CCRIF
The Caribbean Catastrophe Risk Insurance Facility

CARIBBEAN CATASTROPHE RISK INSURANCE FACILITY

A SNAPSHOT OF THE ECONOMICS OF CLIMATE ADAPTATION STUDY IN THE CARIBBEAN

NOVEMBER 2011

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A Snapshot of the Economics of Climate Adaptation Study in the Caribbean

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About CCRIF

The Caribbean Catastrophe Risk Insurance Facility (CCRIF) is the first multi-country risk pool in the world, and is also the first insurance instrument to successfully develop parametric policies backed by both traditional and capital markets. It is a regional catastrophe fund for Caribbean governments designed to limit the financial impact of devastating hurricanes and earthquakes by quickly providing financial liquidity when a policy is triggered. CCRIF was developed through funding from the Japanese Government, and was capitalised through contributions to a multi-donor Trust Fund by the Government of Canada, the European Union, the World Bank, the governments of the UK and France, the Caribbean Development Bank and the governments of Ireland and Bermuda, as well as through membership fees paid by participating governments.

Sixteen governments are currently members of the Facility: Anguilla, Antigua & Barbuda, Bahamas, Barbados, Belize, Bermuda, Cayman Islands, Dominica, Grenada, Haiti, Jamaica, St. Kitts & Nevis, St. Lucia, St. Vincent & the Grenadines, Trinidad & Tobago and Turks & Caicos Islands.

CCRIF therefore helps to mitigate the short-term cash flow problems small developing economies suffer after major natural disasters. A critical challenge is often the need for short-term liquidity to maintain essential government services until additional resources become available. CCRIF represents a cost-effective way to pre-finance short-term liquidity to begin recovery efforts for an individual government after a catastrophic event, thereby filling the gap between immediate response aid and long-term redevelopment.

Since the inception of CCRIF in 2007, the Facility has made eight payouts totalling US$32,179,470 to seven member governments. All payouts were transferred to the respective governments less than a month (and in some cases within a week) after each event. These payouts are shown in the table below.

Event	Country Affected	Payouts (US$)
Earthquake, 29 November, 2007	Dominica	528,021
Earthquake, 29 November, 2007	Saint Lucia	418,976
Tropical Cyclone Ike, September 2008	Turks and Caicos Islands	6,303,913
Earthquake, 12 January, 2010	Haiti	7,753,579
Tropical Cyclone Earl, August 2010	Anguilla	4,282,733
Tropical Cyclone Tomas, October 2010	Barbados	8,560,247
Tropical Cyclone Tomas, October 2010	Saint Lucia	3,241,613
Tropical Cyclone Tomas, October 2010	St. Vincent & the Grenadines	1,090,388
Total for the Period 2007 - 2010		**US$32,179,470**

Introduction

It is well known that Caribbean countries are vulnerable to hurricanes and storms – the impacts of which are likely to be exacerbated by climate change. In the last three decades, the Caribbean region has suffered direct and indirect losses estimated at US$700 million and US$3.3 billion respectively owing to natural disasters associated with extreme weather events. Significantly, two economic sectors of critical importance to the Caribbean – tourism and agriculture – will be heavily impacted by climate change in the years to come. However, estimating the potential economic consequences of the impacts of climate change on Caribbean countries is difficult, due to varying global climate change scenarios, limited geographical projections for the region, and an inadequate inventory of vulnerable assets and resources in these economies.

Caribbean leaders and decision makers have recognised the need for sound quantitative data to support the development of national climate adaptation strategies, plans and programmes. To facilitate this, the Caribbean Catastrophe Risk Insurance Facility (CCRIF) launched a study for the Caribbean region in February 2010 to create a knowledge base which would provide valuable information to decision makers about the optimal use of limited resources for adaptation.

The Economics of Climate Adaptation Study

This Economics of Climate Adaptation (ECA) study provides a sound economic fact base that countries can use to further develop their national climate adaptation and disaster management strategies to increase resilience against climate hazards. It was conducted by CCRIF, with Caribbean Risk Managers acting on behalf of the Facility, and supported by regional partners, the Caribbean Community Climate Change Centre, the UN Economic Commission for Latin America and the Caribbean and others. McKinsey & Company and Swiss Re provided analytical support.

The study focuses on eight pilot countries – Anguilla, Antigua and Barbuda, Barbados, Bermuda, the Cayman Islands, Dominica, Jamaica, and Saint Lucia – and is based on the Economics of Climate Adaptation (ECA) methodology developed by the ECA Working Group[1]. The innovation of this methodology lies in its incorporation of different knowledge arenas, including climate science, the financial industry and economic research.

The analysis focuses on quantifying the potential impact of climate change on three relevant natural hazards:

- Hurricane-induced wind damage
- Coastal flooding/storm surge
- Inland flooding due to both hurricanes and non-tropical systems

For each country, the study examines the impact of these key hazards on different economic sectors such as infrastructure (including housing), tourism and travel, industry, and the service

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[1] A consortium of public and private players including the Global Environment Facility (GEF), UNEP, Swiss Re, the Rockefeller Foundation, Climate Works, Standard Chartered, McKinsey & Company, and the European Union.

sector.

Additionally, the study analyses the economic impact of climate change on the agriculture sector for a few selected countries including detailed analyses for Belize and Jamaica, and assesses the risk of salinisation of groundwater due to changes in rainfall patterns and rising sea levels in Jamaica.

Based on these findings, the study prioritises areas and sectors at risk and provides clear inputs for building an economically viable portfolio of adaptation initiatives designed to increase each country's resilience.

About this Booklet

This booklet provides a snapshot of some of the preliminary results of the Economics of Climate Adaptation (ECA) study. In an easy-to-understand manner using graphs, maps and diagrams, the booklet presents the following:

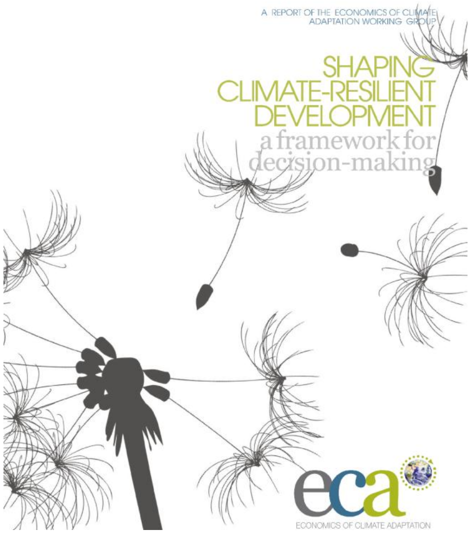
- ECA methodology
- Preliminary results for three of the pilot countries: Bermuda, Jamaica and Saint Lucia
- Analysis of the agriculture sector in Belize
- Case study focusing on salinisation in Jamaica

The booklet can be used by professionals in the disaster risk management arena to quickly demonstrate the value of the ECA study to national and regional decision makers.

The results for all eight pilot countries can be found in a short publication entitled, ***Enhancing the Climate Risk and Adaptation Fact Base for the Caribbean (Preliminary Results),*** available on the CCRIF website at: www.ccrif.org/publications/enhancing-climate-risk-and-adaptation-fact-base-caribbean.

The Methodology

The Economics of Climate Adaptation Methodology



A more detailed description of the ECA methodology and its applications is contained in the report published by the ECA Working Group in 2009, which can be downloaded from the following URL: http://www.mckinsey.com/clientservice/Social_Sector/our_practices/Economic_Development/Knowledge_Highlights/Economics_of_climate_adaptation.aspx

The methodology

Economics of Climate Adaptation (1/5)

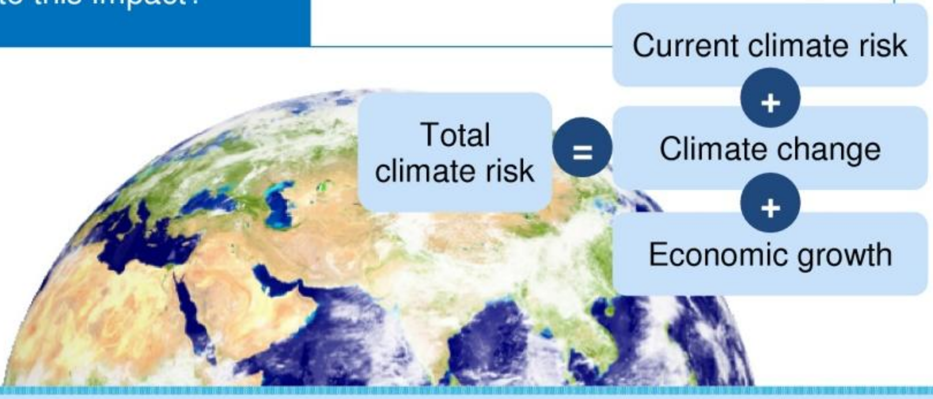
Aim of ECA effort: Help decision makers assess and address total climate risk

Questions

- How can we measure and predict the impact of climate change on our economies?
- How can we prepare to adapt to this impact?

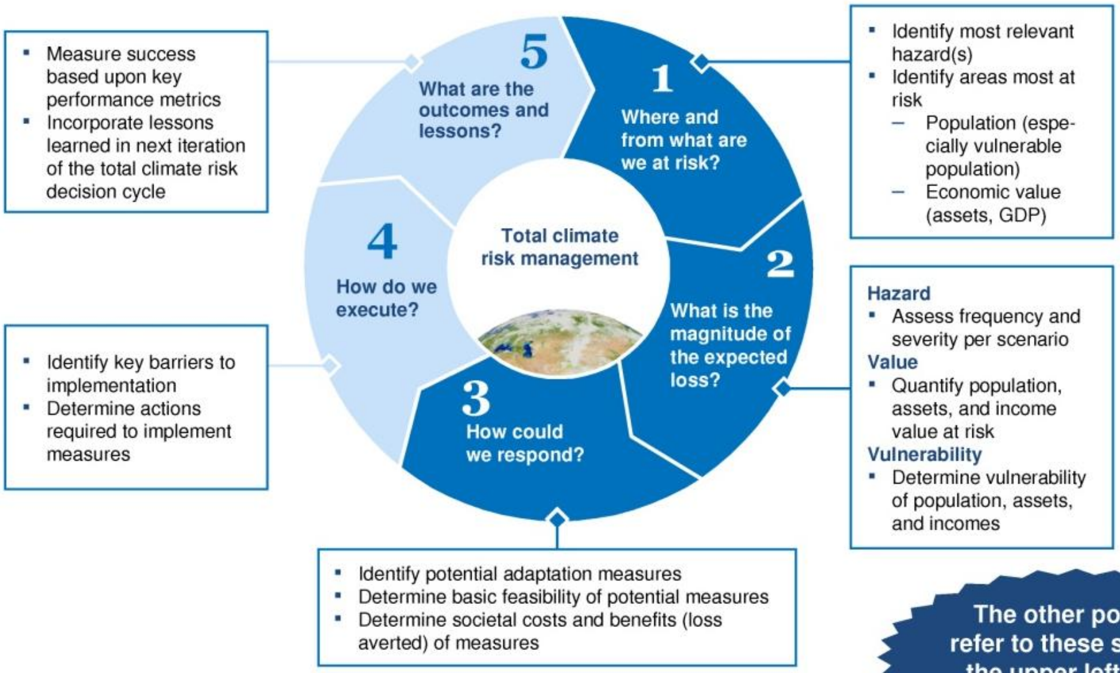
Working group's objective

- Provide decision makers with facts and a common approach to assess and address any location's "total climate risk“ (TCR)



Total climate risk = Current climate risk + Climate change + Economic growth

Our approach for total climate risk management



Total climate risk management

1 Where and from what are we at risk?

- Identify most relevant hazard(s)
- Identify areas most at risk
  - Population (especially vulnerable population)
  - Economic value (assets, GDP)

2 What is the magnitude of the expected loss?

Hazard
- Assess frequency and severity per scenario

Value
- Quantify population, assets, and income value at risk

Vulnerability
- Determine vulnerability of population, assets, and incomes

3 How could we respond?

- Identify potential adaptation measures
- Determine basic feasibility of potential measures
- Determine societal costs and benefits (loss averted) of measures

4 How do we execute?

- Identify key barriers to implementation
- Determine actions required to implement measures

5 What are the outcomes and lessons?

- Measure success based upon key performance metrics
- Incorporate lessons learned in next iteration of the total climate risk decision cycle

The other posters refer to these steps in the upper left-hand corner of each slide

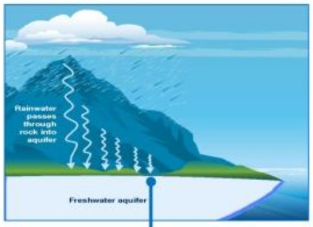
The methodology

Economics of Climate Adaptation (2/5)

WHERE AND FROM WHAT ARE WE AT RISK?

1 We analyze four main hazards

Salinisation



Salinisation of groundwater is modeled separately

Wind

Coastal flooding/ storm surge

- Hazards modeled jointly with CCRIF by Swiss Re/McKinsey
- Existing hazard model of CCRIF will be included into analysis

Inland flooding

Focus on flash flooding induced by torrential rains associated with hurricanes as well as other tropical weather systems

WHAT IS THE MAGNITUDE OF THE EXPECTED LOSS?

2 We use 4 modules to quantify expected losses for each scenario

C

Scenario 1 | Scenario 2 | Scenario 3

Modules	Description	Calculation	Output
H **Hazard module**	Severity and frequency of hazard for different climate change scenarios	H x VA x V	Expected loss per climate change scenario
VA **Value module**	Value of assets, incomes, and human elements		
V **Vulnerability module**	Vulnerability curves for different assets based on hazard severity for different climate change scenarios		

The other posters refer to these steps in the upper left-hand corner of each slide

The methodology

Economics of Climate Adaptation (3/5)

WHAT IS THE MAGNITUDE OF THE EXPECTED LOSS?

2
C

Example for climate: we developed three scenarios – today's climate, moderate change, and high change – for each local climate effect to 2030

Scenarios	Local effects of climate change			
	Sea level rise (SLR)	Sea surface temperature (SST)	Air temperature change	Precipitation change
Today's climate	~ 0 mm/yr	~ Wind speeds and hurricanes same as today	~ Same as today	~ Same as today
Moderate change	↑ **3 mm/yr**, plus local uplift/ subsidence	↑ Wind speeds increase by **2-3%**	↑ 0.3ºC increase	↓ **Decrease of 2 to 3%***
High change	↑ **15 mm/yr**, plus local uplift/ subsidence	↑ Wind speeds increase by **~5%**	↑ 0.4°C increase	↓ **Decrease of 4 to 6%***

* Varies by country. Also, although average annual precipitation is expected to decrease in most cases, the intensity of extreme rainfall events – which drives inland flooding – may either increase or decrease

WHAT IS THE MAGNITUDE OF THE EXPECTED LOSS?

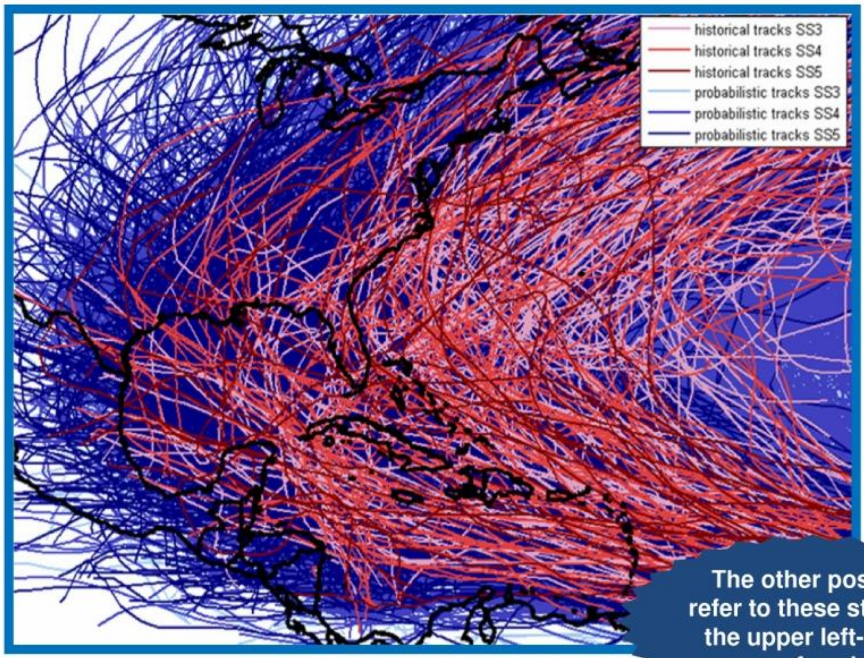
2
H

Example for hazard module: we use the Swiss Re tropical cyclone model to estimate the economic losses caused by hurricanes

North Atlantic tropical cyclone event set

🟥 historic
~100 years

🟦 probabilistic
~10,000 years



The other posters refer to these steps in the upper left-hand corner of each slide

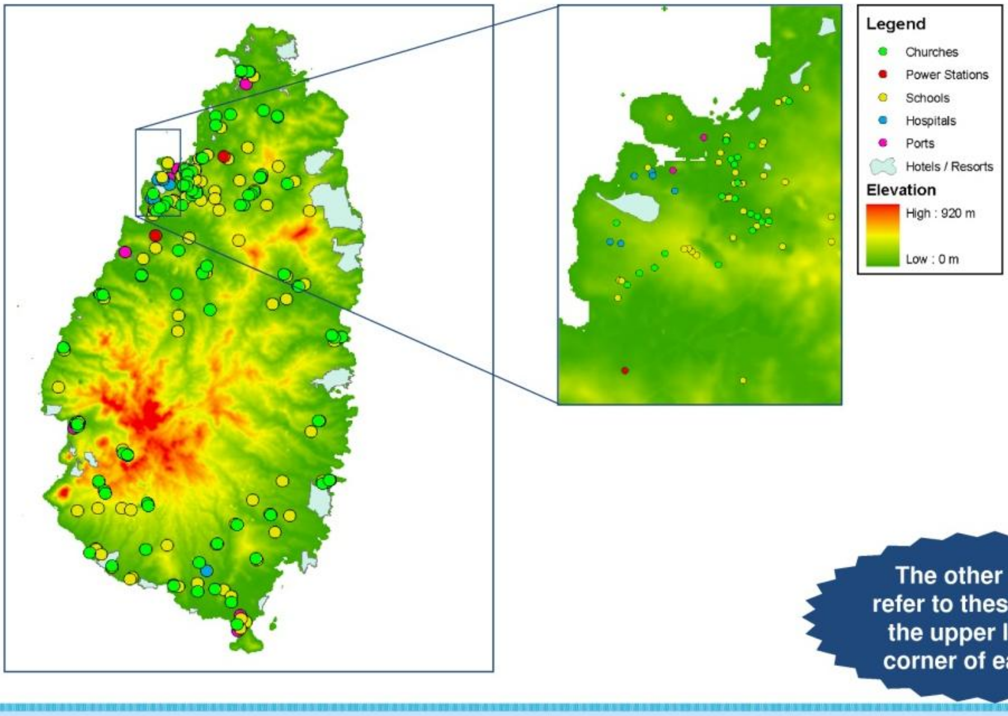
The methodology

Economics of Climate Adaptation (4/5)

WHAT IS THE MAGNITUDE OF THE EXPECTED LOSS?

2
VA

Example for value module: we use GIS data to map countries' economic value against hazard exposure



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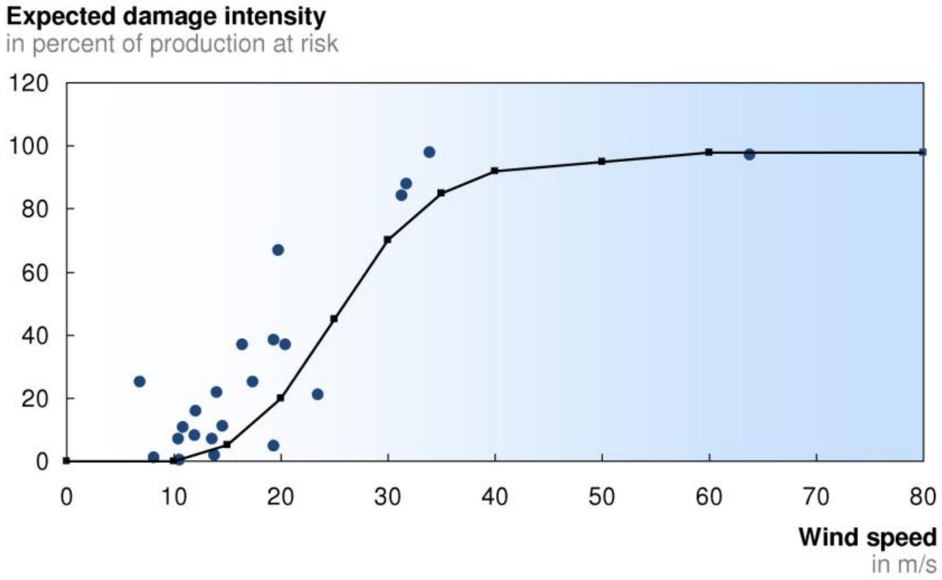
WHAT IS THE MAGNITUDE OF THE EXPECTED LOSS?

2
V

Example for vulnerability module: we use historical data to construct damage functions for the relevant assets

Vulnerability function for bananas



The methodology

Economics of Climate Adaptation (5/5)

HOW COULD WE RESPOND?

3 We consider a broad range of adaptation measures

	Description
Infrastructure/asset based responses	▪ Any measures that require physical changes to existing assets or building of new assets
Systemic/ behavioral responses	▪ Measures that involve behavioral change or a coordinated systemic response at a community level
Financial responses	▪ Financial risk transfer mechanisms and alternative financial solutions

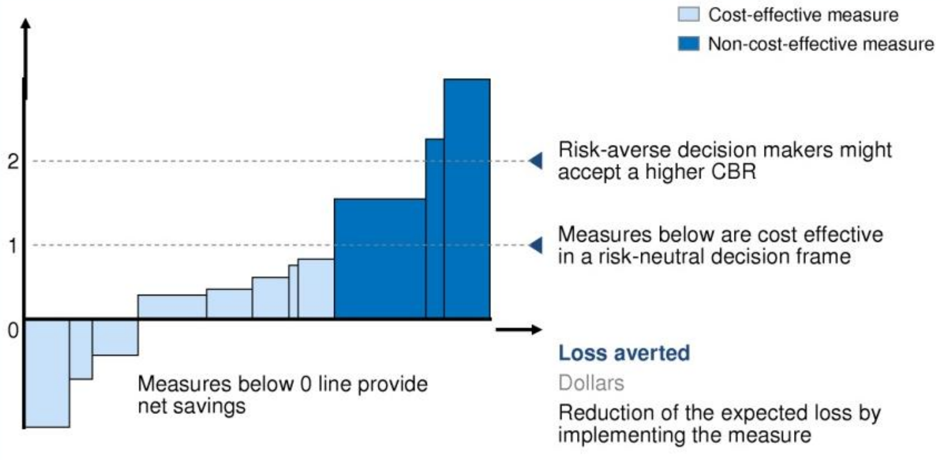
HOW COULD WE RESPOND?

3 We consider a broad range of adaptation measures

ILLUSTRATIVE

Cost-benefit curve of adaptation measures

Cost per loss-averted ratio



Risk-averse decision makers might accept a higher CBR

Measures below are cost effective in a risk-neutral decision frame

Measures below 0 line provide net savings

Loss averted

Dollars

Reduction of the expected loss by implementing the measure

The other posters refer to these steps in the upper left-hand corner of each slide

Country Results

Preliminary Results for
Bermuda, Jamaica and Saint Lucia

Bermuda

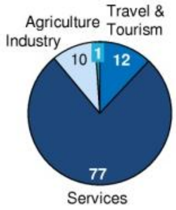
Preliminary country results (1/3)

Key characteristics of Bermuda

Geography

Economy

GDP composition (2009)
Percent



- GDP (2004, PPP)
  - USD 69.9 thousand per capita
  - USD 4.5 billion total
- Unemployment rate 2.1% (2004 est)
- Industries – international business, tourism, light manufacturing
- Most important agriculture products – bananas, vegetables, citrus, flowers; dairy products, honey

Geography and geology

- 54 sq km in area
- 103 km coastline
- Highest elevation – 76 m
- Low hills separated by fertile depressions

Population

- Total population in July 2009 ~ 68,000
  - 100% urban population (2008)
  - 18% below age of 15
  - Median age – 41 years
- Literacy[1] – 98% (2005 est)
- Languages – English (official) and Portuguese

In Bermuda, we examined the impacts of wind hazard, coastal flooding and inland flooding on tourism, the service industry and general infrastructure and housing

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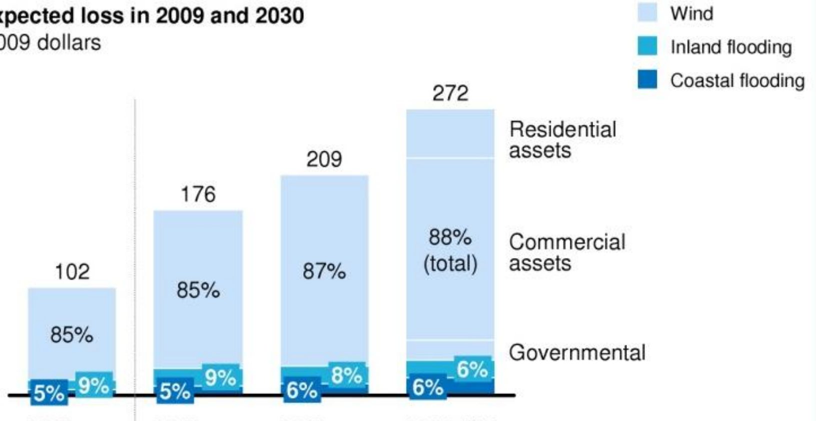
[1] Definition – age 15 and over, has ever attended school

WHAT IS THE MAGNITUDE OF THE EXPECTED LOSS?

2 Annual expected loss in Bermuda today and under climate scenarios for 2030

Annual expected loss in 2009 and 2030
USD m, 2009 dollars



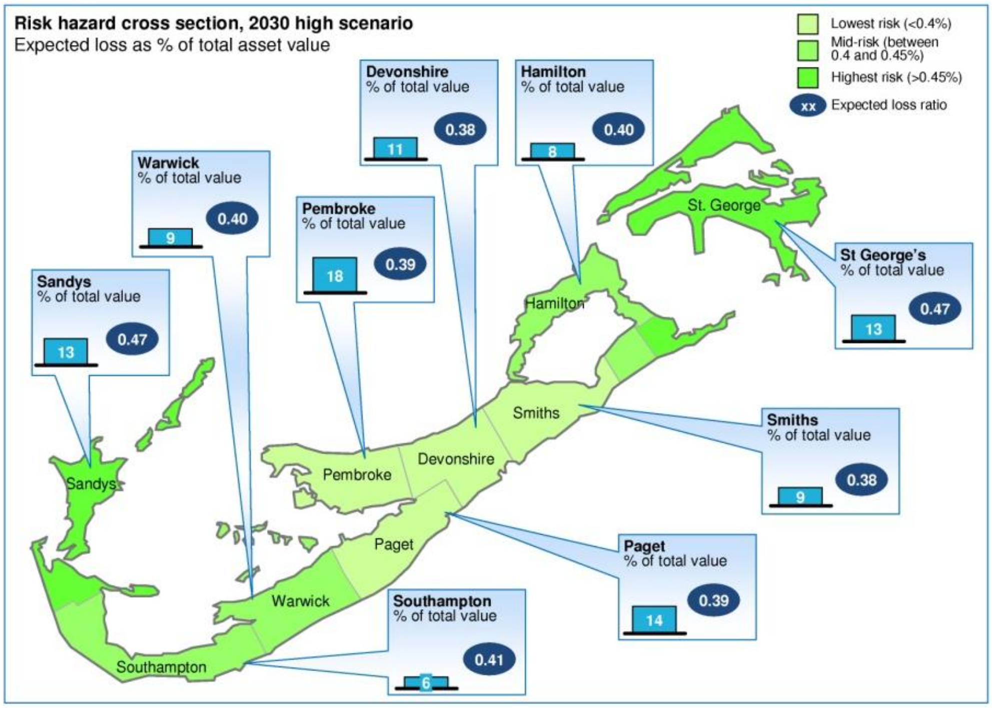
Scenarios	2009 Today's climate	2030 Today's climate	2030 Moderate change	2030 High change
Percent of total GDP	1.7	1.7	2.0	2.6
Percent of total asset value	0.27	0.27	0.32	0.41

Bermuda

Preliminary country results (2/3)

WHAT IS THE MAGNITUDE OF THE EXPECTED LOSS?

2 Geographical distribution of risk and value in Bermuda

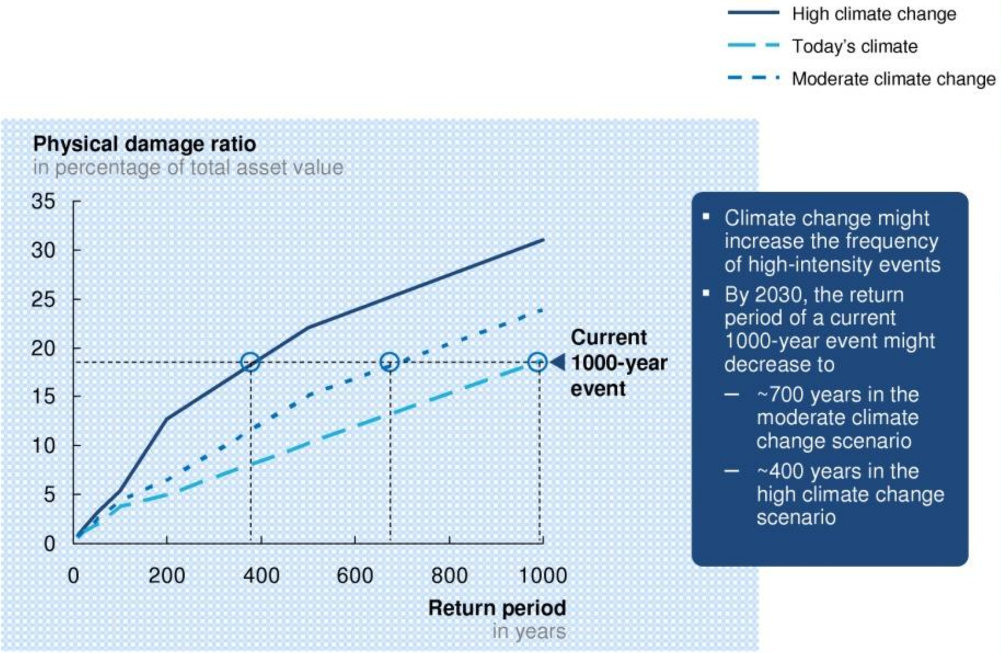


Risk hazard cross section, 2030 high scenario

Expected loss as % of total asset value

WHAT IS THE MAGNITUDE OF THE EXPECTED LOSS?

2 Impact of climate change on return period of extreme events



- Climate change might increase the frequency of high-intensity events
- By 2030, the return period of a current 1000-year event might decrease to
  - ~700 years in the moderate climate change scenario
  - ~400 years in the high climate change scenario

Bermuda

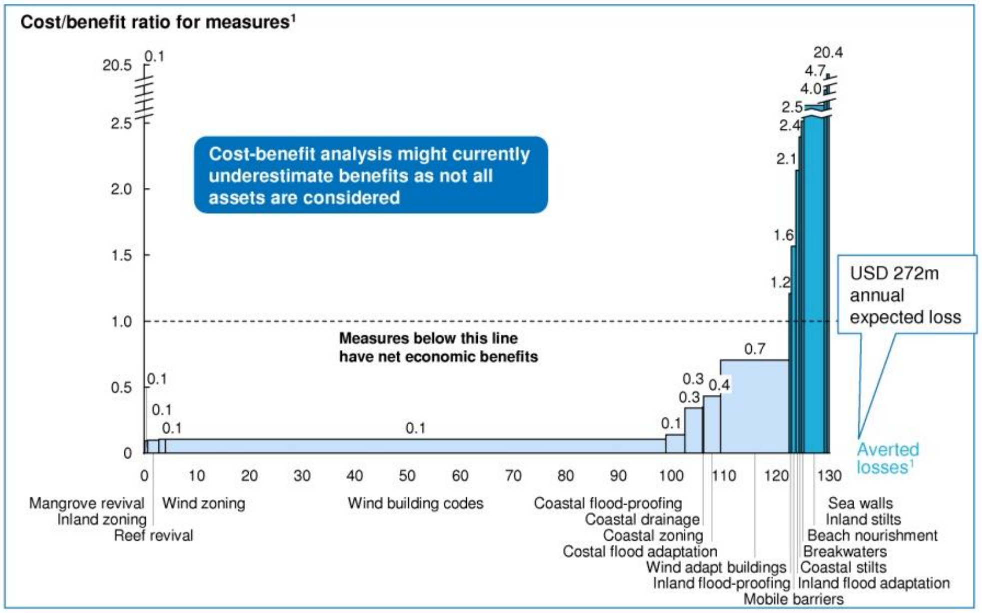
Preliminary country results (3/3)

WHAT COULD WE DO TO RESPOND?

3 Cost-benefit ratio and loss avoidance potential for adaptation measures

In USD m, 2009

2030: HIGH CHANGE

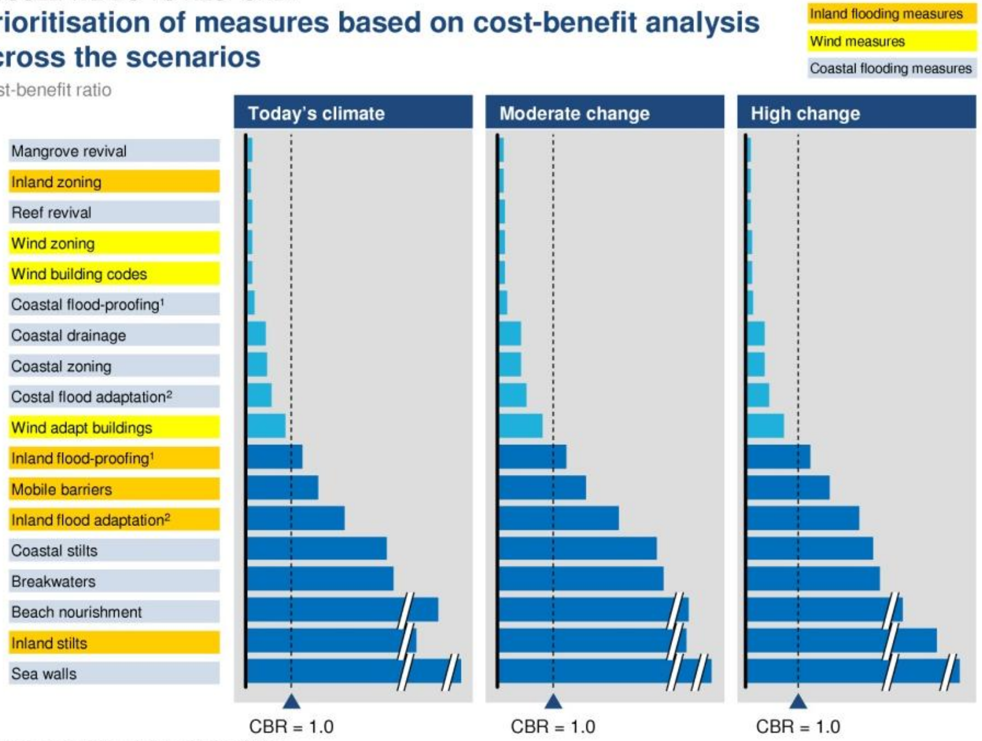


1 Does not account for synergies and dis-synergies between measures (e.g., building seawalls behind a breakwater)

WHAT COULD WE DO TO RESPOND?

3 Prioritisation of measures based on cost-benefit analysis across the scenarios

Cost-benefit ratio



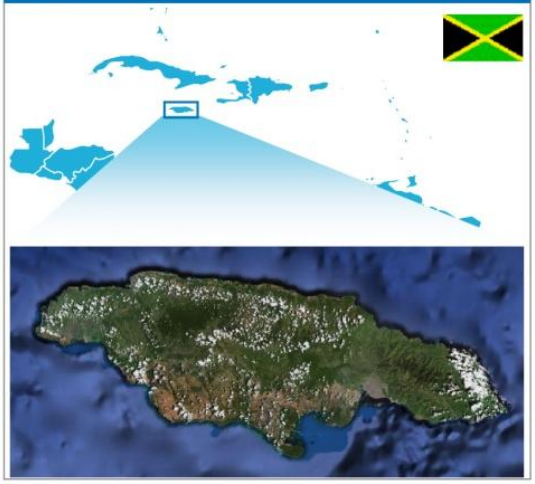
1 For new buildings 2 For existing buildings

Jamaica

Preliminary country results (1/3)

Jamaica: basic facts and statistics

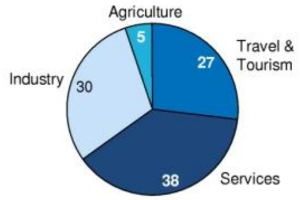
Geography



Geography and geology

- 10,991 sq km sq km in area
- 1,022 km coastline
- Highest elevation – 2,256 m
- Mostly mountains, with narrow, discontinuous coastal plain
- 9.4 km³ of renewable water resources

Economy



GDP composition (2009)
Percent

- GDP (2009, PPP)
  - USD 8.3 thousand per capita
  - USD 23.36 billion total
- Unemployment rate 14.5% (2009 est)
- Industries – tourism, bauxite/alumina, agro processing, etc.
- Most important agriculture products – sugarcane, bananas, coffee, citrus

Population

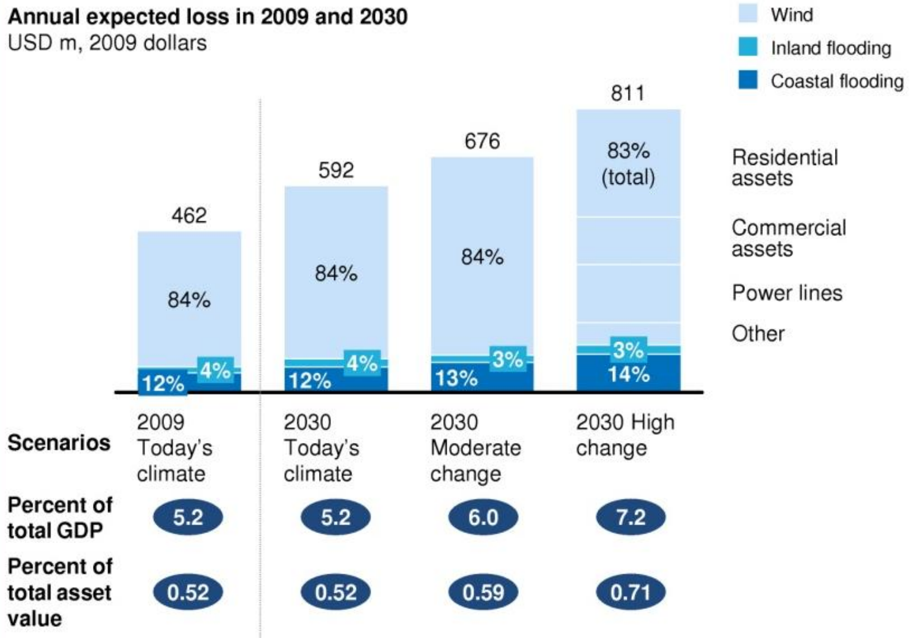
- Total population in July 2009 ~ 2,826 thousand
  - 53% urban population (2008)
  - 31% below age of 15
  - Median age – 24 years
- Literacy[1] – 87.9%
- Languages – English, English patois

[1] Definition – age 15 and over, has ever attended school

In Jamaica, we examined the impacts of wind hazard, coastal flooding, salinisation and inland flooding on tourism, the service industry, agriculture and general infrastructure and housing

WHAT IS THE MAGNITUDE OF THE EXPECTED LOSS?

2 Annual expected loss in Jamaica today and under climate scenarios for 2030



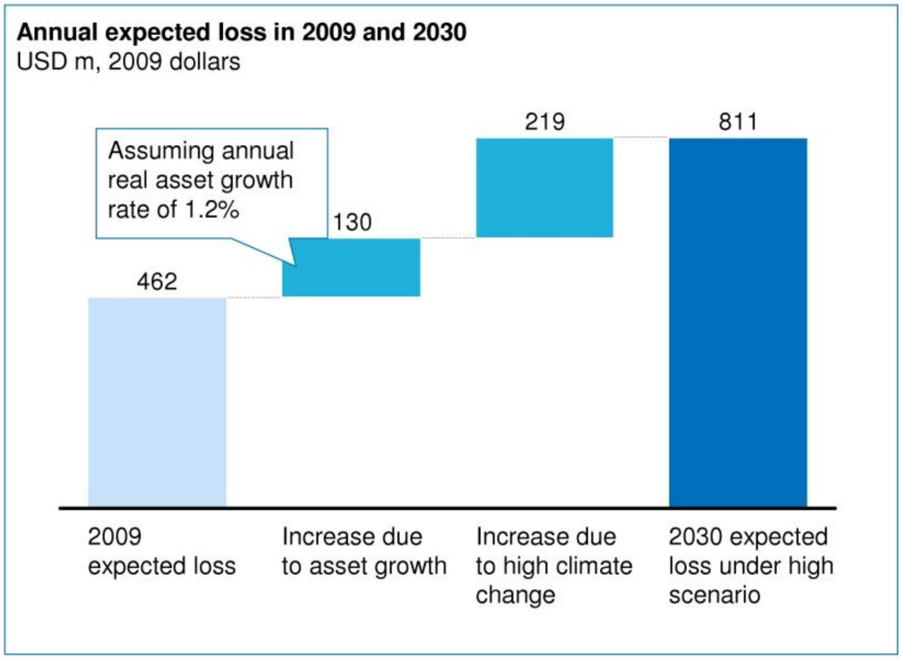
Annual expected loss in 2009 and 2030
USD m, 2009 dollars

Jamaica

Preliminary country results (2/3)

WHAT IS THE MAGNITUDE OF THE EXPECTED LOSS?

2 Contribution of climate change and economic growth in asset values to the increase in expected loss to 2030

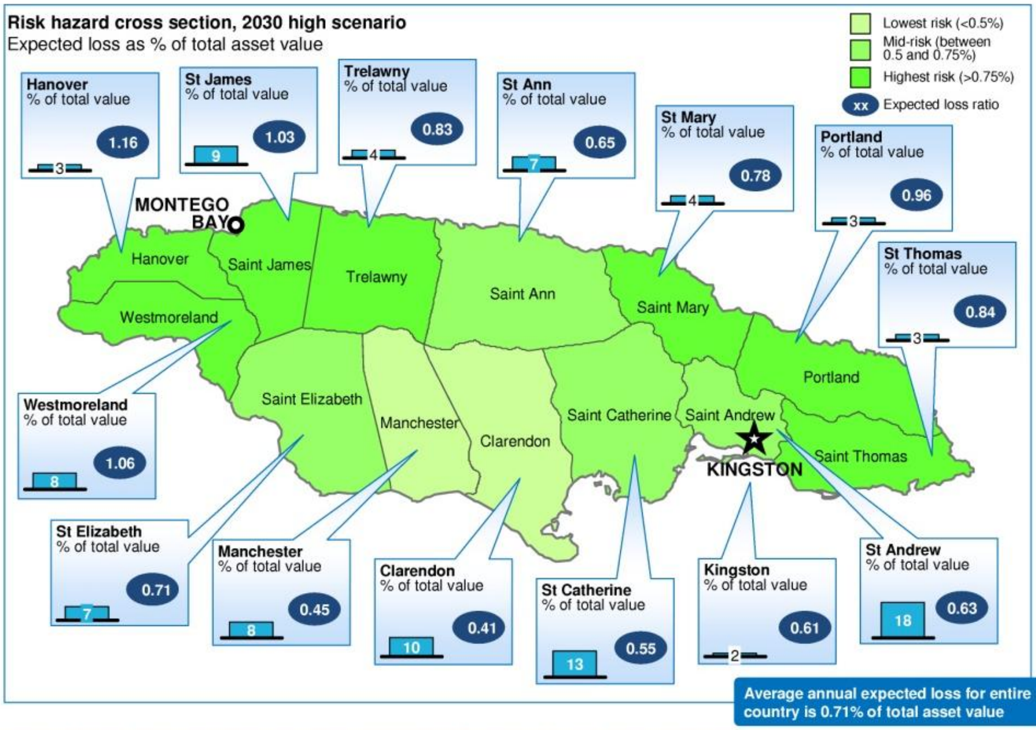


Annual expected loss in 2009 and 2030
USD m, 2009 dollars

WHAT IS THE MAGNITUDE OF THE EXPECTED LOSS?

2030: HIGH CHANGE

2 Geographical distribution of risk and value in Jamaica



Risk hazard cross section, 2030 high scenario
Expected loss as % of total asset value

Average annual expected loss for entire country is 0.71% of total asset value

Jamaica

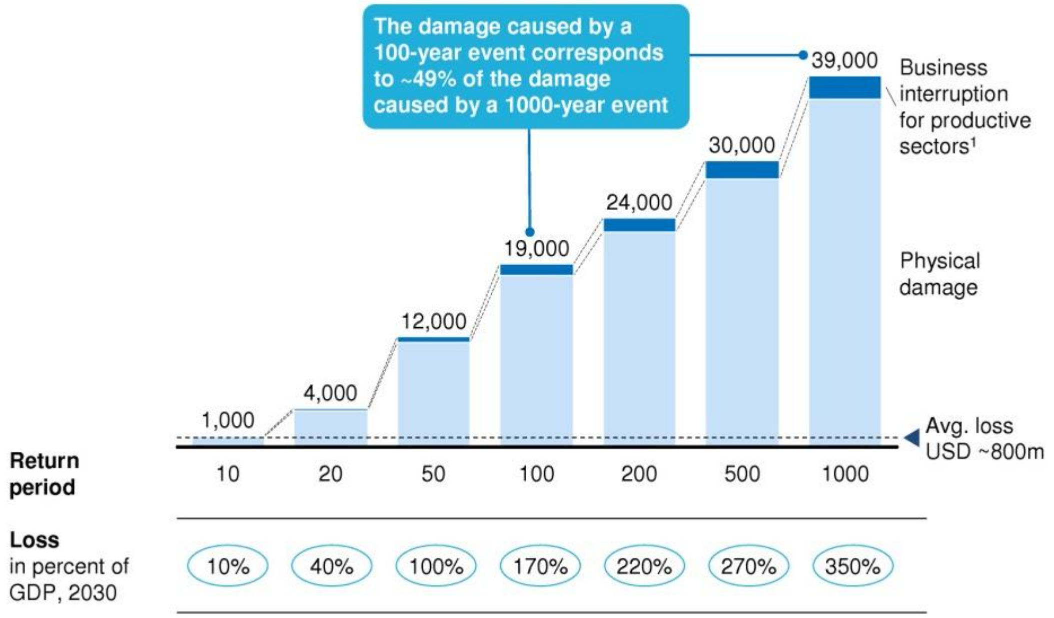
Preliminary country results (3/3)

WHAT IS THE MAGNITUDE OF THE EXPECTED LOSS?

2 Loss frequency analysis

2030: HIGH CHANGE

In USD m, 2009



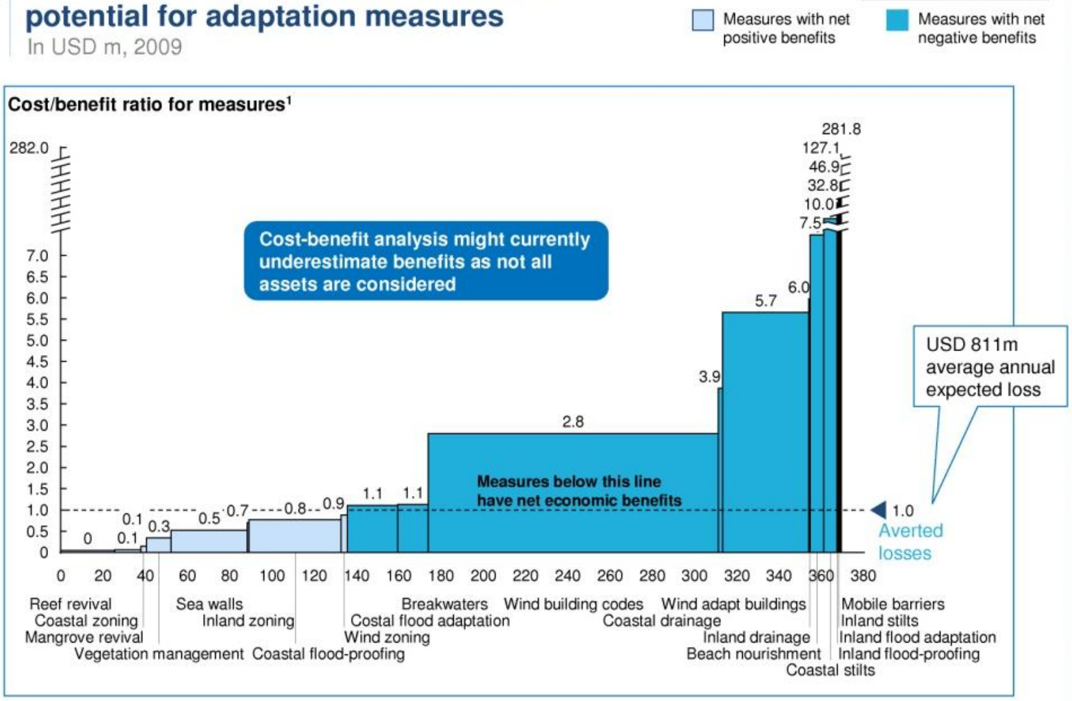
[1] Industry, service industry, travel and tourism sector

WHAT COULD WE DO TO RESPOND?

3 Cost-benefit ratio and loss avoidance potential for adaptation measures

In USD m, 2009

2030: HIGH CHANGE



[1] Does not account for synergies and dis-synergies between measures (e.g., building seawalls behind a breakwater)

St Lucia

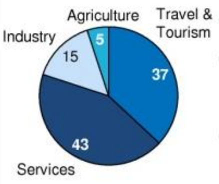
Preliminary country results (1/5)

Key characteristics of St. Lucia

Geography

Economy

GDP composition (2009)
Percent



- GDP (2009): USD 1.04 billion (USD ~11 thousand per capita)
- GDP (2030): USD 1.75 billion total
- Unemployment rate 20% (2003 est)
- Industries – clothing, beverages, corrugated cardboard boxes, tourism; lime & coconut processing
- Most important agriculture products – bananas, coconuts, vegetables, citrus, root crops, cocoa

Geography and geology

- 61 sq km sq km in area
- 158 km coastline
- Highest elevation – 950 m
- Volcanic and mountainous with some broad, fertile valleys
- Annual withdrawal of 0.01 km3 of water

Population

- Total population in July 2009 ~ 160,267 thousand
  - 28% urban population (2008)
  - 24% below age of 15
  - Median age – 29.8 years
- Literacy[1] – 90.1% (2001 est)
- Languages – English (official) and French patois

[1] Definition – age 15 and over, has ever attended school

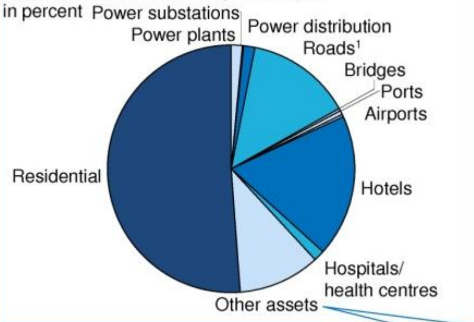
In St. Lucia, we examined the impacts of wind hazard, coastal flooding, and inland flooding on tourism, the service industry, agriculture and general infrastructure and housing

WHAT IS THE MAGNITUDE OF THE EXPECTED LOSS?

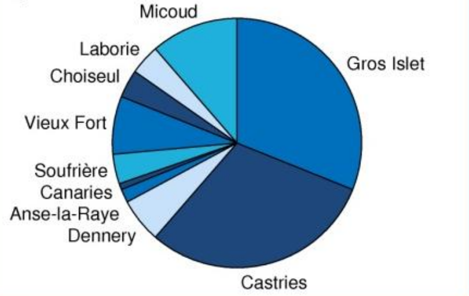
2 Overview of exposure dataset used for analysis in St. Lucia

Physical assets | Income

Split of economic value by asset type
in percent

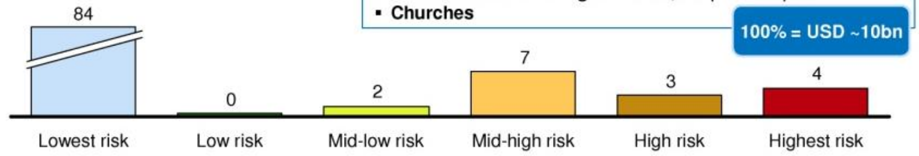


Split of economic value by district
in percent



Other assets include:
- **Commercial assets**: banks, shopping malls, gas stations
- **Governmental buildings**: schools, fire/police depts.
- **Churches**

Split of economic value by flood risk area
in percent



100% = USD ~10bn

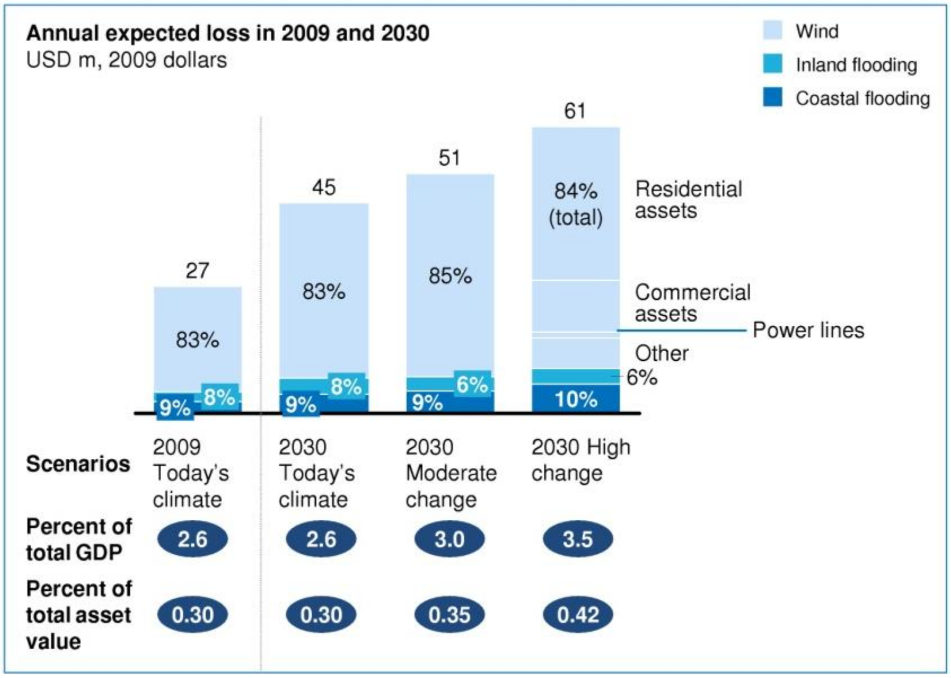
[1] Damage to roads will be included in a second time

St Lucia

Preliminary country results (2/5)

WHAT IS THE MAGNITUDE OF THE EXPECTED LOSS?

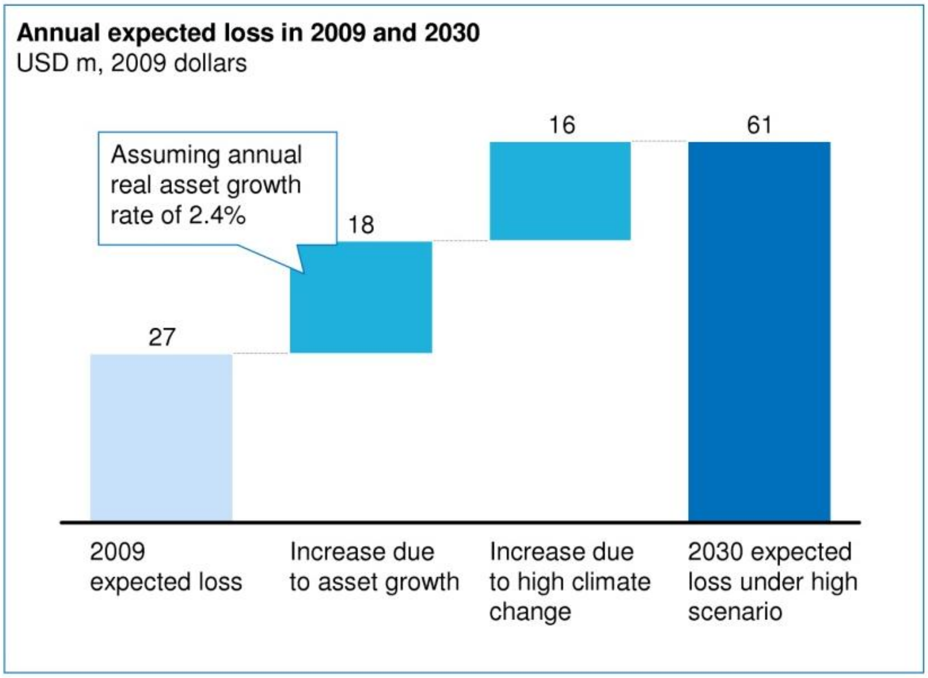
2 Annual expected loss in St. Lucia today and under climate scenarios for 2030



Annual expected loss in 2009 and 2030
USD m, 2009 dollars

WHAT IS THE MAGNITUDE OF THE EXPECTED LOSS?

2 Contribution of climate change and economic growth in asset values to the increase in expected loss to 2030



Annual expected loss in 2009 and 2030
USD m, 2009 dollars

St Lucia

Preliminary country results (3/5)

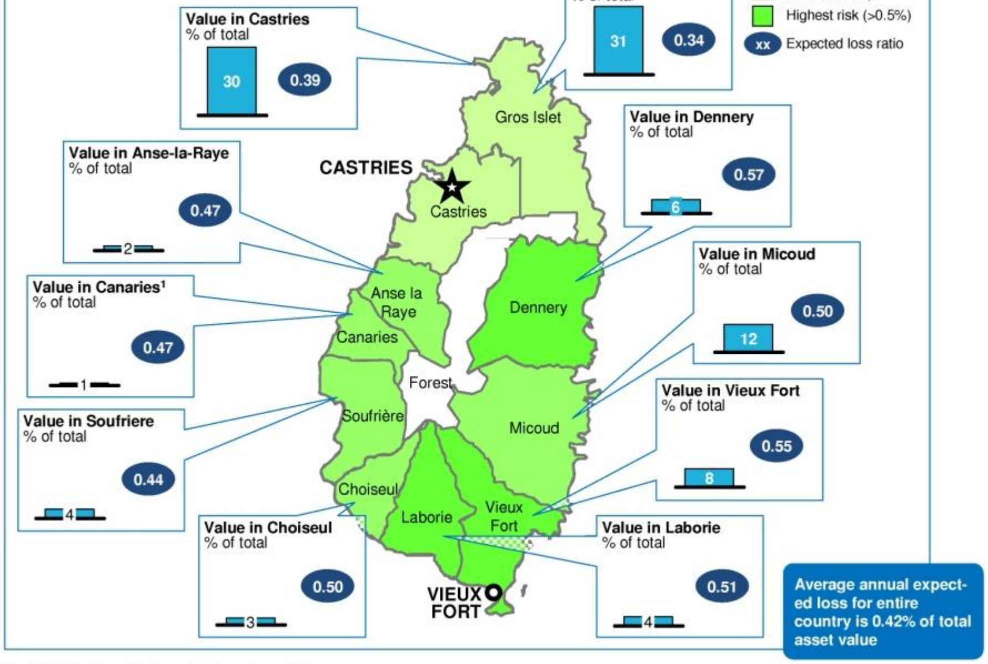
WHAT IS THE MAGNITUDE OF THE EXPECTED LOSS?

2030: HIGH CHANGE

2 Geographical distribution of risk and value in St. Lucia

Risk hazard cross section, 2030 high scenario

Expected loss as % of total asset value



Average annual expected loss for entire country is 0.42% of total asset value

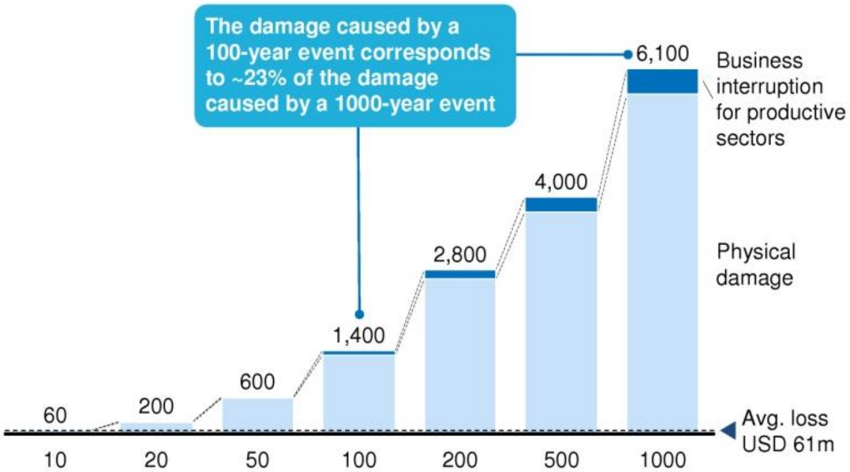
1 Canaries is included in Anse-la-Raye for hazard modeling

WHAT IS THE MAGNITUDE OF THE EXPECTED LOSS?

2 Loss frequency analysis

2030: HIGH CHANGE

In USD m, 2009



The damage caused by a 100-year event corresponds to ~23% of the damage caused by a 1000-year event

Return period	10	20	50	100	200	500	1000
Loss in percent of GDP, 2030	5%	10%	40%	80%	160%	230%	350%

St Lucia

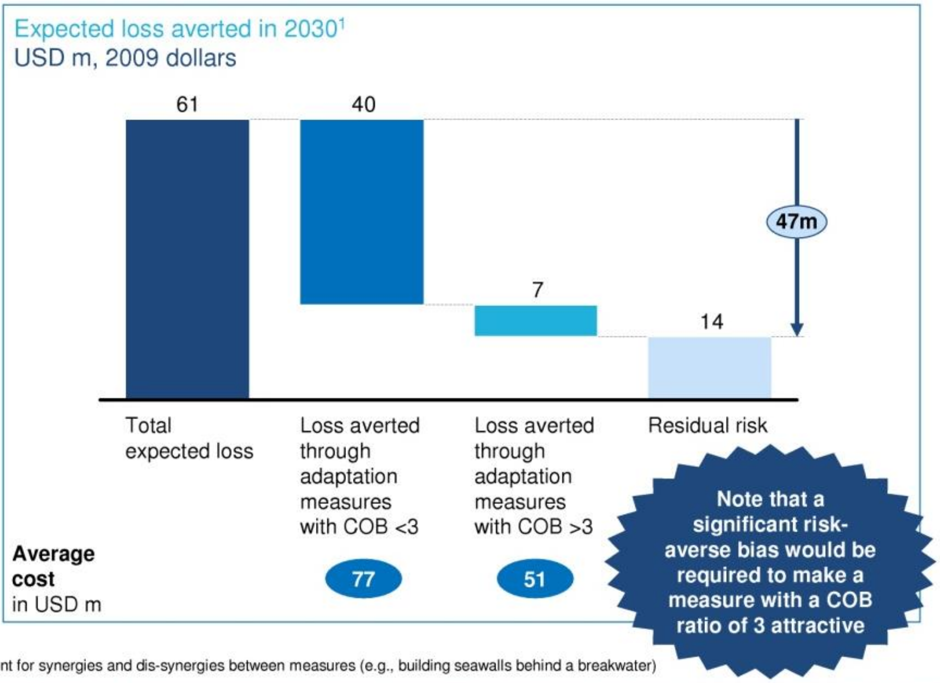
Preliminary country results (4/5)

WHAT COULD WE DO TO RESPOND?

3 Overview of loss avoidance potential for adaptation measures

2030: HIGH CHANGE

SIMPLIFIED



Note that a significant risk-averse bias would be required to make a measure with a COB ratio of 3 attractive

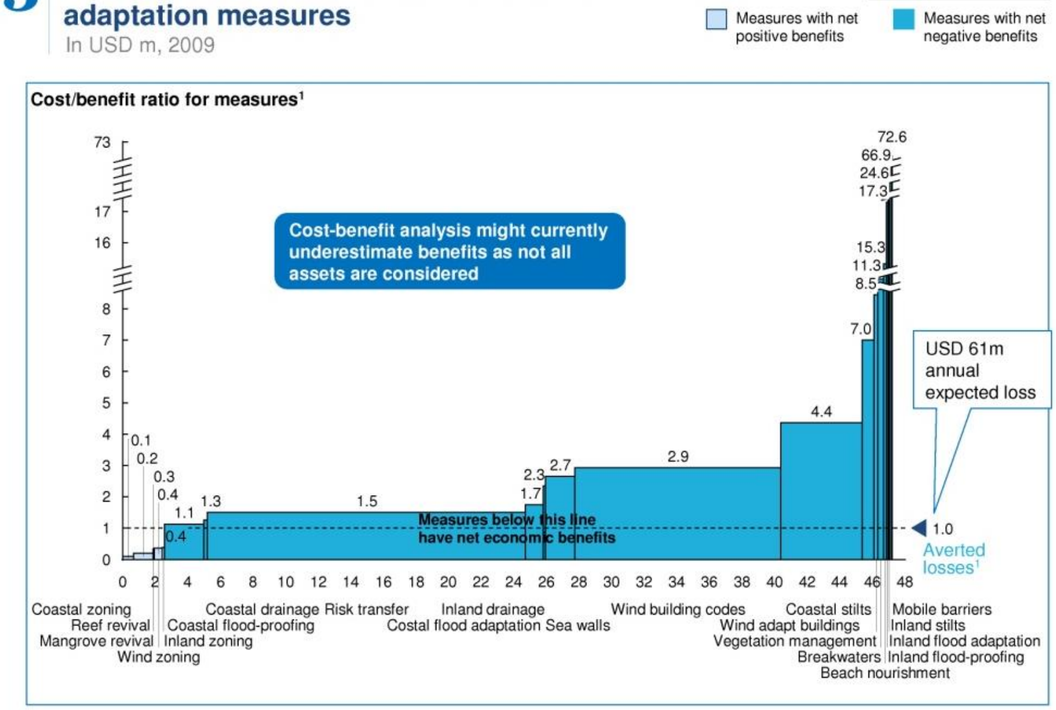
[1] Does not account for synergies and dis-synergies between measures (e.g., building seawalls behind a breakwater)

WHAT COULD WE DO TO RESPOND?

3 Cost-benefit ratio and loss avoidance potential for adaptation measures

In USD m, 2009

2030: HIGH CHANGE



Cost-benefit analysis might currently underestimate benefits as not all assets are considered

[1] Does not account for synergies and dis-synergies between measures (e.g., building seawalls behind a breakwater)

St Lucia

Preliminary country results (5/5)

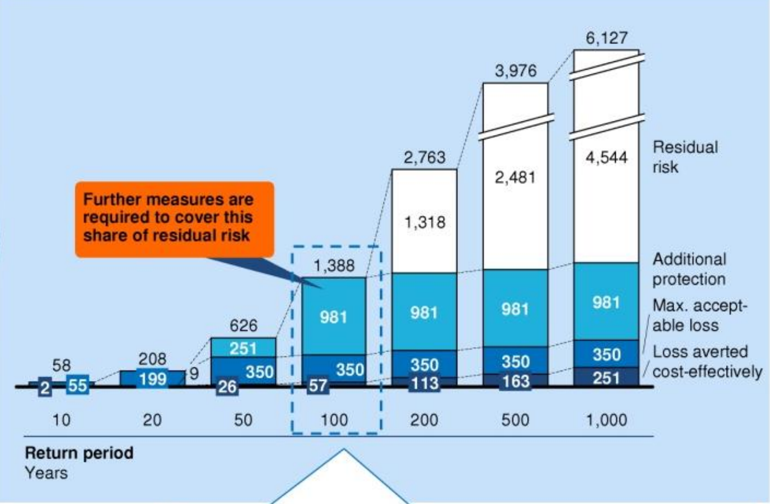
WHAT COULD WE DO TO RESPOND?

3 Quantification of need for additional protection based on subjective optimal level of protection

2030: HIGH CHANGE

- **Level of protection** is a subjective function depending on:
  - **Budget impact** of loss
  - Availability of **emergency relief capital**
  - **Risk appetite** of decision makers
- Level of protection might be **expressed** by specifying:
  - The **maximum acceptable loss** (here: 350 m USD[1]) for this event
  - **Exit level** – for example, this can be expressed by specifying a **reference** extreme **event** (e.g., a one in 100 years event)

Need for additional measures is determined by the desired level of protection
Loss in USD m, 2009



Further measures are required to cover this share of residual risk

A 100-year event corresponds to the maximal loss that can be expected to be exceeded with a probability of max. ~25% in 30 years

---

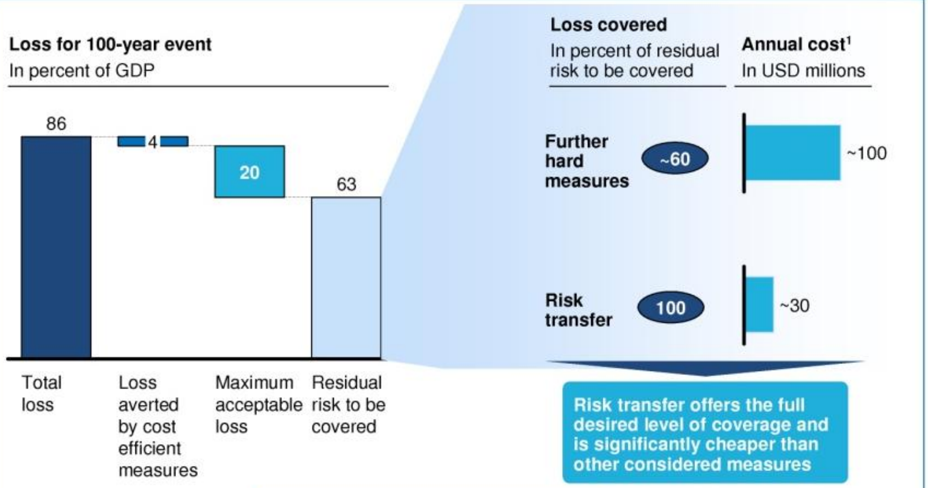
1 This corresponds to approximately 20% of GDP in 2030

WHAT COULD WE DO TO RESPOND?

3 Coverage and costs of risk transfer as a mechanism to cover residual risk

2030: HIGH CHANGE

Example of evaluation of alternative options to cover residual risk



Risk transfer offers the full desired level of coverage and is significantly cheaper than other considered measures

Currently only ~25% of total value of residential buildings in St. Lucia is insured !

---

1 Calculation of cost of risk transfer based on Swiss Re "rule-of-thumb" and CCRIF experience

Agriculture Sector

and

Salinisation

Analysis of the Agriculture Sector in Belize

and

Case Study on Salinisation in Jamaica

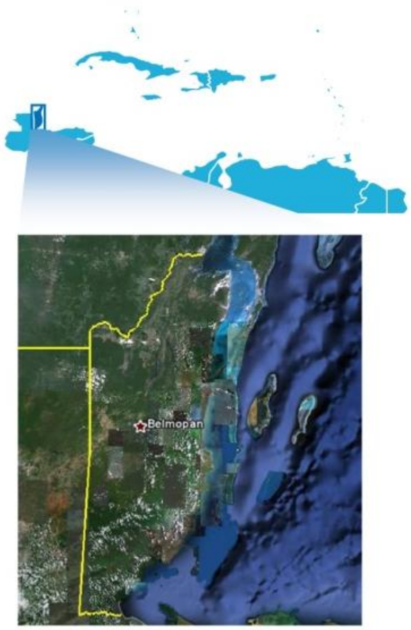
Belize

Preliminary country results (1/5)

WHERE AND FROM WHAT ARE WE AT RISK?

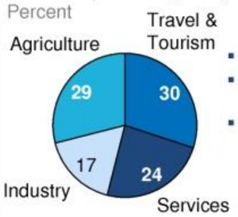
1 Key characteristics of Belize

Geography



Economy

GDP composition (2009)
Percent



- GDP (2009, PPP)
  - USD 8.2 thousand per capita
  - USD 2.53 billion total
- Unemployment rate 8.1% (2008)
- Industries – garments, food processing, tourism, oil
- Most important agriculture products – banana, sugar cane, orange, cacao; fish, cultured shrimp; lumber; garments

Geography and geology

- 22,966 sq km sq km in area
- 386 km coastline
- Highest elevation – 1,160 m
- Flat, swampy coastal plain; low mountains in south
- 18.6 km³ of renewable water resources

Population

- Total population in July 2009 ~ 308 thousand
  - 52% urban population (2008)
  - 38% below age of 15
  - Median age – 20 years
- Literacy[1] – 76.9%
- Languages – English (official), Spanish, Creole, Mayan dialects

In Belize, we examined the impacts of wind hazard and gradual climate shifts on agriculture

---

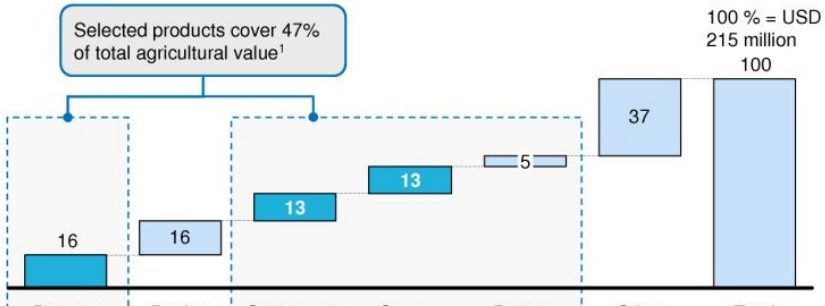
1 Definition – age 15 and over, has ever attended school

WHAT IS THE MAGNITUDE OF THE EXPECTED LOSS?

2 Overview of main agriculture products

▇ Deep-dive analysis incl. crop yield impact

Cumulative value[1] of agricultural products in Belize
Coverage of total production value, percent, 2008



Selected products cover 47% of total agricultural value[1]

100 % = USD 215 million

	Banana	Poultry	Sugar cane	Orange	Papaya	Other	Total
Yield MT/Ha	26.6	N/a	40.4	15.0	63.0	N/a	N/a
Land use 1,000 Ha	2.5	N/a	24.3	15.9	0.4	39.2	82.3
Production in MT	68.1	12.6	980.1	23.9	27.0	448.5[2]	1463.6[2]

---

1 Agricultural output value at 2008 producer prices
2 Only crops

Source: Belize Ministry of Agriculture and Fisheries; FAO; team analysis

Belize
Preliminary country results (2/5)

WHAT IS THE MAGNITUDE OF THE EXPECTED LOSS?

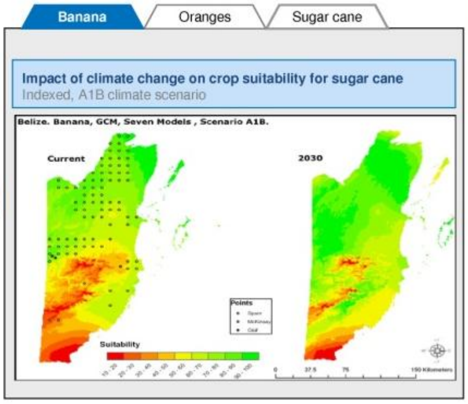
2 Approach to model the effects of climate change on crop yields

Input factors for crop modeling

- Climate change impact on crop yields modeled by International Center of Tropical Agriculture (CIAT) with EcoCrop
- Considered input factors are
  - Downscaled climate data derived from 7 climate scenarios (A1B scenario[1])
  - Crop production locations in each country
  - Today's yields
- Analysis done for
  - Banana
  - Orange
  - Sugar cane

Modeling results

- Crop suitability maps 2009 vs. 2030 for each crop



Impact of climate change on crop suitability for sugar cane
Indexed, A1B climate scenario

- Yield changes calculated for each production location based on suitability change

---

[1] Analysis for this study involved A1B climate scenario – other climate scenarios can also be used for following projects

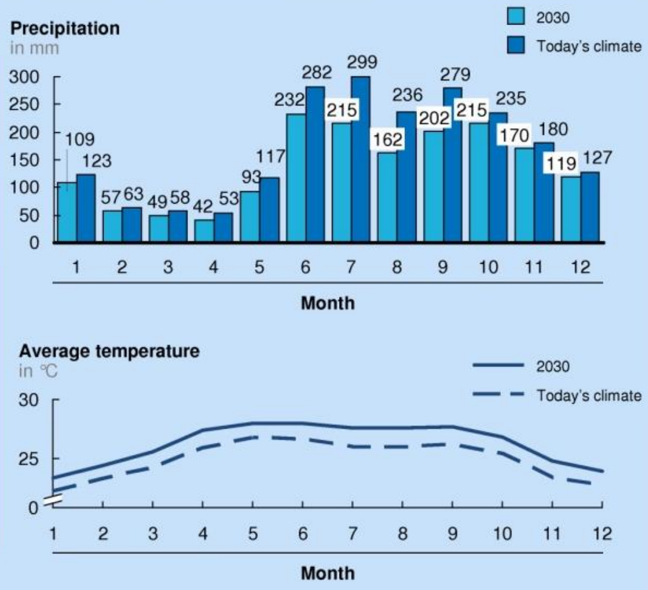
WHAT IS THE MAGNITUDE OF THE EXPECTED LOSS?

2 Climate scenarios used for the analysis of crop yields

Approach description

- We modeled **impact** of **climate change** on **crop yields** by looking at the local effects on key climatic factors
- Most relevant climatic variables for agriculture output are
  - **Temperature**
  - **Precipitation**
- Impact analysis was done by the **International Centre for Tropical Agriculture** (CIAT) based on a comparison of
  - **2030 climate** with
  - **1960-2000 climate** ("today's climate")
- **2030 climate** data has been derived from **averaging** the results of **7 GCM models**
  - From the 3rd and 4th IPCC Assessment
  - Run under the **A1B scenario**

Overview of key climatic changes in Belize



Belize

Preliminary country results (3/5)

WHAT IS THE MAGNITUDE OF THE EXPECTED LOSS?

2 Geographic distribution of selected crops

Approach description

- Estimation of production locations based on land use maps
- Digitizing of production locations

Production locations for

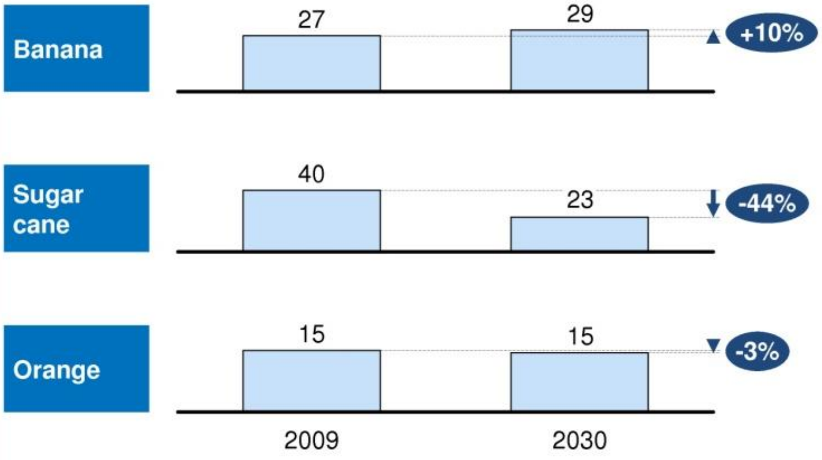
● Banana
● Sugar cane
● Orange

WHAT IS THE MAGNITUDE OF THE EXPECTED LOSS?

2 Yield modeling results

Crop yield development

In mt/ha, 2009 vs. 2030; A1B climate scenario[1]



	2009	2030	Change
Banana	27	29	+10%
Sugar cane	40	23	-44%
Orange	15	15	-3%

---

1 Analysis for this study involved A1B climate scenario – other climate scenarios can also be used for following projects

Belize

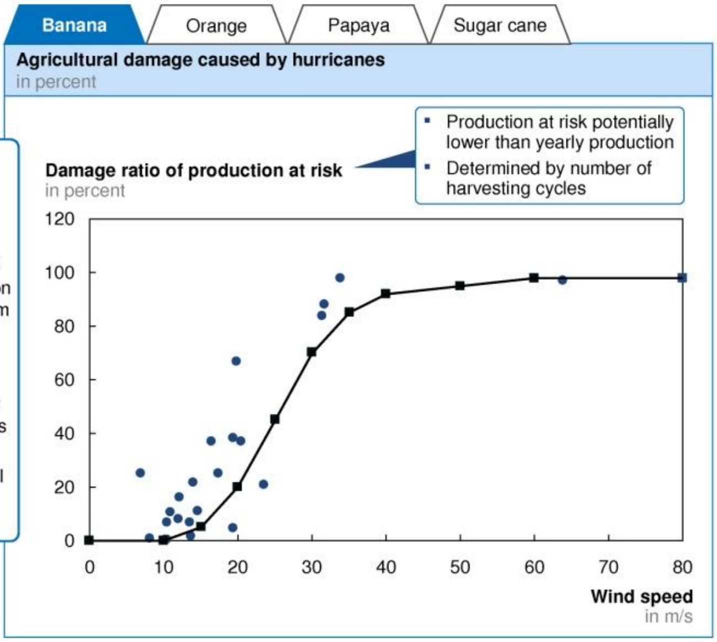
Preliminary country results (4/5)

WHAT IS THE MAGNITUDE OF THE EXPECTED LOSS?

2 Crop-specific damage function used to model impact of hurricane-induced losses

Approach description

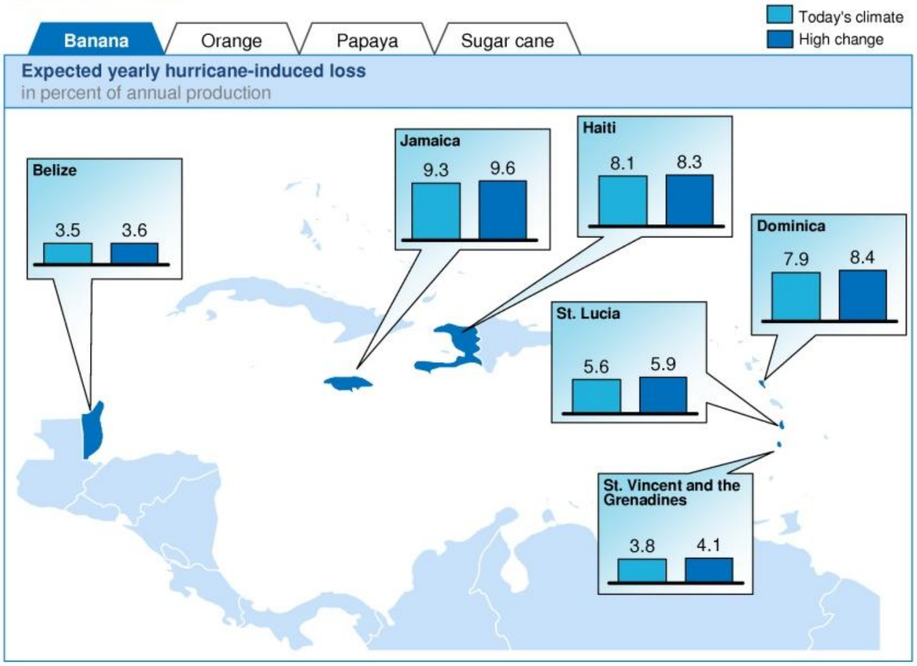
- Collection of damage report data from past hurricanes and link to hurricane wind speeds
- For bananas, evaluation of damage records from WINCROP insurance company
  - Amount paid/ amount insured for all major hurricanes
  - Evaluation on single-country level



- Production at risk potentially lower than yearly production
- Determined by number of harvesting cycles

WHAT IS THE MAGNITUDE OF THE EXPECTED LOSS?

2 Potential impact of climate change on hurricane-induced losses to agriculture sector



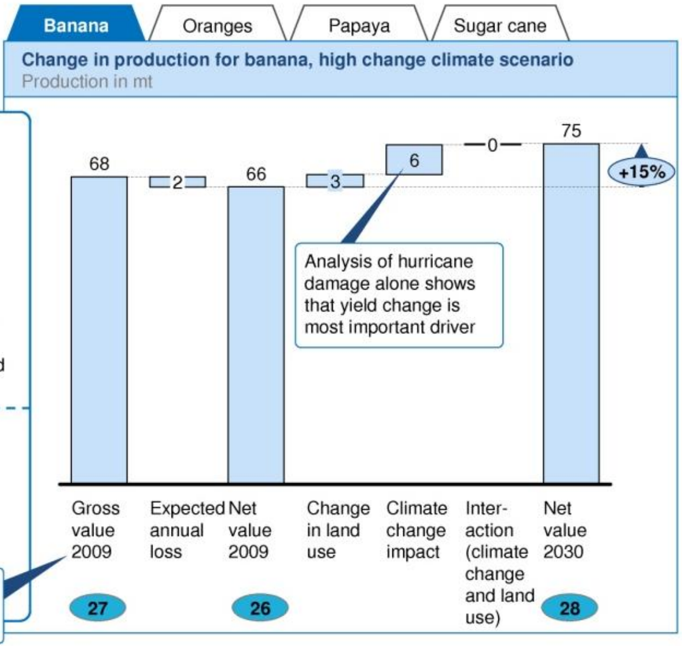
Belize
Preliminary country results (5/5)

WHAT IS THE MAGNITUDE OF THE EXPECTED LOSS?

2 Total net impact of climate change and change in land use on banana production

Approach description
- Baseline 2009 is value net of expected annual loss from hurricanes
- Projected net value 2030 includes
  - Change in land use/ harvested area
  - Climate change (yield and hazard impact)
  - Interaction of land use and climate change[1]

Specific assumptions for banana in Belize
- Damage ratio 3.51% (2009) vs. 3.61% (2030)
- Change in land use 4.4%
- Yield change 10.0%


Change in production for banana, high change climate scenario
Production in mt

Analysis of hurricane damage alone shows that yield change is most important driver

Value of "ideal" year without hurricane impact

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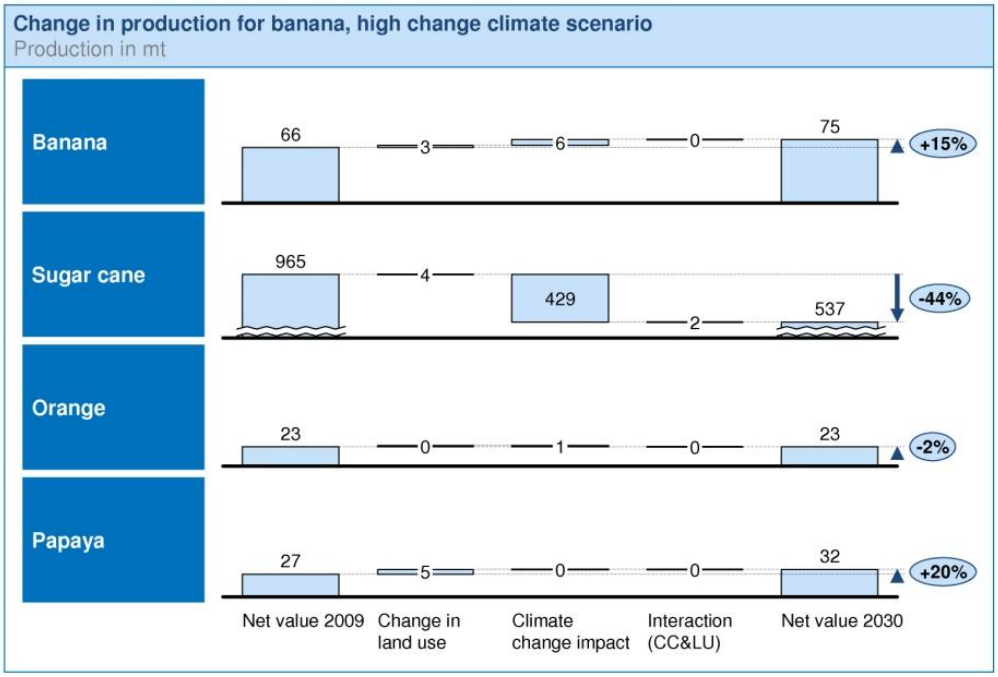
[1] E.g., without climate change a reduction in land use leads to reduced absolute losses from hurricane damage

WHAT IS THE MAGNITUDE OF THE EXPECTED LOSS?

2 Overview of results for the analysed crops in Belize


Change in production for banana, high change climate scenario
Production in mt

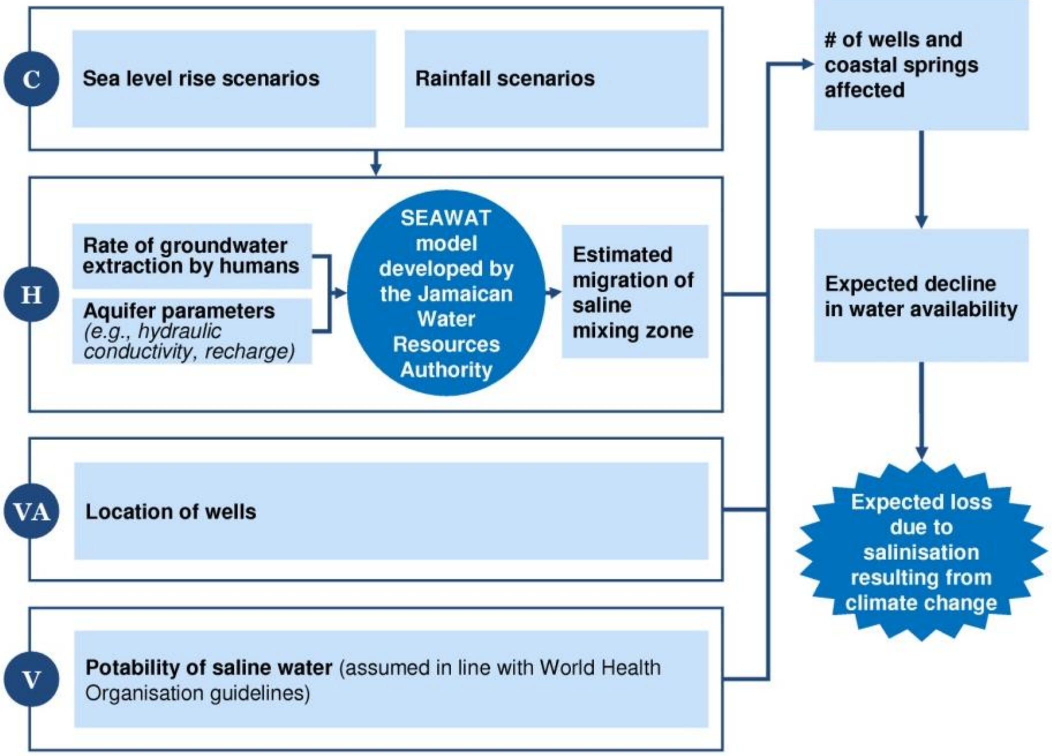
Salinisation

A case study for Jamaica (1/3)

WHAT IS THE MAGNITUDE OF THE EXPECTED LOSS?

2

We input our scenarios into an existing model for Jamaica to approximate the risk of salinisation



C

Sea level rise scenarios

Rainfall scenarios

H

Rate of groundwater extraction by humans

Aquifer parameters *(e.g., hydraulic conductivity, recharge)*

SEAWAT model developed by the Jamaican Water Resources Authority

Estimated migration of saline mixing zone

VA

Location of wells

V

Potability of saline water (assumed in line with World Health Organisation guidelines)

# of wells and coastal springs affected

Expected decline in water availability

Expected loss due to salinisation resulting from climate change

We selected Jamaica for an investigation into the impacts of future climate scenarios on salinisation of groundwater. Caribbean islands fall into one of three categories regarding water availability:

- A number of islands – such as Antigua and the Cayman Islands – are **already water-poor** and must **supply drinking water using desalination** plants. The marginal impact of climate change on these islands will therefore be comparatively small
- Other islands – such as some of the volcanic islands – have **freshwater lenses of sufficient size to sustain human use** even assuming extreme climate change
- A final category – which includes Jamaica – is **currently reliant on groundwater sources**, and due to climate change and human extraction **may become water constrained** in the future. The marginal impact of climate change is the highest in these islands

Salinisation
A case study for Jamaica (2/3)

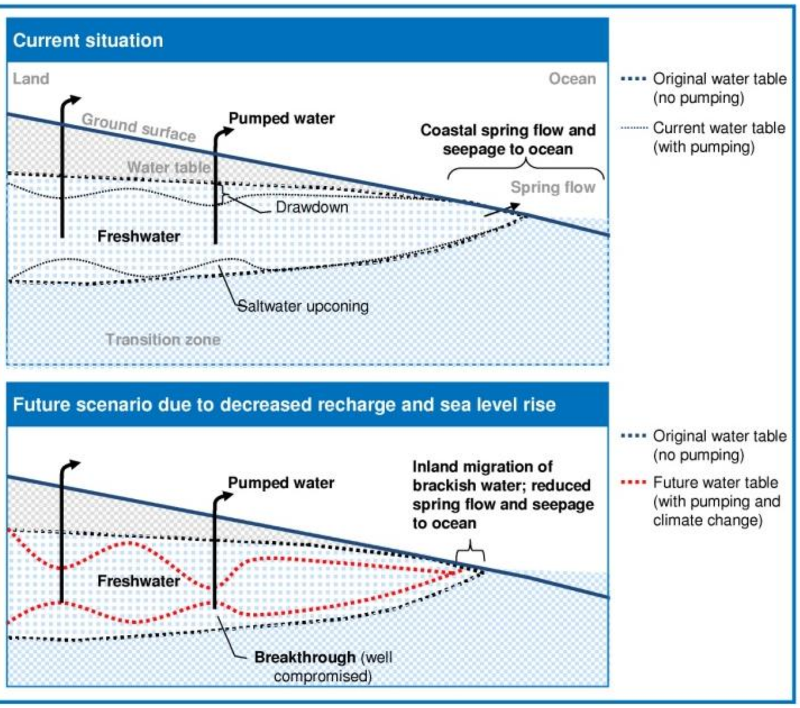
WHAT IS THE MAGNITUDE OF THE EXPECTED LOSS?

2 The combined effects of continued groundwater pumping, decreasing rainfall and sea level rise may result in salinisation of some wells

H

Climate inputs

- Sea level rises
- Rate of abstractions
- Annual total rainfall decreases, driving recharge decreases


Current situation

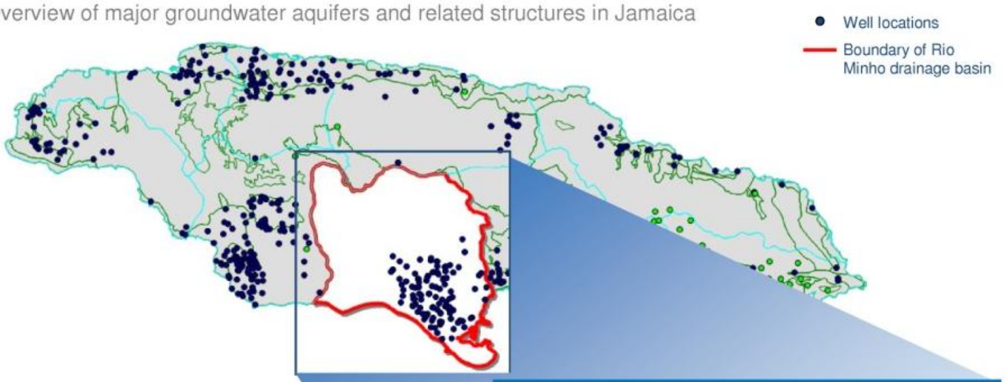
Future scenario due to decreased recharge and sea level rise

WHAT IS THE MAGNITUDE OF THE EXPECTED LOSS?

2 The model is based on many physical parameters of the Rio Minho basin, including measured and approximate values

V

Overview of major groundwater aquifers and related structures in Jamaica



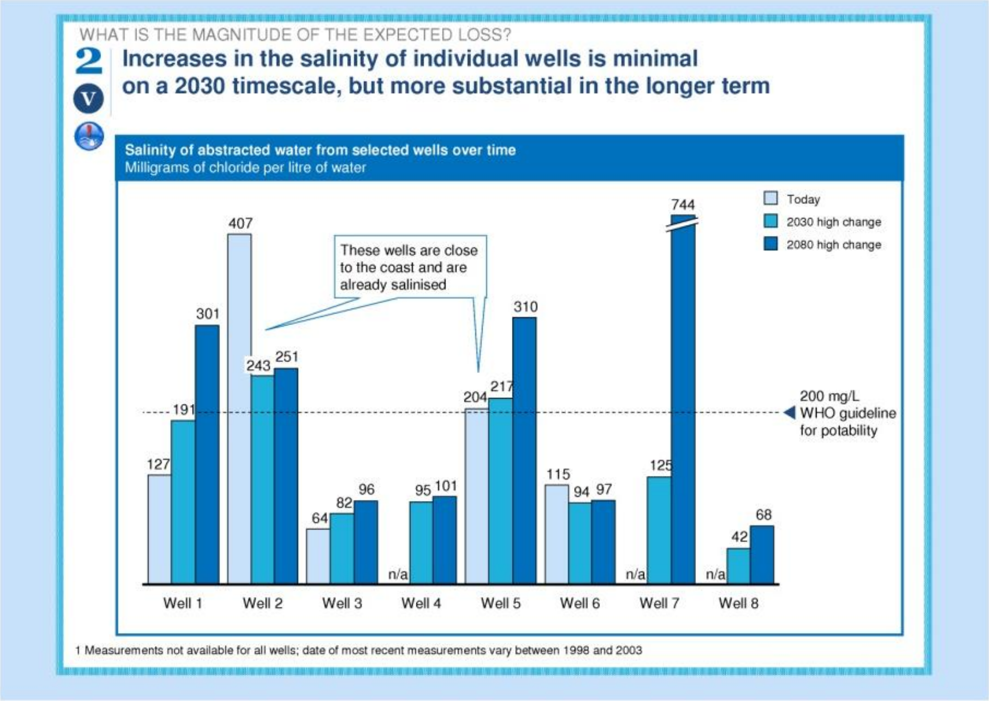
Rio Minho basin inputs to groundwater model

- **Well locations**
- **Empirical data on current water heights and salinity levels**
- **Layers** representing the three-dimensional boundaries of the limestone and alluvial aquifers
- **Parameters** describing the aquifers, including:
  - Recharge rates
  - Hydraulic conductivity
  - Salinity of input water[1]
  - Geologic features (e.g., faults)

[1] Note: even "fresh" water usually has some salinity due to the dissolution of minerals into runoff

Salinisation

A case study for Jamaica (3/3)



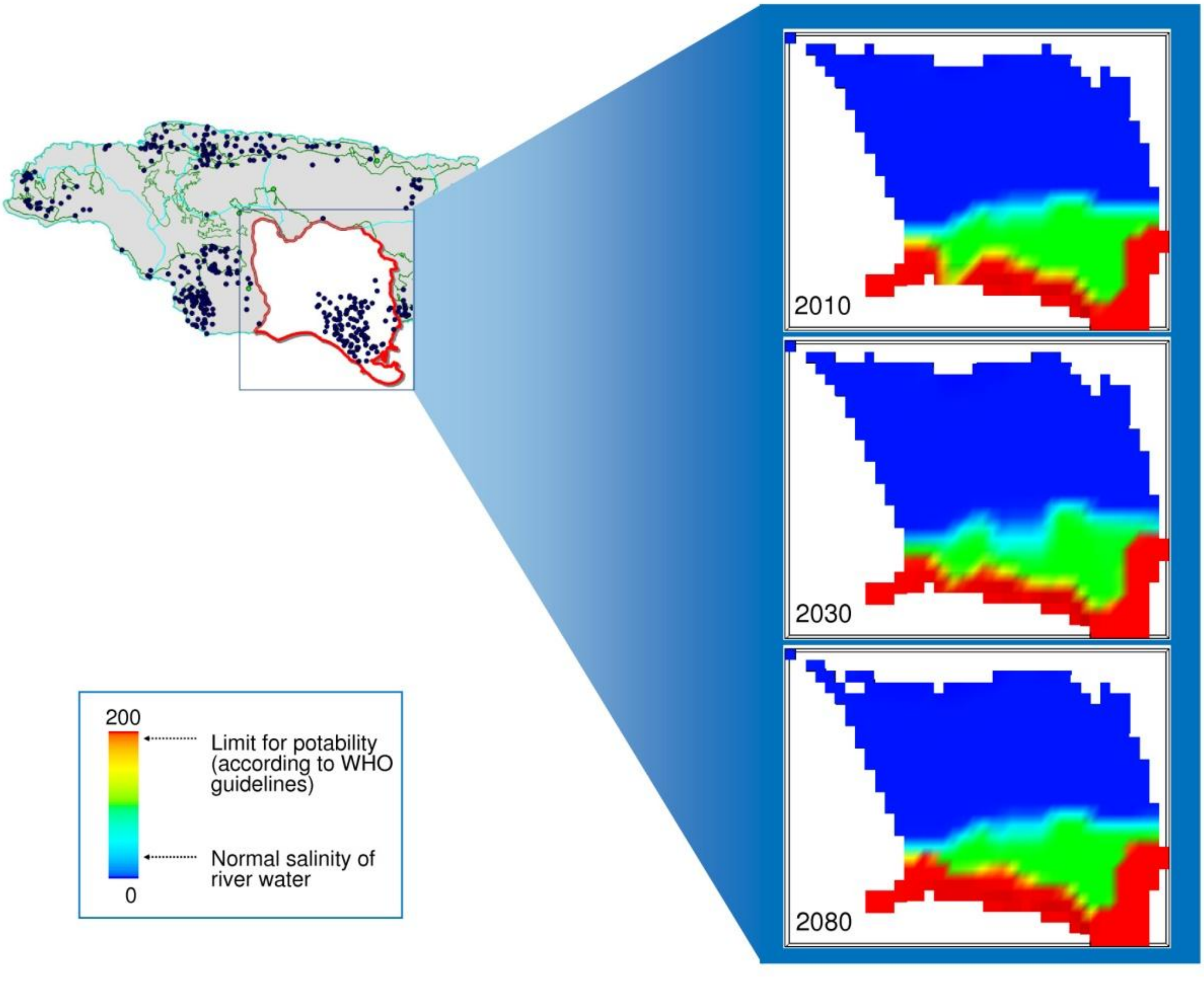
WHAT IS THE MAGNITUDE OF THE EXPECTED LOSS?

2 **Increases in the salinity of individual wells is minimal on a 2030 timescale, but more substantial in the longer term**

Salinity of abstracted water from selected wells over time
Milligrams of chloride per litre of water

These wells are close to the coast and are already salinised

1 Measurements not available for all wells; date of most recent measurements vary between 1998 and 2003



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