ISLANDS AT THE BRINK-COUNTRY BRIEF MALDIVES

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IDRC GRANT / SUBVENTION DU CRDI : - RESILIENCE TO CLIMATE VULNERABILITY AND ENVIRONMENTAL RISK (RECOVER) WITH A FOCUS ON SMALL ISLANDS

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September 2024

RECOVER Working Paper 1

CLARE
CLIMATE ADAPTATION & RESILIENCE

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Canada

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Url: https://www.pexels.com/photo/an-aerial-photography-of-city-buildings-near-the-body-of-water-12858453/

SUGGESTED CITATION

Hafiz, M., Singh, S. J., & Mohamed, S. (2024). Islands at the Brink: Country Brief: Maldives. RECOVER Working Paper 1. RECOVER. University of Waterloo, Canada

ISBN: 978-1-0690642-0-2

The RECOVER Project is supported by the Climate Adaptation and Resilience (CLARE) research programme. CLARE is a £110m initiative jointly designed and run by the UK Foreign Commonwealth and Development Office and Canada's International Development Research Centre. CLARE is primarily funded by UK aid from the UK government, along with the International Development Research Centre, Canada.

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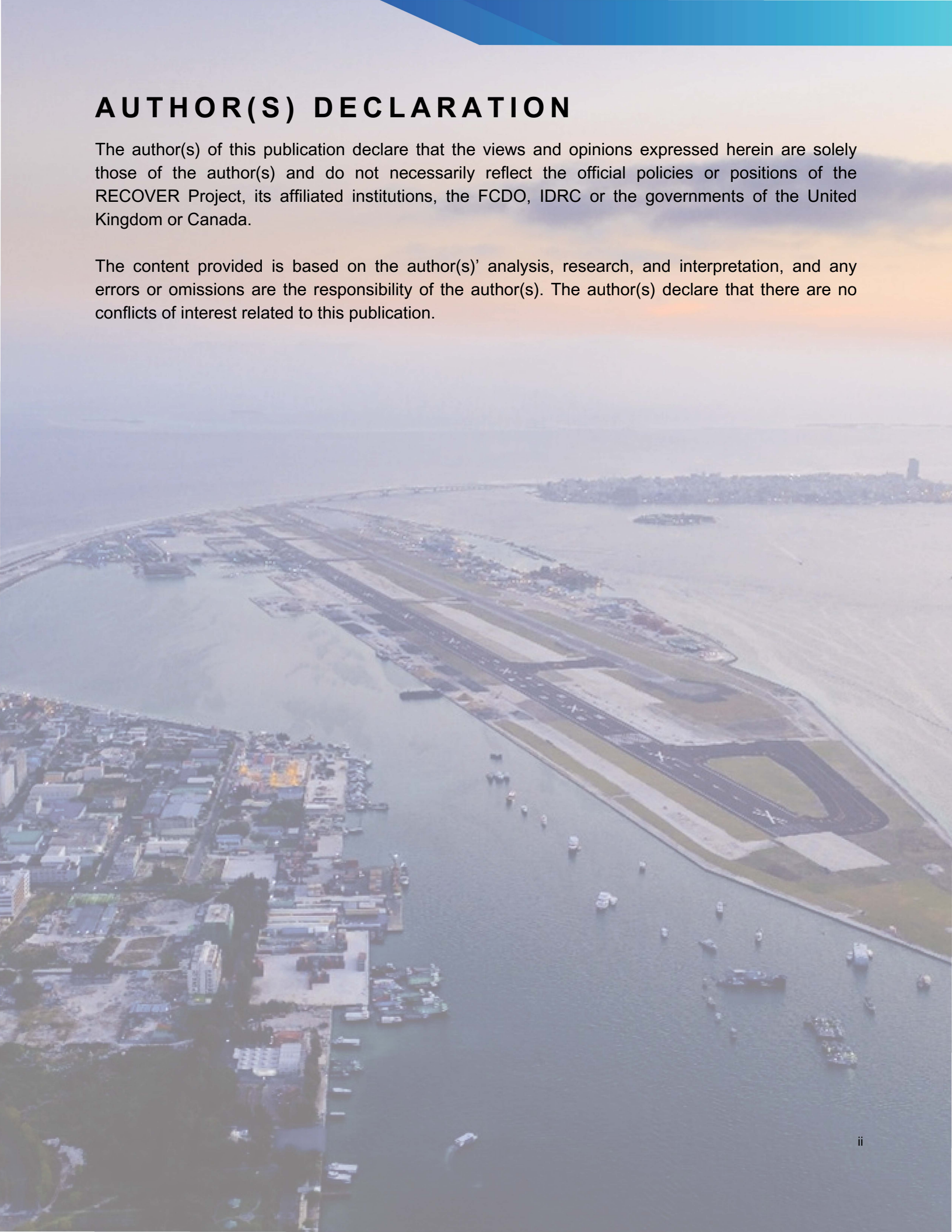

THE RECOVER PROJECT

RECOVER stands for 'Resilience to climate vulnerability and environmental risk' with a focus on small islands. Addressing the needs and the unique challenges of Small Island Developing States (SIDS) that are on the frontlines of climate change, the RECOVER Project aims to address climate change adaptation through a multi-risk and multi-sector approach. By conducting pilot projects in three small island states- Maldives, Mauritius, and Fiji- RECOVER will co-develop scalable and systems-changing climate resilience approaches to enhance understanding of small island climate adaptation capacities and possibilities. RECOVER is led by the University of Waterloo in Canada in partnership with implementing partners in activity countries: Maldives National University, the University of Mauritius and the University of Fiji.

RECOVER is funded and supported by the Climate Adaptation and Resilience (CLARE) programme. CLARE is a £110m, UK-Canada framework research programme, aiming to enable socially inclusive and sustainable action to build resilience to climate change and natural hazards. CLARE is an initiative jointly designed and run by the UK Foreign Commonwealth and Development Office and Canada's International Development Research Centre. CLARE is primarily funded by UK aid from the UK government, along with the International Development Research Centre, Canada.

Through long-term commitments and partnerships worldwide, and needs-driven, action-focused research, CLARE links up short-and long-term issues, providing a better understanding of the risks associated with climate, supporting early action to reduce impacts of climate variability whilst enabling long-term, sustainable, and equitable economic and social development in a changing climate.

EXECUTIVE SUMMARY

Small Island Developing States (SIDS) are on the frontlines of climate change and consistently rank high on a range of risk and climate vulnerability indices. IPCC's Sixth Assessment Report recognizes the urgency of these challenges and the need for transformational adaptation strategies for small islands. At the 1992 UN Conference on Environment and Development in Rio de Janeiro, SIDS were recognized as a distinct category that face similar economic, environmental, and developmental challenges. The 58 island states, including the 20 non-UN Members/Associate Members, are home to approximately 65 million people (or 1% of the world's population), and cover a total area of 690,221 km², with only 3.5% being land. Their surrounding oceans (Exclusive Economic Zones) on which they depend are on average 28 times larger than their landmass.

Constrained by their small size, remoteness, and limited economies of scale, SIDS rely heavily on trade that contributes to over 70% of their GDP. Their imports are significant - often up to 90% of total consumption – to meet basic needs such as food, energy, consumer goods, and construction materials. At the same time, SIDS produce almost three times the solid waste (2.30kg/cap/day) compared to the global average (0.73kg/cap/day), nearly all of which stays on the island. Limited waste absorption capacity, technologies, and poor waste management practices often result in soil and marine contamination. The over-reliance on imports and rising sustainability challenges render SIDS to be highly vulnerable to global economic downturns and climate-related events (e.g., flooding, droughts, hurricanes, sea-level rise) that have pushed 40% of SIDS into unsustainable debt levels, with public debt ratios often exceeding 60% of GDP, hindering their ability to invest in resilience and climate action.

The Maldives is an archipelago of 1,192 islands in the Indian Ocean, spread over 90,000 km² of which only 1% is land. The islands have low elevations ranging from 0.5 to 2.3 meters above mean sea level. Approximately 40% of the nation's total population of ~0.5M live in the capital city of Malé, in what is known as one of the world's most densely populated cities with roughly 25,000 people per km².

The Maldives supports an economy that is heavily reliant on tourism, which constitutes the highest share of its GDP at 25.8% followed by transportation and communication at 10.6%, while in comparison, fisheries and agriculture constitute only 3.5% and 1.2% respectively. The Maldives imports nearly all of its food, energy, and consumer products. Imported diesel is used for electricity production, at a high cost of $0.19 to $0.70 per kWh depending on the remoteness and size of the island, with associated CO2 emissions rising to 3.06 tons per capita in 2017, the highest in South Asia. Food security is another critical issue, with total food import bills increasing from USD 438.79 million in 2017 to USD 542.79 million in 2021.

Climate change poses a severe threat to the Maldives, exacerbating existing vulnerabilities that arise from their underlying resource-use structure. Rising sea levels threaten to submerge significant portions of the islands by 2100, since 80% of the land area is less than 1 meter above sea level. In this regard, the 2004 Indian Ocean tsunami, with waves between 4 to 14 feet, severely impacted the Maldives, causing widespread destruction, displacing over 20,000 islanders, resulting in 83 confirmed deaths, significantly damaging 39 islands, and destroying 14. Additionally, the nation is also experiencing increased frequency and intensity of tropical cyclones, coastal erosion, and flooding. For example, the Very Severe Cyclonic Storm Ockhi in November 2017 damaged 62 islands and flooded 36, emphasizing the need for improved preparedness for future cyclones.

Waste management, particularly plastic pollution, is a growing concern, with significant amounts of waste ending up in the marine environment. The Maldives generates approximately 1.7 kg of waste per person per day in Malé, and 0.8 kg on other inhabited islands, with each tourist generating around 3.5 kg daily. About 80% of the waste generated in the greater Malé region is organic waste, which rises to 88% in Atolls. The country is heavily reliant on Thilafushi, an artificial island for waste disposal, that receives up to 500 tons daily from the greater Malé region. However, due to insufficient treatment and management leading to leachates and fires, the nation was ranked the 4th largest producer of mismanaged waste in 2019 globally. Freshwater resources are limited to shallow aquifers and rainwater, both of which are increasingly threatened by sea level rise, salinization, and contamination. An estimated 11-36% decrease in the volume of fresh groundwater lens on small atoll islands is attributed to sea level rise. Research on seven islands found only 6.4% of 173 well water samples met WHO guidelines for fecal coliform, with 57.7% posing high health risks. Over 84% of 45 surveyed islands reported elevated groundwater salinity, and from 2017 to 2020, 59 islands needed emergency water supplies during the dry season, costing MRF 6.9 million annually.

In response to climate-related challenges, the Maldives has adopted several adaptation strategies. Most common are hard engineering solutions like seawalls and breakwaters that protect against coastal erosion and flooding. Between 2004 and 2016, 45 islands adopted hard engineering methods, while only two opted for nature-based solutions. Land reclamation projects, such as the construction of Hulhumalé, have been initiated to create additional land for housing and infrastructure, elevated above the projected sea level rise. Over 1,300 hectares of new land have been reclaimed across around 100 inhabited islands, with Hulhumalé being the largest project at 430 hectares. Besides the detrimental impacts on the marine environment, large hard engineering projects create “lock-in-effects” with continuous dependency on external technologies, financial resources (often at high-interest loans), and significant volumes of imported raw materials for upgrade and maintenance of these structures.

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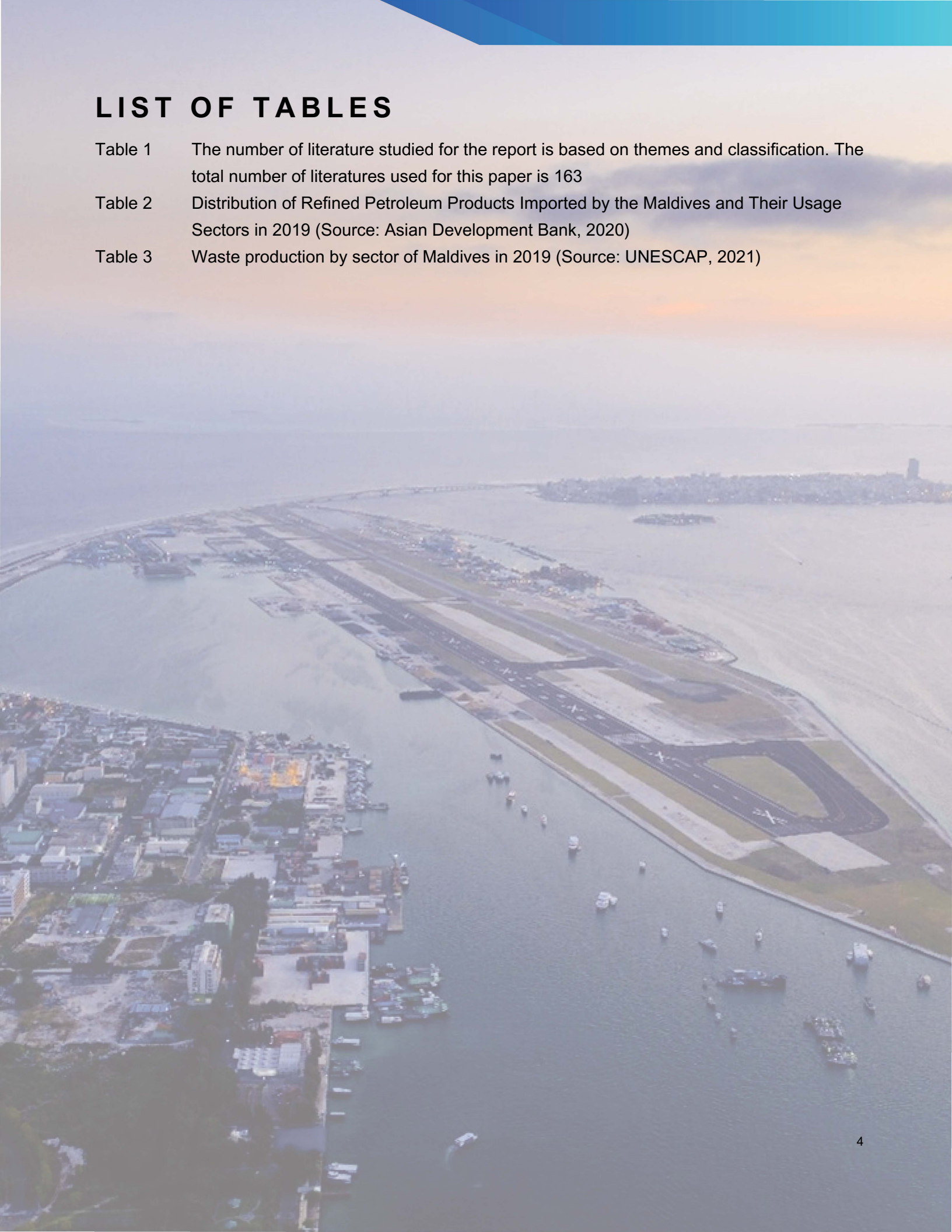

LIST OF ACRONYMS

ADB	Asian Development Bank
AIMS	Atlantic, Indian Ocean, Mediterranean, and South China Seas
CCAP	Climate Change Adaptation Project
CO2	Carbon Dioxide
EbA	Ecosystem-based Adaptation
EEZ	Exclusive Economic Zone
ENSO	El Niño-Southern Oscillation
ESESI	Energy Security and Environmental Sustainability Index
FENAKA	FENAKA Corporation Limited
GDP	Gross Domestic Product
GHG	Greenhouse Gas
GNI	Gross National Income
HDI	Human Development Index
IPCC	Intergovernmental Panel on Climate Change
IRENA	International Renewable Energy Agency
LLDCs	Landlocked Developing Countries
LULC	Land Use and Land Cover
MPI	Multidimensional Poverty Index
MTOE	Million Tons of Oil Equivalent
MVI	Multidimensional Vulnerability Index
NBSAP	National Biodiversity Strategies and Action Plan
ODA	Official Development Assistance
OECD	Organisation for Economic Co-operation and Development
POISED	Preparing Outer Islands for Sustainable Energy Development
PPG	Public and Publicly Guaranteed
PV	Photovoltaic
RECOVER	Resilience to Climate Vulnerability and Environmental Risk
SIDS	Small Island Developing States
SLR	Sea Level Rise
STELCO	State Electric Company Limited
TC	Tropical Cyclone
UN	United Nations
UNDP	United Nations Development Programme
UNDESA	United Nations Department of Economic and Social Affairs
UNESCAP	United Nations Economic and Social Commission for Asia and the Pacific
UNEP	United Nations Environment Programme

1. INTRODUCTION

This report highlights key insights from the state-of-art review on the availability, circulation and integrity of critical resources (e.g., food, water, energy, waste, and infrastructure) and associated climate impacts in the Maldives. The country review is the first in the series of three, conducted as part of the RECOVER project. RECOVER is a needs-driven initiative and a partnership between the Maldives National University, University of Mauritius and University of Fiji, led by the University of Waterloo, Canada. Funded by Climate Adaptation and Resilience initiative (CLARE), the project is aimed at addressing climate change adaptation through a multi-risk and multi-sector approach in the Maldives, Mauritius and Fiji.

This briefing report provides an overview on Maldives, a Small Island Developing State (SIDS) in the Indian Ocean. The overall purpose is to provide a state-of-the-art review on the climate and resource-use challenges in the Maldives, and ongoing efforts to address some of these. The report begins by providing the big picture, or context of SIDS more generally, and the unique development, economic, and climate challenges they face. After a brief country background on Maldives, the report details how climate change is impacting Maldives' critical resources such as water, energy, food, and infrastructure. The review ends with ongoing adaptation measures adopted by this small island nation.

This report was conducted primarily through a secondary literature review of relevant scientific articles, book chapters, international organization reports, government reports, grey literature, and popular media. Additionally, the report will be reviewed by key experts to provide insight into the findings and to enhance the report. The suggestions from the experts will also be included in the report to strengthen the findings from the secondary literature review.
The literature was identified in "Google Scholar" with the keywords "Maldives + Climate Change", "Maldives + Water", "Maldives + Energy", "Maldives + Food/Agriculture", "Maldives + Infrastructure", and a general search with the keywords "Maldives", within the years 2014 - present. A few articles from before 2014 were also included, with the oldest dating back to 2007; no articles from before 2007 were considered for the report. The reports (International and Government) were recovered from the "Google" search engine with the same keywords as mentioned. For the purpose of the report, only literature that focused on the "impacts of climate change" and the "adaptation to climate change" were selected. However, there are a few literature that did not focus on either but were still included as they highlight certain aspects that potentially might be missed by only focusing on climate change issues, such as the impact of microplastics on marine life and ecosystems.

Table 1 shows the number of literatures used for this report, with the total number being 150. Among the total, 123 are articles from scientific journals, 3 are book chapters, 5 are Government reports/policies, 5 are international reports, 9 are grey literature, 5 are from popular media, and 13 are classic articles (articles before 2014). Among these, a total of 75 literature are based on the impacts of climate change, such as the decrease of the freshwater lens in a few islands, and 37 are on various adaptation measures taken or suggested to tackle climate change impacts such as sea walls to combat sea level rise. The impacts of climate change will be highlighted in a general manner in Section 2 and Section 3 will discuss how it is affecting critical resources such as water. Section 4 will

discuss the current adaptation methods undertaken in the country, and other possible methods of adaptation that could be effective. Finally, Section 5 will draw a conclusion by discussing the findings and possible path forward.

Theme	Year	Journal Articles	Book chapters	Government reports	International Reports	Grey Literature	Popular media	Number of articles	Total
Climate Change	2014 - 2024	30	2	1	1	4	4	4	42
Water	2014 - 2024	20	0	3	1	1	1	4	26
Energy	2014 - 2024	21	0	1	3	1	0	4	26
Food and Agriculture	2014 - 2024	10	0	0	0	2	0	0	12
Infrastructure	2014 - 2024	12	1	0	0	2	0	0	15
Miscellaneous	2014 - 2024	30	0	0	0	0	0	0	30
Total		**123**	**3**	**5**	**5**	**9**	**5**	**13**	**150**

Table 1: The number of literatures studied for the report is based on themes and classification. The total number of literatures used for this paper is 150

2. SMALL ISLAND DEVELOPING STATES (SIDS) AND THEIR UNIQUE ECONOMIC, DEVELOPMENT AND ENVIRONMENTAL CHALLENGES

At the 1992 United Nations Conference on Environment and Development held in Rio de Janeiro, Small Island Developing States (SIDS) as a category were recognized as a special case for the unique social, economic, and environmental challenges they face. SIDS are a group of low-lying island states comprising 38 UN Member States and 20 non-UN Members/Associate Members typically grouped into three regions: the Caribbean, the Pacific, and the Atlantic, Indian Ocean, Mediterranean, and South China Seas (AIMS) (UNDP, 2022a). Home to approximately 65 million people (or 1% of the world's population), SIDS encompass a total area of 690,221 Km2 of which approximately 24,111 Km2 (or 3.5%) is land, and the remaining 666,110 Km2 (or 96.5%) is their surrounding ocean that comprised their Exclusive Economic Zones (EEZs) (GEF, 2024; Mead, 2021, p. 5). Often the EEZ for most SIDS are on average 28 times larger than their own land mass (16.1% of the world's total EEZ), leading them to be heavily dependent on natural resources that come from the ocean surrounding them (UN, 2024).

Shared development and economic challenges: While in many respects diverse, SIDS face common development and economic challenges as they are disproportionately impacted and still recovering from global financial crisis and the COVID-19 pandemic, including sluggish growth, insufficient debt burdens, and declining access to stable financing sources (Bishop et al., 2023). These small economies are vulnerable to macroeconomic shocks, as demonstrated by the COVID-19 pandemic's economic impact, which led to a contraction in the real GDP of SIDS by 7.4% in 2020 and a partial rebound by 4.1% in the following year (Brownbridge & Canagarajah, 2024, p. 2). Additionally, SIDS are exposed to high levels of poverty and inequality due to economic and environmental vulnerabilities. Eurodad calculations showed that, before the Covid-19 pandemic, 22.8% of the population in SIDS lived in multidimensional poverty and 9.52% lived in severe poverty (Fresnillo and Crotti, 2022, p. 6).

The Global Multidimensional Poverty Index (MPI) of 2023 encompasses 22 SIDS, a significant number of which exhibit a low prevalence of acute multidimensional poverty. Nevertheless, vulnerability can be elevated, as a substantial fraction of individuals endure poverty or vulnerability. For example, in Fiji, the poverty rate is 1.5 percent, whereas the vulnerability rate is 7.4 percent. Among the 10 SIDS, 13-84% of the population falls under the categories of poverty or vulnerability. Specifically, Kiribati has a poverty or vulnerability rate of 50% (UNDP & OPHI, 2023, P. 8). The UNDP has created a Multidimensional Vulnerability Index (MVI)[1] to specifically tackle the circumstances of SIDS and the financial challenges worsened by the COVID-19 epidemic (UNDP, 2024b).

[1] The MVI is a composite index of four dimensions of vulnerability: environmental, geographic, economic, and financial. Each dimension is calculated as an average of the normalized indicators selected for that dimension. Using 11 indicators for 128 countries (including 34 SIDS). A simulation comparing SIDS to LDCs demonstrates that, if the MVI were used as a financing criterion (rather than just income per capita), SIDS on average would save 1.5% of their GDP per annum in interest payments (UN, 2024).

The MVI captures both traditional and emerging risks faced by SIDS and other developing countries. The MVI, which extends the Environmental and Economic Vulnerability Index (EVI) by adding financial indicators for a total of 11 indicators, highlights that all but five SIDS are more vulnerable than their income levels suggest (Figure 1), addressing calls for reassessing eligibility for concessional financing beyond income level.

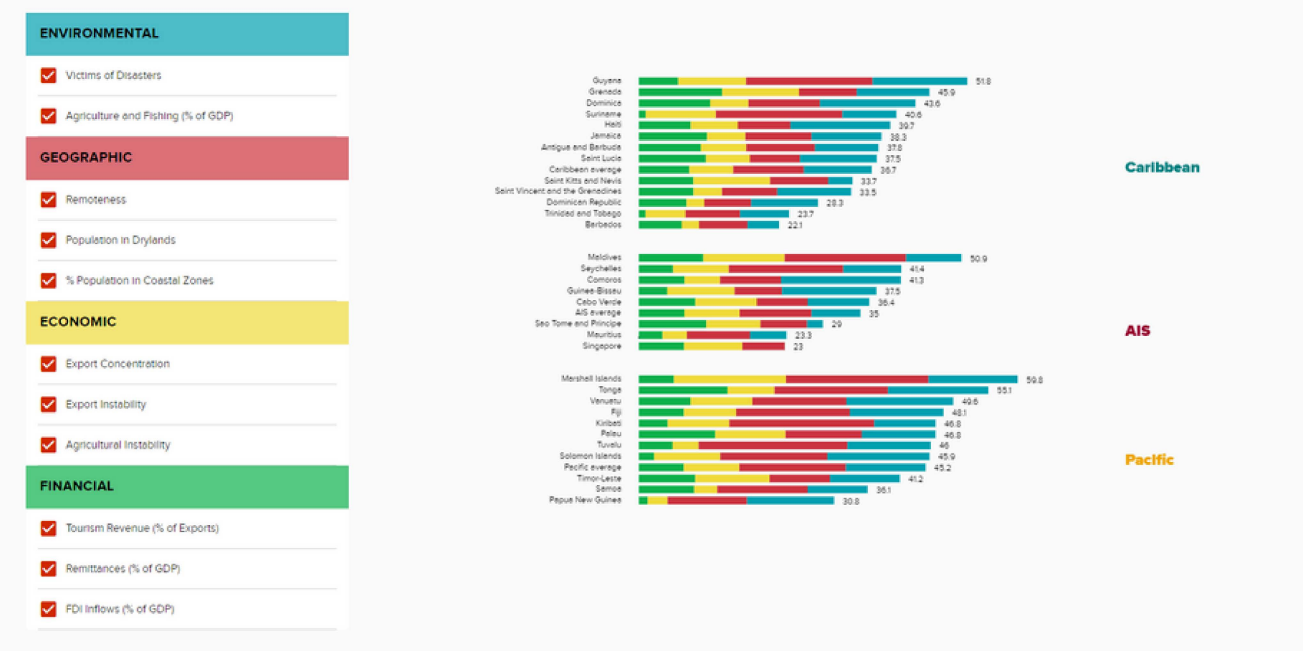

Figure 1: Multidimensional Vulnerability Index (MVI) for Small Island Developing States (SIDS) across the Caribbean, AIS, and Pacific regions (Source: UNDP, 2024b)

Heavy reliance on imports for basic needs: The GDP of small island economies is heavily impacted by trade, constituting more than 71% of their total GDP. In comparison, trade accounts for 50% of the GDP of least developed countries (LDCs) and 60% of the GDP of landlocked developing countries (LLDCs). This is due to the fact that small island economies rely heavily on imports, even to meet their basic needs. On average 60% of their food is imported (UN-OHRLS, 2020, p. 35), with many SIDS importing more than 80% of their food (UNDESA, 2020). The majority of Upper-Middle Income and High-Income SIDS have successfully achieved universal access to electricity. However, their main source of energy for electricity, transportation, and other purposes is predominantly reliant on imported fossil fuels (IRENA, 2024). Their dependence on imported fossil fuels worsens their vulnerability to external risks in global energy markets, while their energy systems are also susceptible to internal disruptions that hinder efficient generation, transmission, and distribution of energy (Genave et al., 2020). Some SIDS import up to 90% of their construction materials (Singh et al., 2020).

Unsustainable debt: More than 40% of SIDS are currently dealing with or are at the brink of unsustainable levels of debt, which greatly hinders their ability to invest in resilience, climate action, and sustainable development (UNDP, 2024a). In 2015, these nations had a higher average ratio of foreign debt to Gross National Income (GNI) at 57%, compared to other developing countries which had an average ratio of 47% (Bishop et al., 2023 p. 8; OECD, 2018, p. 44). The public and publicly

guaranteed (PPG) debt-to-GDP ratio exceeds 60%, with 2 being in debt distress, 14 being judged to be at high risk, and 2 being unsustainable (Antigua and Barbuda, and Suriname) (Brownbridge & Canagarajah, 2024, p. 18). The public debt in SIDS increased from an average of 65.9% of GDP in 2019 to 82.5% in 2020, and it is projected to stay above 70% of GDP until 2025, with 50% of the nations having debt ratios above the SIDS average. Out of this, 10 countries (Bahrain, Barbados, Belize, Capo Verde, Dominica, Fiji, Maldives, Saint Vincent and the Grenadines, Singapore and Suriname) have been maintaining debt ratios exceeding 100% of their GDP for multiple years (Fresnillo and Crotti, 2022, p. 13). Figure 2 presents an analysis of debt sustainability for SIDS undertaken by Fresnillo and Crotti (2022, p. 12). The assessment includes the IMF/WB Debt Sustainability Analysis (LIC and MAC DSA), Debt Justice risk assessment, and Jubilee Germany risk assessment. Many are in high debt distress, with notable cases like Belize and Tonga being in debt crisis, and others like the Maldives and Kiribati marked as very critical in debt risk. This highlights the severe financial vulnerabilities faced by these nations.

	IMF/WB Debt Sustainability Analysis			
	LIC DSA	MAC DSA	Debt Justice risk assessment	Jubilee Germany risk assessment
Antigua and Barbuda		High risk of debt distress	N/A	Very critical
Bahamas		Sustainable	In debt crisis	Critical
Bahrain		No public DSA	N/A	Very critical
Barbados		Sustainable*	Risk of public debt crisis	Critical
Belize		Unsustainable	In debt crisis	Very critical
Cabo Verde	Moderate		In debt crisis	Very critical
Comoros	High risk of debt distress		Risk of public debt crisis	Slightly critical
Dominica	High risk of debt distress		Risk of public and private debt crisis	Very critical
Dominican Republic		Sustainable	In debt crisis	Very critical
Fiji		Sustainable*	No risk identified	Slightly critical
Grenada	In debt distress		In debt crisis	Critical
Guinea-Bissau	High risk of debt distress		Risk of private debt crisis	Critical
Guyana	Moderate		Risk of private debt crisis	Slightly critical
Haiti	High risk of debt distress		Risk of public debt crisis	Critical
Jamaica		Sustainable	In debt crisis	Very critical
Kiribati	High		No risk identified	Critical
Maldives	High		In debt crisis	Very critical
Marshall Islands	High risk of debt distress		N/A	Critical
Mauritius		Sustainable	Risk of private debt crisis	Very critical
Micronesia, Federated States of	High risk of debt distress		N/A	Critical
Nauru		Sustainable	N/A	Slightly critical
Palau		Sustainable	N/A	Missing data
Papua New Guinea	High risk of debt distress		Risk of public and private debt crisis	Critical
Saint Kitts and Nevis		Sustainable	No risk identified	Slightly critical
Saint Lucia	Sustainable		Risk of private debt crisis	Critical
Saint Vincent and the Grenadines	High risk of debt distress		Risk of public and private debt crisis	Critical
Samoa	High risk of debt distress		Risk of public debt crisis	Critical
São Tomé and Príncipe	In debt distress		Risk of public debt crisis	Very critical
Seychelles		Sustainable	Risk of public and private debt crisis	Very critical
Singapore		Sustainable	No risk identified	
Solomon Islands	Moderate		No risk identified	Slightly critical
Suriname		High risk of debt distress	In debt crisis	Very critical
Timor-Leste	Moderate		No risk identified	
Tonga	High risk of debt distress		Risk of public debt crisis	Critical
Trinidad and Tobago		Sustainable	No risk identified	Critical
Tuvalu	High risk of debt distress		No risk identified	Slightly critical
Vanuatu	Moderate		Risk of public debt crisis	Critical

Figure 2: Debt Sustainability Analysis for Small Island Developing States (SIDS), highlighting high levels of debt distress and critical risk assessments across multiple international metrics (Source: Fresnillo and Crotti, 2022)

Disproportionately impacted by climate change: Collectively, SIDS account for less than one percent of greenhouse gas emissions (GHG) (UN, 2024; UNDP, 2022a; UNDP, 2024a,) yet are among some of the world's most vulnerable nations in terms of exposure to climate change impacts such as cyclones and sea level rise. Out of the 192 countries assessed in the Notre Dame Global Adaptation Index sub-index on climate change vulnerability, 10 out of the 19 countries in the highest exposed decile are SIDS (Figure 3) (Brownbridge & Canagarajah, 2024, p. 3; Notre Dame, 2024).

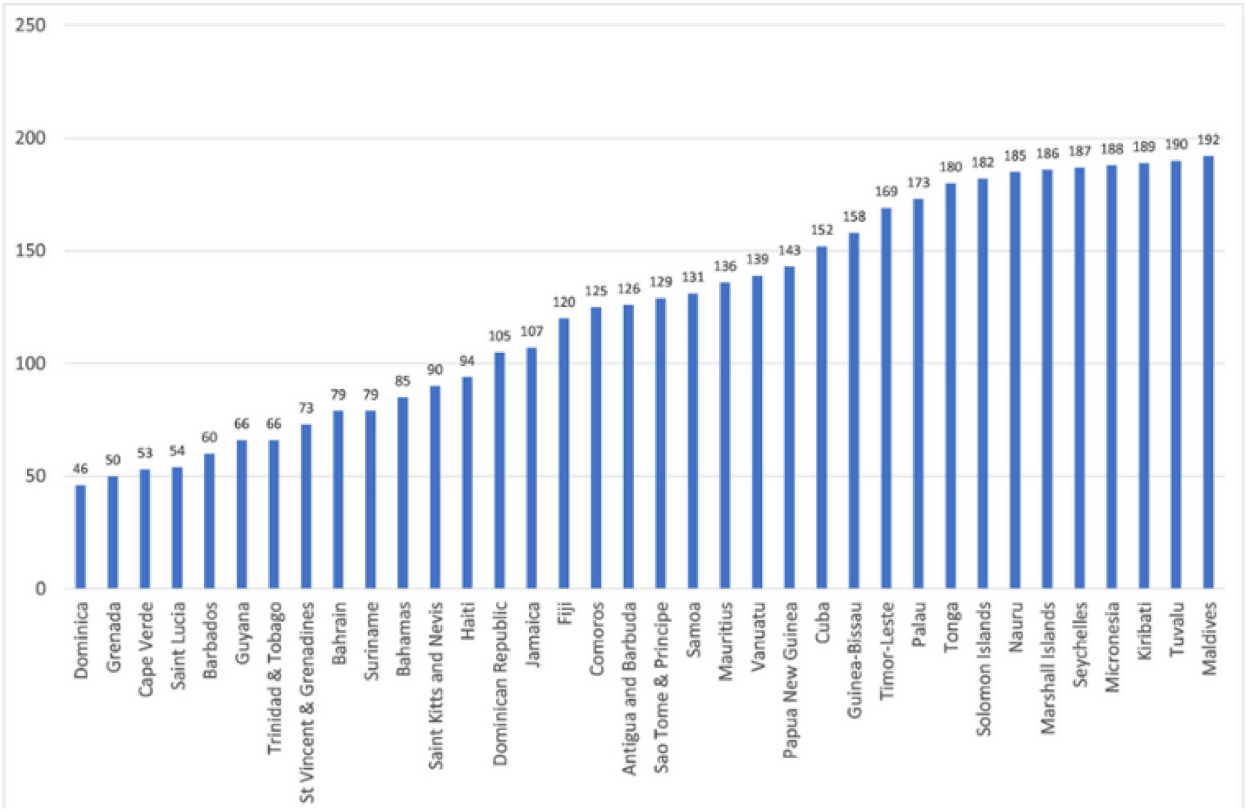

Figure 3: Status of SIDS in the ND-Gain Exposure to Climate Change. (Source: Brownbridge & Canagarajah, 2024; Notre Dame, 2024)

Based on the 6th assessment by the Intergovernmental Panel on Climate Change (IPCC) in 2023, SIDS are experiencing greater numbers of tropical cyclones (TCs), storm surges, coastal floods, droughts, coral bleaching, sea level rise, and invasive species due to the rise in global temperatures. As global temperatures surpass the 1.5°C limit established in the Paris Agreement, these countries may experience more immediate and severe impacts compared to other countries, with some facing potentially existential threats (Bishop et al., 2023). Between 1970 and 2020, SIDS incurred losses of USD $153 billion as a result of weather-, climate-, and water-related hazards (Bishop et al., 2023; Fresnillo and Crotti, 2022; UNDRR, 2024), which is noteworthy considering that the average GDP for SIDS is USD $13.7 billion (UNDP, 2022a, p. 3; UNDP, 2024a).

Since 1995, TCs have resulted in damages exceeding 10% of the GDP in the Caribbean and Oceania on 20 separate occasions, and in eight of these instances, the estimated damages surpassed 50% of the GDP (Brownbridge & Canagarajah, 2024, p. 6). In 2017, 22 among 29 Caribbean islands were affected by at least one category 4 or 5 TC, incurring losses amounting to

279% of Dominica's annual GDP due to TC Maria, 60% of Vanuatu's GDP by TC Pam, and 12% of Fiji's GDP by TC Winston (Brownbridge & Canagarajah, 2024, p. 6; IPCC, 2023; Vousdoukas et al., 2023). Depending on the specific region, maintaining global warming below 1.5 °C could prevent nearly half of the potential damage caused by climate change, as without adaptation measures, the economic impacts of coastal flooding would increase by over 14 times under high-emissions scenarios by the end of the century (Vousdoukas et al., 2023). However, even if this climatic goal were to be achieved, numerous SIDS would still incur economic losses equivalent to large portions of their GDP, which would likely result in forced migration from low-lying coastal areas (Vousdoukas et al., 2023).

Adapting to climate change: SIDS are disproportionately impacted by climate change, and on the rise, hence multiple adaptation measures are urgent. Figure 4 illustrates the adaptation ambitions of SIDS. It shows that 36, representing 90%, are either already implementing or are likely to implement adaptation measures (UNDP, 2022a). This high percentage underscores the critical importance these nations place on adaptation, given their extreme vulnerability to climate change impacts like rising sea levels and increased frequency of tropical storms. Conversely, 7% (3 SIDS) are either not implementing or are unlikely to implement such measures, often due to financial or socio-economic barriers. Additionally, 3% (1 SIDS) have unclear data or no available information regarding their adaptation efforts.

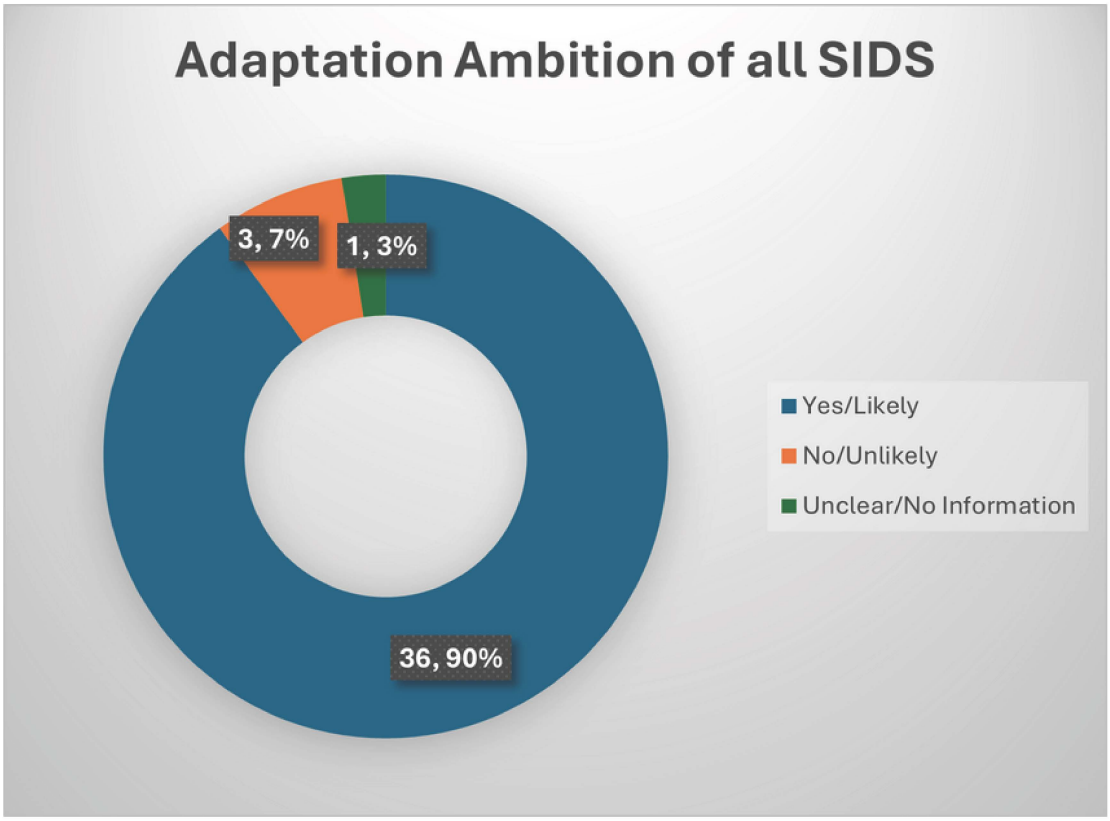

Figure 4: Adaptation Ambition of all SIDS (Source: UNDP, 2022a)

The IPCC (2023) 6th assessment reported on current adaptations being taken by SIDS to adapt to climate impacts for the future (Figure 5), them being hard protection, accommodation and advance as strategies, migration, ecosystem-based measures, community-based adaptation, livelihood responses, and disaster risk management, early warning systems, and climate services. Below are some findings from their assessment:

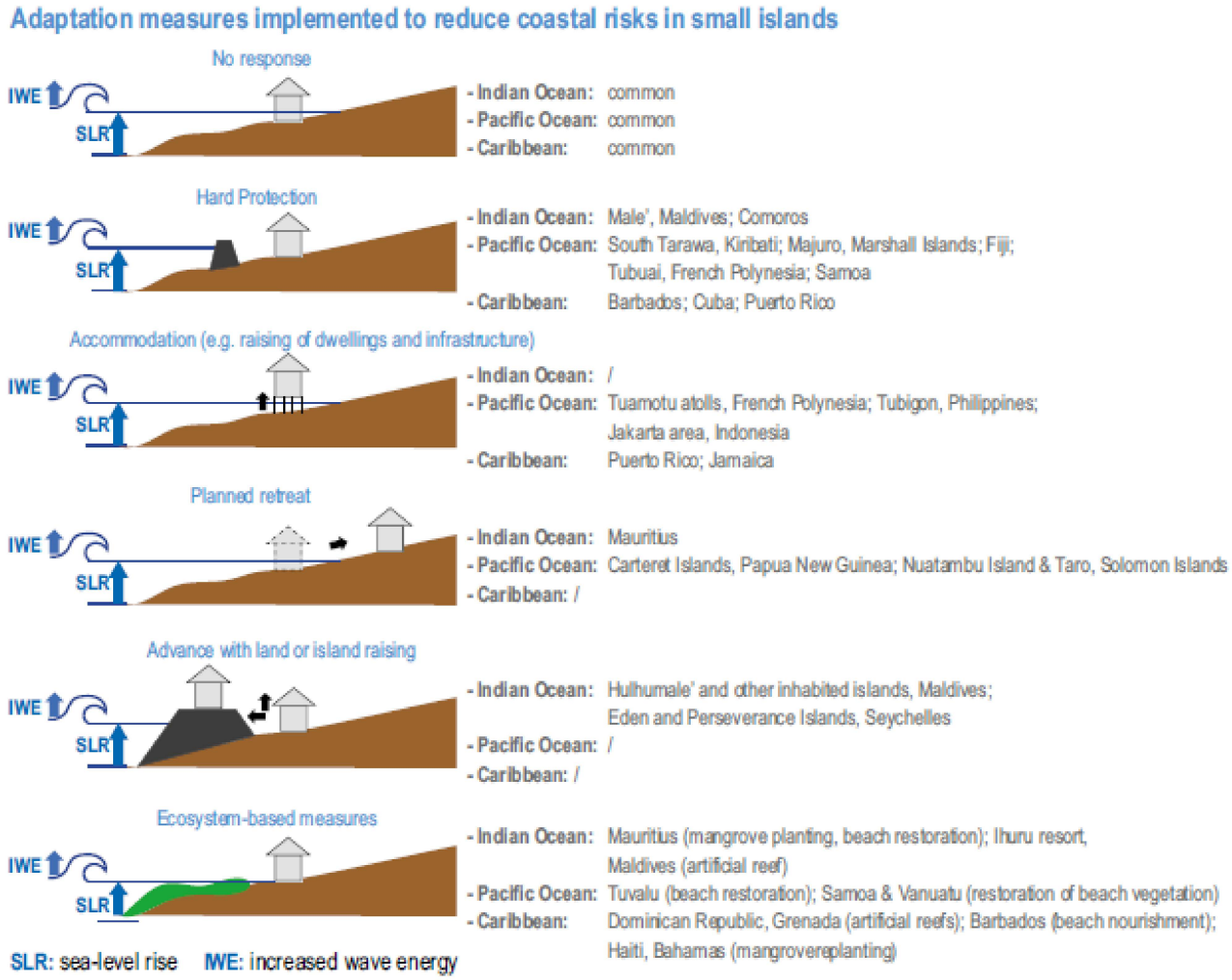

Figure 5: Adaptation measures implemented to reduce coastal risks in small islands. (Source: IPCC, 2023)

a. **Hard Protection**: Seawalls are a preferred coastal protection measure on islands as an analysis of National Communications showed that 28% of coastal protection measures are seawalls, followed by breakwater structure and coastal protection units. In the Caribbean and the Indian Ocean islands, coastal protection has been heavily invested and preferred, but they are difficult to maintain. Hard structures are likely to be ineffective in the future leading to a need for adaptation along most coastlines to be transformative.

b. **Accommodation and Advance as Strategies**: Measures such as elevating residences and important infrastructure, such as coastal roads, have been developed to mitigate the effects of flooding on certain islands. In French Polynesia elevated houses with floors built 1.5 m above the

ground level are subsidized by the government as part of risk prevention plans but have been limited in implementation representing only 7% of the total housing stock in some areas. Land reclamation has been implemented for decades in some small islands to allow for infrastructure shortages and to address land shortages, such as in Malé of Maldives, where 1/3rd of the land is from land reclamation.

c. **Migration**: Planned resettlement is occurring more and more in small islands but there are currently limited evidence and low agreement in the literature as to whether migration of various types is an effective strategy. Two case studies of community relocation in Fiji (Denimanu and Vunidogoloa villages) suggest that all social groups should be involved in relocation planning, including livelihood sustainability planning, to promote positive adaptive outcomes. Forced relocation, involuntary displacement, and low-agency migration, such as when migrants have limited financial resources or are not involved in migration planning, are often linked to unsuccessful outcomes. These can be seen as consequences of climate change rather than deliberate adaptation strategies.

d. **Ecosystem-Based Measures**: Small islands have gradually focused on EbA approaches and other nature-based solutions (NBS), such as restoring or conserving coastal and marine ecosystems along with incorporation of forests in many cases, gearing toward integrated watershed management. Some islands are also constructing climate-smart development plans such as newly established protected areas, restoration of riparian zones, urban forests, etc. Artificial reefs have been increasingly used in small islands of the Caribbean and Indian Oceans to support reef restoration since the 1990s. However, EbA approaches are limited in biophysical terms as coral reefs, mangroves, and many other coastal ecosystems are unlikely to survive increased temperatures and other severe climate impacts.

3. COUNTRY OVERVIEW FOR MALDIVES

Officially the Republic of Maldives, Maldives is a collection of islands consisting of two lengthy chains comprising a total of 26 atolls situated to the southwest of India and Sri Lanka (Ministry of Environment, 2020a). Extending 870 km between 0°34'S and 6°57'N in the central Indian Ocean, the nation comprises of 1,192 islands. It hasa land area of 298 km2, and about 90,000 km2 of surrounding ocean, and average land elevations ranging from 0.5 m to 2.3 m above mean sea level (Duvat, 2020; Gussmann & Hinkel, 2021; High Commission of Maldives, 2024; Ministry of Environment, 2020a). Based on the 2022 census by the Ministry of National Planning, Housing & Infrastructure, the population of Maldives is 515,122 people, with 382,751 being Maldivians and 132,371 being foreigners (26%). Spread across 188 islands (Ministry of Environment, 2020a) the current population density of the country is 1,737 people per km2, among which 38.5% is urban[2] (Worldometer, 2024). At present, 212,138 people reside in the capital of Malé, which is 41% of the population. However, 46% of the residents live in administrative and governing centres,[3] 10% reside in resort islands, and 3% live on islands that have some industrial activity[4] (Ministry of National Planning, Housing & Infrastructure, 2022).

Maldives is geographically dispersed as the small size of the islands results in the scattering of the population, with 61.7% of the inhabited islands hosting less than 1,000 inhabitants in 2014 (Duvat, 2020; Luetz, 2017). Currently, approximately 40 of the islands have a population of fewer than 500 individuals, 72 islands with a population ranging from 500 to 999 people, 70 islands with a population ranging from 1,000 to 4,999, and just two islands with a population ranging from 5,000 to 9,999 persons. The population of only three islands, namely S. Hithadhoo, Hdh. Kulhudhufushi, and Malé, exceeds 10,000 individuals (Ministry of National Planning, Housing & Infrastructure, 2022). The population doubled every 25 years since the 1960s (Government of Maldives, 2018), and tourism has been growing with resort islands rising to 142 in 2018 (Duvat, 2020). Housing appears to be prohibitive for certain segments of the population, as prices in Malé exceed 12 times the average annual income (Luetz, 2017).

The Multidimensional Poverty Index (MPI) showed that 28% of the population was in poverty before the COVID-19 pandemic, exacerbated by disparities between capital city Malé, atoll island residents, and gender roles (UNDP, 2024c). It is an upper-middle-income country with a GDP of $6.6 billion[5] (USD), a growth rate of 12.30%, and a per capita of $10,965 (USD) as of 2022 (Worldometer, 2024)[6]. The Human Development Index (HDI) in 2019 was 0.74, placing then in the highest

[2] Updated on July 16, 2023 by Worldometer based on the latest July 2023-July 2024 estimates from the United Nations, Department of Economic and Social Affairs, Population Division. World Population Prospects: The 2022 Revision. (Medium-fertility variant).

[3] The Administrative Divisions of the Maldives refers to the various units of government that provide local government services in the Maldives. According to the Decentralization Act 2010, the administrative divisions of the Maldives would consist of atolls, islands, and cities; each administered by their own local council, under the basic terms of home rule. Administratively, there are currently 189 islands, 18 atolls, and 4 cities in the Maldives.

[4] The industrial islands include islands used by the state as well as islands leased to private sector for long-term for commercial purposes. Industrial islands in the Maldives are designated areas specifically set aside for industrial activities and related infrastructure. These islands are primarily used for purposes such as manufacturing, warehousing, shipbuilding, fisheries processing, and other industrial operations. The concept of industrial islands allows the Maldives to concentrate industrial development in specific locations. Examples of industrial islands in the Maldives include Thilafushi, which is known for its waste management and industrial activities, and Gulhifalhu, which has been developed to support various industrial and logistical operations.

[5] Based on World Bank national accounts data, and OECD National Accounts data files.

[6] Based on World Bank - World Bank national accounts data, and OECD National Accounts data and World Population Prospects: The 2022 Revision - United Nations Population Division by Worldometer.

development category, with a life expectancy of approximately 80 years and a Gender Development Index (GDI) of 0.93 (UNDP, 2024c; Worldometer, 2024). Figure 6 presents the MVI for the Maldives, highlighting significant vulnerabilities in several key areas. The radar chart shows high vulnerability in tourism revenues (85.27% share of exports), agriculture and fishing (8.24% share of GDP), export concentration (58.42%), export instability (27.87%), FDI inflows (17.04% of GDP), victims of disasters (60.06%) remoteness (53.4%), and population in low elevated coastal zones (100% of the population). Financial indicators reveal critical economic challenges, such as high external debt stocks (52.7% of GNI in 2019), a significant negative current account balance (-26.82% of GDP in 2019), trade (146.99% of GDP), and low personal remittances (0.1% of GDP in 2020).

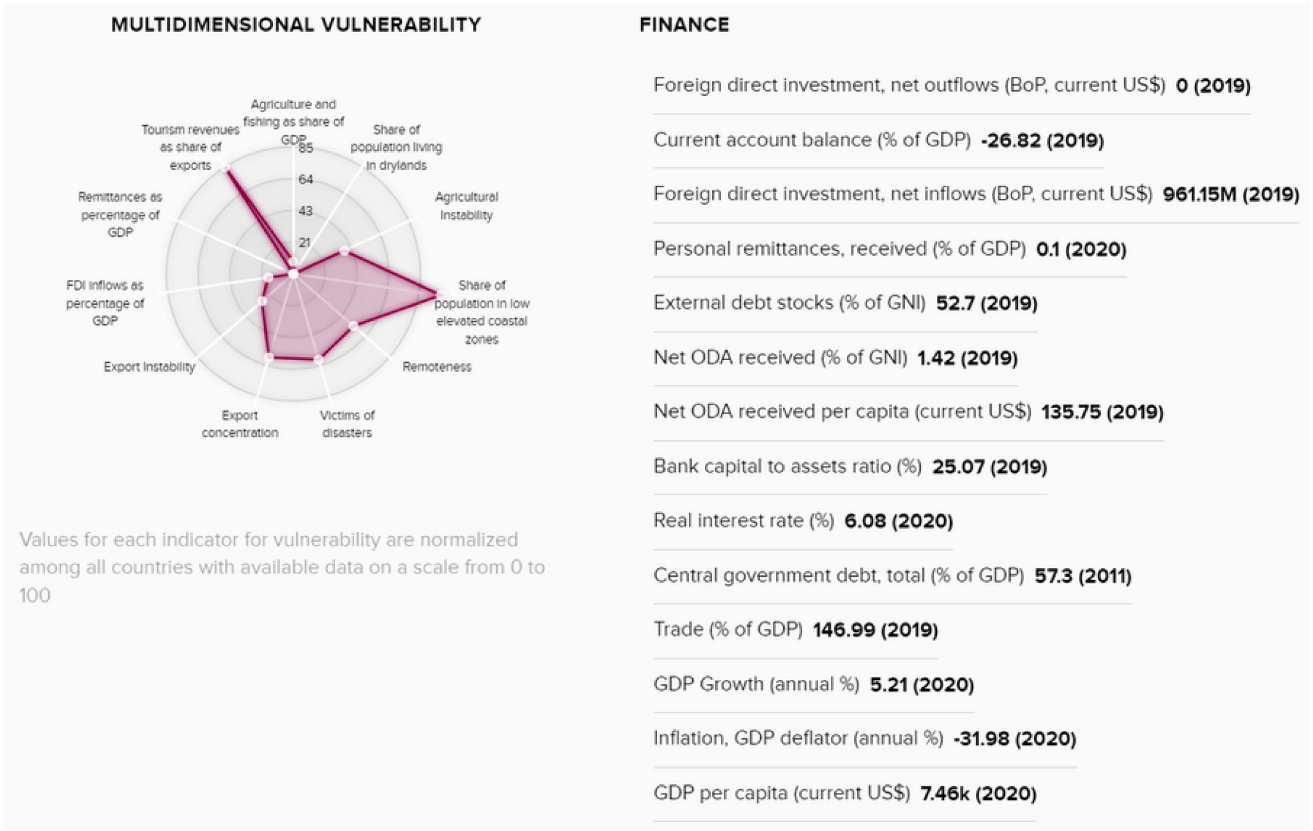

Figure 6: Multidimensional Vulnerability and Financial Indicators for the Maldives (Source: UNDP, 2024c)

These factors above underscore the Maldives' susceptibility to economic and environmental shocks. As a result of their low elevation (80% land area <1m above mean sea level) these islands are highly vulnerable to sea-level rise and flooding as well (Duvat, 2020; UNDP, 2024c). As seen in Section 2 of this report, the Maldives are the most vulnerable- in terms of MVI in the Atlantic, Indian Ocean, and South China Sea (AIS) region (Figure 1 above) with a score of 50.9 and 4th most vulnerable overall, with only the Marshall Islands, Tonga and Guyana being more vulnerable (UNDP, 2024b).Maldives is also reported as the most vulnerable to the impacts of climate change among 192 countries, based on the Notre Dame Global Adaptation Index sub-index on climate change vulnerability (Figure 3 above) (Brownbridge & Canagarajah, 2024). In terms of debt, they are at a very critical stage as can be seen in Figure 2 with most sources indicating a high to very critical debt stress (Fresnillo and Crotti, 2022).

4. CURRENT EFFECTS OF CLIMATE CHANGE

With 80% of its land less than one meter above sea level, the low-lying atoll islands of Maldives are highly vulnerable to the substantial risk posed by the increasing sea levels, as some scientists predict that the islands could be completely submerged by 2100 (Chase-Lubitz, 2024, World Bank & Asian Development Bank, 2021). The island faces a significant risk from climate change, which poses a substantial threat to their ways of life as the repercussions of this situation are likely to disproportionately affect the most disadvantaged, marginalized, and remote communities (World Bank & Asian Development Bank, 2021). In 2011, the sea was within 100 meters of approximately half (44%) of all human settlements and 47% of all homes along with 70% of critical infrastructure (Sovacool, 2011). Mean Sea Level is projected to rise by 70 centimeters above Malé's hourly sea level by 2050, with a long-term relative sea level trend of 1.7 mm/year, slightly higher than the global average, and the highest rate of sea level rise at 7 millimeters per year (World Bank & Asian Development Bank, 2021).

At present, the tourism industry's facilities, the fisheries sector and their facilities, population and housing structure, along with vital infrastructure like communication networks, four international airports, and more than 100 harbors, are predominantly located in areas within 100 meters of the coast, leaving them susceptible to the impacts of increasing sea levels, coastal storms, and floods (World Bank, 2024; World Bank & Asian Development Bank, 2021). Tourism is the primary driver of Maldives' economy, accounting for around one-third of the GDP and being the most rapidly expanding economic sector in the country (Chase-Lubitz, 2024; World Bank & Asian Development Bank, 2021). Despite a decline in their GDP contribution, fisheries (3.5%) and agriculture (1.7%) continue to be vital for the livelihoods of rural areas (World Bank & Asian Development Bank, 2021). According to a study conducted by ADB in 2014, Maldives is projected to experience the most severe economic impact among the six South Asian countries (Bangladesh, Bhutan, India, Nepal, and Sri Lanka) due to climate change. This suggests that by 2050, the average economic loss may amount to 2.3% of GDP, with estimates indicating a potential loss of 12.6% of GDP by 2100 (World Bank & Asian Development Bank, 2021).

To ensure the country's survival and prosperity, the government is implementing a strategy that is commonly employed by numerous nations worldwide: Land reclamation (Chase-Lubitz, 2024; IPCC, 2023; Amores et al, 2021). In a study published by Duvat (2020), it was found that out of 104 inhabited and 82 resort islands across the Maldives 59.1% (110 islands, including 62 inhabited and 48 resort islands) increased in size because of human intervention, including mainly land reclamation and the construction of engineered structures. Amongst these, approximately 52% of the islands that grew had growth rates of 10% or more, with 13 inhabited islands and 6 resort islands experiencing growth rates of 50% or more (Duvat, 2020). The implementation of coastal protection is already extensive in the country, as from 2013 to 2016, a total of 5.7 kilometers of coastal protection measures were carried out which are frequently accompanied by land reclamations (Gussman and Hinkel, 2021). According to estimates by the Maldives Government, over 1300 hectares of lagoon or reef area had been reclaimed up to 2016, which all required to be elevated to 1.5 and 1.75 above mean sea level (Amores et al, 2021; Gussman and Hinkel, 2021).

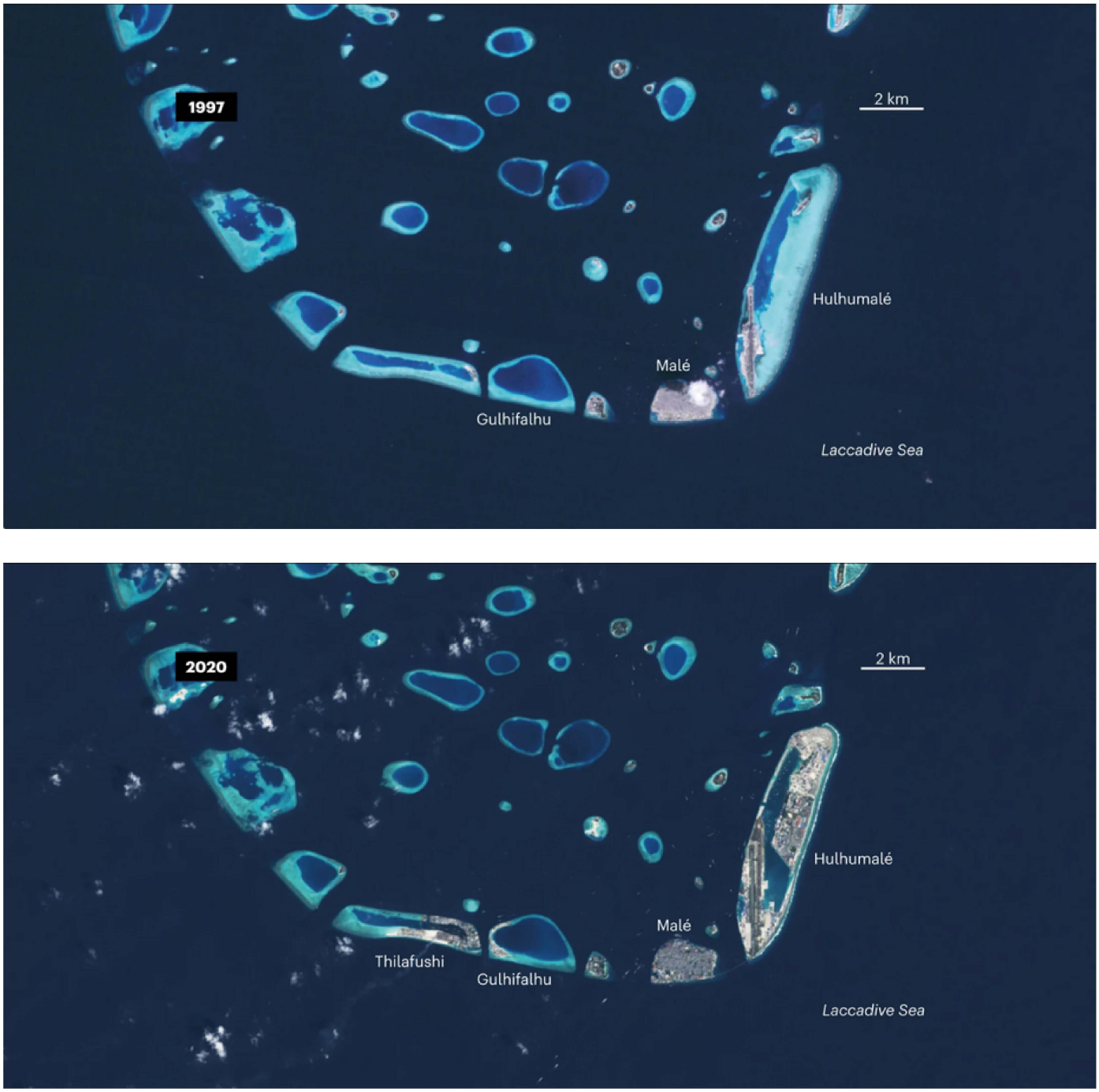

Figure 7: Land Reclamation of Maldives between 1997 and 2020 (Source: Chase-Lubitz, 2024; Lauren Dauphin/NASA Earth Observatory, 2021)

However, as Duvat (2020) pointed out, the ‘reclamation-fortification island model’ raises environmental and financial issues, with major implications on the security of future populations. The compromised ability of the self-sustaining reef-island system to adapt to rising sea levels by growing vertically raises concerns about the Maldives' future ability to maintain and improve defense structures to mitigate growing risks from the sea (Duvat, 2020). This is due to the potential challenges in securing internal funding, as the impacts of more frequent disasters on tourism revenues will likely strain resources. Additionally, uncertainty surrounds the availability of international funding. Furthermore, the accelerated degradation of the reef ecosystem caused by human activities will worsen the negative effects of climate change on food supply. Particularly the impacts on fish consumption is noteworthy, as it is a significant part of the population's diet (with an average per capita consumption of 181 kg/year), and the household-level consumption of reef fish is increasing (Duvat, 2020).

Prolonged flooding poses significant economic and human challenges, jeopardizing livelihoods on numerous islands, but can be mitigated through adaptive measures and natural landscape changes (World Bank & Asian Development Bank, 2021). The significant floods that took place in 1987 and 2007 in the Maldives resulted from the convergence of distant-source swells, high spring tides, and the development of reclaimed low-lying areas (IPCC, 2023). From 2000 to 2006, severe weather events flooded 90 inhabited islands, 37 regularly, and in 2007, 68 islands in 16 atolls were inundated, 500 homes were destroyed, and 1,600 people evacuated due to sea swells (Sovacool, 2011).

The 2004 Indian Ocean tsunami severely impacted the Maldives, causing widespread destruction and displacement of over 20,000 islanders (Luetz, 2017). The tsunami, ranging from 4 to 14 feet in height, resulted in 83 confirmed deaths, significant damage to 39 islands, complete destruction of 14, and severely affecting one-third of the population. It also highlighted the country's vulnerability to climate change-induced sea level rise, as 96% of the islands are less than 1km2 in area, forcing people to live next to the sea where 44% of settlement footprints are within 100 meters of coastline (Luetz, 2017). The Nation has also experienced several cyclones, including the Very Severe Cyclonic Storm Vayu in June 2019 and the Very Severe Cyclonic Storm Ockhi in November 2017. Ockhi caused damage to 62 islands, including flooding in 36 islands, torn roofs on 22 islands, and knocked down trees on 22 islands (World Bank & Asian Development Bank, 2021). The storm highlighted the need for better preparedness for future cyclones (World Bank & Asian Development Bank, 2021).

The Maldives boasts the seventh-largest coral reef system and two of the largest natural atolls in the world, namely the Thiladhunmathi Atoll (Spanning 3,788 km2) and Huvadhoo Atoll (Spanning 3,278 km2) (Sovacool, 2011; World Bank & Asian Development Bank, 2021). In addition to endemic whales, sharks, dolphins, and turtles, the country possesses 23 other natural atolls and 2,041 different coral reefs, which are inhabited by over 1,100 species of fish, 180 types of stony coral, and 240 species of hermatypic coral (Sovacool, 2011). Research by ADB indicates that coral reefs play a significant role in the fisheries and tourism sector as the demand for reef fish had been increasing over the years, and diving oriented tourism is very much dependent on a healthy reef system full of diverse marine fauna (World Bank & Asian Development Bank, 2021). Coral reefs thrive in a narrow

temperature range, meaning that when sea temperatures change too quickly, coral bleaching can occur (Sovacool, 2011).

Coral bleaching and coral mortality have occurred in the Maldives due to ocean warming, as evidenced by instances of bleaching in 1977, 1983, 1987, 1991, 1995, 1997, 1998, 2010, and 2016 (World Bank & Asian Development Bank, 2021). The 2016 ENSO event resulted in a 75% reduction of living coral (IPCC, 2023). Maldives has a continuously warm climate with 0.8°C warming trends occurring between 1978 and 2018, with warming under the highest emissions route expected to be slightly less than the global average of 3.7°C by the 2090s but still over 3°C, which would raise Maldives' temperature and humidity to unsafe levels (World Bank & Asian Development Bank, 2021). The CCKP's (Climate Change Knowledge Portal) examination of annual rainfall totals from 1969-1998 for Malé (central) and Gan (south) indicates a decline of around 2.7 millimeters (mm) per year and 7.6 mm per year, respectively (World Bank & Asian Development Bank, 2021). Figure 8 depicts the combined and successive effects of recent compound events, and how the interdependence of these stresses and their cumulative impacts on human and ecological systems in the Maldives Islands. The occurrence of El Niño Southern Oscillation (ENSO) episodes in 1998 and 2016, as well as the 2004 Indian Ocean tsunami, resulted in elevated sea surface temperatures, which subsequently led to coral bleaching. The 2007 flood disaster has further consequences on these livelihoods. Local human disturbances, such as pollution in coastal waters and land reclamation, impede the recovery of coral.

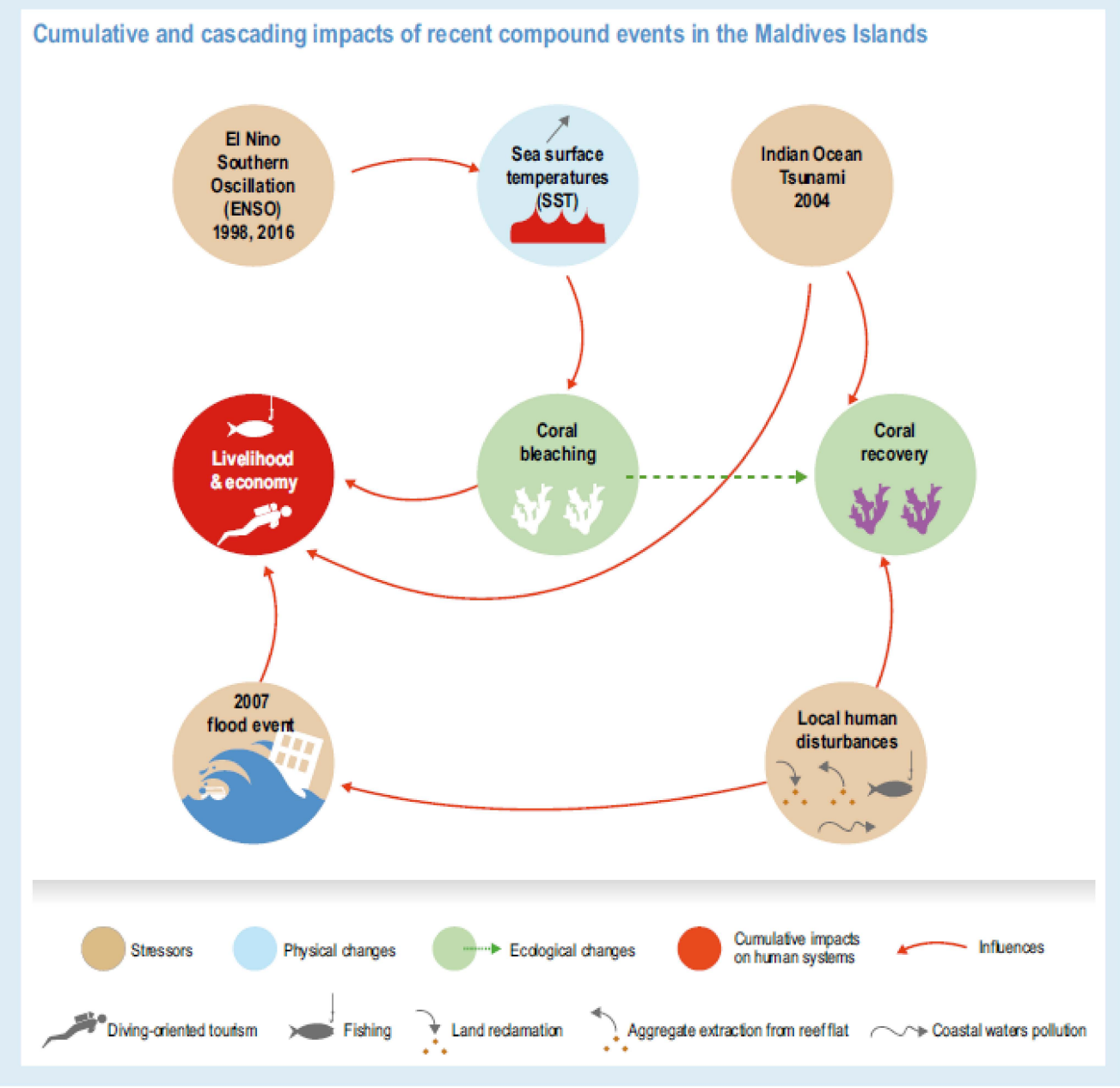

Figure 8: The Cumulative and Cascading Impacts of Recent Compound Events in the Maldives (Source: IPCC, 2023)

5. CLIMATE IMPACTS ON CRITICAL RESOURCES

5.1. WATER AND CLIMATE CHANGE

The Maldives has a few marshes and freshwater lakes but no rivers or streams (World Bank & Asian Development Bank, 2021). The Maldives depends on two primary natural sources of water: groundwater that can be retrieved from shallow freshwater aquifers located beneath some islands, and rainwater collection and catchment, and, additionally, desalination of seawater as an artificial source of water (Sovacool, 2011). Groundwater in basal aquifers, usually unconfined, forms a thin freshwater lens below sea level in the country (World Bank & Asian Development Bank, 2021). Low-lying islands possess a very narrow freshwater lens, as a result, they are susceptible to saline intrusion from rising sea levels and storm surges (Luetz, 2017; Sovacool, 2011; World Bank & Asian Development Bank, 2021). An estimated 11-36% decrease in the volume of fresh groundwater lens located on the small atoll islands (with an area less than 0.6 km²) is attributed to sea level rise (Alsumaiei and Bailey, 2018a; IPCC, 2023). Therefore, with the effects of climate change becoming more apparent, the declining availability of drinkable water is another possible concern for the future (Luetz, 2017).

5.1.1. TEMPERATURE, RAINFALL CHANGES, AND SEA LEVEL RISE

The Maldives has experienced a significant temperature increase of 0.8°C between 1978 and 2018. Projections indicate that future warming under the highest emissions pathway could exceed 3°C by the 2090s (World Bank & Asian Development Bank, 2021). This increase in temperature, combined with high humidity levels, poses dangerous conditions for human health.

Rainfall in the Maldives shows a distinct annual seasonality due to the monsoon periods. The southwest monsoon brings more rainfall, particularly to the southern islands, which receive between 1,715 and 2,380 mm of rainfall annually (Deng & Bailey, 2017). However, long-term trends indicate a decreasing rainfall pattern in central and southern regions, with Malé experiencing a decline of 2.7 mm/year and Gan 7.6 mm/year from 1969 to 1998 (World Bank & Asian Development Bank, 2021). This decline exacerbates water scarcity during the dry period from December to April.

Sea level rise (SLR) poses a severe threat to the Maldives' freshwater resources. For example, the observed long-term trend in relative sea level for Hulhulé (Malé International Airport Weather Station) is 1.7 mm/year, with the maximum hourly sea level increasing by approximately 7 mm/year, slightly faster than the global average (0.44 – 0.74 m) (World Bank & Asian Development Bank, 2021). Figure 9 shows the freshwater lens of the Maldives. SLR leads to significant reductions in the thickness and volume of freshwater lenses on the islands.[7] Deng and Bailey (2017) project drastic

[7] On atoll islands, fresh groundwater occurs as a buoyant lens-shaped body surrounded by saltwater derived from the sea. When precipitation recharge across an atoll island is sufficient, a fresh groundwater lens (FGL) will form, with freshwater floating above denser, saline groundwater derived from the sea. In atoll islands, as in all small islands, the FGL is usually thin, and a mixing zone separates the FGL from the underlying seawater. See Werner et al., 2017.

decreases in lens thickness for small islands (that are up to 200 meters in diameter) by 60% to 100%, moderate decreases (12% to 14%) for medium-sized islands (between 200 and 400 meters in diameter), and slight decrease (1% to 3%) for larger islands (from 400 meters to 1100 meters).[8] Additionally, Alsumaiei and Bailey (2018a) estimate an 11% to 36% reduction in the fresh groundwater lens volume for small atoll islands (<0.6 km²) due to SLR.

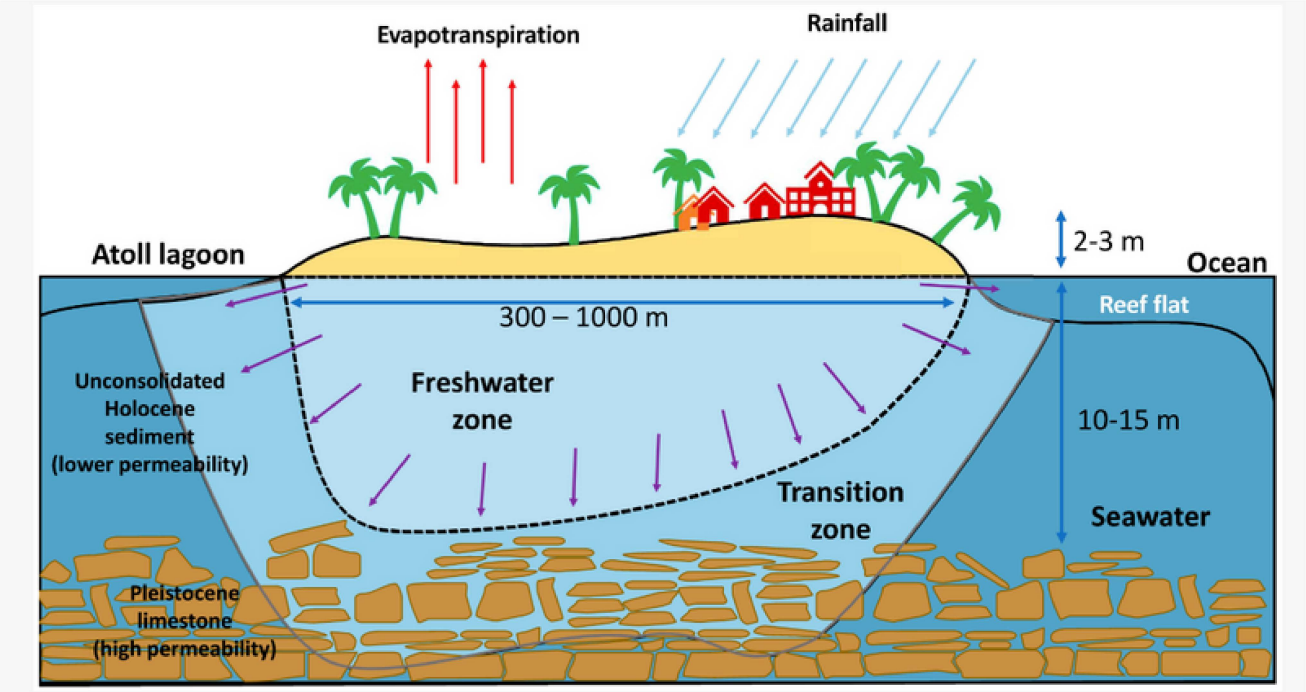

Figure 9: Conceptual image of a typical aquifer of the islands. The vertical scale is highly exaggerated (Source: Jaleel et al., 2020)

5.1.2. GROUNDWATER CONTAMINATION AND WATER SUPPLY

The sandy soils of the Maldives have a high permeability, which means that the freshwater lenses are easily affected by saltwater intrusion and human activity, leading to contamination. The inadequate disposal of waste and the adoption of below-standard sanitation methods have made groundwater unsuitable for drinking purposes in numerous regions (Jaleel et al., 2020; Ministry of Environment, 2020a). Human excreta is the main anthropogenic stress: by the end of 2016, only 48% of the population had access to sewer networks, and 41% had access to clean water supply systems with metered housing connections (Leoni et al., 2021).

According to research conducted on seven islands (Barthiban et al., 2012), just 6.4% of the 173 well water samples satisfied the World Health Organization's Drinking Water Quality Guideline for the indicator value of 44°C thermo-tolerant (Faecal) Coliform (FC). A total of 57.7% of the wells were categorized as having an extremely high degree of microbiological health risk, with fecal coliform (FC) levels ranging from 100 to over 1,000 cfu/100ml. A survey of 45 inhabited islands revealed that over 84% of islands reported varying degrees of elevated salinity in groundwater (Jaleel et al., 2020). Given the challenges with groundwater, the Maldives relies heavily on rainwater harvesting

[8] 33% of the national population are currently living on islands with widths less than 400 meters (Deng and Bailey, 2017)

and desalination (Ministry of Environment, 2020a). However, the harvested rainwater tanks frequently run dry during the extended dry seasons, necessitating expensive emergency water supplies from desalination facilities. Between 2017 and 2020, an average of 59 islands required emergency water supplies during the dry season, costing MRF 6.9 million annually ($450,000) (Ministry of Environment, 2020a). The reliance on desalination has increased, with many urban areas and resort islands using desalinated water due to high groundwater contamination levels caused by over-abstraction and sewage pollution (Ministry of Environment, 2020a).

In 2017, the Maldivian government initiated a project of USD 28.2 million with the assistance of the Green Climate Fund (GCF) and the United Nations Development Programme (UNDP) (Green Climate Fund, 2015). The objective of the project is to ensure a consistent, secure, and dependable water supply throughout the year for the inhabitants of the outer islands, home to around 105,000 individuals, which are particularly susceptible (Green Climate Fund, 2024). While the project concluded in 2024, up until 2022, the project's overall progress was at 96%, with 94.5% of the financial delivery completed. That is, 29 islands had finished their civil works, and out of these, 14 islands were equipped with Rainwater Harvesting (RWH) systems, while two islands had implemented Integrated Water Resource Management (IWRM) systems and were currently operating (Green Climate Fund, 2022) (Figure 10). As of 2024, 25 RWH systems have been constructed (In the 14 islands), with newly built tanks capable of collecting 150 tons of water in residential and public buildings (Green Climate Fund, 2024).

Figure 10: Integrated Water Resources Management systems of the Gleen Climate Fund Project (Source: Green Climate Fund, 2024; Photo by: Ashwa Faheem/UNDP)

5.1.3. COASTAL FLOODING AND INFRASTRUCTURE

The Maldives is highly susceptible to coastal flooding due to its low elevation. Major flood events in 1987 and 2007 were caused by a combination of long-period waves and high spring tides (Wadey et al., 2017). These events resulted in significant damage, highlighting the increasing threat as sea levels rise. Wadey et al. (2017) also show that coastal flooding in the Maldives is caused by multiple interacting sources, including energetic waves generated in the Southern Ocean and wave run-up, which is currently poorly quantified. As sea levels continue to rise, the conditions that produce floods will occur more frequently, suggesting that flooding will become common in the Maldives.

More than 90 inhabited islands already experience annual flooding, which exacerbates groundwater salinization and deteriorates water quality (World Bank & Asian Development Bank, 2021). Coastal flooding not only damages infrastructure but also leads to saltwater intrusion into groundwater aquifers, further deteriorating water quality. The economic impacts are substantial, with a study by the Asian Development Bank projecting that climate change could cause economic losses of 2.3% of GDP by 2050 and up to 12.6% of GDP by 2100 (World Bank & Asian Development Bank, 2021).

As mentioned before, the majority of the Maldives' population, infrastructure, and economic activities are located within 100 meters of the coastline, making them highly vulnerable to sea level rise and coastal flooding. This includes critical infrastructure such as communications, international airports, and over 100 harbors. The tourism industry, which contributes about one-third of the Maldives' GDP, is particularly at risk, as are the fisheries sector and the livelihoods of many Maldivians (World Bank & Asian Development Bank, 2021). To mitigate these risks, the Maldives has developed several policies and plans, including the Strategic Action Plan, Disaster Management Act, and National Emergency Operations Plan. These efforts aim to shift the focus from a reactive approach to a more comprehensive strategy for managing climate and disaster risks (World Bank & Asian Development Bank, 2021).

5.1.4. SOCIO-ECONOMIC IMPACTS

The impacts of climate change on water resources have significant socio-economic ramifications. The tourism industry, which accounts for about one-third of the Maldives' GDP, is highly vulnerable to coastal flooding and water scarcity. Similarly, the fisheries sector, critical for food security and livelihoods, is threatened by changes in sea temperature and coral bleaching, which affect fish stocks (World Bank & Asian Development Bank, 2021). However, the inhabitants of the outer islands and subsequent rural and low-income areas are more vulnerable to water-related hazards due to a lack of sewerage systems or centralized disposal facilities (Jaleel et al., 2020; Ministry of Environment, 2021).

In the past, the people of Maldives used traditional defecation methods (Athirimathi) which comprised burying their waste in shallow holes in their own backyards. During the 1970s and 1980s, the occurrence of diarrhea and cholera outbreaks made it necessary to enhance sanitary infrastructure, however, attempts to create human excreta disposal systems, such as waterless ash

latrines and sealed pit toilets, were not successful because of the potential for contamination (Ministry of Environment, 2020a; Ministry of Environment, 2021). The freshwater lens on many of the islands are no longer safe for potable purposes due to pollution from direct wastewater disposal or leakage of sewage from inadequate onsite sewage disposal systems, such as septic tanks and soakways. The main factor responsible for the transmission of waterborne diseases is the contamination of groundwater caused by leaking wastewater resulting from the incorrect installation and inadequate maintenance of septic tanks (Ministry of Environment, 2021). The government has devised a comprehensive strategy to implement sewage systems on all the populated islands, ensuring coverage for the whole population of the country within 5 years. While the introduction of sewer systems would decrease the detrimental effects on groundwater quality, it is crucial to prioritize effective management and maintenance during system operation (Ministry of Environment, 2021).

Figure 11: Sewerage overflow from a sewer manhole (Source: Ministry of Environment, 2021; Photo: https://www.apr.org/news/2019-06-06/alabama-probes-fish-kill-after-sewage-spilled-near-creek)

Women, who are primarily responsible for water collection in many communities, bear the brunt of water scarcity (Green Climate Fund, 2017; Ministry of Environment, 2020a). In numerous households, it is women who are responsible for fetching water from centralized tap bays and other remote sources, thus the reliance on centralized water supplies and desalination during dry periods underscores the need for improved water management systems to ensure sustainable access to clean water (Ministry of Environment, 2020a). The Green Climate Fund did a gender assessment of Maldives in 2017, focusing on water and gender issues (P. 7), as part of their project- FP007:

Supporting Vulnerable Communities in Maldives to Manage Climate Change-Induced Water Shortages.

Based on their evaluation, 73 percent of women are in charge of managing the home finances, and more than 95 percent of the survey participants stated that women have influence over household spending. Women are disproportionately impacted as a result of their familial responsibilities in food preparation, laundry, childcare, and household maintenance. These problems have decreased the utilization of historically significant groundwater as a potable water supply in the islands, but it is still employed for non-potable purposes such as bathing, laundry, and toilet flushing. Now that the project is complete (Green Climate Fund, 2024), it is expected that the implementation of a piped water system will have a significant positive impact on the lives of both women and men. This will eliminate the laborious task of fetching water from wells and taps, allowing more time to be dedicated to education, childcare, and various economic, social, and cultural activities. Women, who bear the primary responsibility for raising children and are directly affected by the adverse health effects of contaminated groundwater, can play a crucial role in advocating for a safe and affordable water service delivery system, including appropriate pricing (Green Climate Fund, 2017). However, only time will tell whether that will be successful in alleviating women's vulnerability to climate and water-related disasters in the future.

5.2. ENERGY AND CLIMATE CHANGE

The Maldives, a country highly dependent on imported fossil fuels, confront substantial energy security obstacles. Given that the energy sector relies mostly on diesel as its main source of fuel, it is of utmost importance to address the issues of high production costs and environmental sustainability. The government's Roadmap for the Energy Sector 2020-2030 seeks to shift towards renewable energy sources, decrease the release of greenhouse gases, and improve energy efficiency. This section examines the present energy consumption trends in the Maldives, the ambitious objectives outlined in the roadmap, and the significance of these activities in enhancing energy security and environmental sustainability in the face of the urgent consequences of climate change.

5.2.1 ENERGY USE PATTERNS

The Maldives has achieved universal access to electricity with 100% of their population having access to electricity in 2021 and 95% having access to clean fuels for cooking (Figure 12) (Asian Development Bank, 2020; IRENA, 2023; Ritchie et al., 2022). Electricity generation is predominantly fueled by diesel, accounting for most of the energy consumption in the country (Ministry of Environment and Energy, 2016). They heavily rely on imported fossil fuels, accounting for 10% of its GDP. Approximately 50% of these imports are utilized for electricity generation, with diesel being the primary fuel used in electricity generation, industrial processes, sea transport, and petrol for road transport (Asian Development Bank, 2020). In 2021 the country consumed 9 terawatt-hours of primary energy, which is not particularly high as compared to countries such as India, Brazil, and Indonesia as can be seen in Figure 13. However, their per capita energy consumption is higher compared to the 3 countries (India, Brazil, and Indonesia) at 17,669 kilowatt-hours per person, but far lower compared to countries such as Singapore, Canada, the US, China, and Japan (Figure 14) (Ritchie et al., 2022).

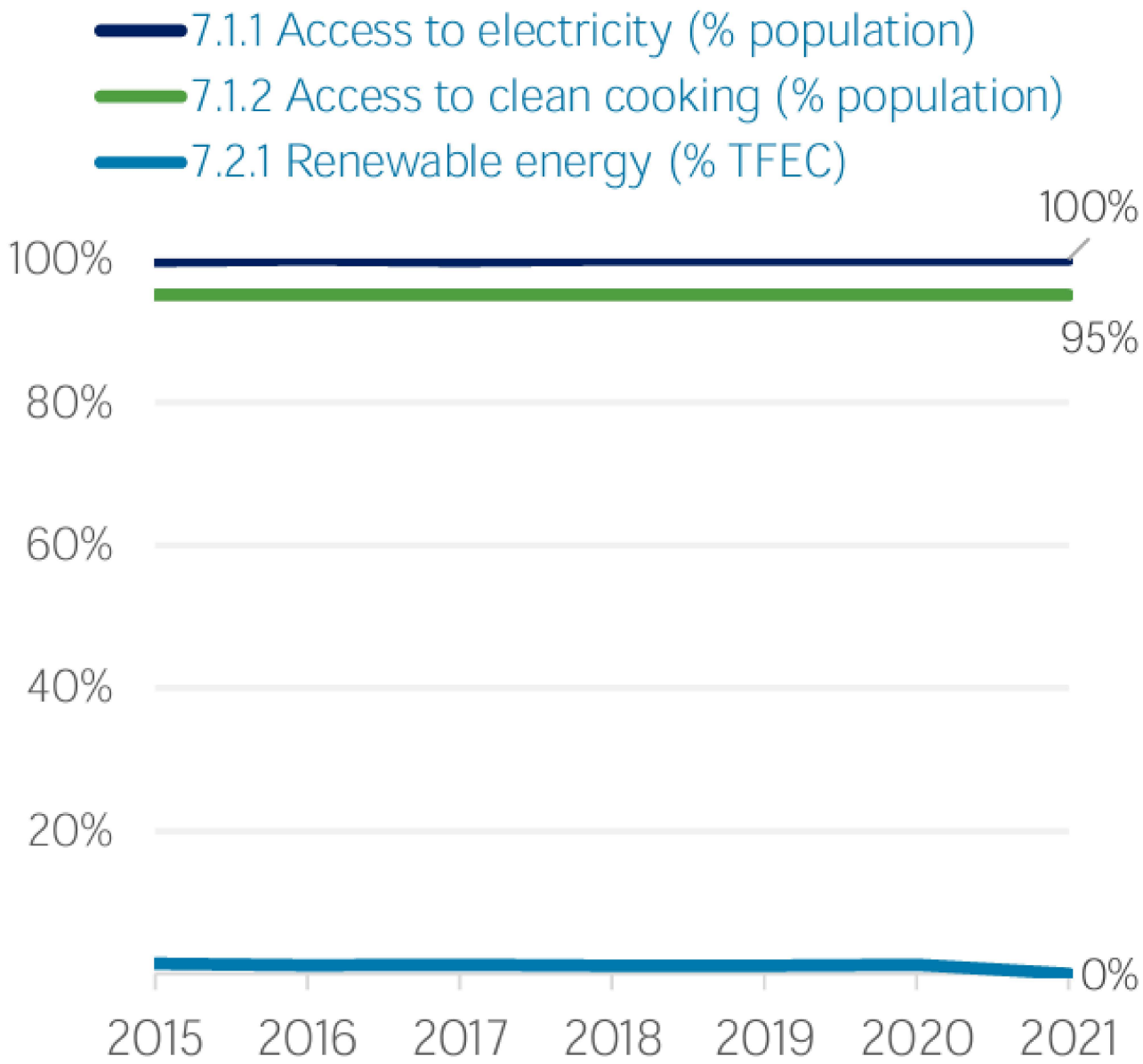

Figure 12: Trends in the Maldives' energy access from 2015 to 2021 (Source: IRENA, 2023)

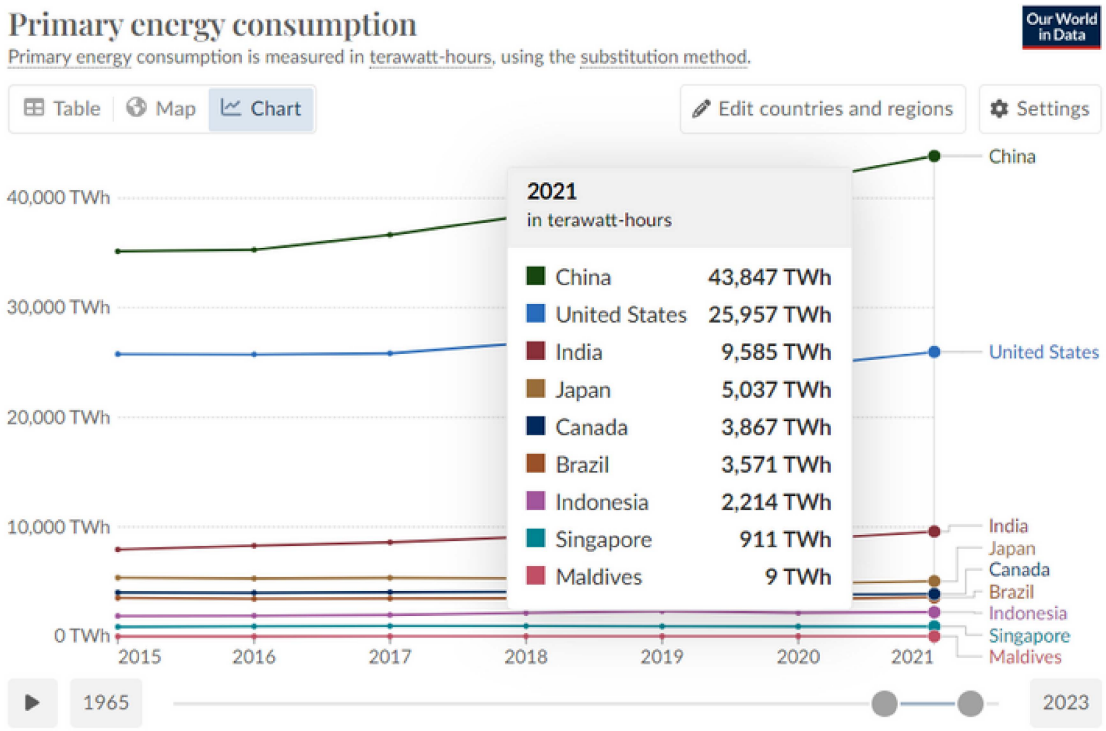

Figure 13: Maldives' primary energy consumption in 2021 was 9 TWh, the lowest among the countries shown (Source: Ritchie et al., 2022)

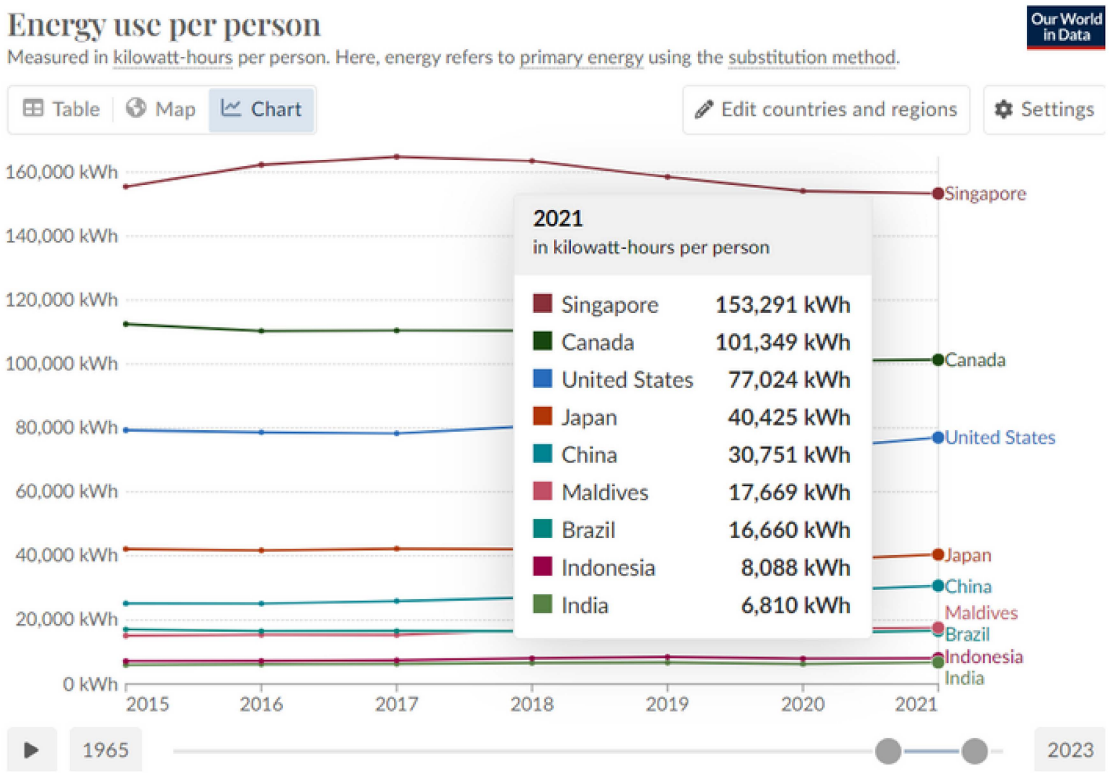

Figure 14: Maldives' energy use per person in 2021 was 17,669 kWh, showing moderate consumption compared to other countries (Source: Ritchie et al., 2022)

According to estimations, the country imported 723,000 tons of refined petroleum products, from which 578,994 tons (80%) was diesel for electricity generation, industries (fisheries and water desalination) and sea transport. In additions, 84,723 tons (12%) was petrol primarily for road transport, 42,422 tons (6%) was aviation fuel, and 16,885 tons (2%) was for liquefied petroleum gas for cooking and water heating purposes (Table 2) (Asian Development Bank, 2020, p. 13).

Product	Tons Imported	Percentage (%)	Sector
Diesel	578994	80	Electricity generation, industries (fisheries and water desalination) and sea transport
Petrol	84723	12	Primarily for road transport
Aviation Fuel	42422	6	Aviation
Liquefied Petroleum Gas	16885	2	Cooking and water heating

Table 2: Distribution of Refined Petroleum Products Imported by the Maldives and Their Usage Sectors in 2019 (Source: Asian Development Bank, 2020)

This heavy dependence on imported fuel is due to the lack of indigenous fossil fuel reserves. As shown in Figure, 15. 99% of the total energy supply comes from fossil fuels (Oil) (Figure 16), the majority of which (more than 80%) is used for electricity generation (Figure 17) (IRENA, 2023). The country possesses a cumulative installed capacity of 290 MW from diesel generators distributed across 186 powerhouses, along with an additional 22 MW from renewable energy installations. The FENAKA Corporation Ltd. manages a total of 148 power stations, whilst the State Electric Company Ltd. (STELCO) manages 35 power stations. The Malé ' Water and Sewerage Company Pvt. Ltd. runs a single powerhouse located near R. Dhuvaafaru. The rest is managed by island councils. Resort islands possess a power-producing capacity of 144 MW, whereas industrial islands have a capacity of 20 MW (Asian Development Bank, 2020).

Country	Coal (million tons)	Oil (million barrels)	Natural Gas (trillion cubic feet)	Hydropower (megawatts)	Biomass (million tons)
India	90,085	5700	39	150,000	139
Pakistan	17,550	324	33	59,000	NA
Bangladesh	884	12	8	330	0.08
Afghanistan	440	1.569	15.687	23,000	18–27
Nepal	NA	0	0	48,300	27.04
Bhutan	2	0	0	30,000	26.6
Sri Lanka	NA	150	0	2000	12
Maldives	0	0	0	0	0.06
Total South Asia	**108,961**	**6187.569**	**95.687**	**312,630**	**223**

Figure 15: Domestic Reserves of Energy Generation in the South Asian Region (Source: Shah et al., 2019)

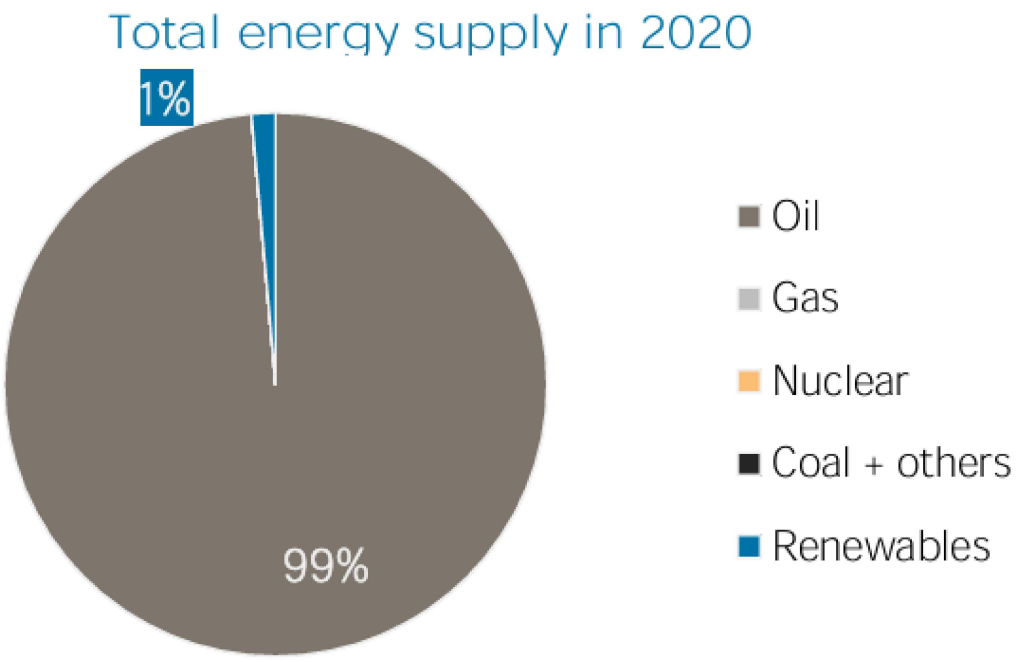

Figure 16: The total energy supply of Maldives in 2020 (Source: IRENA, 2023)

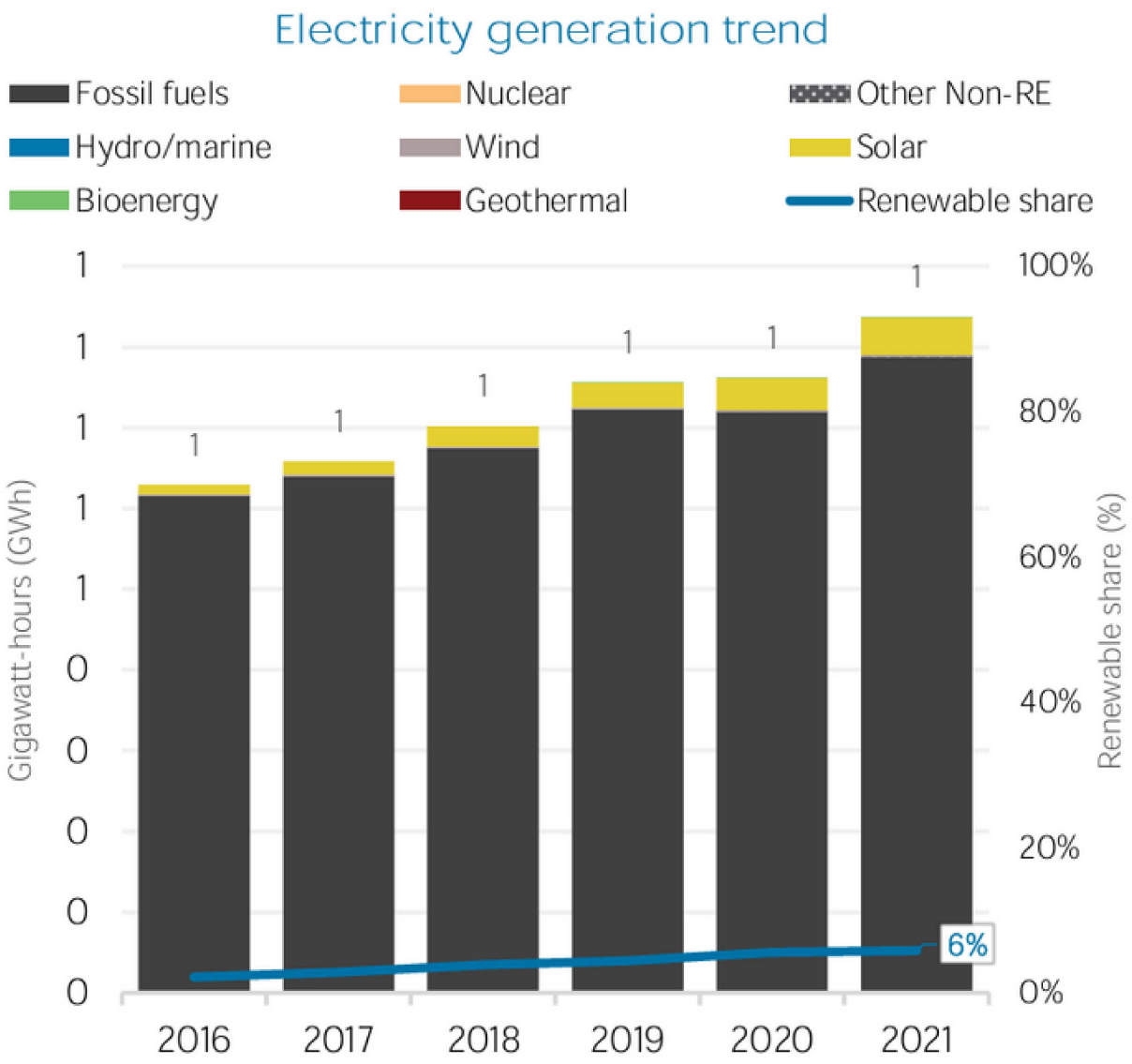

Figure 17: The electricity generation trend of Maldives (Source: IRENA, 2023)

5.2.2 THE COST OF ELECTRICITY TO THE ECONOMY AND THE ENVIRONMENT

As illustrated in Figure 17 and in Figure 18, the Maldives relies heavily on oil for electricity generation, in contrast to other South Asian countries that utilize a mix of energy sources. In addition, the dispersed nature of the islands necessitates individual electricity generation and distribution facilities on each island. However, due to the limited quantities of fuel imported by boat to each island, the Maldives incurs high electricity generation costs, which range from $0.19/kWh to $0.70/kWh, depending on the efficiency of the system. The most cost-effective diesel generators have an efficiency range of $0.23/kWh to $0.33/kWh. However, smaller inhabited islands may incur higher expenses, reaching up to $0.70/kWh (Asian Development Bank, 2020; Ministry of Environment and Energy, 2016). This high cost is mitigated by government subsidies to ensure 24-hour electricity service across all inhabited, commercial, and tourist resort islands (Ministry of

Environment and Energy, 2016). The annual subsidies allocated to the electrical sector stood at Rf1 billion/$65 million as of the end of 2019 (Asian Development Bank, 2020). Both STELCO and FENAKA are highly dependent on these subsidies, as the subsidy accounts for the volatility in fuel prices and made up about 65% of the direct subsidy budget in 2018, but energy supply becomes expensive, and the country cannot guarantee energy security despite having 100% accessibility (Asian Development Bank, 2020).

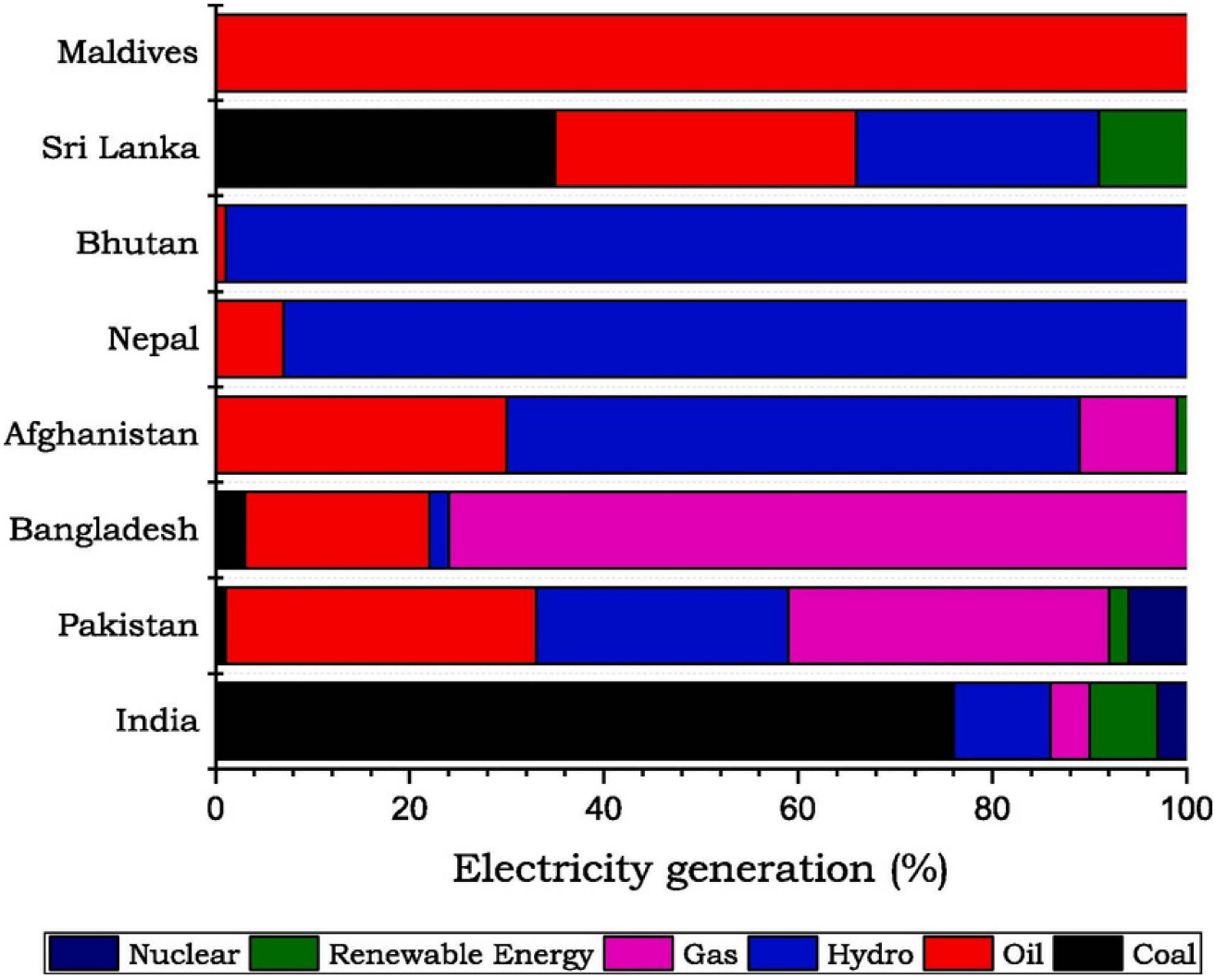

Figure 18: Electricity Generation of South Asian Countries (Source: Shah et al., 2019)

The Maldives has the highest figures of CO2 emission per capita in South Asia, increasing from 1.88 tons in 2006 to 3.06 tons in 2017, with an annual average growth rate of 4.24% (Shah et al., 2019). This is largely due to the reliance on diesel for electricity generation and transportation. The energy consumption per capita in the Maldives remained steady, fluctuating between 0.91 and 1.10 million tons of oil equivalent (MTOE) per million people from 2006 to 2017 (Shah et al., 2019). Figures 19 and 20 illustrate the energy consumption per capita and CO2 emissions per capita, respectively, highlighting the Maldives' high per capita energy consumption and CO2 emissions relative to other South Asian countries. Efforts to reduce CO2 emissions and improve energy efficiency are critical for the Maldives' sustainable development.

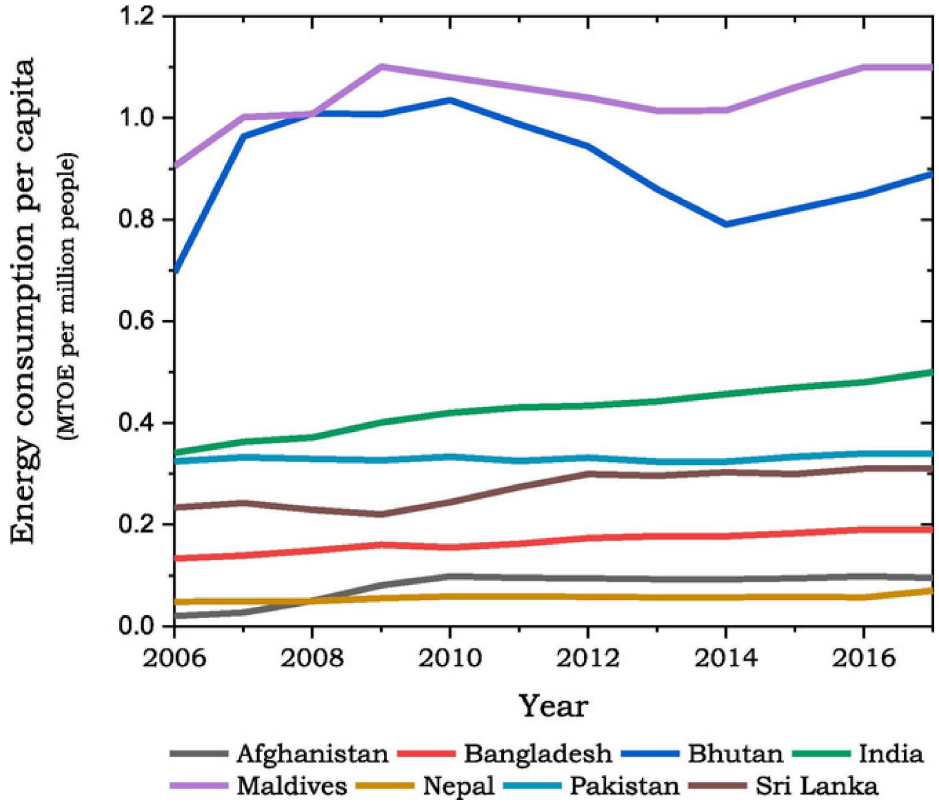

Figure 19: Energy Consumption per Capita of South Asian Countries (Source: Shah., et al 2019)

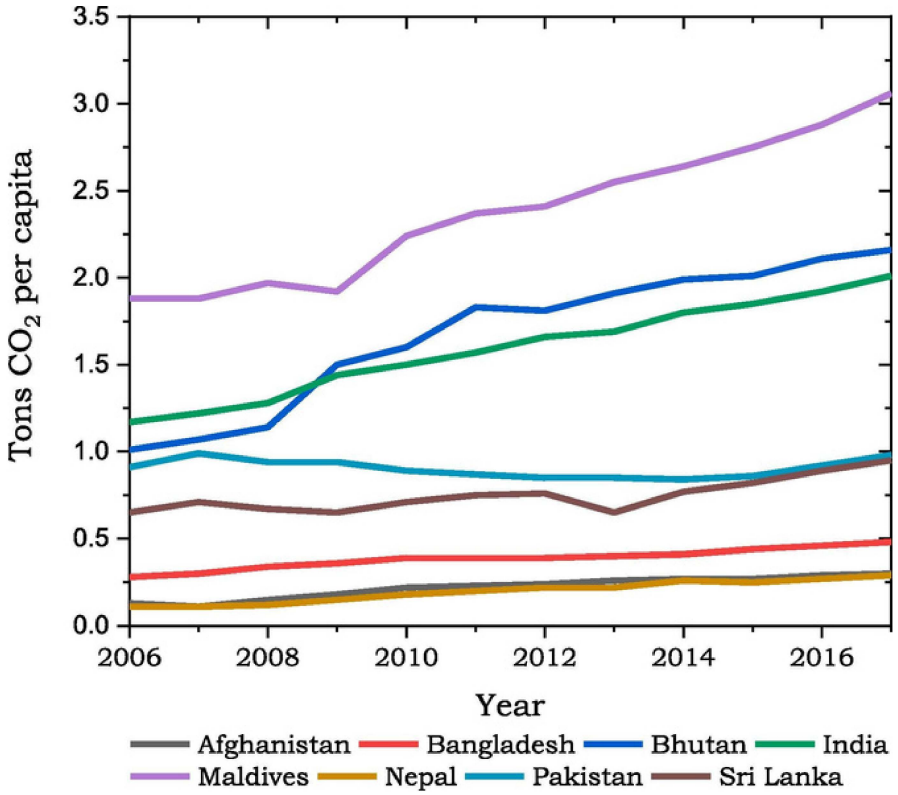

Figure 20: Per Capita CO2 emissions of South Asian countries (Source: Shah et al., 2019)

Country	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Afghanistan	0.18	0.21	0.03	0.19	0.19	0.20	0.21	0.20	0.21	0.20	0.21	0.21
Bangladesh	0.18	0.18	0.18	0.19	0.20	0.21	0.21	0.21	0.22	0.21	0.22	0.22
Bhutan	0.73	0.72	0.71	0.75	0.71	0.73	0.74	0.74	0.72	0.71	0.71	0.73
India	0.65	0.69	0.72	0.73	0.64	0.64	0.57	0.61	0.64	0.67	0.65	0.66
Maldives	0.26	0.23	0.23	0.24	0.22	0.15	0.12	0.15	0.14	0.13	0.12	0.09
Nepal	0.28	0.25	0.23	0.26	0.27	0.22	0.20	0.26	0.24	0.27	0.27	0.26
Pakistan	0.56	0.51	0.50	0.55	0.53	0.46	0.45	0.50	0.47	0.50	0.46	0.40
Sri Lanka	0.18	0.11	0.13	0.22	0.34	0.29	0.23	0.45	0.35	0.49	0.54	0.54

Figure 21: Energy Security and Environmental Sustainability Index (ESESI) score of Asian Countries from 2006-2017 (Source: Shah et al., 2019)

Figure 21 illustrates the ESESI[9](Energy Security and Environmental Sustainability Index) score of the Maldives from 2006 to 2017, indicating a need for significant improvements in energy efficiency and environmental sustainability. A high ESESI score means the potential to deal with energy security and environmental sustainability is higher than the other South Asian countries. As seen above, the Maldives' scores have been declining, meaning they are the least energy-secure and the most environmentally vulnerable (Shah et al., 2019). A cause of this is because of their dependence on fossil fuels, which are major contributors to the emission of greenhouse gases (GHG) and thus contribute to global warming. Moreover, the South Asia region is confronted with significant environmental challenges, such as air pollution, degradation of natural resources, food insecurity, water scarcity, and water pollution (Shah et al., 2019). The ESESI score and the subsequent research were conducted by Shah et al., in 2019, and it was done to assess the environmental and energy security of South Asian countries up until that point, providing a comprehensive, up-to-date, and systematic analysis. The Maldives obtained the lowest score for the study period from 2006 to 2017, indicating that it is the least energy-secure and environmentally sustainable country in South Asia (Figure 22).

[9] The Energy Security and Environmental Sustainability Index (ESESI) for South Asia provides a comprehensive, up-to-date, and systematic analysis. The selection of indicators was made carefully to capture the broader aspects of energy security and environmental sustainability. The indicators selected under the study were energy dependency, energy intensity, diversity in total primary energy supply (TPES), energy consumption per capita (ECPC), Gross Domestic Product (GDP) per capita, Carbon Dioxide (CO2) intensity, CO2 emission per capita, CO2 emission from electricity generation, share of renewable energy sources (RES) in electricity generation, ratio of change in forestry, and electrification ratio. See Shah et al, 2019.

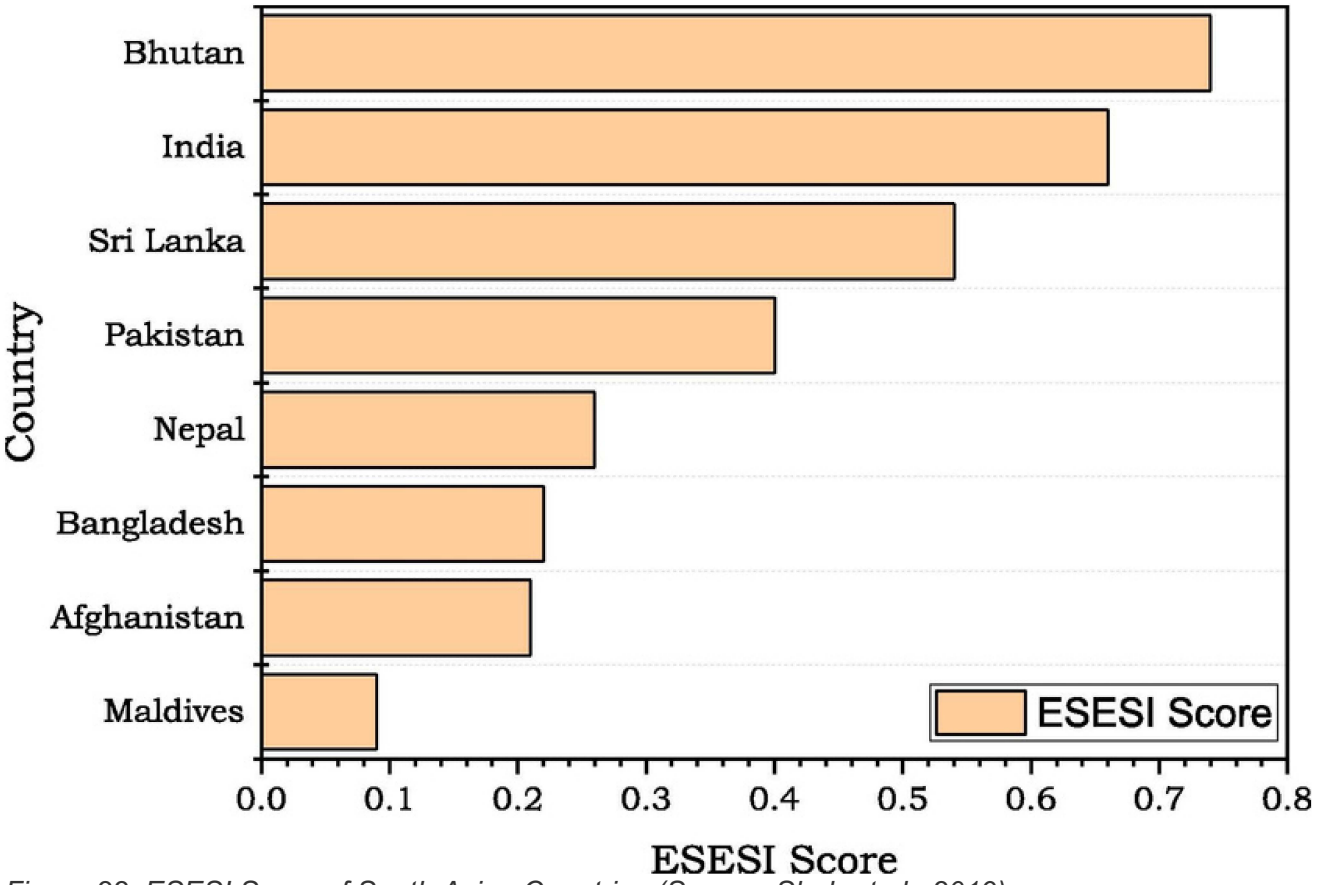

Figure 22: ESESI Score of South Asian Countries (Source: Shah et al., 2019)

5.2.3 POLICIES AND ROADMAPS FOR THE FUTURE

The Asian Development Bank in partnership with the Ministry of the Environment (2020) has proposed a Roadmap for the Energy Sector 2020-2030 in the Maldives, which places a strong emphasis on renewable energy and energy efficiency as a means to decrease reliance on fossil fuels and mitigate greenhouse gas emissions. The government places a high importance on shifting towards environmentally sustainable energy sources by allocating resources to renewable energy projects, to ensure energy stability and reduce dependence on imported energy. The POISED project, initiated in 2014 with the assistance of the Asian Development Bank (ADB), aimed to transform diesel-powered systems into hybrid solar PV-diesel systems, resulting in fuel savings of up to 28% (Asian Development Bank, 2020). As of early 2020, the total capacity of rooftop solar PV panels in the Greater Malé Region exceeded 3,000 kilowatts peak (kWp). The roadmap outlined two scenarios: the base case, which targets a 29% decrease in fossil fuel usage as stated in the Maldives' Nationally Determined Contribution (Ministry of Environment, 2020b), and the paradigm shift, which aims for a more ambitious 52% reduction. Between 2021 and 2030, the rates at which energy demand is likely to increase are anticipated to be lower than the forecasts made before the COVID-19 pandemic. According to the Asian Development Bank (2020), the use of fossil fuels is projected to increase from 674,000 tons in 2020 to 864,000 tons in 2030 in the base case, and to 583,000 tons in the paradigm shift scenario. The roadmap emphasizes the significance of energy

efficiency measures, specifically targeting investments in renewable energy infrastructure such as rooftop solar PV, waste-to-energy systems, and small rooftop wind turbines (Asian Development Bank, 2020). Technological advancements encompass the use of floating photovoltaic (PV) platforms, oceanic energy sources such as tidal, wave, and ocean thermal energy, as well as the utilization of hydrogen and fuel cell technology for energy storage (Asian Development Bank, 2020).

Other than the roadmap by the Asian Development Bank, there are no other policies or projects implemented or to be implemented in Maldives concerning energy and sustainability in the past 5 years (2019 – 2024). Research in energy sustainability and the impacts of energy use on the climate is still lacking in the country, and further research should be done on its impacts. Although it is understood that compared to the rest of the world and most upper-income countries, Maldives' impact on climate change in general is negligible (especially in terms of energy consumption). The dependency on oil imports is a case of vulnerability, as fluctuations in price and global trade can lead to shocks (Such as the Covid-19), can be difficult to navigate and can lead to paying increase of their debts. As seen in section 3.2.1, there are some uses of renewable resources for energy in the country with 1% of total energy being supplied from renewables (Figure 16) and 6% of electricity generated from renewables (Figure 17), however majority of it is still produced from fossil fuel. As such, building renewable energy resources to generate electricity can help mitigate the dependency on fossil fuels and decrease the vulnerability.

5.3 INFRASTRUCTURE AND CLIMATE CHANGE

The Maldives, as a low-lying atoll nation, is extremely vulnerable to the impacts of climate change, particularly sea-level rise (SLR) and extreme weather events. These challenges necessitate significant adaptations in infrastructure to ensure the country's resilience and sustainability (Duvat, 2020). Since the 1970s, the Maldives has predominantly relied on gray infrastructure solutions for coastal protection. These solutions include seawalls and breakwaters, which have been implemented on both inhabited and tourist islands. From 2004 to 2016, 45 islands with human populations adopted hard engineering methods, but just two islands opted for green options, such as beach nourishment, which is considered the most conservative green solution (World Bank, 2024). Over the past decade, the majority of inhabited and resort islands in the Maldives have expanded, primarily through land reclamation and the construction of engineered structures such as seawalls, breakwaters, and groins (Duvat, 2020).

5.3.1 LAND RECLAMATION AND ISLAND EXPANSION

Land reclamation in the Maldives is widespread but lacks a systematic approach to anticipate SLR and consider local flood risk differences (van der Pol et al., 2023). This approach has been extensively employed, with 59.1% of Maldivian islands experiencing expansion between 2004-2016, driven largely by political, demographic, and socioeconomic factors (Duvat, 2020). For instance, the National Population Consolidation Program (NPCP) accelerated island fortification post-2004 Indian Ocean Tsunami, concentrating the population on 'safer' islands through extensive land reclamation

(Duvat, 2020). The largest land reclamation project is Hulhumalé, which was used to alleviate population pressure in Malé (Brown et al., 2020). Hulhumalé is elevated 2.1 meters above mean sea level, 0.6 meters higher than Malé. In Phase I (1997–2004), 185 hectares were reclaimed for residential use, including infrastructure such as roads, schools, and mosques, while Phase II (2006–2016) reclaimed an additional 240 hectares, also primarily for residential purposes, with the first land plots available for sale in November 2016. In Malé, adaptation costs amounted to US$16.1 million solely for raising land by an additional 0.6 meters above protection levels to mitigate long-term sea-level rise risks (Bisaro et al., 2023). Land has also been reclaimed for non-residential purposes, such as airports, tourist resorts, waste management, and industrial land use. The Maldives has not primarily reclaimed land to adapt to sea-level rise, but rather to address current land use needs (van der Pol et al., 2023). Between 1966 and 2022, the Maldives established a total of 17 airports (World Bank, 2024).

Coastal development, such as land reclamation and port and harbor construction, is crucial for the Maldives' economic development and supports the needs of its growing population. Port infrastructure is essential for facilitating international trade in fisheries products and the movement of people within and beyond the Maldives (World Bank, 2024). The Maldivian practice for reclaiming new artificial islands follows a non-binding guideline of reclaiming land 1.5 m to 1.8 m above the current mean sea-level, based on a tidal component of 0.6 m and 1.0 m of SLR (Gussman and Hinkel, 2021). Land extension projects are typically done at the same or similar elevation to avoid drainage issues (van der Pol et al., 2023). The Government of Maldives has prioritized coastal infrastructure, funding US$610 million worth of port, harbor, dredging, and land reclamation projects from 2013 to 2021, representing 4% of annual public expenditure; as a result, virtually all inhabited islands now have a harbor, with four major ports/terminals developed or upgraded since 2005. Several port projects, including Gulhifalhu International Port, Addu International Port, and Ihavandhippolhu Transshipment Port, are in progress (World Bank, 2024).

Driver	Number of islands affected
A1. Land reclamation at harbor end or in harbor area	5
A2. New harbor(s) dredged in reef flat associated with land reclamation at harbor end or in harbor area	32
A3. New harbor(s) dredged in reef flat associated with extensive land reclamation	16
A4. Harbor extension with limited or moderate land reclamation at harbor end or in harbor area	12
A5. Harbor extension with extensive land reclamation	16
A6. Extensive land reclamation	8
A7. Other changes (e.g. breakwater construction or extension)	3
Sub-total	92
n.a. Inhabited island exhibiting no significant human disturbance in 2014-2016	2
A/ Inhabited island exhibiting influential human disturbances in 2004-2006 showing no additional human disturbances in 2014-2016	10
Total	104

Figure 23: Land Area Change among Inhabited Islands (Source: Duvat, 2020)

Driver	Number of islands affected
A1. Land reclamation at harbor end or in harbor area	4
A2. New harbor dredged in reef flat associated with land reclamation at harbor end or in harbor area	3
A3. Extensive land reclamation	6
A4. Engineered protection structures (breakwaters, groins, seawalls)	19
A5. Land reclamation + engineered protection structures	14
A6. New harbor dredged in reef flat associated with land reclamation at harbor end or in harbor area + engineered structures	1
A7. New harbor dredged in reef flat	1
A8. Dredging in reef flat	1
A9. Dredging in reef flat + engineered structures	6
A10. Dredging in reef flat + land reclamation	3
A11. Beach nourishment*	2
A12. Vegetation destruction	2
A13. Quay or jetty	2
A14. Quay or jetty + engineered protection structures	1
Sub-total	65
n.a. Resort island exhibiting no significant human disturbance in 2014-2016	5
A/ Resort island exhibiting influential human disturbances in 2004-2006 showing no additional human disturbances in 2014-2016	12
Total	82

Figure 24: Land Area Changes in Tourist Islands (Source: Duvat, 2020)

Figure 25: Differences in Shoreline among 4 islands between 2005 and 2016. (Source: Duvat, 2020)

5.3.2 HARD ENGINEERING MEASURES

Seawalls, breakwaters, and other hard engineering structures constitute a significant portion of the coastal protection measures in the Maldives. Gray or "hard" solutions, including land reclamation, seawalls, groins, and quay walls, have been preferred in the country since the 1970s, and these engineering measures remain the favored choice for both inhabited and resort islands due to their perceived higher safety and longevity (World Bank, 2024). Approximately 28% of coastal protection efforts involve seawalls, which are essential for safeguarding infrastructure against storm surges and wave action (IPCC, 2023). As mentioned above, between 2004 and 2016, 45 islands had hard engineering solutions, while just two islands underwent NBS, namely beach nourishment. In addition, a significant majority of resort islands (75%) have utilized sandbags and breakwaters to enhance coastal safety over the previous five years. However, the adoption of NBS, such as mangrove restoration and coral restoration, has been quite restricted, accounting for fewer than 12% of the efforts (World Bank, 2024).

These gray infrastructures can be maladaptive, causing unintended side effects like destabilizing sediment transport, preventing reef islands from adapting to sea-level rise, and increasing reliance on further gray solutions such as seawalls, revetments, and breakwaters, while also being affected by infrastructure construction, sand mining, reef entrance blasting, dredging, and pollution (World Bank, 2024). Figure 26 illustrates the percentage of inhabited islands that have implemented various coastal development and protection measures. It shows that a majority (around 50%) of islands have focused on coastal development only, while a smaller percentage (around 20%) have implemented both coastal development and coastal protection measures. Coastal protection only is seen in around 10% of islands, and a minimal number of islands have not implemented any measures (IPCC, 2023). Despite their effectiveness, these structures are challenging to maintain and may not be sufficient to counter long-term SLR, necessitating more transformative adaptation strategies. Furthermore, coastal developments like dredging and land reclamation exacerbate coral mortality during bleaching events, with coral mortality near reclamation sites being 13% higher during the 2016 ocean temperature hike. This is due to sediment reducing coral resilience and population size; sand mining for reclamation and construction disrupts sediment budgets and erosion rates, altering seafloor topography and endangering reefs crucial for protection, biodiversity, fisheries, and tourism (World Bank, 2024). Additionally, a 2022 land reclamation project in Addu Atoll, involving the dredging of seven million cubic meters of sand, has been flagged for potential "significant irreversible damages" to marine ecosystems, raising concerns about long-term environmental and economic impacts despite anticipated local benefits (World Bank, 2024).

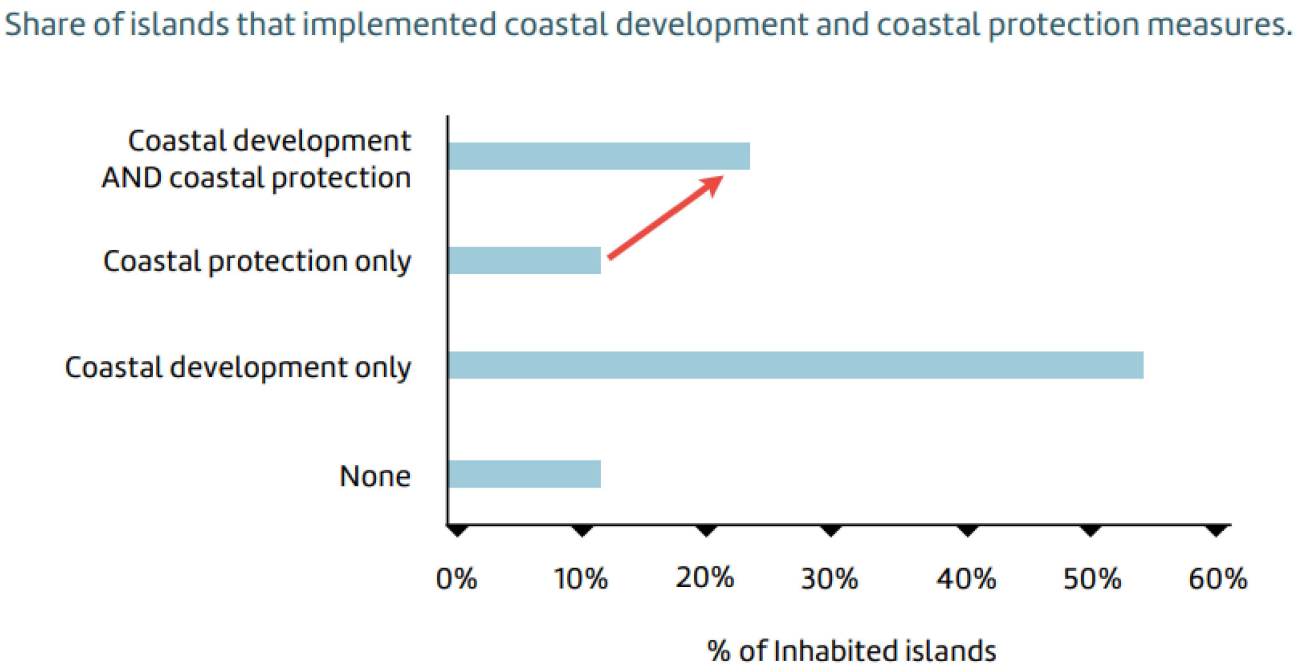

Figure 26: Share of inhabited islands in the Maldives implementing coastal development and protection measures (Source: World Bank, 2024)

5.4 FOOD AND CLIMATE CHANGE

The Maldives faces significant challenges in food production and import dependency, exacerbated by climate change. The country's limited arable land, approximately 2,800-3,000 hectares, restricts agricultural output to primarily horticultural crops such as vegetables and tropical fruits, with minimal livestock breeding confined to poultry and cattle ventures (Ramessur and Bundhun, 2022). It is estimated that about 90% of the food consumed in the country is imported (Ministry of Environment and Energy, 2016, p. 5; World Bank & Asian Development Bank, 2021). Traditional crops like maize, sorghum, and millet have largely been replaced by short-term profitable horticulture crops due to land scarcity and management difficulties (Najeeb and Hassan, 2020). This shift has increased dependency on food imports, making the Maldives vulnerable to global market fluctuations and supply chain disruptions (Ramessur and Bundhun, 2022).

Food import data from 2017 to 2021 highlights the Maldives' reliance on external sources for essential food items. The total food imports increased from USD 438.79 million in 2017 to USD 542.79 million in 2021 (Figure 28) (Driessche, 2024). The United Arab Emirates, India, and Sri Lanka are the primary suppliers, with the UAE accounting for 23% of total imports in 2021 (Figure 27) (Driessche, 2024). This dependency on imports for staples such as rice, sugar, and flour reveal the country's vulnerability in terms of economic and physical access to food (Ramessur and Bundhun, 2022).

	2017	2018	2019	2020	2021
In millions of USD					
Total food imports	438.79	471.98	518.12	367.77	542.79
United Arab Emirates	84.20	88.26	96.22	61.00	127.20
India	75.79	85.52	91.11	77.90	90.92
Sri Lanka	49.65	48.44	64.17	44.05	60.41
Malaysia	28.81	30.18	33.24	28.73	39.43
Singapore	26.19	27.87	30.06	19.36	24.34
Other countries	174.15	191.71	203.32	136.73	200.49
Percentage of value					
United Arab Emirates	19	19	19	17	23
India	17	18	18	21	17
Sri Lanka	11	10	12	12	11
Malaysia	7	6	6	8	8
Singapore	6	6	6	5	5
Other countries	40	41	39	37	37
Total	100	100	100	100	100

Figure 27: Food Import of Maldives from 2017 - 2021 (Source: Driessche, 2024)

Increased temperatures and changing rainfall patterns negatively impact crop yields and the availability of freshwater resources necessary for agriculture (World Bank & Asian Development Bank, 2021). The Government of Maldives has taken measures to address these challenges, including urging citizens to restart farming practices and guaranteeing the purchase of yields at predetermined prices (Ramessur and Bundhun, 2022). However, the COVID-19 pandemic has exacerbated food access vulnerabilities, highlighting the need for resilient agricultural practices and diversified food sources (Ramessur and Bundhun, 2022).

The Maldives' agricultural sector is characterized by subsistence and semi-subsistence farming, with most cultivation occurring in household gardens and small field plots (Driessche, 2024). The average field plot size is 700 m², utilizing low-tech methods and hydroponic systems for crops like fruits, legumes, and salad leaves (Driessche, 2024). Despite these efforts, the sector's contribution to GDP has declined from 7% in 1984 to 1.6% in 2020, with the number of registered farmers decreasing from 9,973 in 2013 to 7,611 in 2019 (National Bureau of Statistics, 2020). Import dependency patterns further underscore the Maldives' food security challenges. Food imports from the UAE, India, and Sri Lanka are crucial, with other countries contributing a significant portion of the total imports (Figure 28) (Driessche, 2024). In 2021, imports from these countries accounted for 23%, 17%, and 11% of total food imports, respectively (Figure 28) (Driessche, 2024). This reliance on a few key partners for food supplies makes the Maldives susceptible to global supply chain disruptions and price volatility (Ramessur and Bundhun, 2022).

Efforts to enhance food security in the Maldives include the promotion of traditional crops and improving market connectivity for local farmers (Najeeb and Hassan, 2020).

Studies suggest that cultivating underutilized crops like taro and breadfruit, particularly in southern islands such as Fuwahmulah and Addu City, could improve food security and dietary diversity (Najeeb and Hassan, 2020). Additionally, addressing market connectivity issues, such as logistics and access to technology, is crucial for enhancing agricultural productivity and reducing dependency on imports (Driessche, 2024). The impact of climate change on the Maldives' food security is profound. Rising temperatures and changing rainfall patterns affect crop yields and increase the frequency of extreme weather events like flooding and droughts (World Bank & Asian Development Bank, 2021). These changes exacerbate the challenges of limited arable land and freshwater resources, necessitating resilient agricultural practices and improved water management strategies (World Bank & Asian Development Bank, 2021).

The Maldives' food security is heavily reliant on imports, with climate change posing significant threats to agricultural productivity and the stability of food supply chains (Ramessur and Bundhun, 2022). Efforts to promote traditional crops, improve market connectivity, and enhance agricultural resilience are essential for mitigating these challenges and ensuring sustainable food security in the face of climate change (Najeeb and Hassan, 2020). The integration of resilient agricultural practices and diversified food sources will be critical in adapting to the impacts of climate change and reducing the country's vulnerability to global market fluctuations (World Bank & Asian Development Bank, 2021).

5.5 WASTE AND CLIMATE CHANGE

Waste management in the Maldives is a critical issue exacerbated by climate change; however, it is not as explored as issues such as sea level rise and energy production. The Maldives is grappling with significant waste management issues. The nation has experienced a significant increase in waste generation, with a 58% rise per capita on local islands over the past decade (Patti et al., 2020). The Maldives has one of the highest rates of garbage output in the South Asia area and among SIDS. In the capital city of Malé, the average amount of waste produced per person per day is roughly 1.7 kg, while in other inhabited islands, it is 0.8 kg per person per day, and additionally each tourist in the Maldives generates around 3.5 kg of waste per day (UNESCAP, 2021; World Bank, 2024). Total 80% of the waste generated in the greater Malé region is organic waste, which rises to 88% in Atoll[10] (UNESCAP, 2021). In 2019, the sector that produced the most waste was households with 205,261 tons, followed closely by construction with 182,500 tons (Table 3).

Furthermore, there is an increasing trend in waste generation, as the amount of waste in the capital city of Malé experienced a 155 percent growth from 2004 to 2014 (UNESCAP, 2021; World Bank, 2024). Daily, the Greater Malé region and 32 inhabited outer islands, including 86 tourist destinations, produce more than 800 tons of municipal solid waste (Asian Development Bank, 2021). This surge in waste production has overwhelmed existing waste management systems, leading to widespread pollution, including the accumulation of microplastics in marine environments.

[10] In the greater Malé region household waste includes food waste, green waste, plastic, metal, paper & cardboard, glass, sanitary waste, textile, E-waste, and hazardous waste. The waste composition of government institutes are most likely similar to households. Quantities of waste in general and specific types of waste may be high depending on what type of business or operation it is. In the Atolls Waste types of households is similar to Greater Male' Area. Economic activities generate waste types similar to households as well as waste related to specific economic and activities. Economic activities in the inhabited islands vary from manufacturing, fish processing, weaving, boat building, carpentry, tailoring, agriculture, and bottling plants to tourism-related activities such as guesthouses and diving schools. For more see UNESCAP, 2021.

Waste Producer (Sector)	Waste Generated (tons)
Households	205,261
Construction	182,500
Tourism	34,765
Health	6,296
Transport	3,431
Imports	542
Total	432,795

Table 3: Waste production by sector of Maldives in 2019 (Source: UNESCAP, 2021)

The Maldives relies heavily on transporting waste to Thilafushi, an artificial island created for waste disposal. Insufficient treatment facilities around the Greater Malé region resulted in the accumulation and disposal of garbage on Thilafushi island, leading to the occurrence of leachate and fires without appropriate control measures (Asian Development Bank, 2021). Most inhabited islands have Island Waste Management Centres (IWMCs) for waste collection and disposal, but the lack of sufficient machinery and technical expertise hinders their effectiveness (Ministry of Environment, Climate Change and Technology, 2022). Thilafushi receives approximately 500 tons of rubbish daily, making it the primary solution for managing municipal waste (Patti et al., 2020). Despite this, the country's waste management infrastructure remains inadequate, contributing to significant environmental pollution. In 2019, the Maldives was ranked as the fourth largest producer of mismanaged waste per capita globally, highlighting the severity of the issue (Patti et al., 2020). Open burning, stockpiling, and dumping waste near the shoreline are still among the most common methods of waste disposal practiced in residential islands and lead to further pollution of air, groundwater resources, and the marine environment (Ministry of Environment, Climate Change and Technology, 2022; Shumais et al., 2022). Moreover, the increase in population has led to the emergence of untreated wastewater as a significant issue, as this effluent contains hazardous chemicals and pollutants that not only threaten marine life but also pose dangers to public health (World Bank, 2024). According to projections, per capita waste production could rise from 2.35 kg per day in 2023 to 4.18 kg per day by 2050, driven by population growth and economic development (Shumais et al., 2022). Royle et al. (2022) highlighted that illegal dumping, lack of policies, empowering legislation, and an environmentally conscious public are key factors contributing to the annual flow of 600 tons of plastic garbage into Maldivian waterways. Other issues include improper transportation to other islands, lack of protection in coastline dump sites, and concerns about toxicity, bioaccumulation, and biomagnification.

The inefficiency of waste management systems is particularly evident in the disposal of sewage and wastewater. Many Maldivian islands, including Naifaru, utilize rudimentary collection systems that discharge untreated effluent directly into nearshore lagoons or onto beaches (Patti et al., 2020). These practices contribute significantly to the pollution of marine environments, as evidenced by the high concentrations of microplastics found in sediment samples around the islands. Untreated wastewater can significantly impact fisheries and fish stocks, leading to eutrophication, anaerobiosis,and fish and shellfish abnormalities in estuarine and coastal marine systems, as well as causing large numbers of benthic and epibenthic animal deaths (World Bank, 2024).

Microplastic contamination is a pervasive problem in the Maldives, affecting both marine sediments and reef-building corals. According to projections made in 2019, it is estimated that Maldives will generate 22.1 kilotons of plastic waste in the year 2020, which represents 7.5% of the total municipal solid waste produced (Royle et al., 2022). A study conducted by Patti et al. (2020) revealed the presence of 1,244 microplastic particles in sediments from 22 sampling sites around Naifaru. These particles were found in filamentous (49%) and fragmented (51%) forms, with an average concentration of 277.90 ± 24.98 microplastic particles per kilogram of sediment (Patti et al., 2020). SUP beverage bottles, primarily containing water, comprised 21% of all plastic items, and are the largest category of plastic items, reflecting a preference for bottled water over tap and the reliance on it by those with limited access to potable water (Royle et al., 2022). The findings indicated that microplastics are ubiquitous in marine sediments around the island, posing a potential threat to marine organisms that might ingest these particles. In 2020, around 1.6 kilotons (kt) of plastic trash from the Maldives, equivalent to 7% of the total plastic garbage, ended up in the marine environment, where the Thilafushi landfill site was identified as the main contributor, responsible for 62% of all plastic pollution in the area (Royle et al., 2022). Further research by Raguso et al. (2022) confirmed microplastic presence in Maldivian reef-building corals. In their survey, 58% of the investigated coral colonies were contaminated with microplastic particles, with the highest concentration recorded at 8.9 particles per gram of coral (Raguso et al., 2022). The contamination did not show significant differences across various depths, exposures, sites, or species, suggesting a widespread distribution of microplastics within the coral reef ecosystem.

The Maldives hosts a rich diversity of marine life, including 3.1% of the world's total coral biomass (Patti et al., 2020). However, plastic pollution is one of several stressors affecting these ecosystems, alongside coral bleaching, disease outbreaks, and corallivorous predators (Patti et al., 2020). The ingestion of microplastics by marine organisms raises concerns about potential health impacts and the broader ecological consequences. Economically, pollution from mismanaged waste poses a significant threat to the Maldivian tourism industry. The pristine beaches and clear waters that attract tourists are at risk of degradation from plastic pollution, which could lead to a decline in tourist numbers and associated revenue. Moreover, the costs of cleaning up polluted areas and mitigating the effects of waste mismanagement place additional financial burdens on the government (Patti et al., 2020). The Government of Maldives over the past five years has enacted many policy adjustments and actions in relation to this matter as can be seen in Figure 28. The World Bank (2024) has a full section (2.4.1.1) dedicated to the regulatory overview of waste management in the country, it is highly recommended to read said section as it is a high-level summary of said regulatory measures.

Policy Name	Description	Year of Implementation
Single Use Plastic Phase-out Plan	A policy aimed at controlling the production, import, and consumption of certain single-use plastics and promoting sustainable alternatives.	2020
Ban Decree (2021/9)	A decree accompanying the Single Use Plastic Phase-out Plan that prohibits the production and sale of selected single-use plastics.	2021
5th Amendment to the Waste Management Regulation (2021/R-109)	Mandates the source separation of selected waste streams at the household level, promoting recycling, re-use, and recovery of household waste, including single-use plastic bottles.	2021
Waste Management Act (Law Number 24/2022)	A comprehensive legislation addressing waste management practices in the Maldives. It includes provisions related to plastic bag fees, waste separation, recycling, and other waste management aspects.	2022
Regulation on Collecting Plastic Bag Fee by Persons Registered for GST (2023/R-76)	Sets out rules and regulations for persons registered with the Maldives Inland Revenue Authority (MIRA) for Goods and Services Tax (GST) in collecting plastic bag fees as required by Chapter 8 of the Waste Management Act.	2023

Figure 28: Waste-related policy interventions in the Maldives (Source: World Bank, 2024)

6. CURRENT ADAPTIVE MEASURES FOR CLIMATE CHANGE

As seen in section 5.3 the Maldives are heavily dependent on infrastructure and hard engineering for their adaptation to climate change and SLR. As mentioned in the section, hard protective measures can often lead to maladaptive practices, since they can cause major damage to coral reefs and accelerate coastal erosion leading to needing more hard measures to protect the coasts, which might lead to a cycle of maladaptation. In recent years, over 1,300 hectares of new land have been reclaimed across around 100 inhabited islands in the Maldives, with Hulhumalé being the largest project at 430 hectares, followed by Alifu Dhaalu Maamigili (73 hectares) and Gaafu Dhaalu Thinadhoo (71 hectares). Yet, the total land mass remains less than 1% of the country's 9,000,000-hectare area, necessitating elevations of 1.5 to 1.75 meters above mean sea level. While land reclamation helps address sea level rise, it requires tackling policy, human, physical, engineering, and economic/financial challenges (UNDP, 2023).

Limits to adaptation occur when measures no longer protect against climate impacts, causing escalating losses and damages, with risks evident even before these limits are reached (UNDP, 2023). The IPCC's (2023) Special Report on 1.5°C highlights rising temperatures leading to soft and hard adaptation limits in natural and human systems, including coral reefs and coastal livelihoods. Soft adaptation measures like Nature-based Solutions (NbS) offer distinct advantages over gray solutions, such as preserving ecosystem services crucial to reef-island systems, avoiding visual disruption, and supporting food security, climate change mitigation, and biodiversity conservation (World Bank, 2024). Soft limits have no current feasible adaptation options but possibly in the future, while hard limits have no effective current or future options (UNDP, 2023; IPCC 2023).

Despite the benefits, soft adaptation requires long-term financial commitment and its effectiveness depends on local factors. The Government of Maldives (GoM) aims to develop criteria to balance hard and soft adaptation measures, moving towards an inclusive approach that values ecosystems like coral reefs, mangroves, and seagrasses as essential components of coastal defense (World Bank, 2024). For SIDS, constraints such as limited ICT for community-based adaptation and lack of data exacerbate these limits, leading to significant risks to ecosystems, infrastructure, and properties, even if global warming remains below 1.5°C (UNDP, 2023). The hard coastal protection systems, such as those found in Malé ', prove to be unsuccessful in preventing localized barrier collapses emphasizing the necessity for more transformative adaptation measures throughout island shores (IPCC, 2023). The Maldives faces constraints in soft adaptation, including finance, data governance, awareness, human resources, and technology. Climate change impacts are particularly evident, with island communities being the first to suffer from migration pressures, displacement, political instability, and cultural loss due to climate change impacts (UNDP 2023).

6.1 POLICIES ENACTED TO ADAPT TO CLIMATE CHANGE IN MALDIVES

The Maldives has a modern legal system responsive to climate and environmental rights violations, including a constitutional duty for every citizen "to preserve and protect the natural environment […] and abstain from all forms of pollution and ecological degradation" (Art. 67 (h) of the Constitution) (UNDP, 2023). Additionally, several policies and frameworks have been enacted in the Maldives to address the challenges posed by climate change (Figure 29). The Environmental Protection and Preservation Act of 1993 marked one of the earliest legislative efforts, emphasizing environmental conservation and sustainable development (Ministry of Environment, 2020b). The Land Act, with three amendments in 2002, aimed to regulate land use to mitigate environmental impacts. The Maldives National Building Code (2008) introduced standards for construction to reduce flood risks, requiring a 60cm ground-level elevation for new dwellings (Gussman & Hinkel, 2021). The decentralization efforts were formalized through the Maldives Decentralization Act (2010), promoting local governance in environmental management. The EPA Regulation (2012) and the EIA Regulation (2012) established frameworks for assessing environmental impacts and integrating climate resilience into development projects. Which lead to the two EIA for K. Thulusdhoo reclamation and K. Thulusdhoo harbor construction.

National laws have been advanced through international commitments such as the United Nations Framework Convention for Climate Change (UNFCCC), the Paris Agreement, the United Nations Convention on Biological Diversity (CBD), the Kunming-Montreal Global Biodiversity Framework (GBF), and the United Nations High Seas Treaty under the United Nations Convention on the Law of the Sea (UNCLOS) (UNDP, 2023). The National Adaptation Plan of Action (2012) outlined strategic priorities for climate adaptation, while the Climate Change Policy Framework (2015) provided a comprehensive approach to integrate climate considerations across all sectors (Gussman & Hinkel, 2021). This comprehensive legal framework ensures protection for current and future generations. Managing climate-related litigation risks justifies early, clear, and consistent climate action by governments, focusing on national efforts and aligning the private sector. Internationally, climate litigation can also represent financial opportunities for present and future generations in the most climate-vulnerable countries (UNDP, 2023).

Document name/title	Year
Environmental Protection and Preservation Act	1993
Land Act (3 Amendments)	2002
Maldives National Building Code	2008
Maldives Decentralization Act	2010
EPA Regulation (4 amendments)	2012
EIA Regulation (4 amendments)	2012
National Adaptation Plan of Action	2012
EIA for K.Thulusdhoo Reclamation	2013
Guidance Manual for Climate Risk Resilient Coastal Protection in the Maldives	2015
EIA for K.Thulusdhoo Harbor Construction	2015
Climate Change Policy Framework Maldives	2015
Building Act	2017

Figure 29: Policies, frameworks and EIA's enacted in the Maldives to address climate change (Source: Gussman and Hinkel, 2021)

6.2 ACTUAL MEASURES IN PLACE

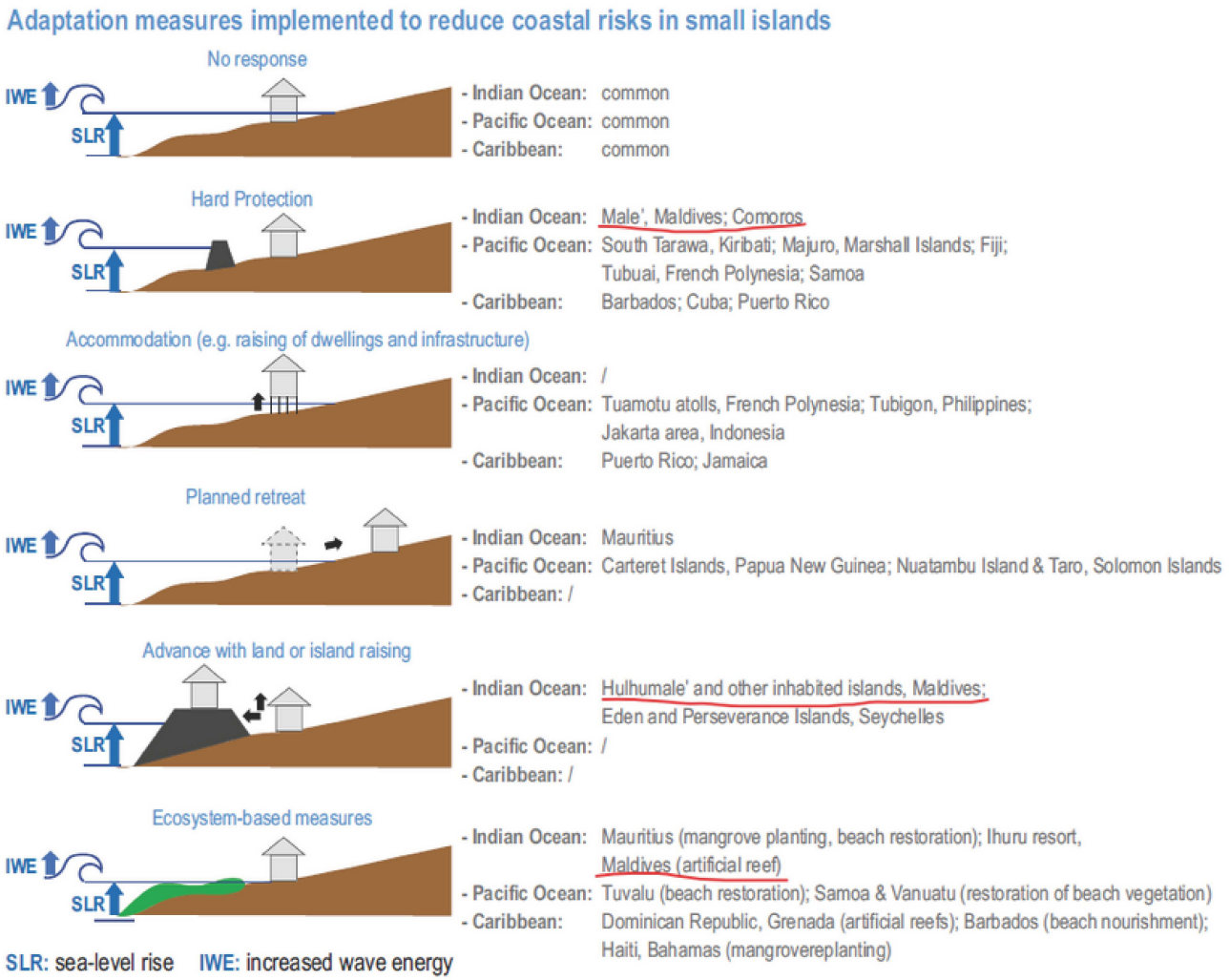

Figure 30: Adaptation measures implemented by the Maldives to mitigate coastal risks (Source: IPCC, 2023)

The Maldives can employ various ways to address the detrimental effects of climate change on sea level rise and flooding. These solutions include: 1) taking no action, 2) adapting to the changes, 3) protecting against the impacts, 4) progressing (such as by constructing new islands), and 5) relocating (World Bank, 2024). Figure 30 highlights the diverse adaptation measures adopted by the Maldives to mitigate coastal risks due to SLR and increased wave energy (IWE). The Maldives employs hard protection measures, such as seawalls, notably in Malé. Accommodation strategies, like raising infrastructure, are applied across various islands. The nation also implements planned retreat strategies and undertakes land or island-raising projects in places like Hulhumalé and other inhabited islands. Additionally, ecosystem-based measures, such as artificial reefs, are employed to protect coastal areas.

However, up to now, the Maldives has been vigorously protecting its current islands by using robust engineering structures and also by reclaiming land through substantial coastal advances.

One of the prominent examples is the creation of the artificial island Hulhumalé in the late 1990s, which is 1.8m high and designed to accommodate urban expansion and future sea-level rise (Brown et al., 2020). This project highlights the government's proactive approach to land reclamation and elevation, aiming to provide safe and sustainable living spaces for its growing population. The implementation of Nature-based Solutions (NbS) for adaptation in the Maldives has been limited and poorly documented, though awareness is growing. Key initiatives include the Green Climate Fund project "Building Climate Resilient Safer Islands in Maldives," which emphasizes the importance of coral reefs for coastal protection (World Bank, 2024). The Government of Maldives (GoM) has also extended conservation status to nine mangrove sites and has a national coral reef restoration and rehabilitation program. However, NbS directly involving mangroves and seagrasses for coastal adaptation is still absent (World Bank, 2024).

Adaptation strategies are determined on an island-by-island basis within a national planning framework, prioritizing the most vulnerable islands based on factors like critical infrastructure, population density, and natural adaptability to sea level rise (World Bank, 2024). Between 2013 and 2016, 5.7 km of coastal protection structures were implemented, often in conjunction with land reclamation projects (Ministry of Environment, 2020b). Many islands have chosen to defend, using seawalls, breakwaters, and groins to maintain shorelines and minimize coastal erosion and floods, or to advance by creating new land. Seawalls, effective for protecting harbors and beaches, are widespread due to limited space and urgent adaptation needs, and some islands use a combination of defense and advanced strategies (World Bank, 2024). These measures are primarily financed through a combination of national funds, loans, and international aid. The cost of these hard engineering solutions is substantial, requiring continuous financial support and maintenance.

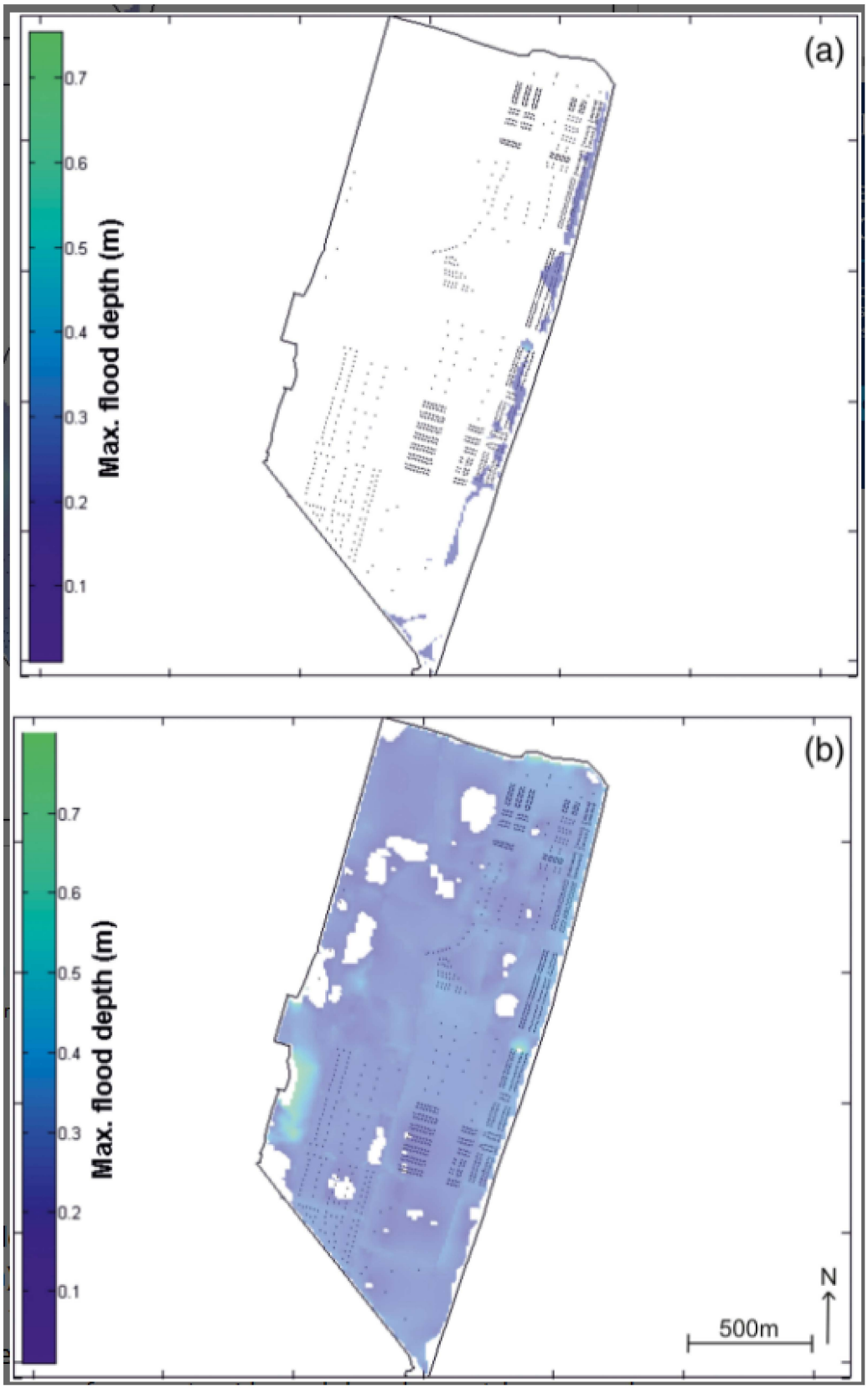

Figure 31: Flooding Risk of Hulhumalé with Future SLR. figure a shows the spread of flood in a 0.6 m SLR scenario while figure b shows the spread of flood in a 0.9 m SLR scenario. (Source: Brown et al., 2020)

The images above illustrate the significant coastal flooding risks faced by the island of Hulhumalé amid future SLR (Figure 31). Brown et al. (2020) found that with a 0.6 m sea-level rise, SWAB predicts overtopping at 2.0 L/s/m, causing temporary flooding. LISFLOOD models show limited overtopping at the southeast shoreline to a depth of 0.1 m. With a 0.65 m rise, 50% of the island could flood below 0.2 m. At 0.9 m, 90% of the island could flood to 0.2 m, threatening 1,200 buildings. A 1 m rise could result in extensive flooding over 0.2 m across the entire island. The flood depth maps highlight the vulnerability of specific areas, necessitating targeted adaptation measures (Amores et al., 2021).

Policy	Objective	Mechanism	SLR integration
Building Code	Reduce flood risk	Requires 60cm ground level elevation for new dwellings	No
Land Use Plan	Reduce flood and erosion risk	Requires a 20m setback zone between the beach and rest of the island. Furthermore, recommends elevating and placing critical infrastructure in the center and elevated parts of an island.	No
Land Reclamation Guideline	**Reduce flood risk and drainage problems**	Recommends new islands to be reclaimed at 1,5 to 1,75 meters above MSL.	Yes
		Recommends land extensions to be at same level as existing island. Minimum distance to the reef edge of 30m.	No
Coastal Protection Guideline	Reduce flood risk and severe erosion	Identifies islands that require most immediate coastal protection measures.	No
Environmental Impact Assessment	Assess environmental impacts of infrastructure and development projects	Requires assessment of potentially negative environmental consequences e.g. human-induced erosion and flood risk in the application and design process of infrastructure and other developments.	No

Figure 32: Policy Measures in Response to SLR (Source: Gussman and Hinkel, 2021)

In response to the imminent threat of sea-level rise, the Maldives has focused on enhancing the resilience of its infrastructure (Figure 32). The Building Code and Land Use Plan are pivotal in this regard, requiring elevated construction and setback zones to mitigate flood risks (Gussman & Hinkel, 2021). The coastal protection guidelines identify critical areas for immediate intervention, ensuring that infrastructure investments are strategically placed to offer maximum protection. The integration of climate resilience into infrastructure planning is further illustrated by the 2017 Building Act, which mandates the incorporation of climate considerations in all new constructions (Ministry of Environment, 2020b). This includes the development of resilient airports, ports, and powerhouses, which are crucial for maintaining economic stability and connectivity in the face of climate impacts. An example of successful NbS implementation is the establishment of Addu and Fuvahmulah Nature Parks in 2018 under the World Bank-funded Climate Change Adaptation Project (CCAP). These parks, developed as ecotourism attractions, include the Eydhigali Kilhi wetlands and Koattey area in Addu Nature Park, and the Bandaara Kilhi and Dhandimagu Kilhi wetlands in Fuvahmulah Nature Park (World Bank, 2024). The project has garnered high community acceptance and interest, contributing to local socio-economic development. Initially managed by the EPA, management responsibilities were transferred to local Island Councils in 2021, marking the first such transfer in the Maldives, though the transition is ongoing (World Bank, 2024).

Migration has emerged as a key adaptation strategy in the Maldives, driven by both environmental and socio-economic factors. The government's relocation policies, particularly post-tsunami, have focused on moving vulnerable populations from high-risk areas to safer, more developed islands (Luetz, 2017). The Population Consolidation Program, initiated in the late 1990s, aimed to facilitate economic development and reduce government expenditure by concentrating the population in fewer, larger islands (Gussman & Hinkel, 2021). Figure 33 illustrates the population changes in the Maldives from 2000 to 2014 and projected populations for 2050 across six narratives (Speelman et al., 2021). Notably, Malé's population shows significant growth from 67,939 in 2000 to 109,635 in 2014, with projections ranging from 154,949 to 228,384 by 2050. Hulhumalé, nonexistent in 2000, reached 14,551 by 2014 and is projected to rise between 91,297 and 136,282, reflecting urban migration trends (Speelman et al., 2021). However, Research conducted in the Maldives indicates that there is an unequal distribution of the ability to use mobility as a means of adapting to climate change between women and men (IPCC,2023). Women face greater challenges in utilizing migration as an adaptation strategy due to factors such as gender roles, societal expectations, economic structures, political laws, religious doctrines, and gender norms and cultural practices (IPCC, 2023; Lama, 2018).

Islands	Census data		Population in 2050 by narrative					
	2000	2014	A	B	C	D	E	F
Malé	67,939	109,635	217,976	223,278	228,384	168,330	154,949	169,819
Hulhumalé	0?	14,551	118,411	128,177	136,282	97,814	91,297	92,614
Hithadhoo (Addu)	9,461	9,894	9,899	7,875	8,051	6,613	6,765	6,862
Fuvahmulah	7,528	8,055	8,666	7,319	7,169	5,612	5,858	5,872
Kulhudhuffushi	6,581	8,055	10,291	8,395	8,842	7,032	6,960	6,801
Villingili	4,291	7,304	8,061	6,446	6,847	5,164	5,521	5,567
Thinadhoo	4,893	4,707	5,004	3,999	4,165	3,148	3,464	3335
Naifaru	3,707	3,844	3,076	2,329	2,453	2,009	2,014	1,977
Feydhoo (Addu)	2,829	3,397	2,768	1,985	2,141	1,545	1,846	1,706
Kandoodhoo	2,224	3,333	5,260	5,113	5,042	3,611	3,809	3,796

Figure 33: Table of population trends in the Maldives from 2000 to 2014 and projections for 2050 across various scenarios (Source: Speelman et al., 2021)

6.3 CLIMATE FINANCE

Climate finance plays a crucial role in supporting adaptation initiatives in the Maldives. The country has actively sought funding through Official Development Assistance (ODA) and international climate finance mechanisms. Twenty-eight SIDS have fully cost Nationally Determined Commitments requiring $287 billion from multilateral climate funds and other sources over the next decade (Bishop et al., 2023). Despite being recognized as ‘particularly vulnerable’ by the GCF and other climate funds, SIDS has collectively lost $153 billion to extreme weather events since 2010 and receives significantly less climate finance than Least Developed Countries (LDCs) (Fresnillo and Crotti, 2022). More affluent countries bear a moral obligation towards groups such as SIDS, yet they receive only approximately 14% of the financial resources allocated to the least developed countries (Muizzu, 2024). A GCF evaluation noted that SIDS attracts substantially less co-finance and that 10 SIDS have never participated in GCF projects. The challenges include a focus on large-scale mitigation projects unsuitable for SIDS, arduous and costly application processes, long project timelines, and perceptions of SIDS as poor investments due to their small size, high bureaucratic demands, and low returns, with many having populations under 100,000 and GCF funding typically going to projects of $10 million and upwards (Bishop et al., 2023).

The Maldives Green Fund, established to attract investments for climate action, is one such example (Ministry of Environment, 2020b). The government has mobilized resources through innovative financing mechanisms, including public-private partnerships and green bonds, to finance large-scale adaptation projects. The nation urgently needs international financing to advance critical climate initiatives, enhance infrastructure, expand urbanization for essential services, and invest in renewable energy sources to create climate-resilient communities and transition through the energy shift, but this depends on support from global financiers (Muizzu, 2024). It needs a comprehensive financing plan for its climate adaptation strategy due to its high debt and expensive adaptation needs. While the NDC outlines goals, it lacks detailed implementation strategies and cost estimates (Ministry of Environment, 2020b). The country's minimal greenhouse gas emissions (0.003%)

imply low mitigation costs, but adaptation costs are high. As such the National Biodiversity Strategies and Action Plan (NBSAP) II: 2016-2025 indicates financing needs at 64% of the 2022 government revenue, highlighting the urgent need for robust financial planning (World Bank, 2024).

A 2022 Technical Assessment of Climate Finance for Island States in the Indian Ocean by the UNFCCC estimates that the Maldives will need approximately US$1 billion to meet its updated mitigation goals, and US$64 million for adaptation necessities related to water security, based on information from the Maldivian Ministry of National Planning, Housing, and Infrastructure, and the Ministry of Environment, Climate Change, and Technology (World Bank, 2024). Coastal protection is critical for the Maldives, with adaptation costs depending on the chosen strategy. Documents such as the "Report of the Survey of Climate Change Adaptation Measures in Maldives" (Ministry of Environment and Energy, 2015) provide potential cost estimates. The Government of Maldives (GoM) references these in its Second Communication to the UNFCCC and its Technical Assessment of Climate Finance for Island States in the Indian Ocean (World Bank, 2024).

The debate around climate finance often revolves around the adequacy and accessibility of funds. For example, even though the proportion of climate money allocated to SIDS for adaptation purposes has increased from 3% in 2019 to 6% in 2020, these nations still have less than 10% of the necessary weather and climate data (UNDP, 2023). While international support is essential, the Maldives has emphasized the need for streamlined access to climate finance to implement timely and effective adaptation measures. Sustainable construction must coexist with environmental stewardship, a responsibility taken seriously by the country by pausing crucial development projects due to severe coral bleaching caused by global heating (Muizzu [president of Maldives], 2024). However, projects like Ras Malé are viewed as infrastructure work by some climate financiers and multilateral banks, resulting in a lack of climate funding for these projects, despite their costs ranging from millions to billions of dollars (Muizzu [president of Maldives], 2024[SM1]). The integration of climate resilience into national development planning is seen as a critical step in enhancing the country’s capacity to attract and utilize these funds effectively (Gussman & Hinkel, 2021).

[SM1]Do we need to highlight that this statement is from the President of Maldives

7. CONCLUSION

The Maldives, being a representative Small Island Developing State (SIDS), demonstrates the significant susceptibility of low-lying island nations to the rise in sea levels and climate change. Due to 80% of its land area being less than one meter above sea level, the Maldives is at a significant risk of being submerged and experiencing severe climatic consequences by the year 2100. The nation has already seen substantial coastal erosion, frequent floods, and salinization of freshwater resources, all of which pose a threat to its socio-economic stability. These repercussions are not just theoretical.

The country has recognized land reclamation as a crucial adaptive strategy. The government's proactive approach to addressing land scarcity and managing flood hazards is exemplified by projects such as the construction of Hulhumalé, an artificial island raised 1.8 meters above sea level. These efforts offer extra land for housing and economic activities, acting as a protective barrier against coastal erosion and flooding. Nevertheless, these endeavors are accompanied by ecological and economic obstacles, underscoring the necessity for sustainable strategizing and global assistance.

The Maldives has enacted a range of initiatives to tackle the difficulties presented by climate change and the rising sea levels. The Environmental Protection and Preservation Act of 1993 and the Maldives National Building Code (2008) play a crucial role in advancing sustainable development and mitigating flood hazards by requiring a minimum elevation of 60cm for new residential buildings. In addition, the Maldives Decentralization Act (2010) and the National Adaptation Plan of Action (2012) emphasize the government's dedication to incorporating climate resilience into national development planning.

Climate financing is essential for providing financial assistance to these adaptation actions. The Maldives actively pursues money through channels such as the Maldives Green Fund and international climate finance routes. Nevertheless, the difficulty of accessing these funds persists, requiring the implementation of efficient procedures to ensure the prompt and efficient execution of adaption plans.

Ultimately, the experience of the Maldives highlights the pressing requirement for comprehensive and diverse strategies to address climate adaptation. The nation's proactive initiatives to reclaim land and its extensive policy frameworks serve as a model for other Small Island Developing States (SIDS) that are also dealing with comparable challenges. To effectively address the increasing climate issues, it is crucial to have ongoing global assistance and creative methods of funding that can strengthen resilience and promote sustainable development.

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THE RECOVER PROJECT:

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