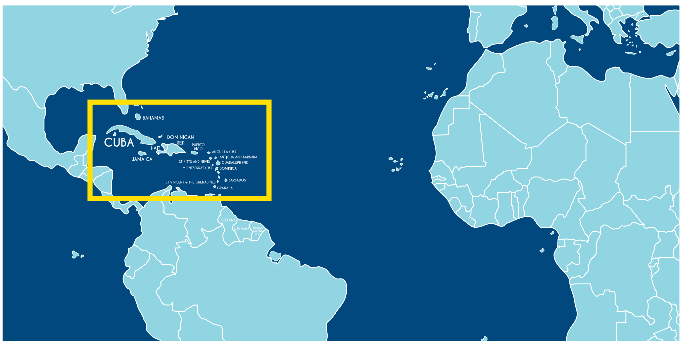
Assessment of adaptation potentials in the context of climate change

The case of tropical cyclones in the Caribbean – Climate Risk management in coastal LDCs and SIDS[1]

GLOBAL CONTEXT

Coastal Least Developed Countries (LDCs) and Small Island Developing States (SIDS), 54 nations spanning the globe, are highly vulnerable to the impacts and risks of climate change in general and ocean- and coastal-related climate change in particular. These countries already experience negative impacts and face significant risks, both from climate change-induced extreme weather events such as storms, and from slow onset processes including sea-level rise, land erosion, and changes in the global water cycle (Thomas et al., 2020)[2]

Map of the Caribbean. Several nations in the region are Small Island Developing States (SIDS), and currently already experience negative impacts from climate change. Climate Change impacts are projected to be some of the largest for SIDS.
(Source: depositphotos)



1 The completed study will be available online
2 Thomas, A., Baptiste, A., Martyr-Koller, R., Pringle, P., & Rhioney, K. (2020). Climate change and Small Island Developing States. Annual Review of Environment and Resources, 45(6), 1–27.

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Current climate impacts and projected risks to the Caribbean. *Source: IPCC, 2019; Thomas et al., 2020.*

	Current Climate change impact	Projected Risk at 1.5°C warming	Projected Risk at 2°C warming
Ecosystem			
Coral	Negative	• Very high	• Very high
Coastal wetlands	Negative	• High	• High
Mangrove	Negative	• Moderate	• Moderate
Human systems			
Fisheries	Negative	• High	• Very high
Tourism	Negative	• Moderate	• Moderate

The Caribbean climate risk profile

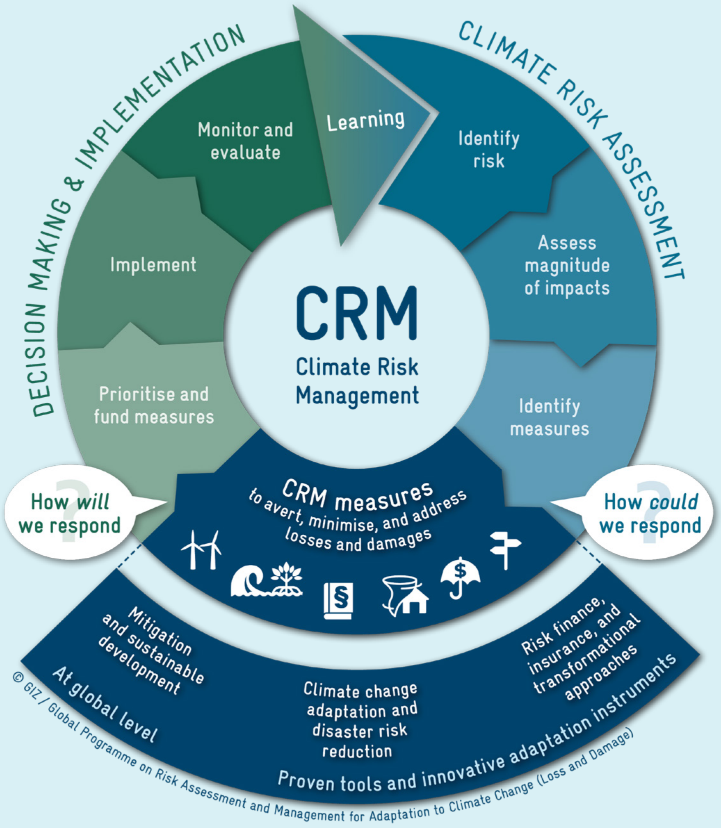
The study region of the Caribbean is extensively exposed to disasters related to natural events – six Caribbean islands are in the top 10 most disaster-prone countries in the world, and all Caribbean countries are in the top 50 (Moody's Investors Service, 2016)[3]. Tropical cyclones are a key coastal and ocean climate change risk relevant to LDCs and SIDS. With projected increases in tropical cyclone intensity and precipitation as a result of climate change (IPCC, 2019)[4], it is crucial to understand the impact of extreme weather events on at-risk coastal developing economies such as Caribbean SIDS, as well as to chart a potential path to resilience through analysis of adaptation potential. Understanding of negative climate change impacts, the potential to avert and minimise such impacts through mitigation and adaptation, and the potential to address the losses and damages that may nevertheless occur due to barriers and limits of adaptation measures, is of vital importance.

OBJECTIVE

The aim of this study is to offer insights into coastal risk in the Caribbean, identify trends of adaptation options and their effectiveness to reduce economic damages. This approach is intended to be a first step towards more detailed analyses at the island level to produce more accurate estimates of projected economic damages. Neverthe-

3 Moody's Investors Service. (2016). Understanding the Impact of Natural Disasters: Exposure to Direct Damages Across Countries. https://legacy-assets.eenews.net/open_files/assets/2016/11/30/document_cw_01.pdf

4 IPCC. (2019). Sea Level Rise and Implications for Low-Lying Islands, Coasts and Communities. In IPCC Special Report on the Ocean and Cryosphere in a Changing Climate



Climate Risk Management Framework developed by GIZ

Climate risk management (CRM)

For coastal LDCs and SIDS, climate hazards that impact coastal areas directly or indirectly combine with the high exposure of population and assets in low-lying and/or coastal areas, and can be exacerbated by existing or potential vulnerabilities for certain groups GIZ's Global Programme on Risk Assessment and Management for Adaptation to Climate Change (Loss and Damage) (GP L&D), supported by the German Federal Ministry for Economic Cooperation and Development (BMZ), has developed a risk-based, iterative framework to manage risk and potential impacts related to natural and climate-induced hazards. It considers biophysical, social, economic, non-economic, and environmental aspects and takes into account the entire spectrum of climate-relatedhazards and triggered risks, from short-term extreme weather events to long-term slow onset processes. To minimise losses and damages, CRM combines a smart mix of approaches from climate change adaptation and disaster risk reduction. To address residual losses and damages, these are complemented by more innovative adaptation tools such as risk finance and insurance, and transformational approaches such as livelihood diversification. Tried and tested measures are linked with innovative instruments and transformational approaches in a comprehensive and integrated way.[5] Ultimately, CRM implies that all sectors factor risks into plans, including considering how risks may affect action across sectors.

less, the results shown here reflect accurate trends in the performance of various adaptation options and portfolios for multiple climate change scenarios.

METHODOLOGY

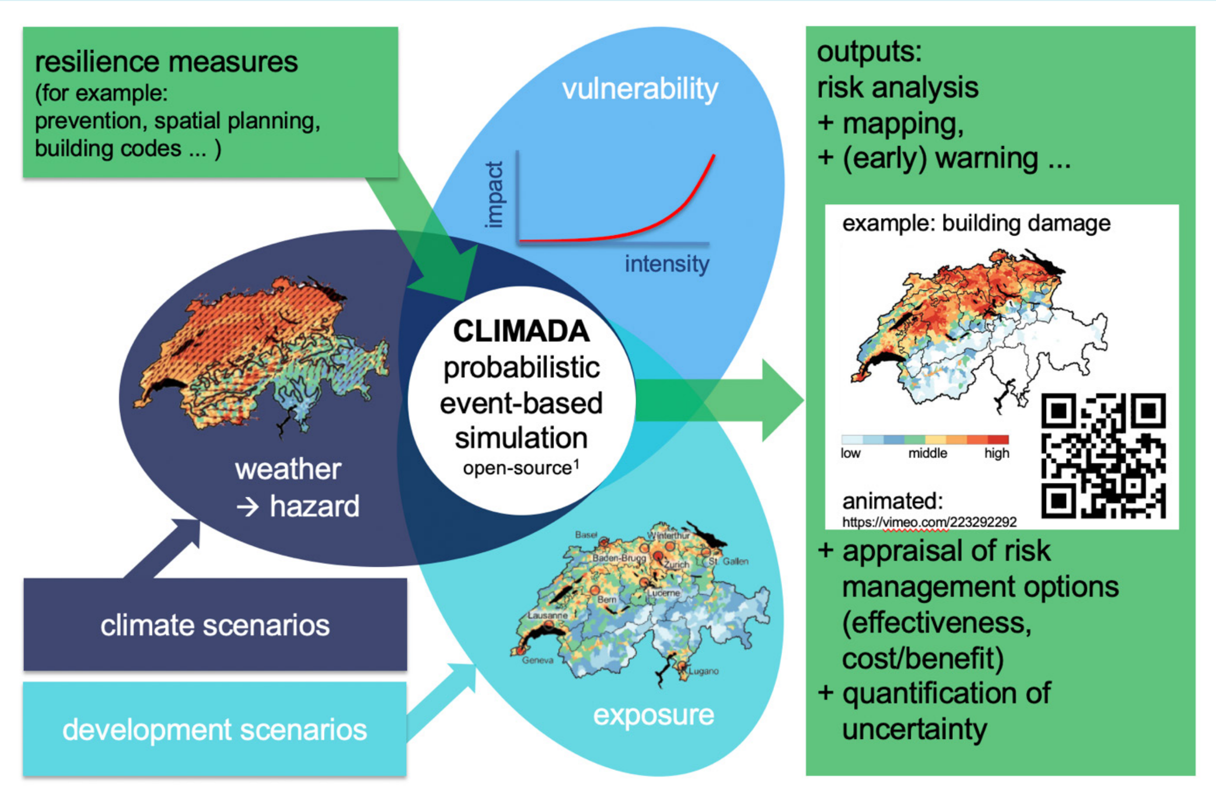
This study was performed at the regional to country level using the northern Caribbean, including 10 SIDS nations of varying size, population, and economic development because of their high susceptibility to the negative impacts of climate change. The case study in this report is based on a quantitative analysis of tropical cyclones, a key coastal and ocean climate change risk relevant to LDCs and SIDS.

5 GIZ Global Programme on Risk Assessment and Management for Adaptation to Climate Change. (2021). Climate risk management: Promising pathways to avert, minimise, and address losses and damages.

Applying CLIMADA to project risk and coastal adaptation potentials

CLIMADA is a tool for climate risk modelling and analysis which provides critical information for comprehensive and climate risk management. It can assist decision-makers to answer the following questions:

- What are the climate risks today and in the future?
- What are the expected climate-related economic losses due to these climate risks?
- What are potential adaptation measures to deal with the risks, and how effective are these measures in terms of damage reduction?
- What are the expected benefits and costs?



Visualisation of the CLIMADA framework. *Source: https://wcr.ethz.ch/research/climada.html*

Input data and selected adaptation measures

A probabilistic modelling approach was applied to quantify the risk from tropical cyclones, and averted damages from a range of adaptation options. A mixed portfolio of adaptation measures, including cost–benefit analysis, was produced. Present-day country risk from tropical cyclone damage, without considering adaptation, was determined. The impacts of climate change in the near term (2030) and at the end of the century (2100) were assessed for two scenarios of climate change: 1) a scenario in line with the Paris Agreement, pursuing efforts to limit global warming to 1.5°C by 2100; and 2) a scenario based on current government policies to reduce emissions, leading to projected global warming of 3°C by 2100.

Open-access data was used as an input for this modelling exercise, including LitPoP (estimates of physical asset values based on nightlight intensity and population count data) and IBTracs (International Best Track Archive for Climate Stewardship).[6] The use of open-access data and the open-source model CLIMADA[7] allows the replication and further customisation of these results. Using CLIMADA thus provides transparent results and enables users to customise the analysis according to their needs and available data.

6 For further information see GIZ & Climate Analytics (2021) which will be available online
7 The code (including the parameters) is available in the Climate Analytics Gitlab repository.

FINDINGS: PROJECTED ADAPTATION POTENTIALS AGAINST TROPICAL CYCLONES IN THE CARIBBEAN

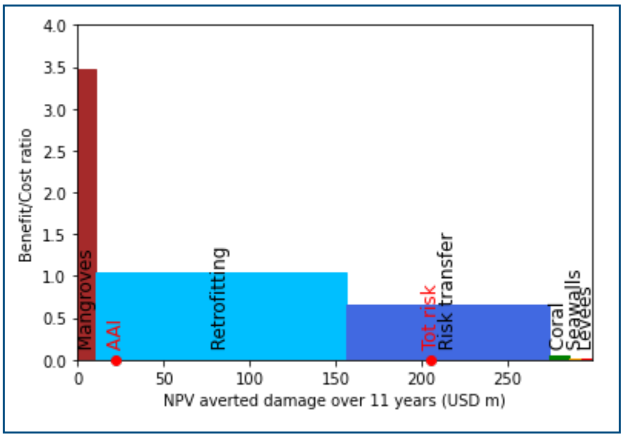
Results show an increase in risk from tropical cyclones in the future due to climate change. This is caused by an increase in the intensity of tropical cyclones, whereas low-probability but high-intensity events are projected to cause most of the damage. Changing exposure and vulnerabilities can also increase the risk but these were not within the focus of this analysis. The risk is reduced if global warming is kept to below 2°C.

Adaptation potentials

Adaptation measures can cover the future risk, though the extent is country-specific and depends on barriers to implementation. Nature-based solutions such as mangroves and coral reefs, and soft measures such as building retrofitting, have been shown to have a benefit–cost ratio greater than 1, indicating that the benefits exceed the costs. More expensive measures such as hard engineering (sea levees or seawalls) show higher costs than benefits. In the short term some measures do not seem to be cost-efficient, but a long-term outlook show that those measures can turn out very cost-efficient. Therefore, considering different time horizons and different scenarios as well as a smart mix of context-specific climate management measures can be underlined as useful if not essential for solid adaptation planning.

Regional comparison

The comparison of the distinct islands shows that some countries have a higher adaptation potential than others. Countries with a greater amount of coastal ecosystem services, in this case mangroves and coral reefs, show especially promising results to cover all present and future risk from tropical cyclones by using a mixed adaptation portfolio. In the case of high-intensity events, e.g. those with a likelihood to occur every 100 years, the risk can be



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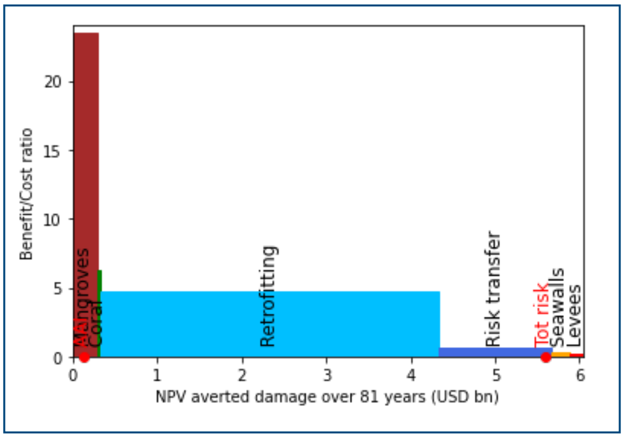

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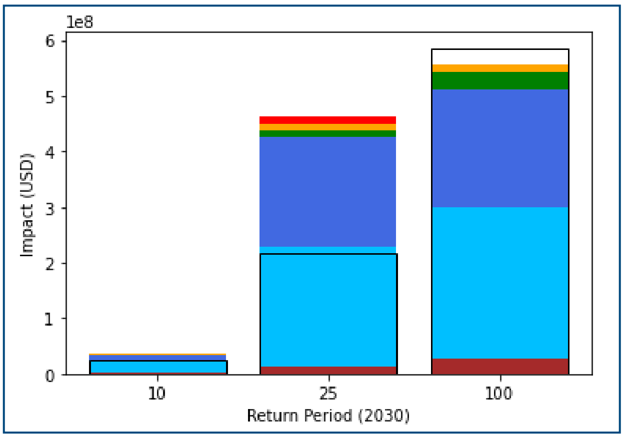

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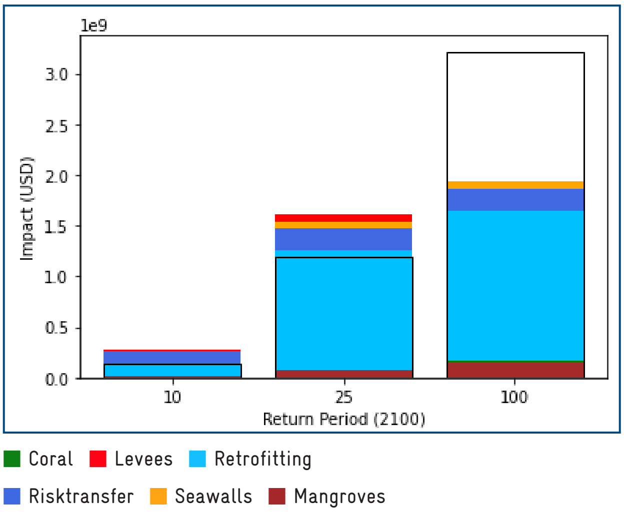

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Adaptation cost curves for Antigua and Barbuda in (left) 2030 (1.4°C global warming) and (right) 2100 (3°C global warming). Net present value (NPV) of averted damages is presented in USD million (left) or billion (right). Two red dots are provided: one for the average annual impact (AAI) and one for the total aggregated risk over the whole period (Tot risk). (See figure 1-2)

Impact of adaptation measures on the adaptation gap resulting from tropical cyclones affecting Antigua and Barbuda once in 10, 25, and 100 years in (left) 2030 (1.4°C global warming) and (right) 2100 (3°C global warming). The y axis shows the impact of events with return periods of 10, 25, or 100 years. The boxes with black outlines show the risk, while the coloured boxes show the avertable damages. The white space indicates the adaptation gap, the economic losses that remain after applying all available adaptation measures. (See figure 3-4) averted in this test case for Antigua and Barbuda. Other countries such as Dominica face an adaptation gap: more than two-thirds of the risk cannot be averted with the underlying adaptation measures under a high climate change scenario. Dominica is characterised by comparably less nature-based coastal adaptation.

CONCLUSION AND OUTLOOK

CLIMADA proves as a tool to quantify not only potential (economic) damages from extreme events, in this case tropical cyclones, but also the potentials of adaptation measures, provided accurate data is available and parameters are chosen purposefully. The tool supports the application of several adaptation measures for distinct hazards to determine averted damages and assess the costs and benefits of individual measures.

Limits of the approach applied here
Results presented in the study provide trends in performance of various adaptation options and portfolios for several climate change scenarios. For the time being, the tool does not consider:

- multi-hazard or compound events
- slow onset processes
- expected changes in exposure or vulnerability due to socio-economic development
- non-economic losses and damages
- further nature-based solutions such as afforestation, reforestation, and restoration of coral reefs

which, among others, significantly determine the resulting risks and are equally critical in understanding the full impacts of climate change. All of these factors must be included in adaptation and disaster risk reduction planning.

Potential application of CLIMADA in decision-making

This approach constitutes a first step towards understanding adaptation potentials in more detail and towards enabling the identification of trends at the regional to local level, not least with the objective of strengthening local capacities and decision-making. The tool can help to understand trends and uncertainties; however, results with absolute numbers should be treated with caution since only a limited set of hazards is available. The role of

available, context-specific, and timely scientific knowledge as the basis for planning and decision-making, as well as the integration of (political) decisions into local policies, constitute crucial parts of the assessment of climate risks and the identification, selection, and combination of suitable adaptation measures. CLIMADA can add value to these processes and further development of the applied approach is therefore recommended by the authors.

CLIMADA can help decision-makers to answer relevant questions.

**responses included below resonate with the findings from the study*

What are the climate risks today and in the future?

- increased risk from tropical cyclones by 2100 under a warming scenario of 3°C associated with current emissions trajectories
- reduced risk if climate action can limit global warming to below 1.5°C above pre-industrial levels by 2100

What are the expected climate-related economic losses due to these climate risks?

- expected accumulated damages from tropical cyclones increasing by up to 5 % in 2030 and 150 % in 2100 relative to 2020, due to increased cyclone intensity as a result of climate change
- when limiting global warming to 1.5°C by 2100, reduction of the increase in risk by 80 % in 2100 in comparison with a 3°C warming scenario

8 Understood here as the economic damages that remain after applying all available adaptation measures.

What are potential adaptation measures to deal with the risk, and how effective are these measures in terms of damage reduction?

- grey infrastructure such as seawalls and levees
- nature-based solutions (high benefit–cost ratios)
- improved infrastructure through retrofitting of houses
- risk transfer through insurance
- For some islands and in some scenarios a mix of adaptation measures have the potential to avert damages from tropical cyclones. For other islands, an adaptation gap[8] may still be incurred

What are the expected benefits and costs?

- identification of regions which are at particular risk
- identification of adaptation measures to be prioritised
- illustration of the change in benefits over time
- for nature-based measures: reductions to damages are high relative to other measures; however, the negative impacts of climate change subsequently reduce the measures' effectiveness.

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