Maldives – Policy Brief." Local Government Authority.

[79] The President's Office. 2020, December 16. "Government Launches Noo Raajje Programme in Partnership with the Blue Prosperity Coalition." See Noo Raajje Initiative website, https://www.nooraajje.org/

[80] Intergovernmental Oceanographic Commission of UNESCO. 2023, April 20. "Marine Spatial Planning."

[81] Reimer, J. M., R. Devillers, R. Zuercher, P. Groulx, N. C. Ban and J. Claudet. 2023. "The Marine Spatial Planning Index: A Tool to Guide and Assess Marine Spatial Planning." *Ocean Sustainability* 2 (1): 15.

[82] Ministry of Environment and Energy. 2018. "Nationally Determined Contributions Implementation Plan - Final Draft." [online] Ministry of Environment and Energy, Malé, Maldives.

[83] Ministry of Environment, Republic of Maldives. 2020. "Updated Nationally Determined Contribution 2020." United Nations Framework Convention on Climate Change.

forecasting, and EWSs. The MMS faces difficulties in maintaining equipment spread across various locations to monitor and forecast climate change impacts and natural hazards. To date, approximately 50 island Community Development Management Plans have been formulated, highlighting the limitations in integrating climate and disaster risk management into local development strategies and ensuring community involvement, as outlined in the National Community-Based Disaster Risk Reduction Framework.

Recommendations on the Policy and Institutional Framework for Climate Change

- **Finalize the NAP and develop actionable island/regional development plans,** explicitly integrating SLR, flooding, and ocean heating scenarios to guide spatial planning and development activities.
- **Establish a high-level inter-ministerial Climate Change Committee** to coordinate climate change policies between different entities and specify the roles, responsibilities, and coordination mechanisms for policy implementation and project development.
- **Enhance existing monitoring and evaluation mechanisms and data sharing** under the Climate Change Policy Framework to track adaptation and mitigation progress and identify potential maladaptation.
- **Continue the MSP process in offshore and nearshore areas** to facilitate the holistic management of the EEZ.
- **Consider launching a national capacity development program on climate change and disaster risk management** focusing on the local level and covering areas such as integrated local planning, service provision including early warnings, and climate and environmental data gathering and monitoring.
- **Define the specific conditions and types of international support needed to fulfill the conditional aspects of the NDCs** and enhance the effectiveness of international support, and formulate a domestic resource mobilization strategy to support climate actions.
- **Consider specifying a carbon budget within the NDC** to provide a target for emission reductions, particularly in high-impact sectors such as energy and waste; based on this budget, develop detailed mitigation strategies that outline specific actions to achieve these reductions.

Note: Maladaptation refers to actions that may lead to increased risk of adverse climate-related outcomes, increased or shifted climate change vulnerability, or diminished welfare (including distributional issues).

3. Toward Climate-Resilient Ecosystems

Given the significance of coral reefs for the economy and climate resilience, safeguarding them is a priority. Coral reefs provide important ecosystem services. They are an important attraction for tourists and a habitat for a range of flora and fauna underpinning the fishery industry. In addition, they prevent damage from storm surges and ensure the country's existence in the face of SLR (see Section 4.1.2). Coral sands represent 90 percent of the sediments of the islands whose continued supply supports the natural adaptation of the islands to SLR. Coral reefs prevent annual flood damages amounting to about 8 percent of GDP.[84] As the simulations of coral cover under different climate scenarios carried out for this report show, coral reefs are expected to be severely affected by ocean heating (see Section 1.2).

The projected dramatic decline in coral reefs even under moderate emission scenarios compels Maldives to advocate for stronger international commitments to protect marine ecosystems. With temperatures poised to exceed 2 °C, an almost total loss of coral cover is expected (see Section 1.2). As SSP2 is considered a 'middle-of-the-road' path, the crucial strategy for coral preservation lies in pushing for the ambitious SSP1 sustainability scenario, which aims for lower global GHG emissions. It is important for Maldives to continue to use international platforms to advocate for global emissions abatement, seeing that its future is so intricately related to what other countries do. Adaptation actions in Maldives itself, while urgently required, will likely not be enough in the high-emission scenario.

Stressors such as pollution, coastal development, and CoTS outbreaks exacerbate coral mortality, which is primarily driven by ocean temperature fluctuations. These additional stressors can all be managed locally. Coastal developments and tourism-related activities contribute to coral reef stress through physical damage, increased sedimentation, pollution, and changes in open water quality. Since 2002, more than 10 km^2 of lagoons have been lost to land reclamation.[85] In addition, coastal development activities stir up sediments deposited on reefs and can prevent coral settlement and survival.[86] During the 2016 bleaching event, coral mortality was higher in reefs located in near land reclamation areas.[87] Wastewater from local islands is currently discharged into the oceans without adequate secondary treatment, as there are only a few operational sewage treatment plants that are limited to resort islands. Frequent outbreaks of CoTS that feed on corals can significantly reduce coral cover. Managing these local stressors can foster coral reef resilience against ocean heating.

Despite the existence of a National Coral Reef Monitoring Program and recent advances in the monitoring of coral reefs and other ecosystems, several significant gaps remain. The National Coral Reef Monitoring Program, started in response to the 1998 bleaching event, is run by MMRI and consists of annual data collection exclusively from 31 long-term sites. Since 2011, indicators have been expanded beyond coral cover and fish to obtain better information on the health and dynamics of reef ecosystems. There is a need for skill and capacity development in data collection to ensure consistency and quality of monitoring data. Regular, periodical reporting is needed to close data gaps. In addition, the current number of monitoring sites is insufficient to capture reef variability; historically coral reef monitoring has also suffered from inconsistent methodologies. Beyond MMRI, which only focuses on the long-term monitoring sites, EPA, the MoCCEE, and the Ministry of Fisheries and Ocean Resources oversee coral reef monitoring in other locations resulting in institutional overlaps.[88]

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[84] World Bank. 2024. *Maldives: Country Environmental Analysis. Towards a More Sustainable and Resilient Blue Economy*. Washington, DC: World Bank Group.

[85] Ibid.

[86] Birrell, C. L., L. J. McCook, and B. L. Willis. 2005. "Effects of Algal Turfs and Sediment on Coral Settlement." *Marine Pollution Bulletin* 51:408-414.

Wakwella, A., P. J. Mumby, and G. Roff. 2020. "Sedimentation and Overfishing Drive Changes in Early Succession and Coral Recruitment." *Proc Biol Sci* 287:20202575.

[87] Pancrazi, I., H. Ahmed, C. Cerrano, and R. Manconi. 2020. "Synergic Effect of Global Thermal Anomalies and Local Dredging Activities on Coral Reefs of the Maldives." *Marine Pollution Bulletin* 160.

[88] World Bank. 2024. *Maldives: Country Environmental Analysis. Towards a More Sustainable and Resilient Blue Economy*. Washington, DC: World Bank Group.

Improved monitoring and use of data form the basis of informed management decisions to foster ecosystem resilience. More effective coral reef monitoring will require improvements in exchange of data between institutions and in the design of monitoring protocols to balance the trade-offs between higher sophistication and increased costs. Citizen science can complement monitoring that aims for long-term consistency with rapid data collection during and after bleaching events or CoTS outbreaks. Enhancing digital infrastructures and building information and decision support systems on top of monitoring data can enable better reef management and provides a basis for prioritizing intervention. A nationally calibrated EWS for bleaching events, providing near real-time monitoring and predictions, would support Maldivian stakeholders to prepare and respond to such events. To cover the vast and dispersed marine and terrestrial ecosystems, digital data collection technologies that enable less resource-intensive data collection via remote sensing and automation should be utilized. Box 1 showcases some of the technologies that are currently being piloted.

Box 1: Novel Digital Technologies for Ecosystem Data Collection and Monitoring

Passive acoustic monitoring enables remote monitoring of marine ecosystems using underwater microphones to record sounds continuously and provide insights into changes and trends in coral reef health, marine biodiversity, and boat traffic to aid conservation and security efforts.

Aerial data capture and advanced algorithms for coastal imaging use drones and specialized cameras and algorithms, such as fluid lensing, to map and monitor extended coastal and sea floor areas to support marine and coral ecosystem health monitoring.

Surface water and underwater unmanned vehicles help monitor changes in climate and marine ecosystems across large areas by collecting atmospheric, physical, and oceanographic data as well as support ocean surveillance across large distances while providing close to real-time data on conditions.

Note: The piloting of these technologies is supported by the World Bank's Digital Maldives for Adaptation, Decentralization, and Diversification (DMADD) Project.

Though a small share of coral reefs is protected as marine protected areas (MPAs), their conservation impact is limited due to a lack of financial resources and technical and institutional capacity. As of 2022, 12 percent of coral reefs have been protected, exceeding the National Biodiversity Strategies and Action Plan protection target of 10 percent but still presenting a relatively small share of coral reefs.[89] Limited national funding is available for environmental conservation and protection efforts, which hampers effective MPA management, and there is a lack of technical skilled staff at the national and local levels for the management of MPAs. Most MPAs, therefore, do not have an established management plan nor are they well managed, leading to limited monitoring of human activity and conservation outcomes.

Full utilization of MPAs to maintain healthy coral reefs will require improvement in management effectiveness and expansion of coverage. To ensure that conservation outcomes are achieved for existing MPAs, enhancement of capacity and financing is required for the development and implementation of management plans. If regulations are enforced, MPAs can limit negative impacts from coastal development. Further expansion of the MPA network, particularly to highly connected, biodiversity-rich sites with temperature-resistant corals that can function as a source reef of larvae for other reefs, can support the resilience of the overall reef network. Other effective area-based conservation measures have started to be recognized and can expand conservation beyond MPAs by including communities or resorts in the implementation and management of conservation efforts.

Even though a National Coral Reef Restoration and Rehabilitation Program was established in 2019, coral reef restoration and rehabilitation efforts remain fragmented and do not achieve the requisite scale. There is no clear, logical framework with a well-developed program of action, which can be publicly shared through the MMRI website, to help understand the goals, priorities, areas of action, calendar, and required budget

[89] Ibid.

for the program. Monitoring data are currently underutilized with no information on their use. There is no compiled information on restoration areas or priorities. Additionally, scattered and uncoordinated restoration activities hinder scalability.[90]

Enhancing the National Coral Reef Restoration and Rehabilitation Program to scale up restoration will be crucial for speeding up recovery following bleaching events and ensuring long-term connectivity within the reef system. The increased frequency of disturbance driven by climate change requires use of recovery windows between successive events more effectively. Traditional rehabilitation options include accelerated recovery, rubble stabilization, and the creation of artificial reef habitat. Natural recovery can be accelerated by increasing coral density, for example, by outplanting coral fragments or saturating the reef with coral larvae. Coral rubble must be dealt with by stabilizing, for example, with a plastic mesh or by supplying alternative stable substrates on which corals can be planted or settle naturally. Stronger intragovernmental, inter-agency, and inter-organizational cooperation will be needed to address capacity constraints and ensure activities align. There is also potential to tap into a growing interest in coral reef restoration and rehabilitation, including in resort islands. More than half of the resorts conduct coral regrowth and rehabilitation activities.[91]

New restoration methodologies are emerging, which offer opportunities but also bring risks that need to be carefully assessed. There are discussions about more interventionist and large-scale practices such as assisted gene flow or assisted evolution. In assisted gene flow, corals from warmer environments, for example, from the Persian Gulf, are moved to cooler environments in the hope that their thermal tolerance will allow them to prosper. Risks are the introduction of diseases and occurrence of hybrids between the introduced and endemic corals, which may have lower fitness than either. In assisted evolution, existing corals are screened and selected for propagation based on their thermal sensitivity. The most interventionist approach to restoration involves genetic engineering to enhance thermal tolerance which carries the risk of affecting the genes of wild populations and overall biodiversity. Scientific support and research will be needed to assess the potential and risks of these approaches and identify risk mitigation measures specific to Maldives. A first step is to foster a stronger link of Maldivian researchers and academic institutions with the international scientific discourse in this area.

In addition to coral reefs, mangrove and seagrass ecosystems require stronger protection from the compounding impacts of climate change and coastal development. Unsustainable coastal development, including examples from harbor construction, channel building, seawall development, and tourism infrastructure, threatens mangroves. Mangroves also suffer from an extended die-off in at least 11 islands. It is suggested that the die-off is caused by drought conditions, which make the mangroves less resilient against disease outbreaks. However, the drivers and future consequences of this phenomenon are poorly understood. The ecosystem services provided by mangroves lack legal protection and are currently undervalued. Land reclamation, chemical pollution, and manual removal by resort operators cause extensive damage to seagrass meadows. These factors paired with ocean warming, pathogens, or storms can lead to seagrass die-off, particularly in populated areas.[92]

[90] Ibid.

[91] Mumby, and Bozec. 2024. *Roadmap for Fostering Coral Reef Resilience in the Maldives*. (Background paper to this report).

[92] Klohmann, C. A., and J. L. Padilla-Gamiño. 2022. "Pathogen Filtration: An Untapped Ecosystem Service." *Frontiers in Marine Science* 9: 921451.

Recommendations on Climate-Resilient Ecosystems

Establish a planning framework and build capacity for coral management:

- **Develop a coral management and funding plan with a time horizon until 2050** to scale up restoration and enable forward planning while avoiding long-term uncertainty.
- **Support MMRI in coordinating and implementing the coral management plan,** including personnel, training, and capacity.
- **Support Maldives National University to develop its coral research capacity** and facilitate links with leading researchers globally.

Improve ecosystem monitoring, data, and decision support:

- **Develop a nationwide mapping and monitoring system** for marine and coastal ecosystems utilizing remote sensing.
- **Facilitate sharing of coral reef data between institutions** by establishing joint protocols and leveraging the existing coral database platform.
- **Establish decision support systems for coral reef management** including a near real-time forecasting system for bleaching events to prioritize interventions in a resource-constrained environment.

Expand the protection and conservation of ecosystems:

- **Strengthen the management of existing MPAs** by building the capacity to develop and implement management plans.
- **Expand the coverage of MPAs,** prioritizing well-connected, biodiversity-rich reefs with temperature-resistant corals.
- **Extend the recognition of** other effective area-based conservation measures to encompass private sector initiatives and community conservation zones, encouraging local efforts for conservation.
- **Safeguard coral reefs from local stressors such as coastal development and pollution** through improved waste and environmental management.
- **Extend the protection to mangroves,** especially those affected by die-off, to preserve national diversity.

Restore and rehabilitate degraded or damaged ecosystems:

- **Enhance the National Coral Reef Restoration and Rehabilitation Program** to harmonize and upscale ongoing restoration activities.
- **Facilitate stronger involvement of the tourism industry** in restoration and rehabilitation efforts.

4. Toward Climate-Resilient Islands and Infrastructure

4.1. Adaptation options

A range of adaptation actions exist to mitigate the adverse impacts of increased coastal flooding and shoreline erosion due to SLR. These actions fall into five broad categories: (1) protection infrastructure; (2) island raising and land reclamation; (3) NbS; (4) accommodation; and (5) relocation and migration (see Table 1). Each category addresses different aspects of climate resilience and requires distinct strategies and resources.[93]

Table 1: Five categories of measures to adapt to SLR

Island-level adaptations	Tools	Flood protection	Erosion protection	Increase flood resilience	Strengthen ecosystem resilience
Protection infrastructure	Seawalls	•	•		
	Breakwaters	•	•		
	Revetments	•	•		
	Groynes		•		
Island raising and land reclamation	Existing island	•			
	Island extension	•			
	New island	•			
Nature-based solutions	Vegetation zone around perimeter	•	•	•	•
	Seagrass	•	•	•	•
	Mangroves	•	•	•	•
	Artificial reef structures	•	•	•	•
	Reef restoration	•	•	•	•
	Beach nourishment	•	•	•	•
	Rubble berm	•	•	•	•
Accommodation	Flood refuges			•	
	Flood-resilient housing, utilities, and infrastructure (for example transport)			•	
	Floating housing and utilities			•	
	Raise building plots			•	
	Flood barriers/gates/routing			•	
	Drainage/pumps			•	
	Coastal planning			•	
	Community-based adaptation			•	
	Land use change			•	
	EWS			•	
Relocation and migration	Within island			•	
	Other island			•	
	New island			•	
	International			•	

4.1.1. Protection infrastructure

Hard coastal protection measures to address flooding, SLR, and erosion exist on nearly every inhabited island. In urban areas and more developed rural islands, where the consequences of land loss are less tolerable, a stronger coastal protection infrastructure is often preferred. Except for Malé, whose surrounding seawall was mainly designed to address flooding, the majority of hard coastal defenses have been established to counteract coastal erosion.[94] As a result, about 20 percent of the inhabited islands now have

[93] The structure and analysis in this chapter is largely derived from: University of Plymouth. 2024. "Sea-level Rise and Coastal Changes in the Maldives: Review for the World Bank." Background study prepared for this report.

[94] Kench, P. 2010. *Coastal Monitoring, Reef Island Shoreline Dynamics and Management Implications Final Report*. Environmental Protection Agency, Ministry of Housing, Transport and Environment, Maldives.

Duvat, V. K. E., and A. K. Magnan. 2019. "Rapid Human-Driven Undermining of Atoll Island Capacity to Adjust to Ocean Climate-Related Pressures." *Scientific Reports* 9: 15129.

predominantly artificial shorelines, featuring a variety of structures such as seawalls, breakwaters, revetments, and groynes.[95] Coastal protection infrastructure designed to prevent flooding and stabilize the shoreline has been the main and preferred strategy of adaptation for urban areas and high-protection rural islands where flooding is intolerable, and it has proven to be effective in reducing coastal flood risk in such densely inhabited islands.[96]

While hard protection infrastructure provides a relatively higher level of flood safety, it often lacks the ability to sustainably address erosion.[97] Hard coastal defenses can leave nearby shorelines unprotected and exacerbate erosion due to disrupted sediment transport. It is important to adopt a balanced strategy that considers the context and specific needs of each island. In rural and less developed areas, preserving natural processes through accommodation measures (see Section 4.1.3) can be the most sustainable and cost-effective approach, fostering natural island growth. In more urbanized areas, it is important to minimize the impact of hard protection on natural sediment transport and island-building processes.[98] Furthermore, there is a well-known moral hazard in fully relying on hard protection. While it tends to attract more population and assets, its failure can be catastrophic, leading to an overall higher social and economic impacts should a failure occur. This underlines the need to complement hard protection with additional contingency planning that includes softer measures, such as EWSs, adaptive social protection, and emergency evacuation procedures and locations or shelters.

Coastal infrastructure development can support or undermine adaptation efforts, depending on its execution and context. While coastal protection measures can help adapt to SLR, poorly planned and executed projects can lead to maladaptation such as coastal erosion and flooding down current of the developing site. Nearly all inhabited islands now have harbors, necessitating significant investment in coastal protection measures to prevent down-current coastal erosion that the harbors caused. The net adaptation benefit of many measures is therefore often unclear, especially their interactions with climate change.

Recommendations on Protection Infrastructure

- **Tailor coastal protection measures to each island,** balancing hard infrastructure, NbS, and accommodation measures depending on the type and needs of the individual island.
- **Preserve natural island processes wherever possible** to avoid maladaptation and lock-ins into a hard infrastructure protection spiral and to maintain visual appeal (which is important for tourism).
- **Raise awareness about the risk of maladaptation and study documented cases** to identify lessons learned and avoid repeating harmful practices and unintended side effects.

4.1.2. Nature-based solutions

NbS are not prominently used in Maldives. Of the 54 publicly financed coastal protection investments from 2002 to 2016 in inhabited islands, 52 were in hard/gray solutions such as breakwaters, groynes, revetments, and seawalls.[99] Low uptake of NbS can be attributed to their relatively lower perceived

[95] Duvat, V. K. E., and A. K. Magnan. 2019. "Rapid Human-Driven Undermining of Atoll Island Capacity to Adjust to Ocean Climate-Related Pressures." *Scientific Reports* 9: 15129.

[96] Ministry of Environment and Energy. 2015. "Survey of Climate Change Adaptation Measures in Maldives."

Duvat, V. K. E., and A. K. Magnan. 2019. "Rapid Human-Driven Undermining of Atoll Island Capacity to Adjust to Ocean Climate-Related Pressures." *Scientific Reports* 9: 15129.

Kench, P. S. 2011. "Maldives." In *Encyclopaedia of Modern Coral Reefs*, edited by D. Hopley, 648-653. Dordrecht: Springer.

[97] Kench, P. 2010. *Coastal Monitoring, Reef Island Shoreline Dynamics and Management Implications Final Report*. Environmental Protection Agency, Ministry of Housing, Transport and Environment, Maldives.

[98] Klock, et al. 2022. "Maladaptive Diffusion? The Spread of Hard Protection to Adapt to Coastal Erosion and Flooding along Island Coasts in the Pacific and Indian Ocean." *Regional Environmental Change* 22 (4): 136.

[99] World Bank. 2024. *Maldives: Country Environmental Analysis. Towards a More Sustainable and Resilient Blue Economy*. Washington, DC: World Bank Group.

effectiveness in counteracting coastal flood risks compared to hard protection measures, especially in densely inhabited islands, alongside the lack of pilot initiatives. Resort islands have also been slow to adopt NbS with only about 15 percent engaging in mangrove replanting and about 5 percent in coral restoration (see Section 5.1).

Nature-based adaptation measures can protect from floods and erosion while supporting the environment and increasing resilience. These nature-based or ecosystem-based solutions[100] are generally viewed as 'no-regret' options as they tend to have few negative impacts. Restoration of vegetation along islands perimeters is an easy and low-cost option to reduce flooding and shoreline erosion. This vegetation dampens the force of overwash surges, promoting sediment buildup and gradually increasing the island's elevation. However, the task of restoring mangroves, seagrass, and coral reefs can be more complex, requiring expertise and continued effort. Natural atoll islands typically feature a gravel ridge on the ocean side to reduce the risk of flooding, with a less pronounced ridge on the lagoon side. On many inhabited islands, these ridges are strengthened or maintained by human efforts. The integration of NbS can complement hard coastal protection measures in almost every inhabited island.

NbS are most likely to succeed on atolls with minimal human modifications. These atolls are ideal settings due to their intact natural processes, rich biodiversity, and natural sediment dynamics. However, in Maldives, NbS have not been implemented on a scale sufficient to significantly reduce flood risks. Diverse ecosystems support vital functions, such as sediment production necessary for beach nourishment. The construction and upkeep of vegetated gravel ridges, emulating natural rubble barriers, represents a soft engineering strategy to prevent island flooding. Conversely, the success of NbS is greatly diminished on atolls modified by human activity. Development and urbanization degrade natural habitats and disrupt key natural processes, thereby limiting the opportunities for implementing NbS. In ecosystems altered by factors such as pollution and land reclamation, natural defenses against events such as storm surges are substantially weakened. Socioeconomic challenges, such as economic dependencies on environmentally harmful livelihoods, also introduce additional obstacles to the deployment of NbS.

NbS offer promising coastal adaptation strategies, but the absence of detailed cost and feasibility analyses hampers their broader implementation and integration with hard engineering solutions. It is crucial to study site-specific feasibility and financial requirements for nature-based coastal adaptation measures. A comprehensive analysis is required to determine whether these methods can fully replace or merely supplement hard engineering solutions. This analysis should also guide the optimal deployment of each method across different islands. There is no one-size-fits-all solution—each segment of coastline may require an approach tailored to its unique circumstances, including combinations of NbS and hard engineering solutions. While NbS are less expensive than gray solutions by a factor of 1 to 15 or even more (see Section 7.2.1), there is no comprehensive cost-benefit analysis to guide investment planning. Careful planning, pilot testing, and adaptive management can result in a harmonized approach that builds on the strengths of both NbS and gray solutions.

Dynamic ecosystems such as mangroves and coral reefs require diverse and integrated restoration strategies to effectively provide coastal protection services. Natural ecosystems evolve over time, influencing their ability to provide services. For instance, young mangrove forests do not offer as effective storm surge protection or erosion control as mature ones. Degraded ecosystems may require significant restoration to offer successful coastal protection. A singular approach may be inadequate, and it would be imperative to rely on a combination of multiple NbS and/or integrated green-gray solutions. In settings where space for traditional NbS is insufficient, hybrid green-gray measures can offer a balanced solution. Living

[100] NbS are defined by the International Union for Conservation as "actions to protect, sustainably manage, and restore natural or modified ecosystems, that address societal challenges effectively and adaptively, simultaneously providing human well-being and biodiversity benefits" (Cohen-Shacham, E., A. Andrade, J. Dalton, N. Dudley, M. Jones, and C. Kumar. 2019. "Core Principles for Successfully Implementing and Upscaling Nature-Based Solutions." *Environ. Sci. Pol.* 98: 20–29. doi:10.1016/j.envsci.2019.04.014).

shorelines, for example, integrate natural elements such as vegetation with hard engineering structures to protect coastlines while providing habitat and maintaining natural coastal processes.

At the same time, the limitations and challenges associated with NbS need to be carefully considered and addressed. NbS generally take longer to realize their full potential compared to conventional hard engineering solutions and their success can be highly susceptible to changes in environmental conditions and human activities, necessitating ongoing management and adaptation efforts. To address these challenges, a systematic NbS piloting program is crucial for evaluating the performance of NbS across various conditions. Enhancing public awareness and education on NbS benefits and challenges among stakeholders—local communities, policy makers, and industry—is also key to collaborative, sustainable coastal protection efforts, paving the way for the more effective and widespread use of NbS in coastal protection.

Recommendations on Nature-based Solutions

- **Assess the viability, effectiveness, and scalability of NbS** for coastal protection and adaptation at a high level of granularity for different island typologies, including supporting pilot programs.
- **Scale up coral reef and mangrove restoration projects** to protect shorelines and reduce flood risks.
- **Explore opportunities for developing hybrid solutions** where NbS are integrated into gray solutions.
- **Improve environmental sustainability and community involvement of island augmentation practices** that address climate change impacts.

4.1.3. Accommodation measures

'Accommodation' measures are designed to reduce the impact of flooding by accommodating coastal stresses, as opposed to preventing them from taking place (as coastal protection measures would). These measures include raising dwellings and other critical infrastructure, planning risk-informed land use, and improving flood routing and drainage systems. Although accommodation measures may not prevent flooding, they are essential for maintaining the natural capacity of atoll islands to raise their elevation naturally through the accumulation of sand and debris brought by waves, supporting the island's natural shape and formation processes. Such measures are particularly beneficial for rural islands with minimal existing protection and are equally applicable to many lagoon and resort islands where extensive construction may not be feasible or desired. These measures are advantageous because they enable islands to maintain their natural dynamics, which is crucial for their ability to adapt naturally to SLR.

The government has launched an ambitious infrastructure program focusing on housing and commercial development, but there are significant gaps in ensuring the climate resilience of this new infrastructure, particularly against SLR. Examples of major construction projects include Hulhumalé island land reclamation, expansion of Malé's international airport, large-scale social housing projects, and a new port around Ghulifalhu.[101] The development of, by far, the largest land reclamation project, the 1,150 ha Ras Malé—or Maldives Eco City—was launched in late 2023.[102] It shall incorporate SLR adaptation measures such as elevation of 2 m at its edge and 3 m at its center.[103] However, critical gaps remain in enhancing resilience and climate-proofing existing infrastructure: robust building codes, improved spatial planning,

[101] World Bank Group. 2021. "South Asia Climate Roadmap."

[102] Maldives Housing Development Corporation. 2024. "Rasmale." https://www.hdc.mv/rasmale/.

[103] Richard, A. 2023. "President Muizzu Launches Maldives' Largest-Ever Land Reclamation Project 'Ras Malé'." *Maldives Republic*, December 2023. https://mvrepublic.com/news/president-muizzu-launches-maldives-largest-ever-land-reclamation-project-ras-male/.

green construction practices, and integration of nature-based and green-blue-gray solutions.[104] A particular area of concern given its widespread use is the absence of regulations for land reclamation.[105] At present, land reclamation planning overlooks climate change and disaster risks and the impacts on ecosystems. Additionally, the infrastructure program's focus has been predominantly in the public sector, highlighting the potential for public-private partnerships (PPPs) (the government is currently developing PPP guidelines) to bring in innovation and funding for low-carbon, climate-resilient solutions.

Maldives lacks a comprehensive framework for resilient building practices, especially for smaller buildings that house the most vulnerable population. The 2019 Maldives Building Regulatory Capacity Assessment[106] identified three key climate-related challenges: absence of resilient features in informal construction; hazard maps of inadequate resolution for land use planning; and limited institutional human resources and capacity for building regulation, monitoring, and inspection. The Ministry of Construction and Infrastructure issued the Construction Act in 2017 to strengthen the building regulatory framework, providing a much-needed institutional mechanism for building construction regulations, standards, and procedures. Yet, while the Building Code was announced in 2019, accompanying documents are not enacted. Currently, architects and engineers refer to code compliance documents from other developed countries that may not fit the local disaster risk profile. The situation is exacerbated by the lack of mechanisms and technical capacity to monitor construction quality as well as to assess structural damages of disaster-damaged and aging buildings for demolishing or retrofitting.[107] New affordable housing provision is overwhelmingly led by the government. There is an opportunity for the government to integrate green construction aspects into its public housing program and to explore green certifications for all new units as a demonstration pilot for the construction sector. Private construction is limited to high-end residential and commercial buildings, hotels and resorts, and owner-driven residential developments for investment and the rental market, particularly in the Greater Malé area. In the medium to long term, the process of integrating resilience into land use planning, regulations, land tenure, building codes, and building approval processes is part of accommodation measures that would further promote resilience in housing and buildings. Digitizing planning and approval could enable quicker and more efficient implementation of new regulations.

Nevertheless, there is well-documented guidance readily available to homeowners, builders, and local governments on climate- and disaster-resilient construction and particularly homes.[108] This includes understanding local climate and disaster risks and land use planning to ensure site safety in the form of location and soil conditions; choosing appropriate and safe construction materials; assessing the '3Cs' of home—configuration, connections, and construction quality; and considering repair, maintenance, expansion, comfort, and green construction aspects.

A significant portion of the required housing stock is yet to be built, presenting a substantial opportunity to develop climate-resilient and low-carbon urban infrastructure and housing. Climate-resilient urban and green housing development scenarios were developed for islands in Greater Malé and one southern island. The scenarios highlight the potential for climate-resilient urban development, embracing densification as advantageous not only for maximizing housing capacity but also promoting sustainability. By implementing energy- and water-efficient technologies, denser housing developments can contribute to lower overall energy and water consumption, reduced GHG emissions, and decreased construction costs. Additionally, densification allows for the selection of hazard-free locations to help increase resilience, provide more public space, and reduce water and electricity consumption and GHG emissions. In Hulhumalé, the dense scenario would consume one-third less water and energy than the base scenario. Similarly, in Villingili, the two denser scenarios would emit only 60 percent of the GHG emissions in the reference scenario. On the financial side,

[104] Ministry of Environment, Republic of Maldives. 2020. "Updated Nationally Determined Contribution 2020." United Nations Framework Convention on Climate Change.

[105] World Bank Group. 2021. "South Asia Climate Roadmap."

[106] World Bank. 2020. *Managing Risks for a Safer Built Environment in the Maldives. Building Regulatory Capacity Assessment*. Washington, DC: World Bank.

[107] Final Report, Maldives Regulatory Capacity Assessment. 2019.

[108] This paragraph is based on the forthcoming World Bank-supported Maldives Handbook for Resilient Housing.

for example, Hulhumalé's infrastructure costs per housing unit could be reduced by eight times with the densification scenarios.

Insufficient drainage infrastructure has become a growing concern. The naturally sandy landscape facilitates the permeability of rainwater into the freshwater lens. However, increased urbanization, notably in Malé, has resulted in a higher concentration of impervious surfaces such as pavements, reducing rainwater recharge. In urban areas, approximately 55 percent of rainwater results in runoff, compared to just 10 percent in natural areas.[109] Therefore, Malé frequently experiences floods nearly a foot high during the rainy season, exacerbated by the absence of an island-wide stormwater drainage system. Most stormwater in Malé is collected through catch pits and discharged into the sea, but these catch pits are often filled with solid waste and debris from roads. This stormwater carries chemical and liquid wastes from transportation and may serve as a primary source of microplastics in water.[110] Malé's urban drainage has not kept pace with the city's rapid growth and increasing threats from climate and disaster risks. The existing drainage system was built approximately two decades ago, catering to a much smaller population and a larger expanse of unpaved land. While newer drainage systems exist in reclaimed areas, rainwater from the older parts of the city tends to overflow into these zones. The low-lying areas between the inner city and reclaimed outskirts are particularly prone to flooding, even from light rains, with most of Malé experiencing flooding after just four hours of rainfall. These frequent floods cause widespread traffic disruptions, property damage, public health risks, and interruptions in business operations.[111]

The vulnerability of the transport sector to climate-induced hazards, especially coastal flooding, further highlights the urgent need for resilient transport infrastructure and services. It is imperative to introduce robust maintenance and management regimes in disaster scenarios including the establishment of a resilient transport asset management (for road, aviation, and maritime transport) system to elevate service quality, reduce maintenance costs, and mitigate economic disruptions following disasters. Fundamental elements of this system would be resilient transport planning (for example, incorporating elevated roadways, culverts, and expanded stormwater management systems), mechanisms for multi-agency collaboration, and a lifecycle approach to transport asset management that considers climate and disaster resilience. Minimizing disruptions to port and airport operations from climate-induced events is key given the vital roles of these transport hubs in providing basic services, facilitating trade and transportation needs, and serving the tourism sector. Engineering solutions for infrastructure, enhanced multimodal transport connectivity, improved logistics efficiency, and comprehensive disaster response plans are among the solutions to reduce disruptions. Within an enabling environment, private sector investments could be mobilized to perform part, if not all, of the proposed solutions, such as provision of digitalized logistics platforms and efficient port and warehouse operations.

In addition to traditional infrastructure-based accommodation measures, the unique geography of Maldives presents underexplored possibilities, such as 'aquatecture'. This innovative approach merges traditional and modern measures by integrating surrounding waters into living spaces, presenting new possibilities for adaptive building and infrastructure designs. A key example is the construction of a floating city 10 km north-northeast of Malé.[112] Additionally, building of floating houses or houses on stilts in the shallow lagoons behind inhabited islands could be an effective strategy against SLR and increased flooding for low-density island communities. Examples of such applications can be found globally, notably in the Netherlands, Viet Nam, Thailand, and Cambodia, where innovative floating house designs enable communities to cope with flooding and land shortages. Widespread implementation of floating houses or stilted structures is still in the conceptual or development stages. However, the country's unique geography

[109] Ministry of Climate Change, Environment and Energy. 2021. "A Guide to Groundwater Improvement Measures in Small Low-Lying islands of the Maldives." Ministry of Climate Change, Environment and Energy, Malé.

[110] Ministry of Climate Change, Environment and Energy. 2021. "A Guide to Groundwater Improvement Measures in Small Low-Lying Islands of the Maldives." Ministry of Climate Change, Environment and Energy, Malé; and World Bank. 2024. *Maldives: Country Environmental Analysis. Towards a More Sustainable and Resilient Blue Economy*. Washington, DC: World Bank Group.

[111] Royal Haskoning DHV. 2024. *Draft Final Report, Detailed Design for the Drainage Management System of Malé*. Report prepared for the World Bank.

[112] https://maldivesfloatingcity.com/

means that strategies successful in other countries cannot always be directly applied here. For instance, restrictions on coastal zone development effective elsewhere may be impractical, where islands are typically only a few 100 m wide. Despite these challenges, such innovative approaches provide new ways to sustainably adapt to changing environments, balancing human and ecological needs.

Recommendations on Accommodation Measures

- **Integrate land use planning and infrastructure design to increase SLR and flood resilience,** including establishing flood-resilient housing and infrastructure, raising building plots, elevating structures (for example, via stilts), installing flood barriers, and improving drainage systems.
- **Accelerate the implementation of and improve the building code for climate-resilient and green housing;** expand it to other building typologies, that is, one- to two-story residential units; improve capacity to monitor and supervise compliance with building code; and ensure that new buildings can bear weight of solar panels.
- **Conduct systematic housing needs assessments and encourage densification** through adapted regulation, verticalization, and infill across settlements.
- **Improve resilient transport planning** that incorporates elevated roadways, bridges, culverts; expand stormwater management systems and improve maintenance; and establish a resilient transport asset management system incorporating flood risk assessments.
- **Continue to explore innovative accommodation measures** such as 'aquatecture'.

4.1.4. Island raising and land reclamation

Increasing island elevation using sediment dredged from the lagoon has become a common practice. An estimated 1,300 ha of land (4.37 percent of the total land area) has been reclaimed up until 2016.[113] However, the main purpose of reclaiming has not been climate change adaptation but population and economic expansion. This is particularly evident as reclaimed land is seldom raised additionally to account for SLR. Yet, elevating significant portions of existing islands or creating island extensions can be a viable option to address the impacts of SLR and provide more resilient living space. This, however, requires continued efforts to uphold the condition of raised or reclaimed land, hard engineering infrastructure, significant economic resources, and careful environmental impact management.

The reclaimed island of Hulhumalé is a primary example of large-scale land reclamation and raising. It is the first planned city in the country and was developed with the objective of reducing congestion in Malé and meeting development demands. At the same time, its planning and design incorporate climate adaptation considerations and the 400 ha landmass sits approximately 2 m above mean sea level. From 2010 to 2020, the government contracted 13 external loans and guarantees amounting to US$1.1 billion to finance the construction of social housing units in Hulhumalé—an additional 11,000 are being planned for development.

Island raising significantly affects the archipelago's delicate ecosystems and coastal stability. The artificial alteration of islands is known to change the natural patterns of sediment distribution, potentially leading to sediment scarcity and disruption in sediment budgets in areas where it is needed for natural island maintenance and growth. This is acutely evident near new infrastructural interventions such as the port on Fuvahmulah islands causing erosion on its eastern side.[114] Continuous maintenance of raised islands

[113] Ministry of Environment and Energy. 2017. "State of the Environment 2016. Republic of Maldives."

[114] David, C. G., T. Schlurmann, and V. Roeber. 2019. "Coastal Infrastructure on Reef Islands–the Port of Fuvahmulah, the Maldives as Example of Maladaptation to Sea-Level Rise?" In *Coastal Structures 2019*, edited by Nils Goseberg and Torsten Schlurmann, 874–885. Karlsruhe: Bundesanstalt für Wasserbau.

against erosion and SLR is required to ensure their long-term viability and adaptiveness. Sand, essential for these projects, can lead to ecological disturbances when mined, including coral reef damage due to sedimentation, and should be carefully regulated and restricted as needed, particularly in protected areas. Such activities can cumulatively compromise natural island-building processes vital for coral growth and island stability. Therefore, there is a need to better understand the environmental consequences of land reclamation and island raising.

Recommendations on Island Raising and Land Reclamation

- **Develop and enforce stringent regulations and guidelines for island raising and land reclamation activities,** including setting standards for construction practices, environmental impact assessments, and community engagement processes.
- **Continuously monitor sediment transport processes** to maintain the structural integrity and ecological balance of reclaimed areas.
- **Integrate comprehensive wave transformation and hydrodynamic studies into the planning and design phases of island raising land reclamation projects** to improve the understanding of the impact of wave energy and water flow on the island structure and help design more resilient landforms that can withstand the effects of SLR and storm surges.
- **Choose and prioritize land reclamation sites (both for inhabited and resort islands) strategically** considering economic benefits, risks of maladaptation, and negative impacts on ecosystems.

4.1.5. Relocation and migration

Historically, populations living in Maldives were considered mobile as houses and outbuildings were traditionally built from coconut fronds, coir rope, and wood and easily disassembled and moved to another location further away from the encroaching sea or to a different island.[115] Migration within and between islands is a long-standing and widespread phenomenon due to a range of economic and social factors and, especially in the last few decades, has resulted in declining populations on many islands and a large urbanization trend around the capital, Malé.[116] Between 1968 to 2018 an estimated 10,100 people relocated.[117] These past relocations were predominantly initiated as means to facilitate economic development, not as a response to rising seas or coastal risk. However, several relocations occurred because of the 2004 Tsunami.

Migration can be considered a last-resort adaptation measure to climate change, but to date, climate change has not been a significant driver for migration in Maldives. Islanders rarely identify potential climate change impacts as influencing their migration-related decisions; rather, past migration was chiefly motivated by seeking better standards/conditions of living via improved services and more job opportunities.[118] While more than 50 percent of respondents in a survey perceived future SLR to be a serious challenge at the national level and accepted that migration out of the country might be a potential option, they do not perceive SLR as an important challenge and consider other factors—cultural, religious, economic, and social—more significant in migration-related decisions.[119]

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[115] Arnall, A. 2023. "Where Land Meets Sea: Islands, Erosion and the Thing-Power of Hard Coastal Protection Structures." *Environment and Planning E: Nature and Space* 6: 69–86.

[116] Speelman, L. H., R. J. Nicholls, and R. Safra de Campos. 2021. "The Role of Migration and Demographic Change in Small Island Futures." *Asian and Pacific Migration Journal* 30: 282–311.

[117] Gussman, G., and J. Hinkel. 2020. "What Drives Relocation Policies in the Maldives?" *Climatic Change* 163: 931–951.

[118] Kelman, I., J. Orlowska, H. Upadhyay, et al. 2019. "Does Climate Change Influence People's Migration Decisions in Maldives?" *Climatic Change* 153: 285–299.

[119] Stojanov, R., B. Duží and I. Kelman. 2016. "Local Perceptions of Climate Change Impacts and Migration Patterns in Malé, Maldives." *The Geographical Journal* 183 (4): 370–385.

Yet, going forward, climate change and SLR in Maldives are likely to significantly affect human mobility, including local resettlements, intra-island mobility, and international migration. By 2050, estimates of climate-related internal migration across developing countries range from 44 million to 216 million people under different climate, demographic, and development scenarios.[120] In Maldives, a significant land mass is at risk (see Section 1.2.1). This possible loss of land can lead to forced resettlement due to loss of housing. Secondary impacts, for example, the destruction of livelihoods and diminished economic potential, can lead to further migration. While climate change, SLR, and population dynamics remain uncertain, it is likely that people, especially vulnerable groups, will be significantly affected in the coming decades. The resulting human mobility,[121] referring to people moving intra-atoll, inter-atoll, or internationally—or even staying behind due to lack of resources and capability—therefore, require urgent attention of policy makers. In Maldives, depending on the future scenario, it might become financially unsustainable for some atolls to adapt to SLR. In these cases, partial or full retreat might be the most suitable, if not the only, adaptation response. SLR estimations, adaptation pathways, and population development can inform policy making and planning to ensure that people, especially vulnerable groups, have multiple adequate adaptation options.

However, compared to other small island nations (see Box 2), Maldives does not currently consider relocation and migration in the context of climate change in policy making and strategic planning. Past and current government climate change policies and strategies have not focused on these aspects aside from challenges related to immigration. There is a need for discussions at the policy and strategic level on how to best address and plan for relocation and migration linked to climate change. Even if SLR and the physical development of the islands remain uncertain, establishment of policy frameworks and plans will require time and effort and should be started as soon as possible.

Box 2: Relocation/Migration in the Context of Climate Change in Other Island States

Other island states are proactively integrating relocation and migration in their climate change policies—especially in the Pacific islands such as Vanuatu and São Tomé and Príncipe. However, it is important to note that in Pacific Island nations such as the Marshall Islands and Tuvalu, most islands are lower than 1 m above sea level compared to Maldives' average elevation of 1.5 m. Yet, these cases provide valuable insights into the complex interplay between environmental changes and human mobility, demonstrating that, while socioeconomic factors are dominant drivers in some regions, environmental factors, including SLR, are already compelling migration in others.

Some of the lessons from other SIDS include the importance of (a) engaging with affected communities early to build an understanding of their risk tolerance, vulnerabilities, and values; (b) enhancing the policy and public understanding of higher risk levels than in the past; (c) designing early and contributing to the funding mechanisms and regulations that can enable implementation of retreat; (d) avoiding developments in places recognized as risky and where existing urbanization trends can be reversed through no-build zones and prohibited land uses; (e) considering locations for new developments or designing them to be movable; and (f) considering whether buying time through temporary accommodation, protection, or NbS will trigger greater risk exposure and therefore worsen the problem over time or whether these approaches facilitate a transition to retreat.

Sources: World Bank. 2023. *World Development Report: Migrants, Refugees, and Societies*.

Dauphin, L., and A. Voiland. 2021. "Preparing for Rising Seas in the Maldives." NASA Earth Observatory.

Haasnoot, M., J. Lawrence, and A. K. Magnan. 2021. "Pathways to Coastal Retreat. The Shrinking Solution Space for Adaptation Calls for Long-Term Dynamic Planning Starting Now." Science 372/6548: 1287–1290.

'Habitability' and 'uninhabitability' of islands and space are key concepts in understanding relocation and migration in the context of climate change. What individuals and communities consider a habitable or uninhabitable island or space and, as a result, whether they prefer to stay or move, is strongly socially and culturally constructed and includes non-material (culture, history, and place attachments) as well as material

[120] World Bank. 2023. *World Development Report: Migrants, Refugees, and Societies*.

[121] Human mobility in the context of climate change comprises different forms, each with unique characteristics and implications, including migration (often voluntary), displacement (forced), planned relocation, immobility, and trapped populations.

aspects (housing, food, and water).[122] Understanding habitability as only a material phenomenon runs the risks of policy development that disempowers affected communities that have wider notions of what makes their place acceptable to live in. Considering communities' view of habitability is therefore critical when designing measures to address SLR risk.[123]

Recommendations on Relocation and Migration in the Context of Climate Change

- **Integrate relocation and migration response options into relevant policy frameworks**, including considering them in spatial planning, financial support frameworks, and decentralization and skill diversification programs to decrease population pressure on overpopulated areas through internal migration.
- **Assess the suitability of relocation and migration responses for different islands** as part of integrated spatial planning that considers criteria such as high climate vulnerability and investment and opportunity costs of investing in island protection and accommodation.

4.2. Integrated adaptation planning: Island typology and adaptation pathways

Categorizing islands based on hazard levels, exposure, and vulnerability can facilitate the planning of SLR adaptation at a national scale. One key challenge in preparing a comprehensive nationwide SLR adaptation strategy is the significant variation in hazard levels, exposure, and vulnerability across the 187 inhabited islands. Due to the heterogeneity, it is difficult and costly to assess risk levels and adaptation options for each island individually. A more effective approach is to develop island typologies (see Table 2).[124]

Considering available adaptation measures and types of islands, this CCDR identifies four archetypical Dynamic Adaptive Policy Pathways (DAPPs) for Maldivian islands. The available adaptation measures in Maldives have been discussed in Section 4.1. Considering these measures in the context of the island typology, the four identified DAPPs are (1) protection, (2) transition to protection, (3) transition to accommodation with nature-based measures, and (4) accommodation with nature-based measures (see Figure 10).[125] These archetypical DAPPs focus only on the principal categories of adaptation (for example, accommodation) rather than on specific adaptation measures (for example, land use planning). While the specific adaptation measures largely complement each other (as indicated by the parallel timelines for the different measures in Figure 10) there are lock-in effects (discussed in Section 4.1) that lead to a path dependency of choosing one DAPP over another. DAPPs are most effective when tailored to individual islands, recognizing that each island possesses unique oceanographic, geomorphological, ecological, and socioeconomic characteristics. The DAPP approach allows decision-makers to decide on short-term low-regret options while maintaining a longer-term view of integrated adaptation. In all DAPPs, EWSs and monitoring systems are necessary to preserve critical infrastructure, protect populations, help identify when key tipping points are reached, and decide appropriate actions in the medium to long term.[126]

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[122] Farbotko, C., and J. Campbell. 2022. "Who Defines Atoll 'Uninhabitability'?" *Environmental Science & Policy* 138: 182–190.

[123] Ibid.

[124] University of Plymouth. 2024. *Sea-level Rise and Coastal Changes in the Maldives: Review for the World Bank*. Background study prepared for this report.

[125] The concept of accommodation generally involves adapting to SLR through methods that allow human activities to continue with minimal disruption, while acknowledging that some level of impact is inevitable. This can include measures such as elevating buildings or enhancing natural buffers. However, the strategy of accommodation in DAPP 2 stops after reaching a tipping point (for example, 0.5 m of SLR) largely due to the limitations of accommodation measures in the face of more severe SLR. Beyond this tipping point, the focus shifts toward more permanent solutions such as relocation or significant land elevation, reflecting an understanding that accommodation alone may no longer be sufficient to manage the increased risks.

[126] University of Plymouth. 2024. *Sea-level Rise and Coastal Changes in the Maldives: Review for the World Bank*. (Background study prepared for this report).

Table 2: Maldives island typology

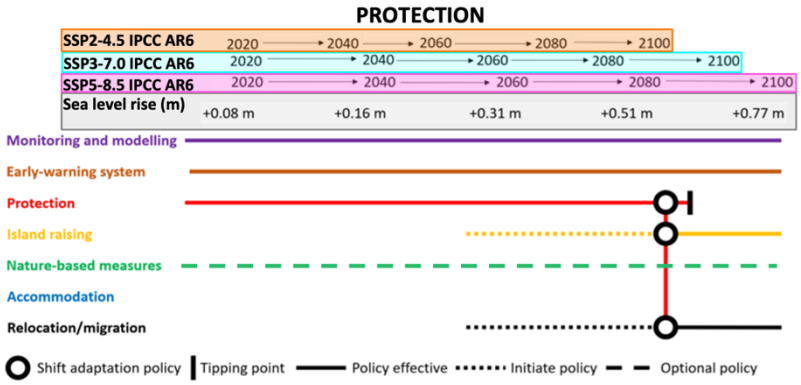
Island type	Examples	Description
Complete-protection urban island	Malé, Hulhumalé	Urban rim islands with coastal protection around their entire perimeter. High level of protection prevents flooding and overwash deposition. Only a few islands match this description. The raised island of Hulhumalé is also included in this category because its elevated surface provides coastal protection.
High-protection rural island (a)	Thinadhoo, Gaafu Dhaalu	Rural rim islands with low-to-medium density housing and coastal protection along most of the perimeter. These islands offer a high level of protection, limiting flooding and wash over deposition.
Medium-protection rural island (b)	Fares-Maathodaa, Gaafu Dhaalu	Rural rim islands with low-density housing and coastal protection along a significant portion of the perimeter, such as the lagoon- or ocean-facing side. These islands offer some flood protection but are still at risk of flooding and overwash deposition.
Low-protection rural island (c)	Fioyaree, Gaafu Dhaalu	Rural rim islands with low-density housing and limited or no coastal protection. These islands are unprotected against flooding and experience overwash deposition.
Lagoon island (d)	Dhevvadhoo, Gaafu Alifu	Inhabited lagoon islands are relatively uncommon, characterized by low-density housing and limited coastal protection. Their lagoonal setting means less energetic waves from various directions, leading to a dynamically changing shoreline.
Natural island (e)	Dhigelaabadhoo, Gaafu Dhaalu	Uninhabited lagoon or rim islands with no coastal protection, fully exposed to natural flooding processes.
Agricultural island (f)	Vaadhoo, Gaafu Dhaalu	Rural rim islands with low-density housing and low-to-medium flood protection, serving a significant role in food production.
Resort island (g)	Maguhdhuvaa, Gaafu Dhaalu	Natural or reclaimed islands used as resort islands, which can be lagoon or rim islands with varying levels of protection, usually from low to medium.

Examples of the different Maldives island types

Figure 10: Archetypical Dynamic Adaptive Policy Pathways for Maldivian islands

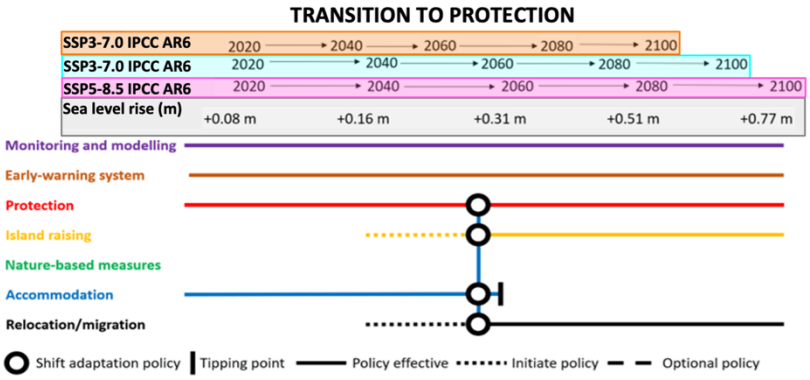
DAPP 1

Best suited for complete-protection urban islands and high-protection rural islands. The critical tipping point that determines the suitability of this pathway is either the failure of flood defenses or an unacceptable flood risk. When this point is reached, adaptation will need to shift to either raising the island or relocation and migration. However, investing in upgrading coastal defenses may also be a viable option.



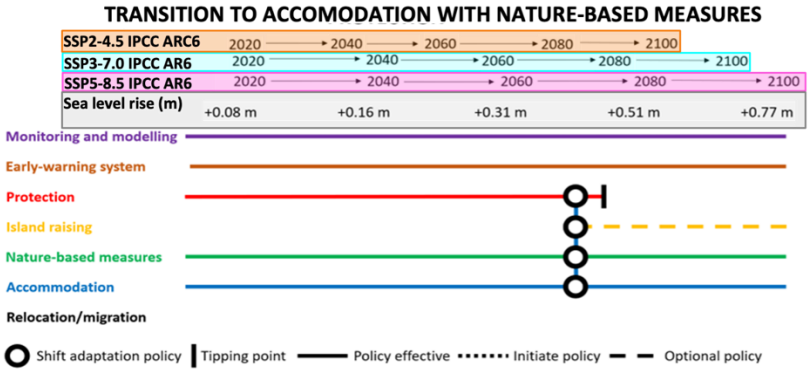
DAPP 2

Best suited for medium-protection rural islands, where coastal defenses protect most of the perimeter, but accommodation strategies can be used in unprotected areas. The tipping point occurs when this approach becomes unfeasible. At this point, policy shifts toward extending coastal defenses to encircle the island, raising the island, or considering relocation and migration.



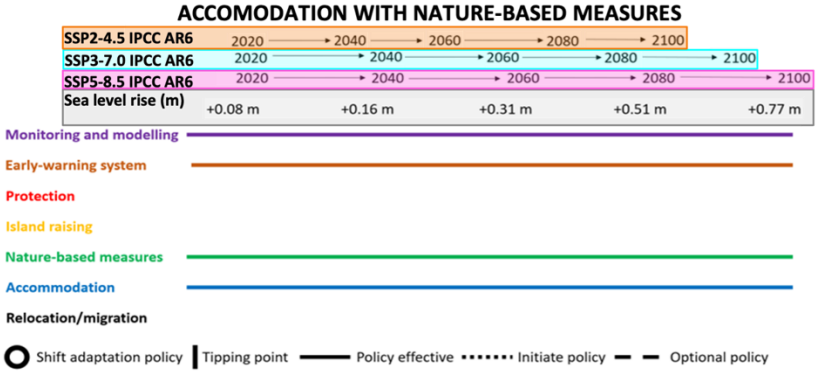
DAPP 3

Ideal for low-protection rural and agricultural islands, including lagoon and resort types. This strategy prioritizes nature-based measures such as beach nourishment and rubble berms to sustain habitability. The tipping point is reached when current defenses are insufficient. Beyond this, adapting policies to include accommodation through nature-based measures becomes essential. Island raising might also be explored. Relocation and migration are not considered necessary, as overwash deposition is expected to keep the islands' elevation in line with sea level.



DAPP 4

Most appropriate for islands like DAPP 3 but lacking any coastal protection. This approach presumes that the flooding regime will consistently allow the island to keep pace with SLR, without significantly affecting the residents' lifestyle. Consequently, there are no defined tipping points, and NbS along with accommodation strategies are deemed sufficient. The change in island height during floods, often overlooked, makes this strategy less considered. However, in a well-informed, integrated DAPP, this pathway could work for many islands.



Recommendations on Integrated Adaptation Planning

- **Develop a national adaptation strategy that explicitly integrates SLR and its cascading impacts,** with clearly defined long-term objectives, within which subnational strategies can be integrated; due to limited funding, there must be an equitable process for deciding where and how adaptation strategies are developed and implemented.
- **Diversify adaptation strategies by combining different adaptation measures to form a comprehensive approach to managing SLR and flooding,** including a mix of protection, accommodation, and NbS tailored to the specific needs and conditions of each island; these measures should be integrated into a comprehensive, island-specific framework that could be developed based on the DAPPs identified in this report.
- **Increase public engagement, awareness, and education around adaptation planning** considering that while most communities desire hard engineering measures, this is not economically feasible at the required scale and not always optimal; involve communities in the decision-making process about their future, which requires education on climate change impacts and adaptation options.
- **Enhance monitoring and modeling to enhance process understanding and describe future impacts of SLR,** including expanded and continuous monitoring of wave climate, water levels, reef platform, and island topography as well as robust documenting of flood events.

Note: Specifically, a step change in coastal monitoring could be achieved through deploying an additional tide gauge between Gan and Malé and several strategically placed long-term directional wave buoys, performing a systematic analysis of island shoreline change using satellite data that can be updated annually, establishing a data collection process to create full island-platform Digital Elevation Models (using LIDAR, photogrammetric drone data, and echosounder data) for all inhabited islands, and expanding the current weather-related incident monitoring program to provide robust data on all island flood events including extent of flooding.

5. Toward Climate-Resilient Livelihoods

5.1. A climate-resilient tourism sector

Tourism is the single most important sector, providing most jobs and livelihoods for Maldivians and revenues for the government. The sector directly accounts for almost 30 percent of GDP and more than 60 percent of foreign exchange receipts.[127] In 2022, tourism revenue contributed almost half of the total government revenue in the land rent, Green Tax, tourism goods and services tax, and lease extension fees.[128]

Maldives has been able to develop a successful high-end tourism sector, primarily by developing its resort model; on the 176 resort islands, it is the resorts that are responsible for implementing and financing climate action. The sector is driven by a one-resort-one-island model, and the resorts account for a vast majority of activity in this sector: the 176 resorts have almost 43,300 beds in operation and comprise 70 percent of all tourism facilities in 2023.[129] These resorts also contributed 92 percent of tourism revenues to the government in 2022. The rest comes from guesthouses on local islands.[130] These resorts are all privately held, and each resort is responsible for its own climate adaptation investment, energy and water production, and waste management. Therefore, any climate adaptation and mitigation action on these islands will have to be undertaken by the investors and/or resort companies themselves. Positioning Maldives as a high-end tourism destination depends on perceptions of sustainability. Stakeholder interviews suggest that many tourists, especially at high-end resorts, care about sustainability and that resorts use it as a marketing tool.

The government diversified the tourism sector by allowing guesthouses on inhabited islands where the government is mainly responsible for climate action. Guesthouses were allowed to operate starting in 2009, when regulations were changed to also allow tourists to stay on local islands. Guesthouses created forward links by providing employment and purchasing services on these inhabited islands. The share of registered guesthouse beds grew from less than 3 percent in 2012 to about 23 percent in 2022.[131] However, unregulated growth and lack of oversight of guesthouses have placed a considerable strain on island infrastructure and waste management services. In addition, guesthouses usually play little to no role in any climate adaptation investments on their respective island, which are the responsibility of the island council or the government.

The tourism sector reports that it faces considerable climate change impacts. The sector critically depends on the country's blue natural capital stocks (beaches, aquatic life, corals, and so on), which are highly vulnerable to climate change impacts (see Section 1.2). Most resorts experience shoreline retreat, more than half experience damages due to swell waves, and slightly less than half experience damages due to storm surges.[132] Original surveying[133] of 55 resorts investigated the perceptions of climate impacts and finds that accelerated beach erosion is the main climate change impact faced by the resorts (see Figure 11). Around 90 percent of resorts reported beach erosion and 50 percent reported damage to infrastructure as a moderate to serious climate change problem.

[127] World Bank Group. 2023. *Maldives Country Partnership Framework*.

[128] Maldives Ministry of Tourism. 2023. *Tourism Yearbook*.

[129] According to the Maldives Ministry of Tourism, resorts and the other tourism facilities (hotels, guesthouses, and safari vessels) had a total of 61,650 beds in operation in 2023.

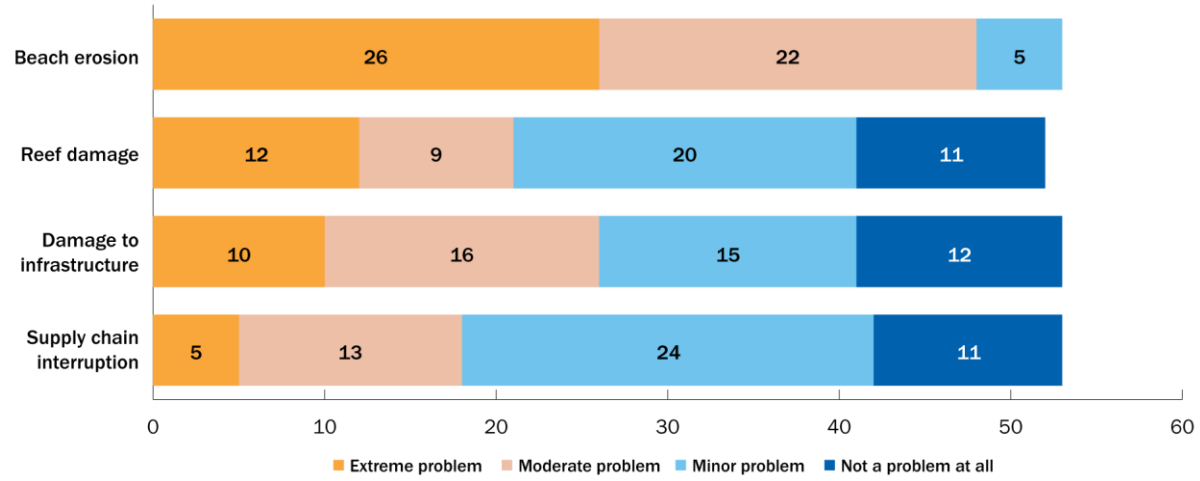
[130] Maldives Ministry of Tourism. 2023. *Tourism Yearbook*.

[131] Ibid.

[132] World Bank. 2024. *Maldives: Country Environmental Analysis. Towards a More Sustainable and Resilient Blue Economy*. Washington, DC: World Bank Group.

[133] The survey covered 55 resorts or 32 percent of all resorts in Maldives. The sample is representative of resorts in Maldives, except for ultra-luxury resorts.

Figure 11: The biggest climate change problems as per resorts surveyed



Source: IFC. 2024. Based on a survey of 55 resorts in Maldives.

Note: Some resorts did not respond to individual questions.

The reported climate impacts, such as beach erosion, are also related to tourism developments being maladaptive. Understanding the resorts' responses requires consideration of the context of geographically locking in island infrastructure and activity in a constantly changing environment. On resort islands (as on local islands), hard and gray coastal protection measures are often a consequence of locking built infrastructure (the hotel and its amenities) in one place, in an environment that is naturally dynamic. The Maldivian islands are ever-changing, because of changing currents, waves, and wind, as has been documented well over the past decades and centuries.[134] It has been a part of these natural dynamics that some parts of the island erode while other parts gain land, during one period, and then the inverse, during another period. However, once tourism infrastructure is designed with beaches in a particular place, the lack of flexibility in resort design creates strong incentives to maintain these beaches in their current positions rather than allowing them to shift elsewhere on the island.

Most resorts have implemented gray coastal protection measures, but around 40 percent have also explored NbS, such as beach replenishment (see Figure 12). As the occurrence of beach erosion increases with more frequent changes in weather and ocean patterns, some resorts are investing in permanent engineering solutions such as breakwaters around the island to reduce the need for frequent beach replenishment. Beach replenishment can cost up to US$10,000 per month for some resorts and it is undertaken as an expenditure from annual budgets, whereas breakwaters are constructed as one-off projects during major resort renovations, which happen in five- to eight-year cycles.[135] Revetments and breakwaters to guard against coastal erosion are expensive and can cost up to US$1 million for a 300 m wall.[136] Most resorts spend less than US$30,000 annually on coastal protection solutions; 20 percent spend less than US$10,000 annually (see Figure 13).

Resorts reported significant barriers to implementing climate adaptation measures (see Figure 14). Any modification to the resort island, such as implementing climate adaptation measures, requires a permit from the government, cited as a moderate to extreme barrier by resorts in terms of 'time to construct'. Stakeholders indicate that the permit process is time-consuming and not tailored to the type of infrastructure change sought. Despite an increase in the number of applications because of rising occurrences of beach erosions and climate events, resources devoted to the permitting process remain unchanged. In addition, over 80 percent of resorts highlighted that the implementation costs are a moderate to extreme barrier.

[134] See Sections 1.2.1 and 4.1 and World Bank. 2024. *Maldives: Country Environmental Analysis. Towards a More Sustainable and Resilient Blue Economy*. Washington, DC: World Bank Group.

[135] Based on IFC stakeholder interviews in the context of the survey.

[136] IFC stakeholder interview.

While gray climate adaptation measures such as beach nourishment are an annual expenditure item, measures such as revetments and seawalls require much larger investment and approvals from the government and are usually undertaken along with periodic renovations carried out by resorts. Lastly, access to low-cost financing and lack of skilled workers were cited as a moderate to extreme barrier by almost 70 percent and 60 percent of resort owners, respectively. Stakeholder interviews identified that resorts learn of new technologies individually, and this is often dependent on the experience and skill of the engineering staff or even coincidental.

Figure 12: Share of resorts that implemented gray and nature-based coastal protection solutions (past five years)

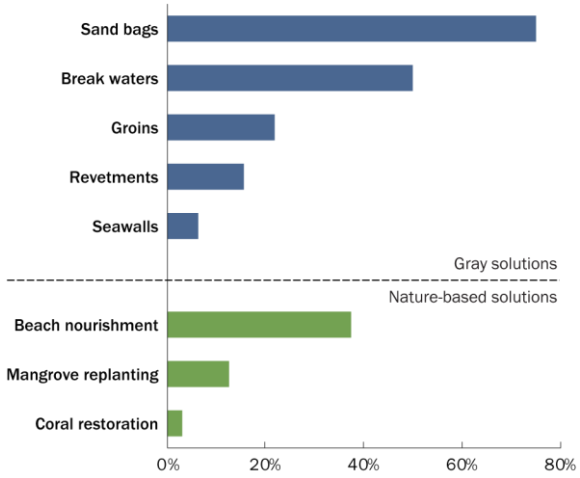
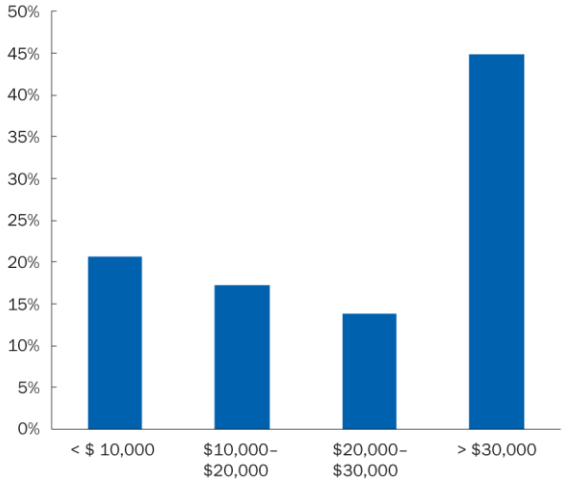
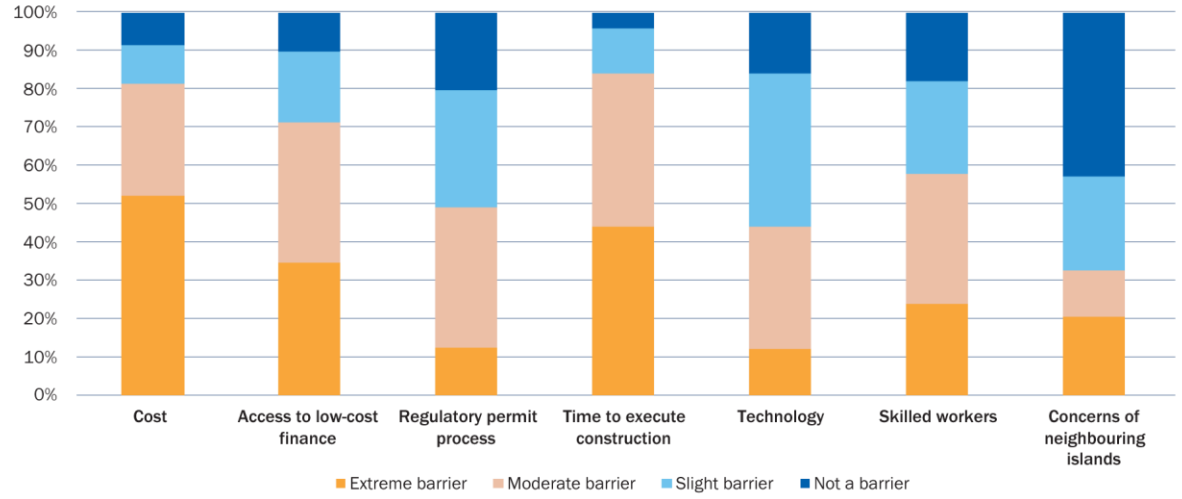


Figure 13: Annualized total expenditure of coastal protection per resort



Source: World Bank. 2024. Maldives: Country Environmental Analysis. Towards a More Sustainable and Resilient Blue Economy. Washington DC: World Bank Group.

Figure 14: Barriers in implementing climate adaptation measures as per resorts surveyed



Source: IFC. 2024. Based on a survey of 55 resorts in Maldives.

Beach erosion is also a major issue for guesthouse operations, but guesthouses have a minimal role in supporting climate adaptation investments. Loss of beach has been identified as a serious concern for guesthouse operations. Unlike resorts, guesthouses cannot by themselves undertake significant action to combat beach erosion as coastal protection projects and beach management in the inhabited islands are undertaken by the government. This is further hampered by the low institutional capacity of island councils (see Section 2.2). According to interviews with island councils, financing for projects to address these risks is limited and dependent on budget allocations from the central government. Many guesthouse islands are

eager for more tourism development which can provide jobs and income to local inhabitants, but they do not have the resources to ensure that the tourism growth is resilient or sustainable.

Recommendations on Resilient Tourism

- **Facilitate adaptation investments by resorts and guesthouses** by increasing government capacity to accelerate permitting processes for resorts and introducing simplified procedures for resorts to repair damage or undertake minor projects without resorting to lengthy permitting processes.
- **Incorporate resilience considerations in building codes for new tourism infrastructure.**
- **Develop sustainability standards and a possible ranking for resorts and guesthouses** by collaborating with accredited certifying agencies.
- **Establish dedicated platforms/events and integrate public and private initiatives** to facilitate the exchange of information, innovation, and best practices for climate adaptation and mitigation in the tourism sector, in particular for NbS.
- **Consider diversifying tourism offerings** by, for example, offering packages that emphasize conservation and education such as guided snorkeling or diving tours that educate tourists about coral reef conservation, marine life watching tours, and participation in conservation activities such as coral planting or beach cleanup.

5.2. A climate-resilient fisheries sector

Fisheries is the second-largest economic activity, contributing to the livelihoods of many Maldivian households,[137] **particularly in the atolls outside of Malé where 92 percent of fishers reside.**[138] Fisheries can be divided into pelagic fisheries (mainly tuna), reef fisheries, and live bait fisheries. Most Maldivian fishers are engaged in tuna fishing (mainly pole-and-line fishing), which represented 99 percent of all-species fish catch in 2020.[139] Maldivian fishers earn incomes that are on par with and slightly above the national average.[140] With less than one in three educated beyond primary school, fishers have limited options for alternative livelihoods and are thus vulnerable to declining fishing incomes.[141]

Understanding the complex interplay of climate change on fisheries and its implications for Maldives is paramount. Climate change affects the distribution of fish stocks and their food, which, in turn, is expected to have a significant impact on fisheries, fisheries-dependent livelihoods, and food security. However, the local impacts of climate change on fisheries remain poorly understood. Existing studies suggest that climate change will lead to an increase in fish catch potential of up to 20 percent in the tropical regions of the Indian Ocean,[142] but these predictions do not consider (sub-) national scale factors, such as fishing methods and island geography. Fisheries are also highly dependent on the health of other marine resources, such as corals. Coral reefs are expected to be affected by ocean heating (see Section 1.2). Yet, the effects on local fisheries remain poorly understood. This is a pressing knowledge gap given that the fisheries sector is highly dependent on live bait collected in coral reefs.

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[137] As per the government's 2016 second National Communication of Maldives to the UNFCCC, the fisheries sector historically served as the primary source of income for over 20 percent of the population. The Ministry of Fisheries, Marine Resources, and Agriculture is currently registering fishermen to obtain a more detailed understanding of the number of people directly and indirectly engaged in the sector.

[138] Maldives Bureau of Statistics, Household Income and Expenditure Survey 2019.

[139] (former) Ministry of Fisheries, Marine Resources, and Agriculture and Maldives Bureau of Statistics. 2021.

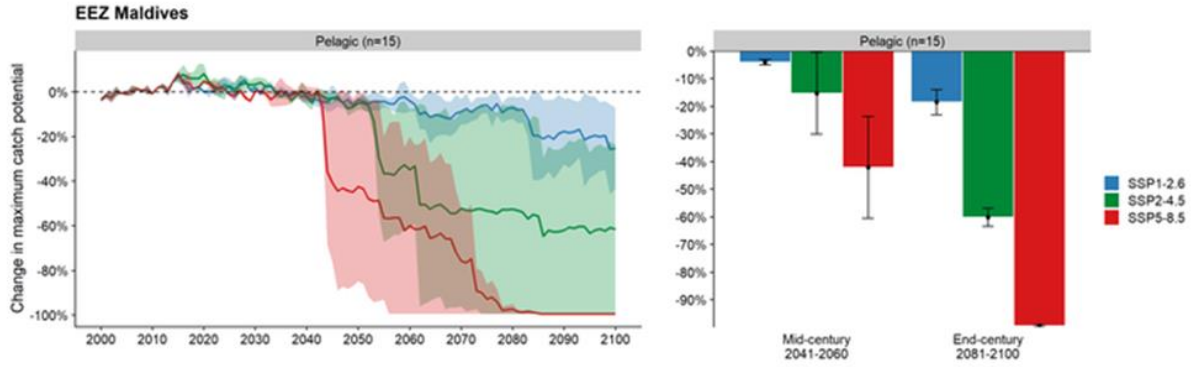
[140] World Bank. 2024. *Maldives: Country Environmental Analysis. Towards a More Sustainable and Resilient Blue Economy*. Washington, DC: World Bank Group.

[141] Ibid.

[142] Cheung, W., V. Lam, J. L. Sarmiento, and K. Kearney. 2010. "Large-Scale Redistribution of Maximum Fisheries Catch Potential in the Global Ocean under Climate Change." *Global Change Biology* 16 (1): 24–35.

The fisheries sector is highly vulnerable to climate change, and fish catch is projected to decrease sharply in high-emission scenarios. Background analytical work for this CCDR analyzed the 15 key pelagic fish species (most importantly including yellowfin, bigeye, and skipjack tuna), accounting for almost all of the fish revenue, with regard to their vulnerability to climate change based on three factors: species sensitivity (such as temperature tolerance, habitat dependence, and susceptibility to ocean acidification), adaptive capacity (such as range of breadth and depth, habitat specificity, and reproductive rate), and exposure to climate hazards. A Dynamic Bioclimate Envelope Model was used to project future changes in total fish catch within the EEZ as proxied by maximum catch potential[143] under high, medium, and low GHG emission scenarios (see Figure 15). Under all three scenarios, maximum catch potential remains stable through 2040. From 2041 to 2100, projected catches decrease as climate change intensifies. By 2041–2060, declines in pelagic fish catches vary from under 5 percent to around 15 percent and 40 percent under low (SSP1-2.6), medium (SSP2-4.5), and high (SSP5-8.5) climate change scenarios, respectively. By 2081–2100, these declines worsen further, with differences between scenarios becoming more pronounced (17 percent, 60 percent, and 100 percent under low, medium, and high scenarios). It is important to note that even under a 'middle-of-the-road' scenario such as SSP2-4.5, which will result in temperature increases of about 2.7°C by the end of the century, there are probabilities indicating a decrease in fish catch by almost 80 percent.

Figure 15: Change in maximum catch potential estimated for three different climate scenarios



Source: The Climate Resilience of the Maldivian Fisheries Sector 2024.

Projected climate impacts on fishing revenues correlate directly with fish catch impacts. Using the tuna fishery as a basis for estimating fish cost, net revenue nationally is expected to decrease by about 3 percent in 2081–2100 compared to the current period (2020s) under a low-emission scenario (SSP1-2.6). Under a SSP2-4.5 scenario, the decline reaches almost 25 percent. Under a high-emissions future, a total loss of revenue (100 percent) is expected (see Figure 16). Under a high-emission scenario, the estimated loss in tons of exports will be 89,180 annually, equivalent to around US$202.3 million per year (3.35 percent of GDP). Under the 'middle-of-the-road' scenario (SSP2-4.5), the annual losses in fisheries revenues and trade values are projected to be around US$10.7 million and US$13.4 million, respectively, by mid-century and to US$42.2 million and US$52.6 million, respectively, by the end of the twenty-first century.

The potential fisheries catch projected by the end of the twenty-first century under SSP5-8.5 may only support around 3.8 percent of the current 17,500 fishers.[144] Fishers' incomes vary from US$500–1,000 per month[145] up to US$2,600 per month.[146] Assuming an average income of US$1,500 per month and applying this to the projected 16,843 jobs that may no longer be supported by the fishery by the end of the century, an estimated US$303 million loss in fishing income is projected. This worst-case scenario suggests

[143] Maximum catch potential refers to the catch level that results in achieving the maximum sustainable yield. In other words, it is the highest possible catch that can be maintained over time without depleting the fishery's resources.

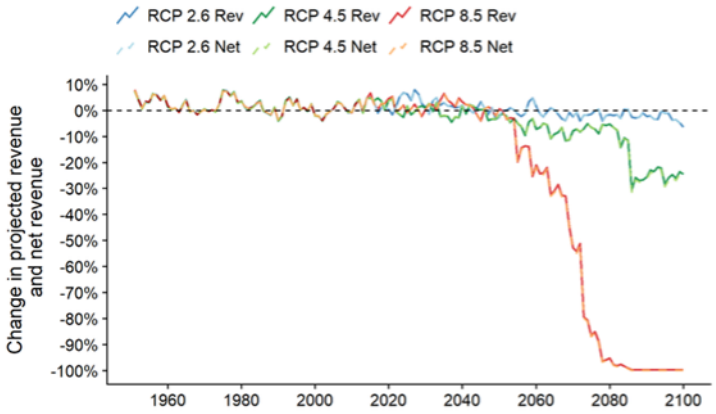
[144] Jauharee, A. R. 2022. *The Tuna Pole and Line FAD (Fish Aggregating Device) Fishery of the Maldives: Towards Science-Based Management through Fishers and Scientific Knowledge*. Université de Montpellier.

[145] Ibid.

[146] Jaleel, A., and H. Smith. 2022. "The Maldives Tuna Fishery - An Example of Best Practice." *Ocean Yearbook* 36 (1): 314–345.

fisheries may cease to be a viable source of income and livelihood for fishers. While this decline is anticipated only by the century's end, it underscores the necessity of planning for the eventual displacement of almost the entire fisher population. Lower projected catches by the end of the century under RCP4.5 could result in one-quarter (4,380) of current fishing jobs being lost, equivalent to approximately US$78.8 million in fishing income.

Figure 16: Projected percentage change in fisheries—pelagic and reef-associated—revenue and net revenue relative to the base period (1990–2010) under different climate scenarios



Source: The Climate Resilience of the Maldivian Fisheries Sector 2024.

Note: Solid lines indicate revenue and dashed lines are net revenue (revenue − fishing cost).

Climate change impacts on fisheries threaten food security. A significant portion of the population relies on fish as a staple in their diet. Maldivians have the highest per capita fish consumption in the world, averaging a pound of fish per day. Fish is the only staple not imported, with tuna alone making up 85 percent of their protein intake. On average, Maldivians consume 94 kg of skipjack tuna annually. As an island nation with limited agricultural land, fish is a readily available and vital source of nutrition compared to other protein sources.

The fisheries economy and those reliant on it have a higher vulnerability to climate change than those of neighboring countries. In a comparison with eight West Indian Ocean Island nations, Maldives' fisheries economy was ranked the second most vulnerable to climate change after Sri Lanka.[147] Of the eight nations, Maldives ranked first in projected fisheries sector exposure to climate change, as its maximum catch potential is estimated to experience the largest decreases in the region. It ranked second in sensitivity based on high fish protein consumption, fisheries sector exports, and population concentrated in the coastal zone. It fared better in adaptive capacity due to the high education rates of its population and significant government subsidies.[148]

There are several adaptation options in response to the expected climate impacts facing the fisheries sector. The options identified include increasing the socioeconomic resilience of fishers, opening opportunities for alternative livelihoods such as mariculture, conserving marine and coastal ecosystems including through MPAs (see Chapter 3 for more details), improving fisheries management, and exploring alternatives to existing fisheries. Providing income assistance to meet unemployed fishers' basic needs in a high-emission scenario would cost an estimated US$76.3 million each year.[149] Increased management costs

[147] The vulnerability analysis included sub-rankings of four categories: (1) exposure, defined as the presence of people and exploited marine resources that could be adversely affected; (2) hazard, defined as the climate-related impact on the marine ecosystem; (3) sensitivity, defined as the importance of fisheries to national economies and food security; and (4) adaptive capacity, including economic capital, human capital, and governmental effectiveness.

[148] Beneficial subsidies in the fishery sector include those that go toward fisheries management, research and development, MPAs, and support to fishers' income, among others. These activities help build and support marine ecosystem resilience as well as the adaptive capacity of fishing communities. See Sumaila, R., et al. 2019. "Updated estimates and analysis of global fisheries subsidies." In *Marine Policy (109)*.

[149] Assuming the assistance covers a minimum wage of US$369 per month.

for fisheries under new regulations are estimated at US$14.7 million to US$29.3 million yearly.[150] The annualized establishment cost to expand MPAs to 30 percent in line with internationally agreed targets is estimated to be US$110 billion per upper-middle-income country. Taken together, the costs of these three adaptation measures could equal up to US$100 million per year by the end of the century.

Recommendations on Climate-Resilient Fisheries

- **Increase the socioeconomic resilience of fishers** by enhancing their adaptive capacity through establishing skills development and educational programs that enable them to diversify their livelihoods and improving access to financial services and insurance.
- **Diversify economic activities in the fisheries sector, including in areas such as mariculture**, which can provide a safeguard for fishers currently solely relying on capture fisheries.
- **Invest in research to fill knowledge gaps regarding the local impacts of climate change on fisheries and marine ecosystems** by establishing a robust monitoring system to track changes in fish populations, their distribution and migration, and the health of marine habitats within the Maldivian EEZ and beyond.
- **Develop and maintain infrastructure that supports climate resilience in the fisheries sector**, such as improved and resilient port facilities, cold storage, and processing plants.
- **Enhance the fish processing industry,** particularly in areas such as fish canning, to reduce reliance on raw material exports and add more value to fishery products domestically.
- **Strengthen policies and governance structures to support sustainable fisheries management, climate change adaptation, and disaster risk reduction,** including integrating climate change considerations into national fisheries policies and plans.
- **Improve the efficiency of fisheries management,** including by reviewing and reforming the Maldives Industrial Fisheries Company.

Note: For a detailed proposed pathway options for Maldives Industrial Fisheries Company's reform, see World Bank. 2024. *Maldives: Country Environmental Analysis. Towards a More Sustainable and Resilient Blue Economy*. Washington, DC: World Bank Group.

5.3. Social protection, people, and skills for climate resilience

Social protection systems can play a critical role in protecting and fostering people's resilience and growth. Maldives has the foundations of a social protection delivery system that can be mobilized to respond to stresses such as those caused by climate change. The digitized ID system, well-developed payment systems, and recent experience of swiftly deploying an income support program through the island councils during the COVID-19 pandemic are a strong basis. A National Social Protection Framework was launched in 2023. The National Social Protection Agency maintains a beneficiary registry system called the Social Protection Information System (SPIS) that securely collects and maintains data provided by applicants, determines eligibility, and records subsequent beneficiary transactions. SPIS is accessible through island councils making it easier to provide coverage to the residents of atolls (where most of the poor live). However, the role of the island councils would need to be further enhanced, particularly in incentivizing people to register for programs and ensuring effective delivery of programs. The coverage of the population in the social registry remains low at 35 percent. Despite the low coverage, all the infrastructure is already available and could be scaled up. Maldives could benefit from a nationwide data collection exercise to populate the SPIS.

[150] Willmann, R., P. Boonchuwong, and S. Piumsombun. 2000. "Fisheries Management Costs in Thai Marine Fisheries." Paper presented at the 10th Biennial Conference of the International Institute of Fisheries Economics & Trade: Microbehavior and Macroresults. Corvallis, Oregon, USA. Compiled by Ann L. Shriver. International Institute of Fisheries Economics & Trade, Corvallis, Oregon, USA, 2000.

A stress test conducted in 2021 found that the most highly rated aspect of the social protection system in terms of adaptiveness and scalability is its delivery systems.[151] It has the foundations for a functioning social registry and electronic systems for enrollment and payment of benefits. It was also found that comprehensive communication mechanisms can be leveraged during climate stressors such as flooding to inform target beneficiaries about their entitlements and associated payment systems. Entitlements are transferred directly to beneficiary bank accounts and may be withdrawn from ATMs on the main islands and from boat-based ATMs that visit the smaller islands regularly. The weakest aspect, according to the stress results, was data and information. The system does not have regularly updated data with adequate coverage of the population. Furthermore, the stress test found that financing and institutional arrangements can be improved.

A well-designed and effective social protection system can protect the poor and vulnerable from the short- and medium-term impact of decarbonization reforms, in particular energy subsidy removal. While energy subsidies lower the cost of energy for households, they also introduce distortions in the market by setting a price below the true cost of energy provision, often leading to suboptimal environmental outcomes that can incentivize pollution and inefficient levels of carbon emissions. Due to lower incomes, however, poorer households tend to benefit more from subsidies in relative terms and would disproportionally be affected by their removal. In 2019, subsidies accounted for 8.3 percent of incomes in households in the bottom 10 percent versus 1 percent for households in the richest decile. Thus, subsidy removal would pose a disproportionate burden on the poor. Poverty rates would be 1.9 percentage points higher in 2019 and inequality would be 0.7 Gini points higher, in the absence of subsidies for fuel and electricity. The poverty increase would be larger in atolls where energy subsidy removal would drive poverty to rise by 3.4 percentage points. This poses a trade-off between the implementation of subsidy reforms and equity that needs to be addressed.

Revenues saved from subsidy reform could be redirected to protect poor and vulnerable households from disproportional welfare losses. Notwithstanding the higher incidence of subsidies on poorer households' incomes, subsidies are an inefficient way to allocate public resources to the bottom of the distribution ladder. About 56 percent of spending on subsidies reaches the top 60 percent; 48 percent and 69 percent of spending on electricity and fuel subsidies, respectively, reach the top 60 percent. Despite the higher progressivity of electricity subsidy—driven by lower incomes among households living outside of Malé who benefit from the subsidy to electricity distribution—a sizable share of spending on subsidies does not reach the poor and vulnerable. Recycling these revenues could free up resources that can be spent on more targeted, pro-poor interventions including strengthening public services and improving social protection schemes. For a more comprehensive discussion on the impacts of subsidy reforms, see Box 5 in Section 7.3.1.

Maldivian climate management and social protection systems need to be better integrated. Integrating climate risk assessment data with beneficiary databases to identify the most vulnerable groups and increasing support to them can further enhance crisis preparedness while also ensuring that resources are directed to those who need them the most. However, there is currently insufficient data on and analysis of the distributional aspects, including poverty and inequality, in the context of climate change impacts that make the targeting of social protection and subsidy schemes hard.[152] Linking social protection information systems such as the SPIS with disaster risk data can help distribute limited available disaster relief resources efficiently. The strengthening of government-owned information systems and systematized financing that allow for the rapid deployment of empirical and efficient interventions can enable the Maldivian government to build its crisis preparedness and inter-ministerial coordination capacity. The coordination of disaster management and social protection agencies through an integrated policy framework is a missing piece in the social protection system.

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[151] World Bank. 2023. *Responsive by Design: Building Adaptive Social Protection Systems in South Asia (English)*. Washington, DC: World Bank Group.

[152] The World Bank-financed Maldives Competitiveness and Growth Project (P179286) is currently developing subsidy reforms and targeting mechanisms.

Early warning and early action approaches are limited, especially when it comes to mechanisms for public dissemination of weather forecasts and alerts, particularly on the small outer islands. Work is under way to develop EWSs, but efforts are scattered across sectors. Maldives has progressed in building weather-related hazard monitoring networks. Yet, effectively sharing risk information with the public remains a hurdle. While these platforms enable quick information sharing in crises, the distribution of risk information is still uneven. The main issue is to unify and interpret data for cohesive, informed decision-making, as various stakeholders use different methods for collecting, handling, and sharing risk information. Advancing EWSs into a comprehensive multi-hazard EWS, including health, marine, and anthropogenic disasters, is essential to overcome the current system's segmented approach to risk monitoring and alerts.[153]

To minimize disaster risk to people and overcome the current system's segmented approach to risk monitoring and alerts, the development of a robust multi-hazard EWS is essential. A nationwide multi-hazard EWS should be integrated with an enhanced data monitoring program. Early warning modeling systems can also be utilized to evaluate future flood risk scenarios, providing coastal managers and planners with a valuable decision support tool for adaptation planning. Therefore, the country needs to strengthen emergency preparedness and modernize weather forecasting and EWSs to help communities act well in advance of extreme weather events and disasters. The MMS needs resources and capacity to regularly maintain geographically dispersed automatic weather stations and other equipment necessary for monitoring the impacts of climate change and high-impact weather. The development of EWSs by improving weather monitoring networks on the ground, digital infrastructure, strengthened forecasting capabilities and use of novel methodologies and tools, and building of capacity at the MMS are essential to fill existing gaps.

Climate change presents significant challenges to education and skills development. Climate and disaster events may destroy or damage school buildings and learning environments, and children could either temporarily or permanently be unable to attend school. In addition, climate shocks can reduce access to health and education services, as health facilities and schools in some remote rural areas are not adequately equipped and staffed during shocks or resilient in the aftermath of crisis. This can lead to significant human capital losses that can have negative economic and social consequences, especially for the bottom 40 percent of the population. Skill development and unemployment insurance could also contribute to mitigating the distributional impacts of a green transition in key economic sectors.

Education and skill development are also critical to drive mindset and behavioral changes that will be needed for sustained resilience and a green transition. This includes the awareness and knowledge to locally develop solutions to promote adaptation and mitigation measures and adapt to the necessary changes in the economy and labor market (see also the discussion on transition risks in Chapter 6). Supporting people, particularly the most vulnerable, in these adjustment processes will be critical to ensure a just resilience and green transition. While they are on the frontlines of climate impacts, local communities often lack a voice in the decisions that affect them. Communities usually have granular knowledge of local conditions, and they have often devised innovative strategies and coping mechanisms to respond to climate risk. However, this knowledge often remains untapped or, worse, can be unintentionally undermined by supply-driven interventions. It is well documented that communities can be engaged as valuable partners to develop solutions to address climate change and can work in partnership with governments to generate solutions that are responsive to local needs. Involving communities from the very start in the design of climate change interventions that affect them is therefore critical for people empowerment, justice, and development effectiveness.

Improving water quality is an essential climate adaptation measure for human capital and health outcomes. Poor drinking water quality undermines these outcomes and affects productivity and income generation, thereby undermining people's resilience to climate shocks. The management of the limited water resources is complicated due to the small catchment areas for rainfall, limited rainwater and groundwater storage capacity, long dry seasons, and the susceptibility of groundwater aquifers to pollution from poor

[153] World Bank. 2024. *Crisis Preparedness Gap Analysis: Maldives Briefing Note (English)*. Washington, DC: World Bank Group.

sanitation and salinity intrusion.[154] Drinking water shortages occur regularly on outer islands during the dry season, with significant impacts on people's health, food security, and productivity. Groundwater was historically the main water source for the outer islands; however, mismanagement and pollution, largely from sewage, have rendered it unsuitable for drinking purposes. Households now typically depend on rainwater as the primary source of drinking water, although unreliable, while groundwater is used for secondary purposes, including toilet flushing, bathing, and washing, while emergency supplies of potable water from Malé are common but expensive and indicative of critical socioeconomic thresholds being reached.

Recommendations to Strengthen Social Protection and Skills for Climate Resilience

- **Broaden and deepen the social protection system by adding and enhancing shock-responsive features,** which include improving the connection between climate risk and social protection management as well as introducing anticipatory cash transfers and other swift assistance actions such as increasing digital payment options during climate emergencies.
- **Scale up the social registry and better integrate information and response systems** (including EWSs).
- **Develop a nationwide multi-hazard EWS coupled with a data monitoring program and tailor EWSs to each island in an integrated manner,** considering flooding caused by sea level, tides, storm surges, and waves.
- **Develop a robust program for skilling, upskilling, and reskilling** and include climate change knowledge and awareness in the curricula for all education and skills programs.
- **Develop integrated climate-resilient water management systems** that combine desalination and rainwater harvesting, managed aquifer recharge, and a shift from emergency measures to long-term solutions for water security.

[154] World Bank, and Australian Aid. 2013. "Combating Water Insecurity in the Maldives: An Integrated Water Management Approach."

6. Toward a Green Transition in Key Sectors

GHG emissions are predominantly driven by diesel-based electricity, transportation, water and waste management, with tourism significantly affecting energy use. As per the *First Biennial Update Report*,[155] energy industries fueled primarily through diesel-based electricity generation account for 67 percent of total emissions. The transportation sector, crucial due to the geographical dispersion of islands and reliant mainly on fossil fuels, contributes another 25 percent (of which tourism accounts for 28 percent, domestic air travel for 26 percent, land transport for 24 percent, and marine transport for 22 percent). Waste management, including open burning practices, constitutes 4 percent of emissions. Notably, the tourism sector is the largest consumer of electricity, responsible for 47 percent of the emissions from energy use. The country's focus for emission reduction as per its NDC is on rapidly scaling up RE to 15 percent of the electricity mix by 2030, up from less than 1 percent currently. This will require significant investments in solar, wind, and energy storage infrastructure as well as efforts to strengthen the enabling environment for RE deployment. The NDC also prioritizes energy efficiency improvements, particularly in the tourism sector, which is a major driver of energy demand. In the transport sector, Maldives aims to promote a shift toward low-carbon mobility through a combination of electrification, public transport improvements, and efficiency enhancements in the marine and aviation subsectors. For waste management, the emphasis is on expanding waste-to-energy capacity to reduce methane emissions from open dumping and burning while also investing in better waste collection and disposal infrastructure.

Maldives can reap significant economic benefits from a green transition in key sectors, particularly energy. The potential fiscal and foreign exchange savings from switching to solar energy could help facilitate investments in climate resilience and other development objectives. Additional multiplier effects from domestic green energy investments include reduced vulnerability to global energy shocks and the creation of quality jobs for the local population, particularly for medium-skill occupations. Green transitions in the transport and housing sectors also have significant development potential.

At the same time, there are transition risks from the shift toward low-carbon development in Maldives and globally that need to be carefully analyzed and managed. These can be categorized into policy and legal, technology, market, and reputational risks.[156] Policy risks can be domestic and external. Domestically, it is critical to ensure that policies aiming to facilitate low-carbon development are just and carefully address impacts on different parts of society, particularly people of low socioeconomic status, such as in the case of a fossil fuel subsidy reform (see Box 5 in Section 7.3.1). There are also external policy transition risks in the form of possible negative impacts related to the implementation of climate change mitigation response measures such as carbon pricing in the aviation and maritime transport sectors. For instance, a study found that, by 2045, airfares could be significantly higher due to the impacts of the Carbon Offsetting and Reduction Scheme for International Aviation and negatively affect revenue from tourism for Maldives.[157] Legal risks include, among others, exposure to climate change-related litigation. While most such cases to date have been filed in high-income countries, a recent case against the government over removing trees for road construction illustrates possible legal transition risks.[158] If the opportunity to transition to a green economy on time is missed, technology and market-related transition risks could emerge, including inadequate skills in the labor market leading to unemployment and lower productivity (see Section 5.3) as well as stranded assets and carbon lock-in related to investments in unsustainable energy systems and infrastructure. Finally, there might be reputational transition risks, particularly to the tourism sector, if

[155] Government of Maldives. 2018. *Maldives First Biennial Update Report*.

[156] Task Force on Climate-related Financial Disclosures. 2017. "Recommendations of the Task Force on Climate-related Financial Disclosures."

[157] UNFCCC. 2023. "Assessment of Impacts of Implementation of Domestic and International Response Measures - A Case Study on Maldives." Carbon border adjustment mechanisms are another form of response measures. However, given Maldives' trade profile, they are not expected to have a meaningful impact on the country. In the European Union, for instance, they cover emission-intensive industrial goods such as iron, steel, aluminum, cement, fertilizer, and electricity—none of which Maldives exports. Fisheries, the country's main export, is not expected to be covered by the EU's nor the proposed United Kingdom's mechanisms.

[158] UNDP. 2023. "Loss and Damage and Climate Litigation: How Can the Maldives and Other Small Island Developing States Position for Greater Climate Action?" New York, New York.

Maldives cannot credibly present itself as a green destination at a time when awareness about climate and environmental issues is rising globally.

6.1. The energy transition

Maldives is heavily dependent on imported diesel fuel for electricity production, accounting for over 90 percent of its energy needs. Despite its globally negligible emissions, Maldives has one of the highest carbon intensities per unit of electricity worldwide.[159] The cost of fuel imports exceeded US$753 million in 2023, representing almost 22 percent of total imports.[160] Approximately half of the fuel imports (diesel) are used for electricity generation. With an estimated electricity demand of nearly 1,600 GWh in 2020, it is expected to increase to almost 2,700 GWh by 2030. Correspondingly, diesel consumption for electricity production is expected to increase from 377,000 to 677,000 tons, resulting in about 2,000 kilotons of carbon dioxide equivalent in 2030.[161] To maintain affordable energy tariffs, the government currently provides substantial subsidies for diesel supplied to generation companies and the electricity tariffs themselves, which are crucial for low-income households. With high and volatile diesel prices, these subsidies impose a considerable fiscal strain on the government (see Box 5 in Section 7.3.1 for more details on subsidy reform). At the same time, energy generated from diesel currently is four to six times more expensive than solar energy.[162] Planned RE capacity additions could help reduce diesel fuel imports by up to 30 percent by 2040.

The country is embarking on an ambitious energy transition to reduce its reliance on imported fossil fuels, strengthen energy security, and combat climate change. The government has set ambitious targets to increase the share of RE in the mix to 33 percent by the end of 2028[163] and to reduce emissions by 26 percent by 2030.[164] To achieve these goals, Maldives is collaborating closely with development partners to implement initiatives that aim to accelerate the shift toward RE sources, particularly solar, and enhance the power sector's efficiency and resilience (see Box 3). Further, there is a growing focus on exploring alternative solutions such as solar-water pumping.

Box 3: Lessons to Enhance RE Adoption from the World Bank-financed Maldives Energy Program

The World Bank-supported energy program, particularly through the Accelerating Sustainable Private Investments in Renewable Energy (ASPIRE) and Accelerating Renewable Investment and Sustainable Energy (ARISE) initiatives, has contributed to enhancing Maldives's RE landscape. ASPIRE seeks to increase solar photovoltaic (PV) adoption through private sector investment and has successfully facilitated the operationalization of 17.5 MW of solar PV projects. The innovative de-risking structures employed in ASPIRE have reduced the tariff discovery rates from US$0.21 per kWh to US$0.0982 per kWh, greatly enhancing the economic viability and attractiveness of RE projects. The number of investors participating in the program also saw a dramatic increase, rising from 4 to 63.

The implementation of a robust three-tier risk mitigation framework has been instrumental in managing risks and attracting private sector investments. The first tier is guarantees such as termination guarantees, which provide security to investors in case of project termination, thereby reducing investment risk. The second tier is the payment security mechanism that uses an escrow account to cover up to six months of payment delays by the utilities, ensuring that project developers receive timely payments and risks of payment defaults are mitigated. The third tier is a currency convertibility clause, which ensures that investors can convert local currency revenues into foreign currency, addressing the risk of currency inconvertibility and transfer restrictions. These strategies can collectively help manage risks, attract private sector participation, and support the successful implementation of RE projects.

[159] Asian Development Bank. 2022. "Pay Less for Electricity with Renewable Energy in the Maldives."

[160] Maldives Customs Service, February 2022.

[161] Maldives Investment Framework for Net Zero.

[162] World Bank ARISE Project PAD. World Bank. 2020. *Maldives - Accelerating Renewable Energy Integration and Sustainable Energy Project (English)*. Washington, DC: World Bank Group. The assumptions and specifications used for the comparison were (a) solar tariff of US$0.98 based on the recent lowest bid received under the World Bank's Accelerating Renewable Energy Integration and Sustainable Energy project; (b) average electricity generation cost of US$0.37 per kWh for Greater Malé region based on STELCO's inputs using imported diesel fuel; and (c) average electricity generation cost of US$0.69 kWh for Outer islands based on FENAKA's inputs using imported diesel fuel transported to the islands.

[163] The President's Office. Press Release 2023-576. December 3, 2023. Republic of Maldives.

[164] "Maldives Nationally Determined Contributions." UNDP Climate Promise, UNDP.

Evolving energy systems and increasing decentralized RE generation come with the technical challenges of maintaining stability, reliability, and power quality. Comprehensive power system planning studies have been conducted to develop a roadmap for optimal RE integration in consultation with the MoCCEE and utilities, targeting a reduction in electricity sector emissions of up to 30 percent by 2040 compared to a BAU scenario. Further efforts are needed to overcome barriers related to affordability, infrastructure upgrades, and mobilization of sustainable financing. The government is exploring innovative solutions, such as regional grid interconnections, advanced control technologies, and cost-competitive storage options to enable higher penetration of renewables. Regulatory reforms, including the introduction of time-of-use tariffs and ancillary service markets, can also play a crucial role in incentivizing investment and ensuring the financial viability of the energy transition. If the sustainable energy transition is implemented well, Maldives can significantly reduce its carbon footprint, improve energy security, and create opportunities for sustainable economic growth. Yet, success will depend on continued collaboration between the government, utilities, private sector, and development partners to align policies, optimize investments, and build local capacity.

Desalination plants currently also generate energy from burning fossil fuels, making an RE transition important for a sector that continues to expand as more and more islands deploy desalination infrastructure. Traditionally energy-intensive desalination processes such as seawater reverse osmosis consume about five times more energy than surface freshwater treatment.[165] Transitioning to RE is becoming feasible and cost-competitive, with projections showing that renewable-powered seawater reverse osmosis can achieve water production costs that are comparable to the range of current fossil-based plants.[166]

Maldives has been grappling with setting electricity tariffs that achieve cost recovery while maintaining affordability for end users, which is essential to ensure inclusive access to electricity. The existing tariff regime incorporates direct and indirect subsidies to offset the high costs associated with electricity generation and reliance on imported diesel. Nonetheless, achieving an equilibrium between cost recovery and affordability remains challenging, especially in the context of the archipelago's unique geography and dispersed population. Under the current tariff structure, electricity production costs range from US$0.19 to US$0.33 per kWh for the most efficient generators even with the fuel subsidy. These costs increased to US$0.69 per kWh for more remote outer islands where fuel supply costs are higher, and transportation is logistically challenging. Despite the government's efforts to subsidize these costs, end user tariffs remain relatively high compared to peer countries. For instance, the end user tariff for around 400 units of electricity is approximately US$0.26 in Maldives, while in countries such as India, it is around US$0.05. This significant difference in tariffs could affect economic competitiveness and hinder the nation's potential for growth in sectors such as tourism and industry.[167]

Investments in renewable generation and distribution can reduce energy costs and improve the environmental sustainability of the power sector. First, investing in RE sources, most prominently solar, can reduce generation costs and generate fiscal and external savings in the long term. Second, the distribution network can be strengthened through investments in grid infrastructure and storage systems for improving operational efficiency and flexibility to integrate RE. Battery energy storage systems are also a crucial investment to address the variability of power output from RE sources and allow continuous service despite fluctuations in supply and demand.[168] The government could consider diversifying its sources of RE to include green hydrogen and further explore its potential.

[165] Water Scarcity Atlas. n.d. "Desalination Powered by Renewable Energy." https://waterscarcityatlas.org/words/desalination. Accessed April 3, 2024.

[166] Ibid.

[167] World Bank. 2022. *Maldives Development Update. April 2022*.

[168] World Bank. 2020. *Maldives Accelerating Renewable Energy Integration and Sustainable Energy*. Project Appraisal Document.

Research conducted for this CCDR assessed the feasibility, costs, and benefits of various RE deployment scenarios.[169] Based on this analysis, Maldives could witness a remarkable transformation in its power systems by 2040. Greater Malé could harness solar power with a strategic combination of 291 MW of solar PV, including floating solar panels and widespread rooftop installations. Meanwhile, Addu could develop 78 MW of solar PV, distributed across floating installations and rooftop arrays. To overcome the intermittent nature of solar power, diesel generators will continue to play a supporting role, stepping in when needed, as the systems navigate the challenges of high solar PV penetration, which could reach up to 80 percent during peak hours. This ambitious transition would require approximately US$516 million investment in RE capacity and grid enhancements.

Regional grid expansions, interconnections, synchronous condensers, and grid forming controls could increase grid stability and further increase the potential of RE. Grid interconnections within regions have a high potential to generate cost-competitive round-the-clock firm and dispatchable electricity from RE sources and can help accelerate the long-term energy transition beyond the current plans. Adding substantial battery storage capacity to support the integration of high shares of variable RE technologies will require that adequate systems be put in place, particularly monetization frameworks (such as time-of-use tariffs) to compensate for system stability, flexibility, and ancillary services for managing RE intermittency. Optimum risk-sharing frameworks in the procurement of RE and payment security mechanisms can help optimize the cost of capital and reduce the landed cost of energy storage as a service for the RE off-takers. A working group consisting of the State Electric Company, utilities, Maldives Energy Authority, and the MoCCEE could help align, sequence, and optimize policies to attract private investments.

Stepping up energy efficiency measures such as constructing and retrofitting green and energy-efficient buildings is critical to counterbalance the rising energy demand and facilitate peak demand management. The growing pipeline of new construction happens without requirements for green and energy-efficient construction. While the 'Maldives Energy Efficiency Guideline for Buildings' was developed in 2021, the guidelines currently lack enforcement (see Section 3.1). Aside from reforms in building regulations, the Low-Carbon Development Strategy calls for several specific actions, including the installation of solar PV; scaling up the use of light-emitting diodes (LEDs) for efficient lighting in residential areas; efficient air-conditioning and refrigerators in households; efficient water pumping; and improvement of water security with rainwater harvesting, groundwater recharging, and desalination.

Transitioning to RE is a key priority for the tourism sector. Tourism accounts for 40 percent of national GHG emissions, with 31 percent of total GHG emission caused by electricity generation in resorts. Resorts have a considerable potential to reduce emissions through an increased reliance on solar energy. According to the resort survey conducted for this CCDR, about 40 percent of resorts have invested in RE and the investments are increasing steadily. However, with only 15–20 percent of electricity sourced from solar, there is significant scope to increase this further. Interviews with stakeholders suggest part of the motivation for investments in RE is to brand the resort as sustainable. Guesthouse owners also believe that investments in RE would be attractive to potential guests. The demand for electricity at resorts is increasing with growing guest expectations for cooling. The resorts are now investing in about 1 MW peak (MWp), while larger resorts and ultra-luxury resorts are planning for a large capacity of 2–3 MWp. For resorts, floating solar may be a viable option to switch to RE but there are unclear regulations for permits and fees when the floating solar PV panels are beyond the resort boundary of 1 km. For guesthouses, there is uncertainty on the net metering regulation that prescribes the 30 percent quota for businesses and whether the guesthouses can benefit from this.

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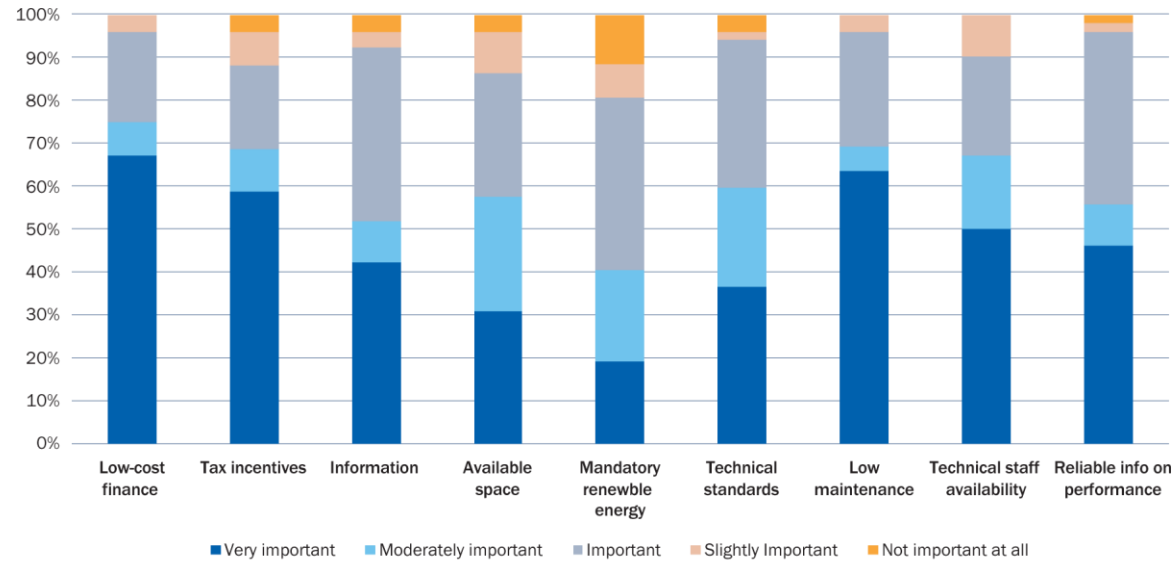
[169] Least-Cost Generation Capacity Expansion (LT), Operational/Dispatch (ST) Simulation, and Network Study for Maldives. World Bank's comprehensive technical studies and power system modeling for the Greater Malé and Addu region.

[169] The analysis employed a four-step methodology that included long-term least-cost capacity expansion planning, short-term dispatch simulations, steady-state power flow analysis, and grid stability assessments. By evaluating different combinations of solar PV, battery storage, and diesel generation, the study helps determine the technically and economically optimal mix of resources for each region until 2040 and establish a roadmap for RE capacity additions in greater Malé and Addu to accelerate the energy transition and reduce GHG emissions from electricity generation up to 30 percent by 2040.

Low-cost financing and maintenance are key factors that can encourage RE adoption among resorts (see Figure 17). Resorts have a strong preference for power purchase agreements when they set up their solar projects as they do not have to worry about maintenance costs, up-front capital expenditure, and permits. About 50–60 percent of resorts consider more reliable information on the performance of solar, available technical staff, and tax incentives as additional 'very important' factors to encourage RE adoption. Around 70–80 percent of resorts highlight that the installation costs of solar PV and batteries, as well as limited financing and availability of low-cost financing, are moderate to extreme barriers to expanding their RE systems (see Figure 18). Resorts surveyed also highlighted technical issues such as recycling and disposal of batteries (67 percent of resorts), lack of rooftop space (57 percent), and lack of lagoon space (49 percent) as moderate to extreme barriers to expanding their RE systems. While increasing, the installation of battery backup has been limited by space constraints as resorts need to allocate a container-size space near the power generation facility for the battery. According to stakeholder interviews, battery storage and floating solar projects present an important opportunity to scale up the adoption of RE among resorts. Based on the survey and interviews conducted for this report, resorts are keen to invest in and scale up RE, with an opportunity to attract US$100–150 million in green finance.

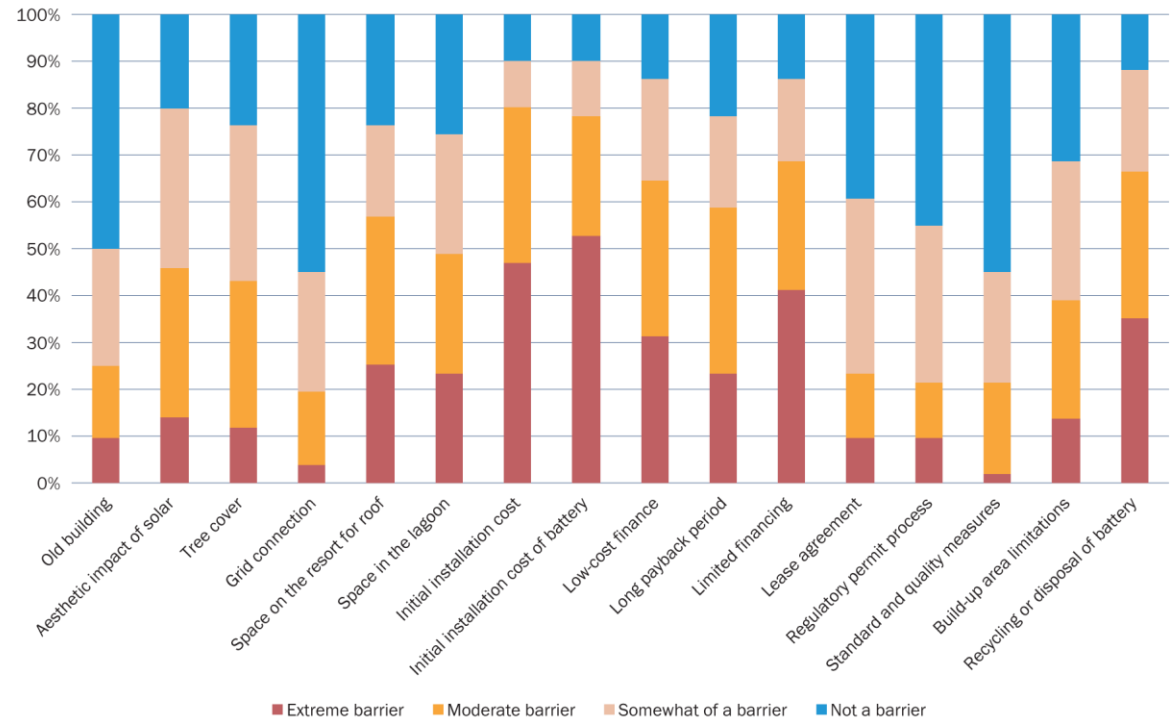
In contrast to resorts, the adoption of RE among guesthouses is low as they face informational and operational challenges. Few guesthouses have invested in RE or solar PV for electricity. Many lack information about the financial savings they can achieve by switching to solar energy and the price of solar PV. They also lack the capability to calculate the amount of solar PV needed for their facilities. In addition, most guesthouses operate on properties under short lease periods, and operators do not have the incentive to invest in rooftop solar. More importantly, there is a regulatory cap based on the net metering regulation that imposes the amount of RE that can be fed into the grid for each island. Guesthouses are often unclear about the cap and how much solar PV they can install.

Figure 17: Factors that encourage investment in RE systems as per resorts surveyed



Source: IFC. 2024. Based on a survey of 55 resorts in Maldives.

Figure 18: Top 10 barriers to the expansion of RE as per resorts surveyed



Source: IFC. 2024. Based on a survey of 55 resorts in Maldives.

Recommendations for the Energy Transition

- **Promote risk-sharing frameworks to attract private investors to RE projects,** once fiscal conditions allow, including collaborating with development partners to design and implement a credit enhancement or political risk guarantee program that provides private investors with increased confidence in the RE market.
- **Consider a dedicated blended financing facility for RE,** and a green bond program, supported by guarantees, to attract private sector finance.
- **Introduce an RE mandate for resorts to increase RE generation in the tourism sector**, distinguishing between new and existing resorts in terms of ambition and time frame with more ambitious targets for new developments.
- **Explore the feasibility of green hydrogen,** and, if feasible, develop a green hydrogen roadmap.
- **Step up energy efficiency measures,** for instance, by promoting greener construction practices and retrofitting existing buildings.
- **Encourage solar adoption among resorts and guesthouses** and improve information provision to the tourism sector on the benefits and financial savings of RE solutions.
- **Review net metering regulations** that constrain the adoption of solar by guesthouses.

6.2. The mobility transition

The transition to a sustainable mobility system based on the Avoid-Shift-Improve Framework[170] can significantly reduce emissions, air pollution, and dependence on imported fossil fuels in the transport sector.[171] Transportation accounted for 60 percent of emissions in 2019, with road and marine transportation, respectively, accounting for approximately 35 and 25 percent. Maritime transportation is critical for moving people and goods across the archipelago but is energy intensive, accounting for 31 percent of overall energy consumption and growing.[172] Inter-island transport remains primarily diesel- or petrol-based sea transport. Transport systems rely heavily on highly subsidized fossil fuels with more than 40 percent of the fuel imports utilized in this sector,[173] causing high levels of pollution and contributing to growing fiscal and current account deficits. While air pollution is overall limited, densely populated areas such as Malé have witnessed a decrease in air quality.

Vital for cleaner mobility is encouraging active mobility such as walking and cycling, shifting to more sustainable modes such as public transportation, and improving the sustainability of motorized transportation. The lowest cost, highest return investment in sustainable mobility is encouraging walking and cycling instead of using more energy-intensive modes of transport. Creating dense and multifunctional districts, safe infrastructures, awareness, and targeted incentives to change behaviors are some of the most effective approaches. Low-hanging fruits are the improvement in and building of safe sidewalks and bicycle paths, especially in new developments, improvements to road safety regulation and road designs, and expansion of pedestrian and bicycle bridges. Aside from decreased reliance on personal vehicles, active mobility has multiple co-benefits, such as a reduction in transport expenses and improved personal health.

Expansion and greening of public transport—especially for intra-island trips—and shared mobility can improve accessibility to services and economic opportunities while decreasing emissions and reliance on imported fuel. Buses currently serve 39.6 million passenger km per year with new projects such as Maldives Eco City expanding the existing network. Improved public transport infrastructure, combined with incentives and digitization, can support shifting the modal share further from private vehicles to public transport and bring important benefits to vulnerable populations through increased opportunities for work, education, and health care. In hand with a transition toward electric buses, this could result in fuel savings of almost 1 million liters per year translating to US$1 million of fiscal benefit annually. Currently, capex subsidies and solar charging would still be needed to achieve parity in the total cost of ownership (TCO) when comparing currently available electric with diesel bus operations.[174] However, once it can be financed, this could translate to US$7.5 million of fiscal savings over eight years and a payback period of six to seven years. Currently, six electric buses are in operation in Malé, with an estimated cost of US$15 million for the electrification of the remaining fleet (53 buses). Public fleet operators derive value from electric vehicle (EV) transition largely from opex savings; therefore, the high cost of retail electricity for EV charging operations is a significant challenge. This is particularly the case for commercial (~US$0.21–43 per kWh) and government institutions (~US$0.21–28 per kWh). Shared mobility, enabled through a conducive policy environment and continuing digitization, can further decarbonize the mobility sector. Vehicle sharing and ridesharing, enabled through improved data availability and access to the internet, are two common solutions that combine moving away from the dependency on individual-owned vehicles with investment opportunities for the private sector.

Transitioning to solar e-ferries could save 1.3 million liters of fuel per year, translating to US$1.2 million per year of fiscal benefit. Because of the decentralized nature of the islands, many people travel to the capital for work, education, or medical reasons. Due to the high capital expenditure for an e-ferry (2.5 times compared to a diesel ferry), the TCO of an e-ferry surpasses that of a diesel ferry. A capital subsidy along with

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[170] "Avoid" travel or the need to travel, "Shift" to more energy-efficient modes, and "Improve" efficiency through vehicle technology.

[171] If not indicated differently, the analysis and numbers referred to in this Section 6.2 are based on World Bank. 2023. *Assessment of Electric Mobility Potential in Maldives*.

[172] United Nations Statistics Division, 2019.

[173] Government of Maldives. 2023. "Maldives' Investment Framework for Net-Zero."

[174] World Bank. 2023. *Assessment of Electric Mobility Potential in Maldives*.

renewable power would be required to match the current TCO of an e-ferry with existing diesel ferries but will be difficult to implement in the current macro-fiscal situation. If implemented, this could translate to US$12 million of fiscal savings over 10 years and a payback period of only one to two years. Solar-powered electric ferries (onboard PV panels) built with lighter materials, long and slender catamaran hull designs, and other energy-efficient structural designs would also provide enhanced comfort and safety resulting from reduced noise, vibration, and exposure to harmful air pollutants for onboard crew and passengers. An alternative solution is using green fuels to power inter-island ferries. The deployment of these fuels is still at a nascent stage, but there may be significant potential to use these fuels to decarbonize the maritime transport sector.

Finally, motorization management and the electrification of personal vehicles, especially of two-wheelers, can contribute to significant fuel savings and emissions reductions.[175] A motorization management framework can support the development of policies and measures aimed at managing vehicle stocks in a proactive, phased, and systematic manner to make them safer, cleaner, and more fuel efficient, including the regulation of the number, type, engine, and size of vehicles.[176] Relevant measures range from raising emission standards and updating related taxation schemes to shifting away from fossil fuels. Electrification of two-wheelers by 2040 has been estimated to reduce a potential 40 million liters of petrol, worth US$40 million. The TCO analysis indicates that owning and operating an electric two-wheeler is up to 20 percent more economical when compared to owning an internal combustion engine scooter when import duty is applicable. Missing electric charging infrastructure is one of the main binding constraints for EV adoption.[177] A further constraint on the uptake of EVs is the need for improved technical skills and after-sale services to maintain the vehicles, batteries, and associated infrastructure.

If implemented in siloes, the electric mobility transition simply shifts emissions from vehicle tailpipes to diesel power plants located within island systems, highlighting the importance of the green energy-mobility nexus. A sustainable mobility transition must be accompanied by zero-emission charging operations powered by renewable power for both economic and environmental imperatives. Sourcing of renewable power can reduce power purchase costs and is required to lower emissions of EVs. This underlines the importance of following an integrated approach for the decarbonization of the energy and transport sectors.

Recommendations for the Mobility Transition

- **Develop an active mobility strategy to avoid motorized trips,** including constructing pedestrian and cycling infrastructure, planning multifunctional districts, improving road safety, providing shared bicycles, integrating routing applications, building awareness to shift to active mobility, and reducing the growing reliance on personal vehicles while reaping social and health co-benefits.
- **Shift toward more sustainable modes of transport such as public transport and shared mobility** by expanding and greening public transport, both on road and water, and creating an enabling environment for vehicle-sharing models.
- **Improve motorization management, including through the development of an e-mobility strategy and action plan** and measures such as updating emission regulation and vehicle taxation and setting up an ecosystem for EV adoption—focusing on two- and three-wheelers and shared vehicles—and charging infrastructure.
- **Scale up the e-bus program and explore an e-ferry program,** with a focus on mobilizing private capital investments, and develop comprehensive technical guidelines for charging stations that encompass standardized protocols for charging, construction, testing, and safety measures to ensure consistency and reliability, promoting interoperability and seamless user experiences.

[175] Ibid.

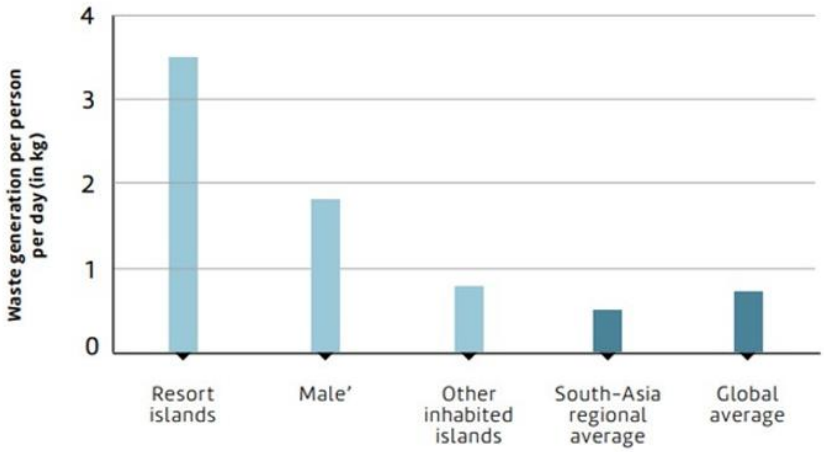
[176] Gorham, R., D. Bose, M. Cordeiro, G. Darido, J. Koupal, R. Krishnan, K. Neki, and Y. Qiu. 2022. *Motorization Management for Development. An Integrated Approach to Improving Vehicles for Sustainable Mobility*. Washington, DC: World Bank.

[177] Ibid.

6.3. The waste transition

Maldives faces a critical challenge in managing solid waste pollution, a significant threat to its environmental sustainability and economic prosperity, as the tourism and fisheries sectors are particularly affected. Waste generation rates from tourists and locals are high (see Figure 19) with tourists producing approximately 3.5 kg of waste per day and residents of Malé contributing 1.7 kg per capita daily.[178] Illegal dumping and inadequate waste management practices lead to around 600 tons of plastic leaking into the marine environment annually.[179] The presence of microplastics poses a severe risk to marine life through ingestion and toxicity.[180] Furthermore, Maldives faces significant challenges in managing industrial and hazardous waste, exacerbated by infrastructural inadequacies and a lack of regulatory frameworks, across key sectors including maritime and aviation. The maritime sector lacks port reception facilities for handling ship-generated waste.

Figure 19: Waste generation per capita in Maldives, South Asia, and globally



Source: World Bank. 2017. Maldives Clean Environment Project. Project Appraisal Document.

GHG emissions from waste accounted for 5 percent of the total emissions. Waste management varies among islands depending on the availability of solid waste disposal facilities. Household-level segregation of waste is not practiced. The most common method of waste disposal is uncontrolled open burning. Composting and small-scale incineration is practiced in a few inhabited islands. The National Solid Waste Management Policy was formulated in 2008 (updated in 2015) and a waste management regulation was enacted in 2013. Under the former, regional waste management centers are to be established in seven regions.

Inadequate waste disposal and unregulated burning accelerate climate change and threaten the islands' climate resilience and natural adaptive capacities. Unregulated disposal and open dumping and burning of waste exacerbate climate change by releasing black carbon and methane from decomposing residual mixed waste. Moreover, waste leaking into the ocean and dumping of organic waste harm coral reefs, weakening natural climate adaptation mechanisms. This impact on marine ecosystem health compromises the islands' resilience, affecting fish populations and biodiversity critical for local economies and food security. Furthermore, marine litter endangers marine life and the fishing industry by disrupting ecosystems and introducing toxic substances into the food chain, significantly affecting tourism and local livelihoods. In response, the NDCs propose adoption of measures to mitigate pollution of coral reefs and ecosystems,

[178] UNESCAP. 2021. "Maldives National Waste Accounts 2018 and 2019."

[179] Royle, J., B. Jack, H. Parris, T. Elliott, A. C. Castillo, S. Kalawana, and L. C. Woodall. 2022. "Plastic Drawdown: A Rapid Assessment Tool for Developing National Responses to Plastic Pollution when Data Availability Is Limited, as Demonstrated in the Maldives." *Global Environmental Change* 72: 102442.

[180] Patti, T. B., E. K. Fobert, S. E. Reeves, and K. B. da Silva. 2020. "Spatial Distribution of Microplastics around an Inhabited Coral Island in the Maldives, Indian Ocean." *Science of the Total Environment* 748: 141263.

particularly marine life, through relevant policies and the continued expansion of waste and resource management facilities, including the phase-out of single-use plastics.

Efforts to develop effective waste management systems have historically been hampered by the nation's unique geographic and resource challenges. Small island sizes and low elevation have made traditional engineered landfills impractical, while financial and technical limitations hindered the establishment of advanced waste treatment facilities. Consequently, Thilafushi Island became the central waste repository since its inception in 1991. Over the next couple of decades, the site evolved into a significant dumpsite with inadequate management practices that led to environmental contamination through continuous fires, smoke, toxic fumes, and waste spillage into the sea.[181] Owing to the considerable effort and investment over the past decade, the site is now better managed. Additionally, waste-to-energy technology is being introduced, which is expected to bring significant carbon savings.

As Maldives faces escalating waste management and pollution challenges, a series of policies and legislative measures have been implemented. These include reducing the use of single-use plastics and enhancing waste management practices.[182] A comprehensive approach was adopted in 2022 with the enactment of the Waste Management Act,[183] which broadened the scope of waste management regulation to include plastic bag fees, waste separation, and recycling among its provisions. Despite progressive improvements in waste and resource management, the practice of waste burning on many inhabited islands continues.[184]

Efforts to improve waste management, including establishing Island Waste and Resource Management Centers (IWRMCs) and recycling initiatives, show promise despite challenges in remote areas. The establishment of IWRMCs on every inhabited island was a key component of the waste management strategy, alongside initiatives for resort islands, regional disposal facilities, and a marine transfer system.[185] Despite these improved facilities, the Waste Management Corporation's service provision has struggled with regular waste collection and transfer services, leading to delays and some islands continuing to practice open burning or improper disposal of waste. Particularly in remote islands, financial constraints hinder the development of regular waste transfer systems to Thilafushi.[186]

A green waste management transition is particularly important in and for the tourism sector. Waste management is a big challenge for tourist resorts, especially those located far from the Thilafushi facility. According to the resort survey conducted for this CCDR, resorts identify the management of garden waste, food waste, and glass bottles as very difficult. Many resorts identified a lack of cost-effective transport solutions as the major barrier to waste management (see Figure 20). The lack of space, access to low-cost financing, and lack of tax incentives have also been identified as barriers to implementing better solid waste management systems. Similarly, waste management is a major challenge for local islands, especially with the rise in the number of guesthouses contributing to an increase in waste. While waste is segregated at the guesthouse level, it is then collected and stored in the IWRMC or a designated area on the island, which fills up quickly. Open burning of waste is also carried out in some islands to reduce the volume, which causes air pollution and health risks.[187] Food waste is often dumped into the sea near the island or composted along with garden waste. [188] Several resorts have biogas systems for running kitchen stoves or boilers. For biogas

[181] Ebrahimi, P., S. Abbasi, R. Pashaei, A. Bogusz and P. Oleszczuk. 2022. "Investigating Impact of Physicochemical Properties of Microplastics on Human Health: A Short Bibliometric Analysis and Review." *Chemosphere* 289: 133146.

[182] MoCCEE. 2022. "The Maldives Bans Production and Sales of Single-Use Plastics Effective from June 1, 2022."

[183] Utilities Regulation Authority. 2022. Waste Management Act No. 24/2022.

[184] Scott, S. R., P. E. Hailemariam, P. V. Bhave, M. H, Bergin, and D. E. Carlson. 2023. "Identifying Waste Burning Plumes Using High-Resolution Satellite Imagery and Machine Learning: A Case Study in the Maldives." *Environmental Science & Technology Letters* 10 (8): 642–648.

[185] World Bank. 2024. *Maldives: Country Environmental Analysis. Towards a More Sustainable and Resilient Blue Economy*. Washington, DC: World Bank Group.

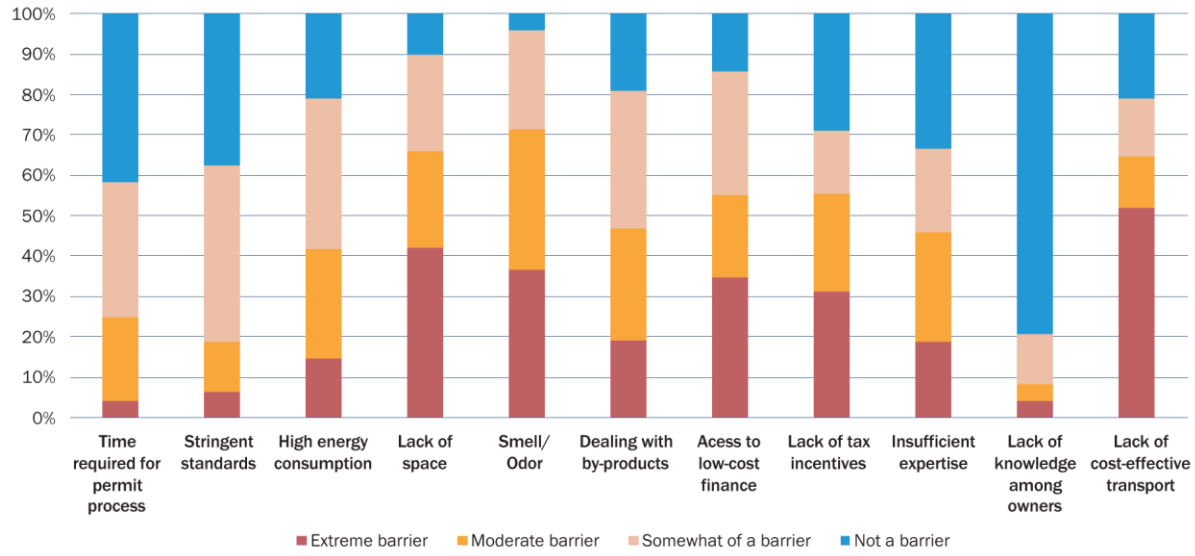
[186] Ibid.

[187] Scott, S. R., P. E. Hailemariam, P. V. Bhave, M. H. Bergin, and D. E. Carlson. 2023. "Identifying Waste Burning Plumes Using High-Resolution Satellite Imagery and Machine Learning: A Case Study in the Maldives." *Environmental Science & Technology Letters* 10 (8): 642–648.

[188] Ibid.

generation, there is a continuous flow of organic waste from kitchens and gardens, which reduces the need to import, ship, and store liquefied petroleum gas (LPG) on islands.

Figure 20: Major barriers to implementing solid waste management as per resorts surveyed



Source: IFC. 2024. Based on a survey of 55 resorts in Maldives.

Recommendations for the Waste Transition

- **Separate wet waste and properly manage it on site, preventing the need to move it off island** to avert methane generation and reduce fuel usage for unnecessary transporting of quantities.
- **Operationalize and equip IWRMCs across the archipelago** to ensure efficient, sustainable waste processing (sorting and separation, reuse and baling for recycling, and processing wet wastes).
- **Implement source separation and waste stream management at regional centers,** reserving incineration for only residual wastes to reduce methane emissions and the need for transporting waste between islands.
- **Expand and increase the efficiency and organization of systems for household and inhabited island community compost systems** and expand in situ processing and reuse of food at resorts.
- **Develop selected waste-to-energy facilities** at IWRMCs for the combustion of residual wastes, ensuring the systems also have environmentally sound emission management systems.
- **Carry out an assessment of current generation trends and final disposal flows** to better understand the environmental and social impacts of current practices.
- **Strengthen waste management regulations and enforcement tools** for implementation of existing policies, including provision of incentives for recycling efforts, through minimizing waste at the source and promoting the adoption of sustainable materials.
- **Foster partnerships and knowledge exchange between the government, private sector, and civil society** to leverage expertise, resources, and innovation in waste management solutions, particularly for the tourism sector.
- **Launch education and awareness campaigns** to inform citizens, island councils, resorts, and businesses about the importance of waste segregation, recycling, and sustainable waste practices, fostering a culture of environmental responsibility.

7. Macroeconomics and Financing for Climate Resilience

The transition to a climate-resilient and sustainable economy will require decisive policy steps to restore fiscal and external buffers, ensure macroeconomic stability, and establish an enabling environment for climate finance. Over the medium term, this could be achieved through significant expenditure adjustments via reforms in subsidies, health sector spending, public infrastructure investment, asset and debt management, and state-owned enterprises (SOEs), as well as up-front planning on priority areas for climate adaptation needs. The distribution of adaptation investments can be smooth (for example, the country spends 1 percent of GDP per year) while economic losses will be volatile (insignificant for most years, possibly enormous during exceptional events). Structural reforms are needed to reduce fiscal and external vulnerabilities and support the development of financial and capital markets by lessening dependence on the banking sector for public debt financing. This will expand the pool of investors through competitive financial instruments and allow funds to be channeled toward private sector development.

Private sector development outside of high-end tourism has been minimal. Maldives' small market size, along with the distance to markets created by the wide dispersion of islands, poses constraints in scaling up, for instance, private sector agriculture or manufacturing activities. However, there is scope for diversification within the tourism sector to areas such as ecotourism and sports. The potential for diversification to other sectors will require comprehensive additional analysis that is beyond the scope of this report. Maldives' merchandise export base is small and undiversified, with fishery products accounting for 50 percent. Small and medium enterprises (SMEs), which constitute almost 90 percent of the 8,000 registered businesses, face an uncertain business environment and limited access to formal sources of finance, hampering their ability to grow. In addition, significant government borrowing is likely crowding out the private sector, particularly SMEs. Diseconomies of scale that limit firms' ability to establish a comparative advantage, high transportation costs, and skill shortages are some of the other constraints that the private sector faces.

SOEs play a significant role in the Maldivian economy, hampering private sector development in some sectors. Many of the 32 SOEs, which jointly contribute almost 10 percent of GDP,[189] are among the largest commercial entities in the country and provide critical infrastructure and public services. However, some of these SOEs operate in competitive sectors and are the sole providers or dominant market participants, which constrains private sector development. In some sectors, such as energy, finance, and telecommunications, the dominance of SOEs also constrains the private sector in downstream industries, leading to higher usage costs, limited services and products, or barriers to innovation. In addition, SOEs contribute to the government's fiscal burden due to subsidies equivalent to around 2 percent of GDP which are provided to control the price of essential goods and public services in addition to capital injections capital when SOEs record losses. Sovereign guarantees and on-lending to SOEs also create fiscal risk.[190] Yet, SOE reform has made limited progress.

7.1. Macro-fiscal challenges and climate change investments

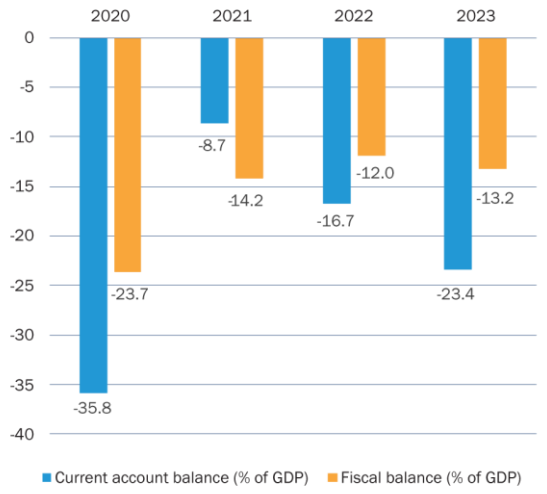
Sustainable and resilient development requires a synchronized policy response to tackle climate, development, and macroeconomic challenges. The presence of a heavy public debt burden, coupled with large fiscal and external vulnerabilities, leaves little room to finance much-needed investments in climate resilience. The fiscal deficit has widened from 6.5 percent of GDP in 2019 to over 13 percent of GDP in recent years. Total public and publicly guaranteed debt has risen consistently over the past decade to US$8.0 billion or an estimated 122.9 percent of GDP in 2023, compared to US$4.4 billion or 77.2 percent of GDP in 2019 pre-pandemic. Combined with a sharp decline in economic activity during the pandemic, the increase in the debt stock was mostly driven by elevated spending for infrastructure projects and rising

[189] World Bank. 2022. *Maldives Public Expenditure Review*.
[190] Ibid.

subsidy bills in the last decade, which has led to a rapid surge in budget and current account deficits and financing needs. This poses great concerns over macroeconomic and debt sustainability.

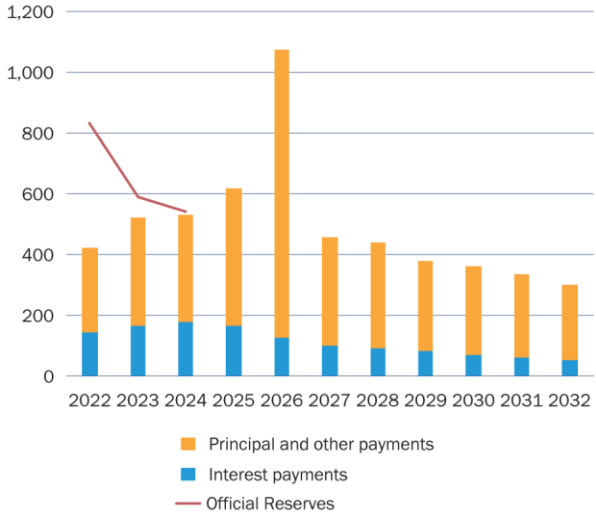
The persistent and large twin deficits (fiscal and current account) in recent years have increased the risk of debt distress.[191] Currently, fiscal and external buffers are minimal. The overall fiscal and current account deficits were, on average, respectively, 13 percent and 16.2 percent of GDP between 2021 and 2023 (see Figure 21). With the increasing need for foreign currency, official reserves have fallen by 29.3 percent since end-2022, declining to US$541.8 million in March 2024. This level of reserves is only sufficient to cover 1.8 months of imports (see Figure 22), leaving the economy extremely vulnerable to external shocks.

Figure 21: Fiscal and current account balances (% GDP)



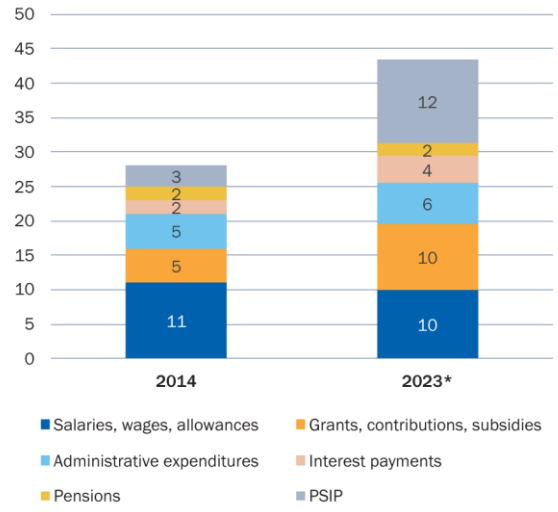
Source: Maldives Monetary Authority Monthly Statistics and World Bank estimates.

Figure 22: Official reserves and external debt service needs (US$, millions)



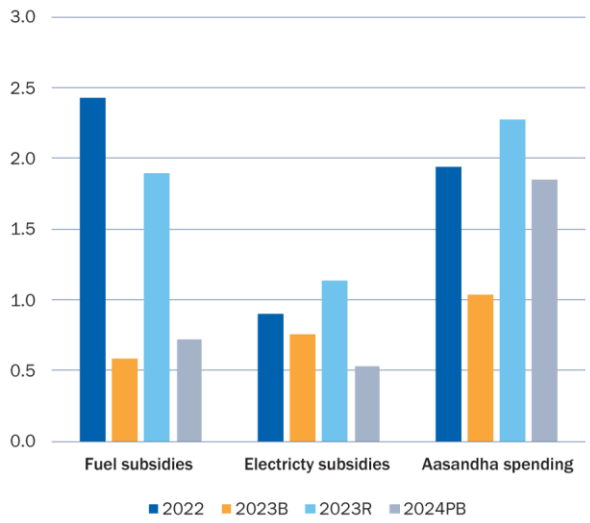
Source: Maldives Monetary Authority Monthly Statistics, Ministry of Finance Debt Service Projections, World Bank staff calculations.

Figure 23: Composition of expenditures (% GDP)



Source: Ministry of Finance Fiscal Statistics, World Bank staff calculations (2023 figures were calculated with World Bank's growth projections).

Figure 24: Selected subsidies expenditure (% GDP)



Source: Ministry of Finance Budget Statistics.

[191] According to the IMF's Article IV 2024, Maldives is assessed as high risk of debt distress.

The bulk of the budget goes to capital spending, subsidies, and public sector wages, limiting the scope for climate-related spending (see Figure 23). Maldives' total public spending has grown rapidly over the past decade, outpacing GDP growth. Spending on the Public Sector Investment Program (PSIP) leaped from an average of US$123 million in 2013–2014 to US$790 million in 2023. While capital spending has remained high, recurrent spending on grants and subsidies has started to place upward pressure on the budget and drive expenditure growth in recent years. This was due to rising global commodity prices and the blanket subsidy scheme for food, fuel, electricity, and transportation as well as the payment of arrears related to health insurance (Aasandha) (see Figure 24).

A lack of financing has led to the accumulation of expenditure arrears. Total expenditure for 2023 reached MVR 47.2 billion (US$3.1 billion), 17.4 percent higher than 2022 expenditure and 15.9 percent higher than the initially budgeted level. Subsidy reforms that were planned for 2023 were not implemented.

The exposure of the Maldives Monetary Authority (MMA) and commercial banks to sovereign debt remains high, leading to concerns about the sovereign-bank nexus.[192] Following the suspension of certain clauses of the Fiscal Responsibility Act during the pandemic, MMA has been heavily financing public debt. Although the suspension of the act was terminated at the end of 2023, overall exposure of MMA to the sovereign has remained high. Repeated debt exchange operations in 2023, through the securitization of MMA's advances for budget needs, have expanded its total exposure to the central government, reaching MVR 14.6 billion, or 59.6 percent of MMA assets, in January 2024. Commercial banks' exposure was equivalent to around 30 percent of total banking sector assets at the end of 2023. The current lending of the financial sector to the government likely crowds out private sector finance for climate investments.

Debt sustainability concerns raise the risk of a crisis. High fiscal deficits and growing external liquidity pressures in recent years, coupled with already elevated debt stock, have led to short-term liquidity and solvency risks. Maldives remains at a high risk of external and overall debt distress.[193] Increasingly higher amortizations and large interest payments would trigger protracted breaches in several debt indicators, rendering debt unsustainable. Failure to implement planned fiscal reforms, while obtaining new external debt at expensive terms, leaves the country extremely vulnerable to a macro-financial shock.

A strong multiyear fiscal consolidation program is required to ensure macroeconomic stability and domestic finance for climate adaptation measures. Along with the accumulation of expenditure arrears and fiscal vulnerabilities, external debt service needs are rising and will peak at an estimated US$1.1 billion by 2026, twice as much as present-day reserves. Significant fiscal adjustment is critical for the sustainability of economic growth and for accessing capital markets to finance spending and climate adaptation investments. The transition to a more resilient economy primarily relies on the success of the policy actions to restore fiscal well-being.

[192] The sovereign-bank nexus refers to large holdings of domestic sovereign debt by the banks that deepen the ties between the sovereign and banking sectors, crowding out private investments.

[193] IMF Article IV Staff Report. 2024; World Bank, and IMF. 2024. "Maldives Debt Sustainability Analysis."

Recommendations to Address Macro-fiscal Challenges

Improve fiscal position and reduce debt vulnerabilities:

- **Reduce spending on subsidies, capital expenditures** (PSIP projects), **and expensive health care options** to return public expenditure to sustainable levels.
- **Implement SOE reforms** to strengthen corporate governance, improve financial viability, and encourage greater private sector participation.
- **Implement revenue mobilization and tax system reforms,** including measures such as increasing the Green Tax (see Section 7.3.1) and airport development fees.

Strengthen the policy framework and institutions to restore macroeconomic stability:

- **Implement the revised Fiscal Responsibility Act** that includes targets for debt and fiscal deficits over the medium term to enhance fiscal responsibility.
- **Strengthen the public investment management (PIM) framework** to provide a better understanding of the public assets owned by the government, risk exposure of public assets and ways to manage it, and the future investment needs of the assets.
- **Implement the new Public Debt Management Bill** to improve accountability and strengthen and consolidate the legal framework governing public debt management.
- **Enhance the monetary policy framework** by implementing liquidity management and developing the interest rate corridor.

Address macro-financial vulnerabilities:

- **Limit the sovereign-bank nexus** to reduce the exposure of the financial sector to the public sector to ensure banking sector's solvency and liquidity and free up additional resources for private sector lending.

7.2. Adaptation costs and macroeconomic impacts from SLR

7.2.1. Costs of adapting to SLR

The total cost of adaptation to SLR and flooding in Maldives is estimated to range between US$1.8 billion and US$4 billion and depends on the ambition and types of measures applied.[194] This cost range is lower than the government's estimate of US$8.8 billion (US$11.4 billion in 2022 prices).[195] The government's number assumes full protection for all inhabited islands with the most ambitious hard engineering measures (that is, tetrapod breakwater), rather than island typology-specific adaptation measures, as calculated for this CCDR.[196] While protection levels vary and each island requires a tailored approach (see discussion in Chapter 4), the unit costs of NbS are significantly lower than those of hard engineering or gray solutions (see Figure 25). Hard engineering measures supplemented with NbS may be the most appropriate strategy for highly populated islands, whereas stand-alone NbS or NbS combined with cheaper gray solutions may work better for smaller tourism islands and less populated islands. Furthermore, not all islands need to be protected with the strongest hard engineering measures—and not the entire coastline of an island. For example, on less populated islands, the population might be concentrated on a small stretch of the coastline,

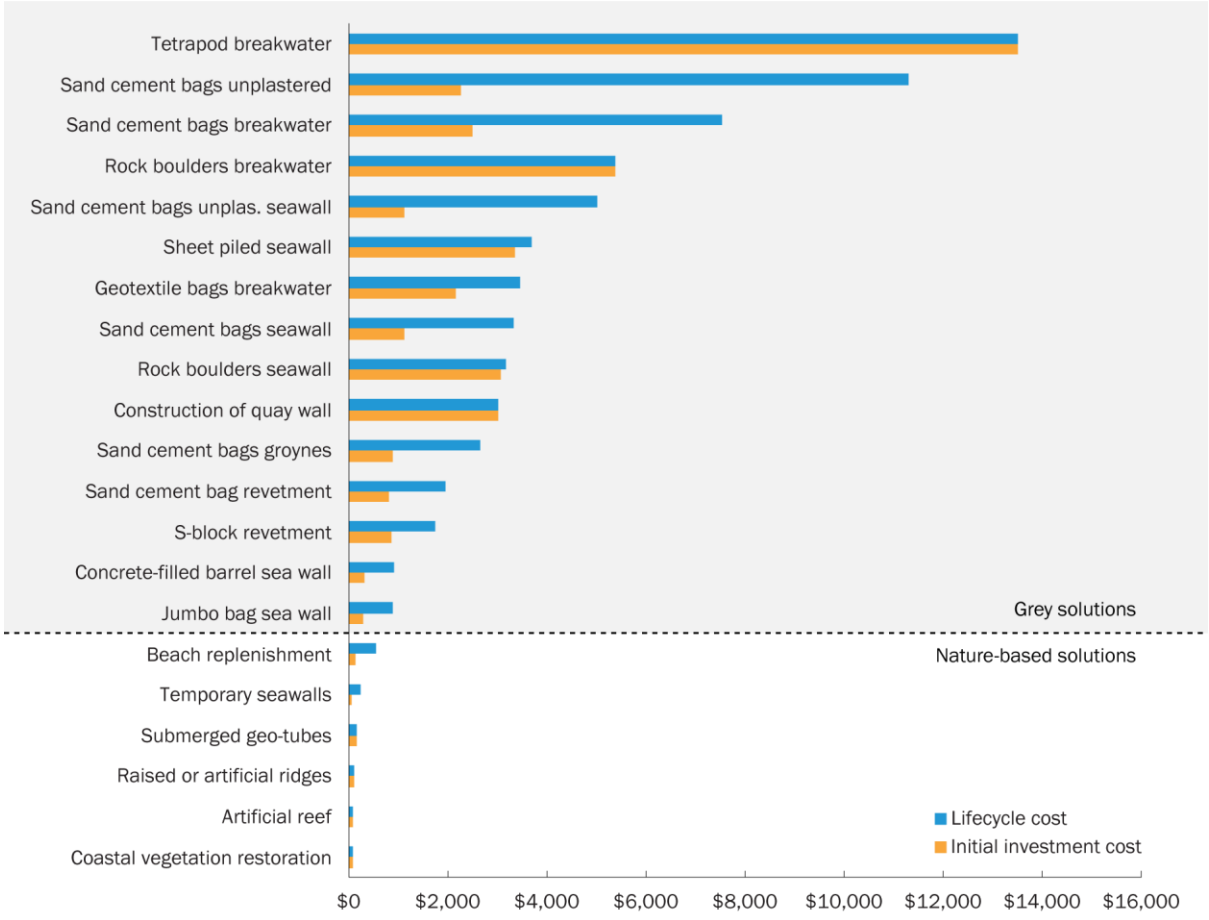
[194] World Bank staff calculation based on costs per linear meter for different types of measures. It does not consider the temporal horizon of the investment, but rather the total cost needed to protect a certain share of shorelines in all populated, tourism, and industrial islands. The analysis assumes the same unit cost per linear meter for each measure in all islands, while transport costs are higher for remote islands.

[195] Government of Maldives. 2016. "Second National Communication to the UNFCCC."

[196] For example, the upper bound of the estimate (US$4 billion) assumes that 80 percent of the coastlines of all highly populated islands are protected: 50 percent by concrete tetrapods and 50 percent by sheet piled seawall. In addition, the estimate assumes that coastal vegetation restoration is carried out in 20 percent of the protected coastline. Different fractions of protected shorelines and mixes of protection infrastructure are applied for other island types.

resulting in lower total SLR adaptation cost. Furthermore, these cost estimates are only for medium- to long-term 'protection' measures as discussed in Chapter 4. In the long term (for example, to cope with high-end SLR from 2090 onward under the SSP5-8.5 scenario), 'island raising', 'accommodation', and 'relocation/migration' measures might be required, as illustrated in the adaptation pathways in Figure 10 (Section 4.2). The costs for these other measures are not accounted for in this analysis.[197]

Figure 25: Unit cost of gray versus NbS to protect a linear meter of Maldivian shoreline (in 2022 US$)



Source: Ministry of Environment and Energy. 2015. "Survey of Climate Change Adaptation Measures in Maldives." https://www.environment.gov.mv/v2/en/download/13712.
Note: For that study, a survey of existing and past coastal protection infrastructure in 40 islands was conducted. Therefore, the numbers (including the cost estimates in this CCDR) are based on past projects, rather than forward-looking considering the rate of SLR.

In addition to adapting to SLR, there are significant financing needs to help the tourism and fisheries sectors adapt to climate change and make households more resilient to climate change. It is important to note that the above-quantified costs of SLR and flooding adaptation are only a part of the overall cost of climate change. For instance, the tourism and fisheries sectors' resilience interventions have not been quantified and neither have the support programs for the households. As discussed in Chapter 5, preparing the tourism and fisheries sectors for future climate realities will require significant investments, some of

[197] While several island raising projects have been carried out in Maldives, they were aimed at creating more land and space for people and economic activities rather than in the context of adapting to SLR.

which, particularly in the tourism sector, will be borne by the private sector. Decarbonization investments have been estimated to total US$1 billion.[198]

7.2.2. Macroeconomic impacts from SLR

SLR is expected to have significant macroeconomic impacts of up to 11 percent of GDP by 2050 under a high-emission scenario and assuming slow reconstruction.[199] The modeling conducted for this CCDR assesses the impact of SLR on economic growth and debt trajectory for various scenarios with different assumptions about fiscal consolidation, reconstruction investments, and adaptation investments[200] with different protection levels. Two response scenarios were modeled to assess the impact of SLR on economic growth: (1) no fiscal consolidation, slow reconstruction,[201] and no adaptation and (2) fiscal consolidation, fast reconstruction, and adaptation (assumed to be 50 percent financed through public debt financing between 2027 and 2039 and 50 percent financed by the private sector through higher-cost private capital). Under the second scenario, three different degrees of adaptation effectiveness (assuming 25, 50, and 75 percent damage reduction) were modeled. The CCDR estimates SLR impacts on GDP under three different emission scenarios and finds that the median impact is an 11.3 percent reduction by 2050 under RCP8.5, 10.7 percent under RCP4.5, and 10.2 percent under RCP2.6.

GDP impacts can be significantly reduced with context-informed and fast reconstruction and adaptation action. For instance, under the worst-case emission scenario, GDP impacts can be reduced from about 11 percentage points to about 5 percentage points by 2050**.** Under the first response scenario (no fiscal consolidation, slow reconstruction, and no adaptation), there is a significant adverse impact on GDP with an about 11 percentage point reduction from the baseline by 2050 under RCP8.5. However, under the second scenario with fiscal consolidation, fast and context-aware reconstruction taking effect just one year after SLR-induced flooding, and adaptation investments, the GDP decline is reduced to about 9 percentage points, assuming a protection level of 25 percent. Under the scenarios of adaptation investments with higher adaptation effectiveness (50 percent or 75 percent), investments are estimated to further cushion the negative impact to less than 7 percentage points or 5 percentage points of GDP reduction from the baseline by 2050, effectively reversing compounding negative impacts over time.[202] However, failure to implement planned fiscal reforms could lead to a potential macro-financial crisis and therefore adversely affect the country's growth and debt profile, causing delays in required asset reconstruction and climate adaptation investments. Low-emissions and average-emission scenarios are shown in Annex 1.

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[198] Potomac Group. 2023. *Assessment and Options Analysis of Climate and Nature Financing Instruments and Opportunities in the Maldives*. Background report prepared for the World Bank's Maldives Country Environment Analysis report (2024).

Note that while the total SLR adaptation cost may cover coastal protection infrastructure needs beyond 2050, the mitigation cost estimate is only through 2030.

[199] The modeling undertaken for this CCDR is based on the climate-aware version of MFMod (CC-MFMod) that uses inputs from biophysical models and associated damages. SLR will lead to damage to land and assets (both permanent and temporary). The estimated asset damages affect the allocation of resources in Maldives. There are three distinct features of the model that are utilized to account for SLR impacts: stochastic run of shocks, reconstruction, and adaptation. Shocks are drawn from externally modeled SLR damage distribution and hit aggregate capital stock continuously. Lower capital stock in the economy has consequences for Maldives' economic growth—the level of output is a function of the level of existing capital stock and future investments. Capital damage reduces potential output directly and actual output indirectly through the macroeconomic propagation of the shock.

[200] The assumptions are (a) an adaptation cost of US$2.61 billion (constant 2022 dollars) based on the midpoint estimate of the most comprehensive investment scenario; (b) the adaptation cost uniformly distributed across 13 years from 2027 to 2039; and (c) adaptation benefits start to materialize three years after the cost starts incurring and are fully realized by 2042.

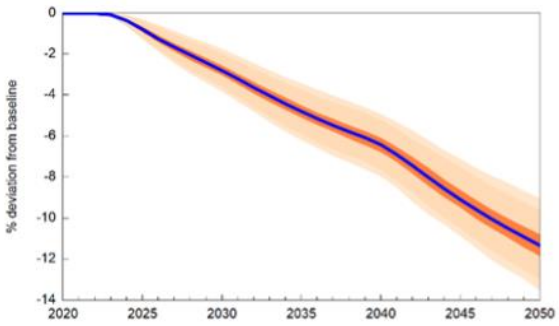
[201] Reconstruction refers to repairing damaged capital stock. The assumption is that shocks destroy capital with average productivity. Therefore, reconstruction brings higher returns (average) than other productive investments (marginal). Thus, it is assumed that reconstruction is prioritized and financed. The cost of reconstruction crowds out productive public investment. Relocation aspects are not considered due to a lack of granular data.

[202] GDP reaction is sensitive to adaptation investment intervention. Despite a general downward trend over the time horizon until 2050, GDP bounces back slightly when the adaptation investment kicks in around 2027, while accelerating to decline when the investment phases out around 2039. However, the response is temporary and returns to the trend quickly.

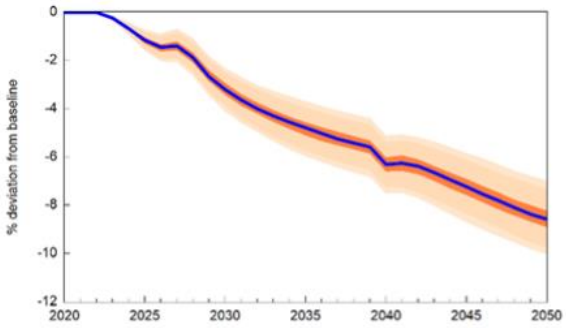
Fiscal consolidation helps lower the debt ratio and creates necessary fiscal space for reconstruction and adaptation investments, which reduce the debt ratio by 2050 under a high-emission scenario due to a growth effect (see Figure 26). The same two response scenarios were modeled to assess the impact of SLR on the debt-to-GDP ratio (see Figure 27). Under the first scenario, GDP losses accrue under climate change, and consequently, debt as a share of GDP rises sharply. The debt-to-GDP ratio becomes almost 10 percentage points higher than the baseline by 2050. In contrast, the debt-to-GDP ratio declines substantially in the initial stage in the second scenario by more than 16 percentage points from the baseline due to a fast fiscal consolidation in three years, which provides resources to protect against future climate events. Though the debt ratio bounces back due to the partially publicly financed adaptation investments until 2040, it declines by more than 8 percent (protection level = 75 percent) and about 6 percent (protection level = 25 percent) from the baseline over a longer term until 2050. Overall, the debt ratio under a fiscal consolidation scenario stays on a downward path and is much lower compared to the scenario without a fiscal consolidation.

Figure 26: GDP impact from SLR under RCP8.5

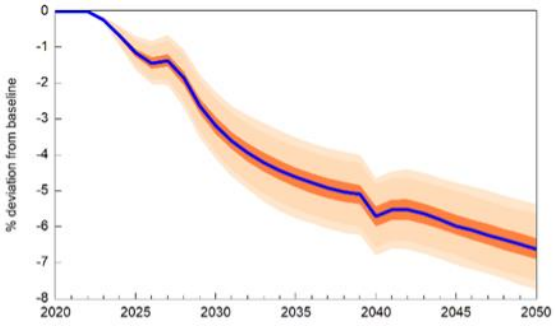
1. No fiscal consolidation; slow reconstruction; no adaptation



2a. Fiscal consolidation; fast reconstruction; adaptation with protection level of 25 percent



2b. Fiscal consolidation; fast reconstruction; adaptation with protection level of 50 percent



2c. Fiscal consolidation; fast reconstruction; adaptation with protection level of 75 percent

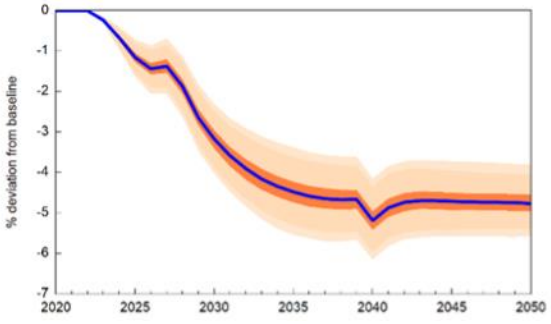
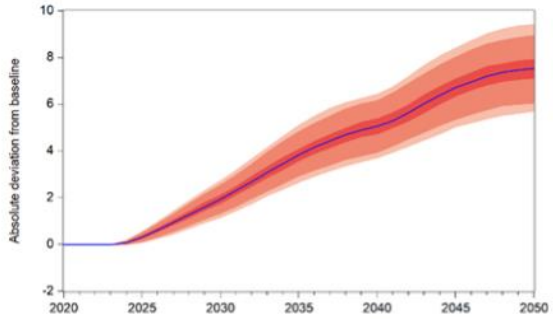
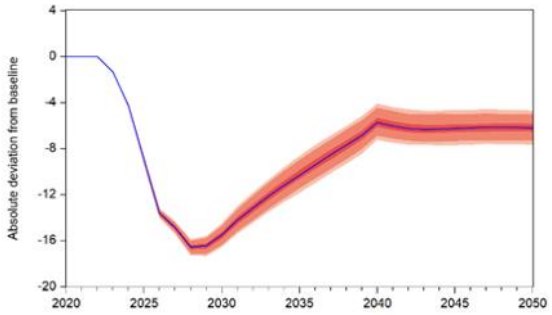


Figure 27: Debt/GDP impact from SLR under RCP8.5

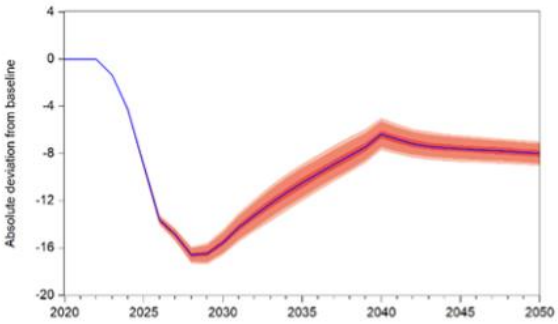
1. No fiscal consolidation; slow reconstruction; no adaptation



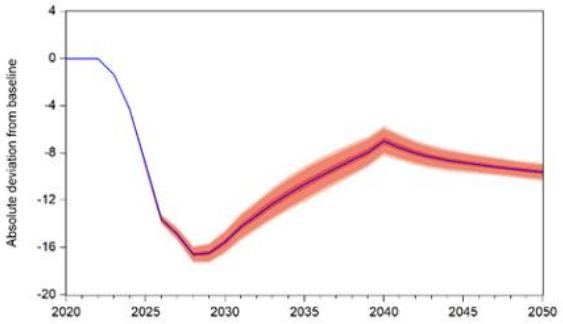
2a. Fiscal consolidation; fast reconstruction; adaptation with protection level of 25 percent



2b. Fiscal consolidation; fast reconstruction; adaptation with protection level of 50 percent



2c. Fiscal consolidation; fast reconstruction; adaptation with protection level of 75 percent



An important limitation of the modeling results is that only impacts from SLR are assessed while other hazards such as ocean temperature rise are not accounted for—the macroeconomic impact of all climate change threats combined would thus be significantly larger. As discussed in Section 1.2.2, the impacts of ocean temperature rise on coral reefs and fish stocks are the other main climate change threats. For instance, without adaptation to ocean heating, annual fisheries catch by mid-century is estimated to be on average 17,885 tons (around 12 percent) less than the current 2020s catches of 151,000 tons under RCP8.5. By the end of the century, the reduction in annual catch is estimated to increase to 149,500 tons less than the current catch, essentially indicating that almost the entire fishery would be lost. Similarly, as discussed in Section 1.2.1., degrading coral reefs will have significant impacts on the tourism industry. The loss of income for the fishing and tourism industry would impose additional significant macroeconomic implications that are not currently assessed. There are also significant other losses and damages from climate change that are not accounted for (see Box 4).

Box 4: Loss and Damage from Climate Change

Losses and damages from climate change occur when adaptation limits are exceeded and adaptation or mitigation measures are insufficient, unsuccessful, or impossible to implement. The Intergovernmental Panel on Climate Change acknowledges that extreme conditions exceeding the resilience of certain ecological and human systems and testing the adaptive abilities of others are already a reality, with vulnerable populations and human systems, as well as climate-dependent species and ecosystems, being most under threat and facing possibly irreversible impacts.

Losses and damages might be economic (resources, goods, and services that are tradable) or noneconomic (other non-tradable and/or value-based items) in nature. Noneconomic losses might include loss of life, quality of life, health, human mobility, territory, cultural heritage, indigenous knowledge, societal/cultural identity, biodiversity, or ecosystem services. SIDS, such as Maldives, are particularly affected by losses and damages, facing higher impacts than non-SIDS.

Sources: IPCC. 2022. *Climate Change 2022: Impacts, Adaptation and Vulnerability*. Working Group II Contribution to the IPCC Sixth Assessment Report.
UNFCCC. 2018. "Loss and Damage - Online Guide".
ODI 2023. "The Costs of Inaction: Calculating Climate Change-Related Loss and Damage from Extreme Weather in Small Island Developing States."

7.3. Climate finance

The significant financing requirements for climate change adaptation needs and decarbonization ambition cannot be met by domestic public finance alone. Bringing in domestic and international investors in the climate space has been challenging given the size of the economy, high public debt, ongoing fiscal and external vulnerabilities, and the less-developed financial sector. Private finance as well as non-debt-based instruments will be critical to scale up investments in resilience and the green transition. Foreign direct investment (FDI), supported by de-risking instruments, and international development finance will be important in financing climate adaptation and green transition over the medium term.

The lack of well-designed, bankable projects due to weaknesses in project planning, preparation, selection, and budgeting has been a bottleneck for attracting climate finance.[203] At the planning stage, there is no sector-specific guidance on the preparation and costing of climate change-related considerations for public investments. As a result, sectoral and climate change strategies are not costed realistically. At the selection and budgeting stage, the prioritization methodology for the inclusion of projects in the PSIP is not public and not standardized across sectors. It is thus unclear how far climate change considerations are currently incorporated in the PSIP project selection. At the implementation stage, there is no system to monitor climate-related public. Climate budget tagging can help track how much is spent against specified climate goals and expand green labeling standards for assets. The recently launched Integrated National Financing Framework seeks to unlock climate financing across different public and private sources. The government also adopted the National Strategic Framework for Mobilizing International Climate Finance in the Maldives (2020–2024). It outlines mechanisms for tracking and managing climate finance, establishing a National Climate Change Emergency Trust Fund, and creating incentives for private sector investment in green development. However, there continues to be a lack of awareness of, and incentives to, engage in climate investment opportunities for the private sector. Further, there is limited policy coordination across ministries about national climate policies and plans (see Chapter 2). The recently announced plan to launch a Climate Finance Hub[204] is a step in the right direction and its operationalization will be critical to ensure policy alignment.

The lack of reliable and accessible data to guide climate investment is another obstacle to scaling up public and private climate financing. Important climate and environmental data are not regularly collected by firms and authorities, and the data collected are scattered across different entities, making it difficult to assess projects' environmental impacts and identify green or resilient investment opportunities. There are also no labeling standards, exacerbating the identification of resilient and green projects and tracking of climate finance. A taxonomy will be critical in guiding investment decisions and facilitating reliable and comparable disclosures.[205]

Recommendations to Increase Climate Finance

- **Operationalize the Climate Finance Hub** to support a coordinated approach toward climate finance.
- **Develop a climate investment plan** building on the Integrated National Financing Framework and prepare a pipeline of bankable projects.
- **Develop a centralized database to consolidate climate-related data and make relevant information available to the public and investors** for facilitating the identification of investment opportunities and project development.
- **Introduce a national green/transition taxonomy and develop a framework for tracking green finance** provided by public and private sources.
- **Integrate climate considerations into planning and budgeting** by introducing standard methodologies that account for climate change in investment appraisals by ministries and SOEs and include climate change as a criterion for inclusion of investments into the PSIP.

[203] The analysis in this paragraph draws from the forthcoming Climate–Public Investment Management Assessment (IMF 2024).

[204] The Maldives Climate Finance Hub, housed within the MoF, is intended to support inter-ministerial coordination on climate finance and to track the implementation of the Integrated National Financing Framework.

[205] IMF Global Financial Stability Report, October 2022.

7.3.1. Public climate finance

There is considerable scope to better integrate climate change considerations into public finance processes, especially in terms of climate budget tagging. Currently, climate change considerations are insufficiently addressed when formulating the overall fiscal strategy at the time of budget preparation and implementing the budget. Some progress has been made to strengthen ex post audits of investment projects from a climate change lens. The MoF has also commenced a climate budgeting exercise. This is an important step that will allow Maldives to provide a comprehensive picture of spending to support climate goals, help in terms of accessing climate finance and engaging with possible green investors, and allow for improved consideration of climate change at the time of budget formulation. The climate budget will complement the ongoing work on program budgeting and Sustainable Development Goal tagging and should be completed and rolled out as a priority.

While the absence of a climate budget tag precludes a deeper analysis of climate-related spending, available data indicate low and declining spending on related environmental protection. The budget allocation for environmental protection—including waste and wastewater management and biodiversity and landscape protection—was MVR 2.1 billion (US$136.3 million), MVR 2.4 billion (US$154.4 million), and MVR 1.8 billion (US$118.2 million), respectively, in 2022, 2023, and 2024. This accounts for 4.9 percent of overall spending in 2022, 4.8 percent in 2023, and only 3.7 percent in 2024.[206]

An increase in climate-related spending is contingent on improved fiscal sustainability. The government's early 2024 fiscal reform agenda includes important measures in this regard, including the elimination of blanket subsidies, reforms of health spending, strengthening of SOE corporate governance and financial viability, and a solid PIM framework with a reprioritization of public investment decisions. These measures will help reduce the high levels of public expenditure, replenish fiscal buffers, and lower the cost of growth-enhancing investments. Box 5 discusses the fiscal impact of the potential subsidy reforms, which will also support the climate agenda. Moreover, revenue mobilization can be improved by diversifying the tax base and mobilizing more domestic sources of revenue, reducing informality, and enhancing the tax morale and equity of the tax system.

Box 5: Potential of Subsidy Reforms to Build Fiscal and External Resilience with Cleaner Domestic Energy Options

High energy subsidies constrain fiscal space and undermine spending efficiency. Due to direct and indirect electricity subsidies provided on diesel and electricity tariffs and on essential foods, the government faces significant fiscal pressures. Maldives has one of the highest costs of power generation in South Asia. In 2022, around 30–40 percent of imported fuel cost was likely subsidized by the government with a budgetary expenditure allocation of approximately US$120 million. Furthermore, higher global commodity prices pushed fuel and electricity subsidy spending up by 165 percent (year on year) in 2022 to MVR 3.2 billion (US$205 million); the fuel and electricity subsidy remained elevated at MVR 3.1 billion (US$199 million or 3 percent of GDP) in 2023.

The government plans to eliminate blanket subsidies on fuel and electricity starting in Q4 2024. As a result, subsidy spending on food, fuel, and electricity is expected to fall by 55 percent in 2024 to MVR 1.5 billion (US$99 million). According to the approved budget, this will result in expenditure savings of around MVR 1.5 billion (US$99 million) or around 1.3 percent of the projected 2024 GDP. However, the removal of blanket subsidies is expected to lead to a substantial rise in overall food, fuel, and electricity prices. To mitigate the negative impact of subsidy reforms on the poor and vulnerable households, the government plans to implement a direct cash transfer program, leading to a net subsidy saving of about 0.7 percent of GDP.

The Green Tax is a key instrument for raising revenues for vital climate and environmental projects and could be further increased. Since its inception in 2015, the Green Tax has mobilized over US$336 million in

[206] Government of Maldives, 2022, 2023, and 2024 Budgets.

revenue, accounting for nearly 40 percent of climate- and nature-based financing through 2022. As of April 2024, the government charges US$6 per night as Green Tax to tourists staying in resorts and vessels and US$3 per night to tourists staying in guesthouses. With an average vacation duration of 9.2 days in 2021, tourists were charged an average total of US$55 per stay.[207] In 2018, the government established a Green Fund to collect and manage the proceeds from the Green Tax. The proceeds are used to finance environmental projects. Between 2019 and 2022, most of the proceeds were used to finance improvements in the sewage and waste infrastructure, water supply systems, and coastal protection. The Green Tax equaled about 1 percent of GDP in 2021 and is hence a meaningful addition to other tax revenues (around 19 percent of GDP since 2015).[208] However, there is scope to further increase the Green Tax. For instance, an increase from US$6 to US$10 per night for tourists staying in resorts and vessels could raise MVR 1 billion (US$65 million) in three years, generating additional revenues of 0.2 percent of GDP in 2024, 0.3 percent in 2025, and 0.4 percent in 2026. In addition, once fiscal balances and debt sustainability are improved, tax incentives linked to the Green Tax could be considered to encourage more climate and environmental investments by resorts and hotels.

Recommendations to Increase Public Climate Finance

- **Introduce climate budget tagging and report on climate-related spending** as part of regular budget documentation.
- **Phase out fossil fuel subsidies and reduce expenditure** while mitigating impacts on poor and vulnerable households.
- **Raise the Green Tax and dedicate proceeds to environmental and climate-resilient interventions** such as the newly established Maldives Nature Fund.

7.3.2. Private climate finance

Foreign financial flows toward climate investments will be important in financing climate adaptation and mitigation needs. In 2022, Maldives attracted FDI of US$722 million (11.7 percent of GDP), directed mostly toward new resort investments. Due to the lack of disclosure, reporting, and green taxonomy, it is unclear what share of these financial inflows were climate related. However, climate-related expenditures (for example, coral reef research and development and solar panels) likely represent a small share of foreign investments in resorts.[209] To promote green FDI, regulations should be updated to include climate disclosures and reporting, while the visibility and attractiveness of climate project pipelines should be enhanced.

The domestic financial sector's contribution to climate goals has been limited to date, including due to the sovereign-bank nexus. Only two banks and one non-bank financial institution offer 'green credit', focusing on climate mitigation projects in RE and energy efficiency. The scale of green lending is negligible, representing about 0.1 percent of total financial sector assets. Domestic financial institutions lack the data, incentives, and guidance to develop green financial products. For example, there is no green or transition taxonomy in place and MMA has not yet provided guidance on the issuance of green financial products nor mandated financial institutions to provide disclosures on environmental, social, and governance (ESG) performance of entities and their portfolios (including on financing of climate-unfriendly projects and companies). Commercial banks are generally reluctant to lend to climate projects, especially for climate adaptation, that usually have a longer payback and higher up-front costs, particularly given the gaps in the insolvency and creditor rights regime as well as lack of de-risking mechanisms; the current macro-fiscal challenges exacerbate their deployment.

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[207] Maldives Bureau of Statistics. 2021. *Maldives Statistics Yearbook 2021*.

[208] OECD. 2020. "Revenue Statistics in Asia and the Pacific: Key Findings for the Maldives."

[209] World Bank. 2024. *Financial Sector Assessment Program - Technical Note: Climate-Related and Environmental Risks and Opportunities?* Washington, DC: World Bank Group.

Corporate green bonds and other similar financial instruments are currently not anticipated to have a major impact in Maldives. The Capital Market Development Authority has implemented ESG reporting requirements for listed companies, as part of its corporate governance code. Nevertheless, the authority's initiatives to promote sustainable finance are likely to have a limited effect unless there is substantial development of the capital markets, which includes establishing a solid base of local investors and issuers. In addition, while the current market conditions are unfavorable for the issuance of government green bonds, the MoF is in the process of developing an ESG sovereign financing framework that can be used once conditions improve.

Private sector development in the fisheries industry faces numerous challenges, primarily due to the dominant role of the Maldives Industrial Fishing Company (MIFCO). MIFCO controls a significant portion of the sector, leading to market inefficiencies and limited competition. This dominance hampers the growth and innovation of SMEs and emerging private enterprises, who struggle to compete with MIFCO's resources and influence. Moreover, issues such as access to finance, infrastructure limitations, and regulatory barriers further hinder the emergence of a vibrant private fisheries sector. Despite efforts to introduce competition and privatization, MIFCO retains its dominant position, especially in fish processing and export, with a significant share of the market and control over the fishing operations. However, concerns persist regarding MIFCO's financial weaknesses and its reliance on government support, raising questions about its long-term sustainability and its contribution to government revenues. Addressing these challenges is essential for nurturing a more competitive and sustainable fisheries industry that benefits the economy and local communities.[210]

Investors continue to face challenges in accelerating the green energy transition. Private investors perceive off-taker risk to be significant due to high financial losses at state-owned utilities and a retail electricity tariff that does not reflect cost structures. Additional hurdles are the limited track record of utilities as counterparts to power purchase agreements with independent power producers (IPPs) and currency convertibility risks. Floating solar projects are currently not financially viable because of diesel subsidies. A comprehensive plan, along with a pipeline of renewable projects that can be bid out to IPPs and a comprehensive risk mitigation framework, would help private capital mobilization.[211]

There is significant private sector investment potential in the green mobility transition. While active mobility infrastructures are primarily provided by the public sector, private capital can support the transition through investments in shared mobility, for example, shared bicycles or electric scooters, as well as through the construction of quality public infrastructure in new developments. This can be achieved through enabling regulation and instruments such as land value capturing and betterment charges. The expansion and greening of public transport—buses and ferries—has significant investment opportunities. While high initial investment costs and extended payback periods currently hinder private investments, innovative public-private or blended financing models could mobilize urgently needed capital. PPPs for charging infrastructure and integrated transition planning with the energy sector have the potential to raise private finance to decarbonize the transport sector; reduce fuel import dependency; and generate multiple social, public health, environmental, and economic co-benefits.

Attracting private sector investments to the green and resilient housing sector has been challenging. The Public Buy and Sell Housing Program is the primary government housing scheme, which has absorbed significant public resources (US$1 billion or 19 percent of GDP as of 2020). Access to long-term financing and housing finance programs is limited. The mortgage market is small, with outstanding loans at 7 percent of GDP. Financing is restricted for low-income and non-salaried workers due to limiting guidelines and is inaccessible due to high down payment and underdeveloped regulations. Private finance for the housing sector could, for instance, be mobilized by developing alternative credit scoring for informal and low-income

[210] For a more detailed discussion of the fisheries sector in general, and options for reforming MIFCO, see World Bank. 2024. *Maldives: Country Environmental Analysis. Towards a More Sustainable and Resilient Blue Economy*. Washington, DC: World Bank Group.

[211] The World Bank's ARISE project included three risk mitigation measures that helped get a power purchase agreement rate of US$0.98 for the 11 MW project, the lowest rate in Maldives and one of the lowest for an island nation worldwide.

workers in partnership with financial technology companies to improve underwriting capacity and exploring innovative loan products such as incremental housing loans that better meet the needs of the consumers. Green and resilient construction requirements and incentives should be incorporated systematically into housing financing schemes and related policies.

Private investment in resilient infrastructure is hindered by the dominance of public sources and the lack of an enabling environment, including favorable PIM. Most of the infrastructure investments have been financed through public funding or external borrowings which has led to public debt rising to unsustainable levels. SOEs play a significant role in the provision of infrastructure services, yet they operate inefficiently and pose fiscal risks, with SOEs in the energy and transport sectors being loss-making. The use of PPPs and private investment in infrastructure has been relatively limited. The PIM framework does not support the identification of potential PPP projects and there is no clear PPP policy and enabling environment for private investment in resilient infrastructure, including digital infrastructure. It is critical to strengthen the PIM framework to ensure that key infrastructure services are planned, prioritized, and delivered to enhance connectivity while ensuring affordability, sustainability, and resilience. An updated PIM framework can also identify projects that can be bid out through PPPs and help mobilizing private capital and skills to meet climate goals. However, due to the small size of the projects and limited private sector capabilities, mechanisms such as credit enhancement or risk mitigation frameworks, including political risk guarantees, might be needed to attract investors. Improved transparency of contingent liabilities associated with PPPs and improved coordination across relevant entities involved in developing sector policies and planning investments will be important to leverage cross-sector synergies.

A framework for managing fiscal commitments and contingent liabilities (FCCL) must be an integral part of a PPP framework. The government should adopt a PPP framework with a set of rules, decision criteria, and institutional responsibilities to manage the fiscal risks of PPP projects, including contingent liabilities in case of risk mitigation instruments that might be needed to attract private investments. The management of FCCL for PPP projects is critical to avoid exposure fiscal shocks. The FCCL framework could include rules and/or procedures to control the government's aggregated fiscal exposure to PPPs throughout the PPP lifecycle and ensure the upstream involvement of the MoF and the MMA. A PPP Fiscal Risk Assessment Model can help quantify the macro-fiscal implications of PPPs, understand the risks assumed by the government, and identify potential mitigation measures.

Recommendations to Mobilize Private Sector Financing for Climate Action

- **Identify opportunities for private sector investments in resilience and the green transition** by (a) systematically assessing project pipelines of relevant ministries, agencies, and SOEs to identify projects with the potential to mobilize private sector capital and (b) developing a comprehensive national PPP bankable project pipeline to help attract investors with project designs incorporating sustainable design and construction practices.
- **Update the PIM framework to identify projects that can be bid out to the private sector through PPPs** to mobilize private capital and capabilities for climate action and, once fiscal conditions allow, consider mechanisms such as credit enhancement frameworks or political risk guarantees to attract investors.
- **Strengthen the institutional, legal, and regulatory enabling environment for PPPs** by establishing a central government PPP unit to act as a center of excellence and ensure that it has the necessary resources, capacity, and authority to carry out its designated functions in a coordinated manner.
- **Promote FDI in resilience and the green transition** by requiring climate disclosures and reporting and enhancing the visibility and attractiveness of climate project pipelines supported by de-risking instruments.

- **Issue guidelines and incentive mechanisms to stimulate the green and sustainability-linked loan market** and explore guarantee facilities (for example, for PPP projects and micro, small, and medium enterprise [MSME] green loans) and blended financing facilities for green and blue investments.
- **Expand the domestic investor base for climate action** by assessing the regulatory framework for the pension sector and life insurance market to determine the feasibility of allowing pension funds and insurance companies to invest in resilient and green infrastructure assets.
- **Prepare a pipeline of bankable solar projects** that could be bid out to IPPs, including a comprehensive risk mitigation framework.
- **Conduct regulatory reforms to improve the enabling environment for private sector sustainable housing financing,** including in the areas of foreclosure processes, title registration, and bankruptcy.

7.3.3. Concessional climate finance

Grants and concessional financing have steadily contributed to financing climate projects. The country received over US$325 million in grant financing since 2015. Additionally, nearly US$189 million was raised for climate and nature projects through external debt-based development financing. This amounts to a total of around US$515 million for climate and nature-related funding since 2015.[212] Grants should continue to be an important source of financing, particularly for investments in adaptations that are usually not commercially viable. Access to donor funding, however, is expected to become more difficult for Maldives as it is classified as an upper-middle-income country at high risk of debt distress. Additional barriers to securing concessional funds include a shortage of local experts to develop and execute projects, the absence of specific frameworks for investment in adaptation and mitigation, and gaps in climate data (see previous sections).

A dedicated conservation trust fund (CTF) focused on NbS could function as a vehicle to channel the proceeds from concessional climate finance and help attract additional resources for climate adaptation. CTFs are private, legally independent institutions that receive, manage, and invest money from various sources to finance conservation and restoration projects. In other countries such as the Seychelles and Madagascar, CTFs have been used to channel proceeds from debt-for-nature swaps or blue bonds.[213] Maldives has experience with atoll-level CTFs such as the Baa Atoll Conservation Fund,[214] but these are limited in scale. The government is currently exploring the establishment of a national CTF to strengthen financing for NbS. Such a CTF could provide opportunities to mobilize additional concessional climate and nature finance from international donors and philanthropic organizations. To be attractive for such contributions, the CTF will need to adhere to global best practices such as an independent board and transparent governance and allocation mechanisms.

Additionally, the government might consider other instruments that are debt neutral or help lower the debt burden, such as debt-for-nature swaps or outcome-based bond structures. Under a debt-for-nature swap, creditors provide debt relief in return for a government commitment to climate action. For Maldives, this could be an option under a scenario where the government addresses debt vulnerabilities with a credible fiscal adjustment path. Credible enforcement mechanisms and simple-to-monitor metrics supported by data collection are key elements in facilitating such transactions. While debt-for-nature swaps can unlock financing for resilience in a challenging fiscal environment, they are usually costly, limited in scope, and not

[212] Potomac Group. 2023. *Assessment and Options Analysis of Climate and Nature Financing Instruments and Opportunities in the Maldives*. Background report prepared for the World Bank's Maldives Country Environment Analysis report (2024).

[213] SeyCCAT. Case Study: Debt-for-Nature Finance Swap.

World Bank. 2018. "Press Release: Seychelles launches World's First Sovereign Blue Bond."

[214] http://www.bacf.gov.mv/.

a comprehensive solution to climate and debt problems.[215] The government might also explore donor outcome-based bond structures whereby principal investment is paid for by the donor and, instead of coupon payments, investors receive payments based on the achievement of specific climate or environmental outcomes that are calculated and verified by independent parties. The feasibility of these instruments will need to be further evaluated and will depend on donor willingness to pay investors for the positive outcome and credibility of monitoring and verification frameworks.

Recommendations to Increase Concessional Climate Finance

- **Set up a conservation and climate adaptation CTF(s)** with appropriate governance structures to help attract additional concessional finance for climate adaptation and environmental protection.
- **Further explore and assess the viability of innovative financing instruments that do not contribute to the debt burden,** such as debt-for-nature swaps or outcome-based bond structures.

7.3.4. Carbon markets

The country can leverage international carbon markets to finance its decarbonization efforts and bolster financial support for projects that may struggle to secure funding. The participation of SIDS in international carbon markets has traditionally been marginal and primarily based on a project-by-project approach. Barriers preventing SIDS from benefitting from carbon market opportunities include higher relative transaction costs associated with smaller-scale project activities and limited institutional and technical capacity to engage in sophisticated carbon crediting and trading mechanisms. However, participation has been increasing owing to heightened global demand and growing interest in voluntary carbon projects with strong local development benefits. With an ambitious 2030 net zero target and a global private sector increasingly committed to sustainability and climate goals, Maldives offers an attractive prospect for monetizing emission reductions generated in low-carbon infrastructure and nature-based climate solutions and selling carbon credits to nations, corporations, and individuals, across both compliance and voluntary markets. To fully unlock the potential of carbon markets and establish itself as a reliable supplier of high-integrity carbon credits in both market segments, Maldives should develop a comprehensive host country strategy. This would guide the nation's involvement in international carbon markets and formulate a transparent policy framework and governance arrangements. Additionally, the country should prioritize building its capacity to set up a core carbon market infrastructure, including a national carbon asset registry and robust monitoring, reporting, and verification systems aligned with the UNFCCC's enhanced reporting requirements.

Maldives can also harness blue carbon ecosystems as a strategic asset for results-based climate financing. The term 'blue carbon' broadly refers to the carbon captured by marine ecosystems, including mangroves, seagrasses, and potentially other marine and coastal habitats. Cooperative arrangements with other Parties under Article 6 of the Paris Agreement could be facilitated or piloting of new approaches with corporate buyers in trustworthy voluntary carbon markets could be fostered. Despite the potential benefits, the nascent nature of blue carbon opportunities still poses significant challenges, such as limited data, methodologies, and understanding for accurately quantifying the carbon removal potential of blue carbon ecosystems. The integration of results-based payments for blue carbon solutions would require establishing a comprehensive monitoring, reporting, and verification system for tracking mitigation outcomes and ecosystem changes

[215] Banque de France Bulletin no. 244: Article 2 "Debt-for-nature swaps: a two-fold solution for environmental and debt sustainability in developing countries?" February 2023.

There are several examples of debt-for-nature swaps in SIDS. Examples include Seychelles' 2015 transaction that offset debt of US$21.6 million in return for expanding MPAs to 30 percent and implementing a marine spatial plan to safeguard biodiversity. In 2021, Belize signed a debt-for-nature swap that reduced its external debt by 10 percent of GDP in return for an endowment supporting marine conservation and a commitment to yearly spending on marine conservation and expansion of protected ocean area to 30 percent.

associated with these mitigation actions. This would have the dual benefit of being able to attract funds through carbon credit sales and enhance national data for climate action, as highlighted as a cross-cutting issue throughout this report. Furthermore, a blue carbon action plan should be developed that delineates tangible goals and initiatives and includes specific targets for the various ecosystems—such as seagrasses, mangroves, and potentially kelp-seaweed.

Recommendations to Tap into Carbon Markets

- **Develop a clear national strategy and build capacity to access compliance and voluntary carbon markets,** including by establishing policy guidance, governance arrangements, and operational procedures for national market participants.
- **Promote the development of robust, high-integrity, high-impact carbon crediting programs for mitigation actions,** especially targeting 'blue carbon', leveraging the rich mangrove and seagrass resources.

7.4. Managing financial impacts of climate and disaster risks

7.4.1. Disaster risk financing and insurance

While Maldives has established post-disaster risk financing tools, the lack of strategy, funds, and instruments to adequately manage the financial impacts of climate and disaster risks persists. Even though the government has set up a Disaster Management Fund, there is no disaster risk financing policy. Disaster financing needs tend to be met through reallocations across budgeted lines of expenditure and the use of MoF's contingency budget.[216] In some instances, international assistance is also being used to fund or reduce contingent liabilities. As climate change is expected to exacerbate the severity and frequency of disasters and extreme weather events, the government should ensure that sufficient funds are available to respond to and recover from disasters. For this, the government should develop a comprehensive disaster risk finance strategy, by initiating an analysis of contingent liabilities from disasters and then formulating a strategy based on a risk-layering approach. For low-severity events, the government should strengthen its use of reserves, annual budget allocations, and contingency budgets, including ensuring that the disaster fund under NDMA is adequately funded for such events. For medium-risk events, contingent credit instruments should be secured. For high-severity events, risk transfer options, including for public assets, may be the most suitable option. In addition, the government should consider introducing climate-resilient debt clauses into loan agreements to be able to defer debt repayments in the event of severe climate-related shocks.

The range of climate-related disaster risk products offered by the insurance sector is currently limited in scope. This is in part due to the lack of formal regulations for a variety of insurance and risk financing tools. The 1981 legal framework for insurance companies constrains supervision and growth. A new insurance bill is in the pipeline to address these issues. The scarcity of comprehensive and granular meteorological data, stemming from insufficiently functioning weather station networks, exacerbates the creation and use of specific financial instruments such as index-based and parametric insurance products.[217] While major tourism resorts typically have insurance that covers catastrophic events, such as flooding and storm damage, many resorts do not.[218] In addition, some resorts have insurance for business interruptions, but there are significant coverage gaps in other areas, such as household property,[219] guesthouses, fisheries, and crops.

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[216] World Bank. 2024. *Crisis Preparedness Gap Analysis: Maldives Briefing Note (English)*. Washington, DC: World Bank Group.

[217] Ibid.

[218] IFC. 2024. "Based on a Survey of 55 Resorts in the Maldives."

[219] Data on the percentage of insured properties are not available. However, the products to insure buildings and their content against storms, floods, and, more broadly, natural disasters are available from four insurance companies. While MMA does not report gross written premiums for property insurance separately, the demand for this type of insurance is expected to be low (see World Bank. 2024. *Financial Sector Assessment Program - Technical Note: Climate-Related and Environmental Risks and Opportunities?* Washington, DC: World Bank Group).

Insurance for public assets is also underdeveloped; most of the public assets remain uninsured. There is no parametric insurance product available nor has the government issued any guidelines for such products. Insurance companies pass on approximately 95 percent of their premiums to reinsurance companies, which also cover natural disasters and climate change impacts. The repercussions of climate change may manifest in the short term as increased reinsurance premiums or in the long term as challenges in securing reinsurance for climate-related events, particularly coastal floods. This could result in insurers reducing or withdrawing coverage for climate-related events, which would affect both the banking and real sectors, including vulnerable households and crucial industries such as tourism and fisheries.[220] Climate risk management is also limited within the insurance sector.

7.4.2. Financial sector risks

The banking sector is moderately exposed to physical climate risk. Financial institutions and supervisors are at a nascent stage of developing their capacity in analyzing and managing climate-related financial risks. Climate hazards may cause damage to the immovable capital stock and diminish the value of these assets that usually back up loans. Indirectly, banks could also be affected through effects of climate events on households' and corporates' income and their ability to repay loans. The coastal flood risk assessment conducted for this report suggests that direct damages to the capital stock may reach up to around 2 percent of total asset stock by mid-century, while the International Monetary Fund stress testing estimates a total direct damage of 3.4 percent for the same time horizon.[221] For the mid-century scenario, the impact on the banking sector is estimated to be relatively mild, resulting in a decline of the capital adequacy ratio by about 0.5 percentage points,[222] but it can be significantly exacerbated by the end of the century. Further assessments of climate change impacts, including beyond coastal flooding, on the financial sector are needed to fully understand the sector's vulnerabilities to climate physical risk.

Understanding the vulnerability of banks' portfolios to climate transition risks (see Chapter 6) requires further analysis. While GHG emissions are low, it is heavily reliant on imported fossil fuels. Decarbonization of the power sector might affect energy, manufacturing, and transport sectors, among others. While these sectors represent only a small share of the banking sector portfolio, more detailed analysis and stress testing of banks' portfolios is needed to fully understand the potential impact.[223]

A supervisory response should be developed to address potential vulnerabilities of the financial sector to climate change. Currently, no bank has published targets, policies, or procedures related to climate risk management nor have they integrated climate risks in governance frameworks, risk management, and disclosures. Banks have limited their climate risk mitigation strategies to requiring insurance for the loan collateral. MMA has not taken any actions to address climate risks; it should start building its climate risk management capacity and engage with other authorities and international peers. In the medium term, MMA should consider introducing supervisory guidance to the banking sector, including more granular data collection, development of climate risk scenarios, and stress testing.

[220] See, for example, the case of the Netherlands https://www.afm.nl/en/sector/actueel/2021/oktober/schade-klimaatverandering-vaker-onverzekerbaar, as well as general discussion BIS (2023) https://www.bis.org/fsi/publ/insights54.pdf; IAIS (2023) https://www.iaisweb.org/uploads/2023/11/IAIS-Report-A-call-to-action-the-role-of-insurance-supervisors-in-addressing-natural-catastrophe-protection-gaps.pdf .

[221] IMF. 2024. *Maldives: Financial Sector Assessment Program - Technical Note on Bank Stress Testing and Climate Risk Analysis*.

[222] These results need to be interpreted with caution, given the high uncertainty surrounding the climate data, limited data to model the geographical exposures, and the possible indirect damages and spillover effects in Maldives' tourism-dependent economy.

[223] World Bank. 2024. *Maldives: Financial Sector Assessment Program - Technical Note on Climate-Related and Environmental Risks and Opportunities*. Washington, DC: World Bank Group.

Recommendations to Improve the Management of Financial Impacts from Climate and Disaster Risks

- **Develop a disaster risk finance strategy** based on a risk-layering approach and assess the potential of credit and sovereign risk transfer products within the framework of this strategy.
- **Improve the enabling environment for market-oriented risk financing and insurance** by formulating regulations and policies for mechanisms such as catastrophe pools, parametric insurance, and microinsurance, focusing on most vulnerable sectors such as fisheries and tourism.
- **Raise public awareness about available insurance products** to increase insurance use by households (for example, for property) and MSMEs.
- **Consider offering supervisory guidance and provide capacity building for the insurance sector to manage climate risks.**
- **Introduce a strong Central Bank governance framework and develop an institutional strategy** to address climate-related financial risks and opportunities, including improved data collection.
- **Issue MMA supervisory guidance on the integration of climate risks** into business strategies, governance, and risk management of banks and other financial institutions.
- **Raise awareness about and build regulatory and financial sector capacity on climate risk management and supervision.**

8. From Analysis to Action

The six climate change and development High-Level Objectives identified by this CCDR, based on the conceptual framework presented in the Executive Summary, are as follows:

1) Improve macroeconomic stability and fiscal space to finance climate action.
2) Mobilize climate finance.
3) Enhance the climate resilience of islands and infrastructure.
4) Enhance the climate resilience of ecosystems.
5) Enhance the climate resilience of livelihoods (fishers and tourism).
6) Unlock the development benefits from green transitions in energy, mobility, and waste sectors.

Key Recommendations for achieving the six High-Level Objectives are presented in Table 4. These Key Recommendations synthesize the long list of detailed recommendations that are identified throughout the report at the end of the individual sections. They are assessed and ranked in terms of their time frame and urgency as well as synergies and trade-offs with other development objectives (see Table 3). The time frame for the progress indicators covers the next five years, after which this CCDR is envisioned to be updated. In this context, short-term actions refer to a 1-year time frame, medium-term actions to a 2–3-year time frame, and long-term actions to a 4+ year time frame. Additionally, implementation barriers (including political economy considerations, institutional capacity and readiness, affordability, and financing) and progress indicators are identified. Key Recommendations include policy actions (marked with a '' symbol), investments (marked with a '' symbol), and research/analysis/knowledge (marked with a '' symbol). Given the challenging macro-fiscal context and limited availability of public finance, the focus of the Key Recommendations is on policies and planning, which are key to improving the enabling environment for and prioritization of climate investments.

Table 3: Prioritization criteria for the key recommendations

	Urgent *(delay in action increases the cost of achieving the same end point)*	**Less urgent** *(delay in action does not increase the cost of achieving the same end point)*
Synergies *(action facilitates the achievement of other development objectives)*	**Synergetic and urgent actions are to be prioritized** and should be part of the recommendations (but important to identify the obstacles that explain why it has not been done already)	**Synergetic actions that should be implemented but can be delayed,** only if implementation capacity allows it. With limited capacity and political capital, it may be preferable to delay them (especially if net benefits are small or uncertain)
Trade-offs *(cost of action makes the achievement of development objectives more difficult)*	**Actions that create trade-offs but are urgent and the most challenging.** Options to explore include specific designs to minimize or reverse trade-offs or protect the poor or opportunities to mobilize concessional financing	**Actions that create trade-offs with other development objectives and can be delayed should be delayed**

Table 4: High-Level Objectives and Key Recommendations

Recommendation	Implementation barrier	Time frame and urgency	Synergies and trade-offs	Progress indicator
High-Level Objective 1: Improve macroeconomic stability and fiscal space to finance climate action				
(**1.1**) Reduce expenditure related to subsidies, infrastructure, expensive health care options, and SOEs to return public spending to sustainable levels; address fiscal vulnerabilities; create space for climate-related spending over the medium term; and increase private sector participation	Strong political leadership and commitment required to implement urgent, far-reaching, and complex macroeconomic reforms	**Short term** **Urgent** (current expenditure levels are not sustainable and expenditure arrears have been accumulating)	**Synergetic** (facilitates investments in other areas) **Trade-off** (potential adverse effects on poor and vulnerable households that should be mitigated through measures such as targeted social transfers)	Reduction of fiscal deficit as a percent of GDP (2024–2029) Increase in climate-related budget allocation (2027)
(**1.2**) Implement revenue mobilization measures including tax reforms such as raising the Green Tax and dedicating proceeds to environmental and climate-resilient interventions		**Short term** **Urgent** (current revenue levels are not sufficient to meet expenditure, investment, and debt service requirements)	**Synergetic** (facilitates investments in other areas) Trade-off (increased tax burden might reduce private sector investment and household spending)	Reduction of fiscal deficit as a percent of GDP (2024–2029)
(**1.3**) Pass a new Public Debt Management Bill and a revised Fiscal Responsibility Act to address debt vulnerabilities		**Short term** **Urgent** (current debt levels are not sustainable)		Reduction of debt stock as a percent of GDP (2027)
(**1.4**) Limit the sovereign-bank nexus to allocate more resources to the private sector for climate adaptation investments, and enhance banking regulation and supervision to ensure financial stability		**Medium term** **Urgent** (public sector borrowing from the financial sector limits resources available to the private sector)		Reduction in financial institutions' exposure to the sovereign as a percent of their total assets (2027)
High-Level Objective 2: Mobilize climate finance				
(**2.1**) Operationalize the Climate Finance Hub and develop a climate investment plan with bankable projects	Overlapping mandates and competing agendas of different agencies Capacity shortages and lack of funding for additional staff	**Medium term** **Urgent** (improved leadership and coordination on climate finance is urgently needed and a prerequisite for other actions in this area)		Climate Finance Hub operational (2025) Climate investment plan developed (2026)
(**2.2**) Set up a conservation and climate adaptation trust fund with appropriate governance structures to help attract additional concessional finance for climate adaptation and environmental protection		**Medium term** **Less urgent**	**Synergetic** (biodiversity, carbon sequestration, helps mobilize finance for NbS)	Conservation and climate adaptation trust fund established (2025)
(**2.3**) Develop a national carbon market strategy and infrastructure, and promote the development of robust carbon crediting systems to tap into finance from voluntary and compliance markets		**Medium term** **Less urgent**	**Synergetic** (biodiversity, carbon sequestration, supports climate data generation and monitoring)	National carbon market strategy developed (2026)

Recommendation	Implementation barrier	Time frame and urgency	Synergies and trade-offs	Progress indicator
(**2.4**) Introduce climate budget tagging to improve climate-related spending and decision-making and facilitate the engagement with green investors		**Short term** **Less urgent**		Climate budget tagging introduced (2025)
High-Level Objective 3: Enhance the climate resilience of islands and infrastructure				
(**3.1**) Develop a NAP and related island/regional development plans that explicitly integrate SLR, flooding, and ocean heating scenarios to guide future spatial and development planning	Insufficient capacity on the local level exacerbates the downscaling and implementation of the NAP to individual islands and atolls	**Short term** **Urgent** (in the absence of a comprehensive national plan, interventions are ad hoc)	**Synergetic** (can inform planning and investments across sectors)	NAP adopted (by 2025)
(**3.2**) Develop guidelines for island raising and land reclamation to optimize their use, and when used increase the resilience and sustainability of newly developed land and limit negative environmental impacts	Opposition from developers as guidelines might increase costs and limit the scope Inconsistent enforcement of guidelines	**Medium term** **Urgent** (to avoid maladaptation and lock-ins given the lifetime and scale of new land investments)		Guidelines developed/updated (2026)
(**3.3**) Systematically study the feasibility and unintended side effects of hard/gray protection infrastructure and preserve natural island processes to avoid maladaptation and lock-in effects	Preference of communities and decision-makers for hard/gray infrastructure Lack of awareness about natural island processes and NbS	**Medium term** **Urgent** (once islands are locked into hard protection, there is practically no going back)		Study on maladaptation and improved understanding of optimal conditions and side effects of hard protection infrastructure (2028)
(**3.4**) Update building codes and practices to increase the resilience and sustainability of infrastructure	Opposition from developers as updated codes might increase construction and compliance costs Inconsistent enforcement of codes	**Medium term** **Less urgent** (changing codes and practices is a gradual process)		Building codes updated with resilience standards (2026)
(**3.5**) Further assess the feasibility and effectiveness of NbS to support their scale-up	Insufficient baseline data and monitoring systems to manage ecosystems and assess their effectiveness Preference of communities and decision-makers for hard/gray infrastructure and lack of awareness about NbS Despite lower up-front costs, budgetary constraints hinder introduction of NbS at scale	**Long-term** **Less urgent** (gradual scale-up needed)	**Synergetic** (biodiversity, carbon sequestration, food security/fisheries, attractive landscapes/tourism) **Trade-off** (very limited fiscal space and competing spending priorities)	Increased share of NbS among coastal protection measures (2029)

Recommendation	Implementation barrier	Time frame and urgency	Synergies and trade-offs	Progress indicator
High-Level Objective 4: Enhance the climate resilience of ecosystems				
(**4.1**) Develop a coral management and funding plan with a time horizon until 2050 to scale up coral reef restoration, including exploring emerging restoration technologies	Lack of coordination between actors Capacity constraints to implement the plan Limited availability of funding for the implementation of the plan	**Medium term** **Urgent** (severe impacts from ocean heating on coral reefs are expected by mid-century)	**Synergetic** (biodiversity, fisheries, and tourism)	Coral management and funding plan developed (2026)
(**4.2**) Improve waste management and coastal infrastructure development to reduce local stressors on coral reefs	Preference of communities and decision-makers for coastal development and hard/gray infrastructure	**Long-term** **Urgent** (coral reef protection is urgently needed, particularly given ongoing mass bleaching and impacts from coastal development)	**Synergetic** (biodiversity, fisheries, and tourism) **Trade-offs** (coastal development needs, limited fiscal space, and competing spending priorities)	Number of coral reefs not negatively affected by coastal development and pollution (2029)
(**4.3**) Systematically develop and implement MPAs to conserve high-biodiversity marine and coastal ecosystems	Limited funding and resources Conflicting stakeholder interests (for example, fishing communities and tourism operators) MPA enforcement against illegal activities	**Long-term** **Less urgent** (rollout will have to be gradual)	**Trade-off** (limited fiscal space and competing spending priorities)	MPA management plans developed and implemented for all MPAs (2029)
(**4.4**) Establish a coral reef management decision support system to guide the targeting of conservation and restoration interventions	Capacity constraints to develop and operationalize the system Lack of data on the connectivity of the reef system and thermal refugia. Insufficient data sharing between different entities	**Medium term** **Less urgent**	**Synergetic** (biodiversity, fisheries, and tourism)	Coral reef management decision support system established (2027)
High-Level Objective 5: Enhance the climate resilience of livelihoods (fishers and tourism)				
(**5.1**) Research pelagic and reef fish migration and other impacts under different climate scenarios to inform fisheries planning	Limited or unreliable data and technological limitations	**Medium term** **Urgent** (impacts of total depletion or migration could be devastating to the fisheries sectors and many livelihoods if not properly assessed and adapted to)		Possible fish migration patterns assessed (2026)
(**5.2**) Assess alternative livelihood opportunities for fishers such as diversification of deep-sea fisheries and mariculture development to improve the resilience of fishing communities	Limited knowledge and experience in these new areas, insufficient financial resources for investment and research, and weak regulatory framework	**Long term** **Less urgent**		Option paper prepared and implementation pilot approved (2027)

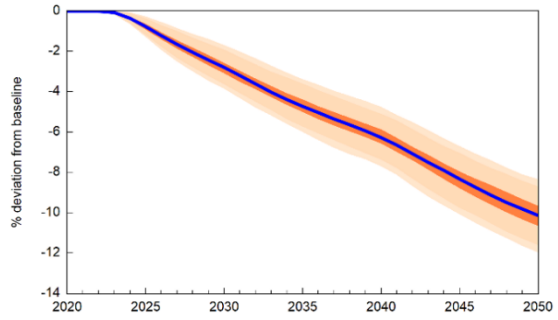
Recommendation	Implementation barrier	Time frame and urgency	Synergies and trade-offs	Progress indicator
(**5.3**) Strengthen the regulatory framework to ensure that new resorts and guesthouses design climate-resilient and green infrastructure; existing resorts and guesthouses receive advice on and support for upgrades/retrofits; and minor repair and climate resilience upgrades works can proceed without lengthy approval processes	Some elements of the tourism sector might oppose stricter regulations	**Medium term** **Less urgent**	**Synergetic** (climate mitigation and environmental sustainability due to greener construction including solar)	Regulatory framework strengthened (2026)
High-Level Objective 6: Unlock the development benefits from green transitions in the energy, mobility, and waste sectors				
(**6.1**) Phase out fossil fuel subsidies and reduce expenditure while mitigating impacts on poor and vulnerable households	Opposition from current beneficiaries of fossil fuel subsidies (SOEs, households, and private sector)	**Short term** **Urgent** (current expenditure levels are not sustainable)	**Synergetic** (climate mitigation and environmental sustainability) **Trade-offs** (need to mitigate impacts on poor and vulnerable households)	Blanket subsidies for fuel and electricity are removed and replaced with targeted cash transfers (2025)
(**6.2**) Promote risk-sharing frameworks, increased private sector participation, and PPPs to increase RE adoption and improve waste management	Limited capacity and coordination for developing frameworks and PPPs Existing macroeconomic challenges	**Long term** **Less urgent**	**Synergetic** (climate mitigation and environmental sustainability) **Trade-off** (existing fiscal and external vulnerabilities limit the government's ability to provide guarantees)	Increase the share of renewable sources within the energy mix over the medium term (2028 compared to the 2023 baseline)
(**6.3**) Introduce a renewable energy mandate for resorts to increase the share of renewable energy	Some elements of the tourism sector might oppose mandates	**Short term** **Less urgent**	**Synergetic** (climate mitigation and environmental sustainability)	RE mandate adopted (2025) that distinguishes between new and existing resorts in terms of ambition and time frame with more ambitious targets for new developments
(**6.4**) Develop a strategy and action plan to promote green mobility, including non-motorized transport, e-scooters, e-buses, e-ferries, and charging infrastructure	Public resources for investments and financial incentives are highly constrained	**Medium term** **Less urgent**	**Synergetic** (climate mitigation and environmental sustainability)	E-mobility strategy and action plan developed and adopted (2026)

Annex 1

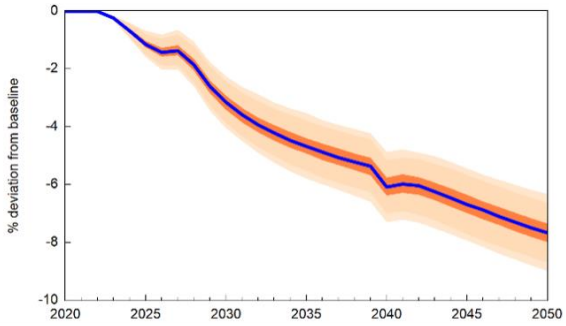
GDP Impacts from SLR Under Low-Emission and Average-Emission Scenarios[224]

Figure A1: GDP impact from SLR under RCP2.6

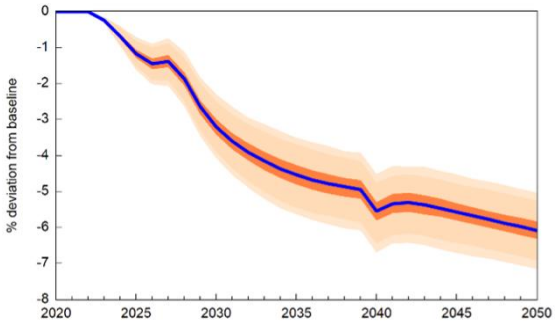
1. No fiscal consolidation; slow reconstruction; no adaptation



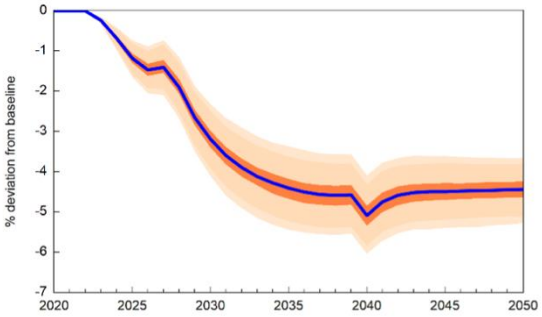
2a. Fiscal consolidation; fast reconstruction; adaptation with protection level of 25 percent



2b. Fiscal consolidation; fast reconstruction; adaptation with protection level of 50 percent



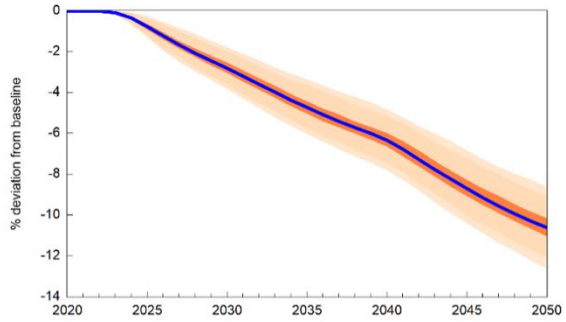
2c. Fiscal consolidation; fast reconstruction; adaptation with protection level of 75 percent



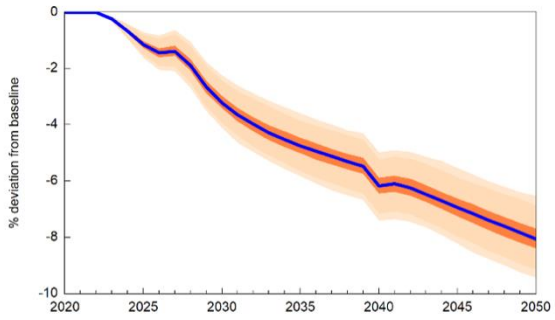
[224] See Section 7.2.2 for context and a discussion of the methodology.

Figure A2: GDP impact from SLR under RCP4.5

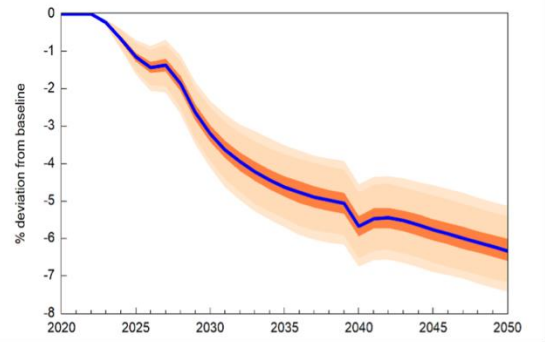
1. No fiscal consolidation; slow reconstruction; no adaptation



2a. Fiscal consolidation; fast reconstruction; adaptation with protection level of 25 percent



2b. Fiscal consolidation; fast reconstruction; adaptation with protection level of 50 percent



2c. Fiscal consolidation; fast reconstruction; adaptation with protection level of 75 percent