

Extremes, risk, and change in the Caribbean:



Experts
say rainfall
may lessen
drought

By Julia Glick

The Associated Press

DALLAS—Heavy rainfall that
flooded roads, drenched prop-



Roger S. Pulwarty

National Oceanic and Atmospheric Administration
(CCCCC, CIMH, INSMET, UWI, NOAA/NCEI)

What is at risk?

Who is at risk?

What can be done about it?



Estimated threat level

- Low
- Medium
- High
- Very high

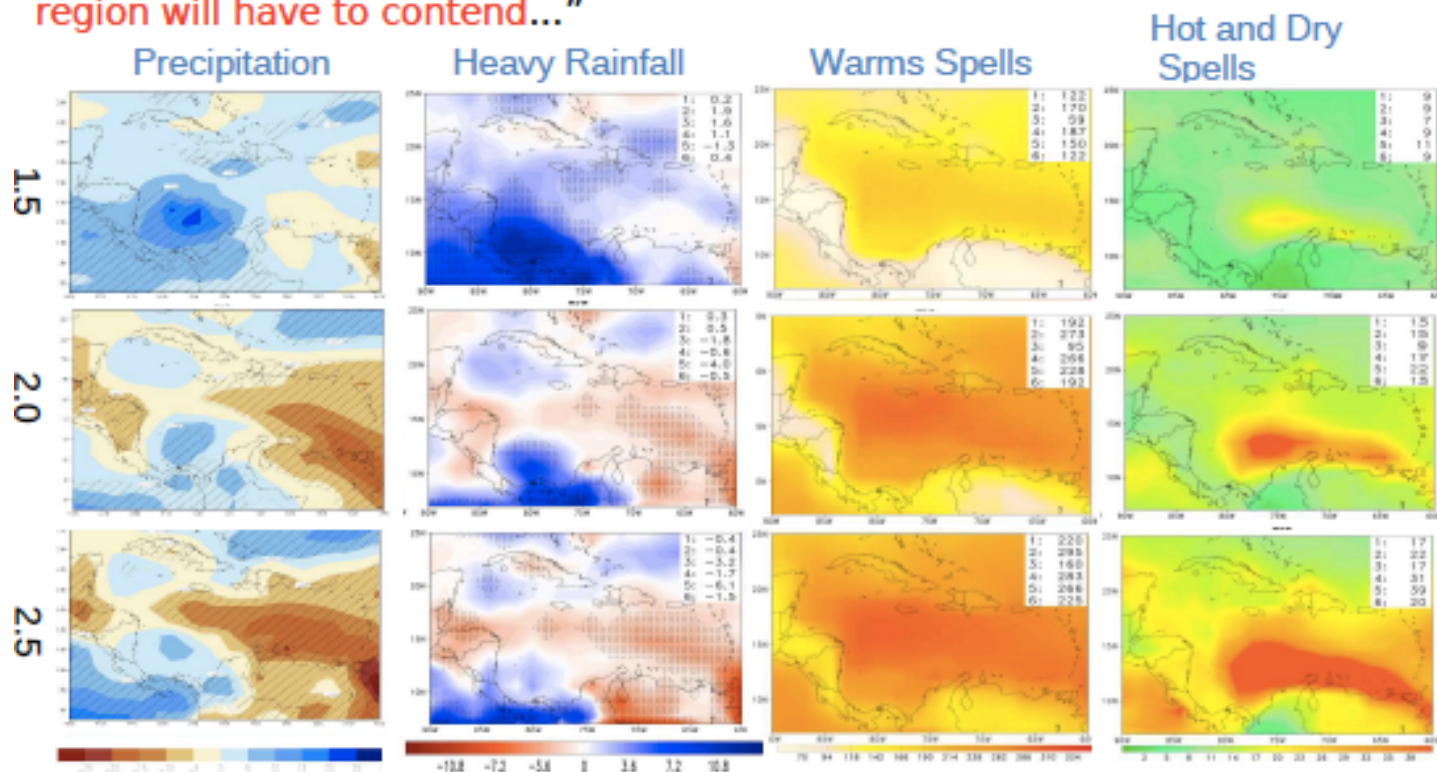
Projection: Lambert Equal-Area
Azimuthal



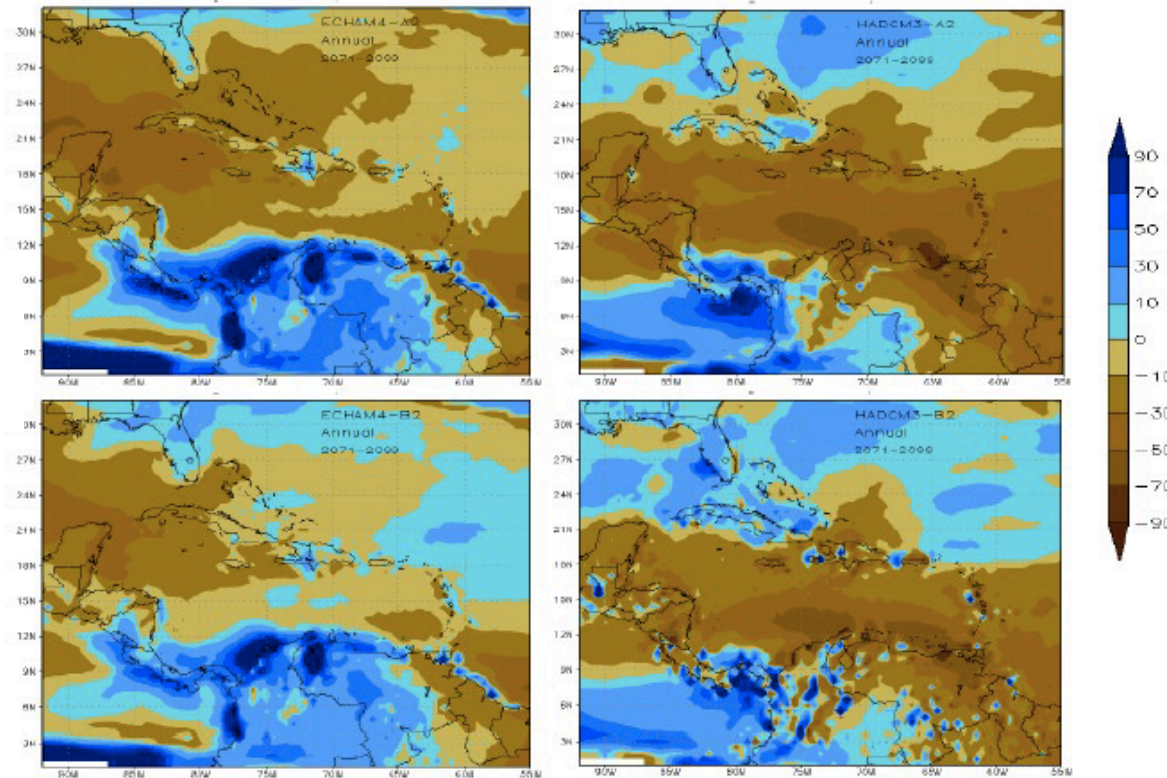
THE CARIBBEAN 1.5 PROJECT



“The Caribbean 1.5 project reported that **limiting global warming to 1.5 does not stop further significant changes in regional climate with which the region will have to contend...**”

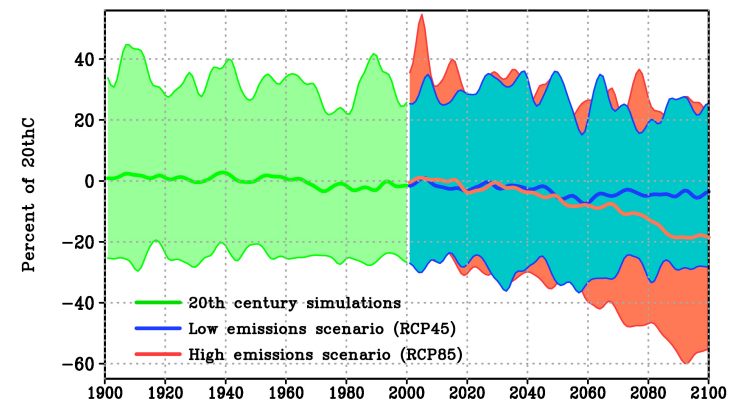


**Net
Drying trend**



Mean changes in the annual rainfall for 2071-2099 with respect to 1961-1989, as simulated by regional climate models.

Caribbean Annual Precipitation Change
CMIP5 (36 models) 1901-2100



DROUGHT: Some impacts of the regional drought of 2014-2016

- **Rainfall:** 2014/2015 driest on record in 7 territories;
- **Food & Agriculture:** reduced agricultural production in 13 countries; destructive bush fires in several countries;
- **Water:** water shortages (forcing rationing) in 8 countries;
- **Tourism:** St. Kitts & Nevis curtailed water delivery to cruise ships.

National Water Commission of Jamaica estimates that the tourism sector require 10x more water per capita than the domestic sector.



Increased food prices and food shortages in Haïti Credit: LatinAmerican Post



Destructive bush fires in Jamaica Credit: Daily Observer

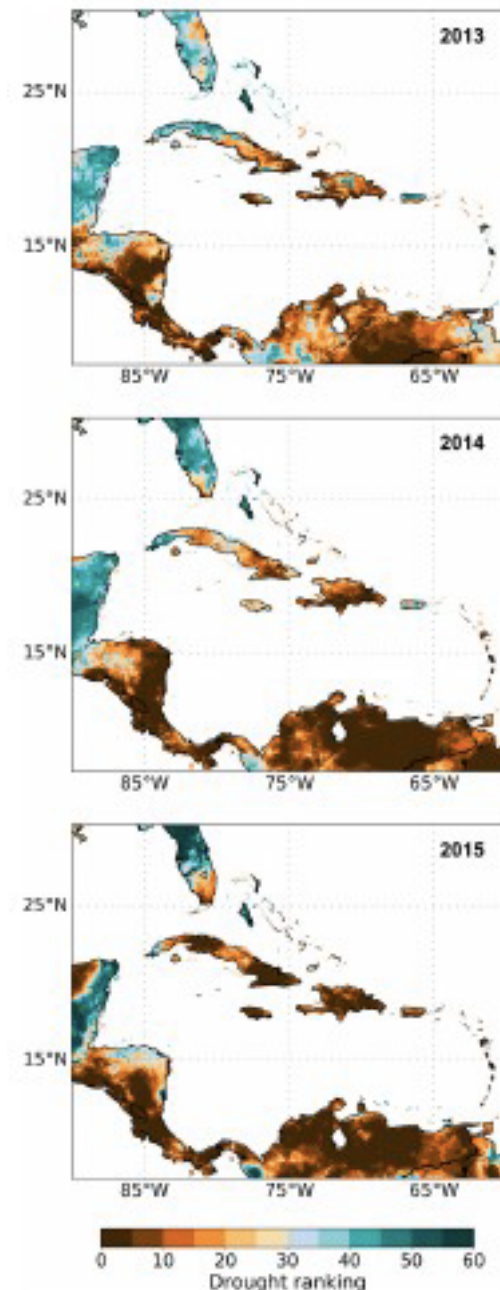


FIG. 17. Annual drought rankings between 2013 and 2015. Drought conditions in 2014 ranked as the most severe since 1950 in a greater area than in 2015. However, in the Caribbean, 2015 ranks as the driest year during the 2013–16 drought.

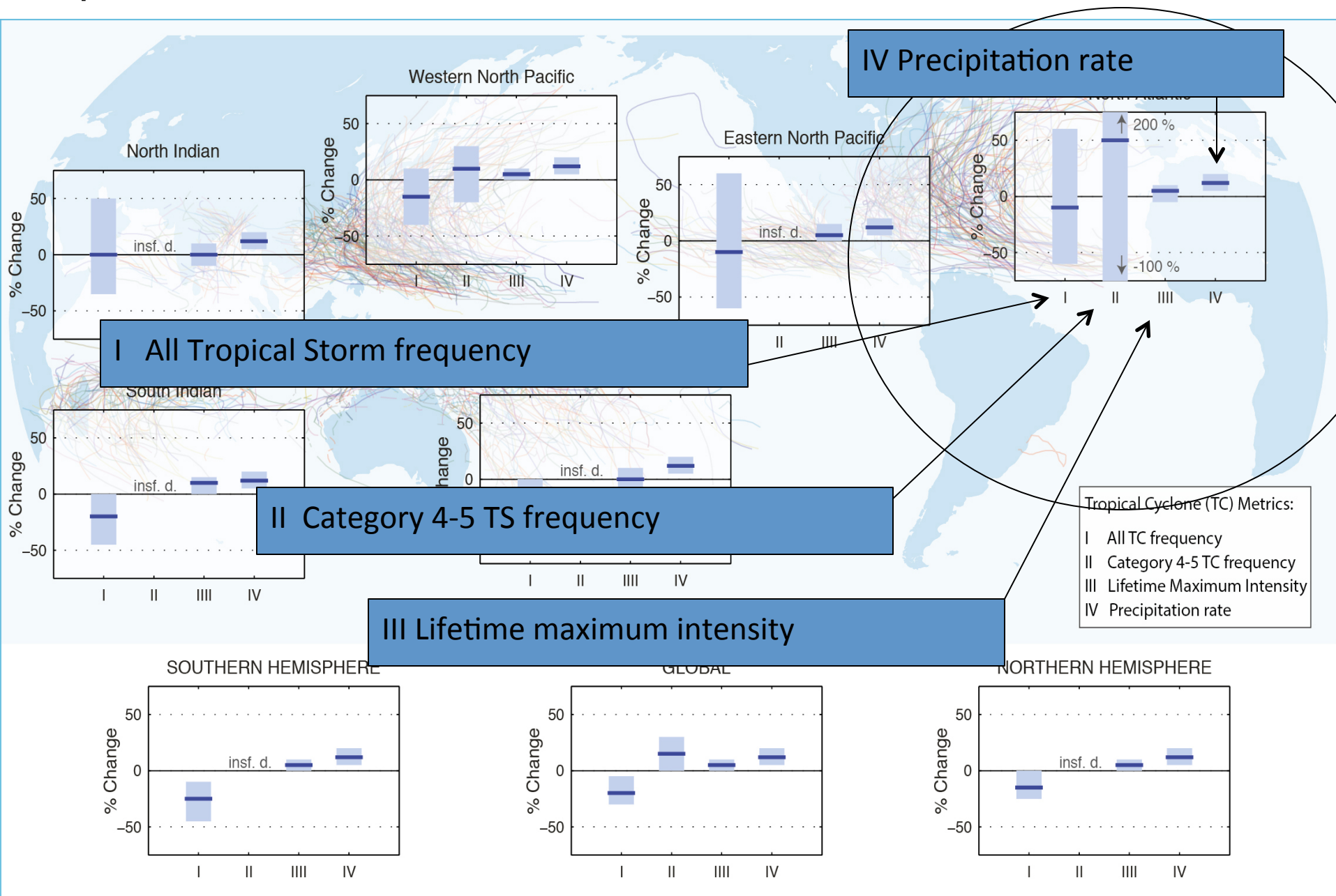
	Trend	Implication	Feature
Present Climate	High temperatures Variable Rain More intense storms Rising sea levels	Emergence of a new climate regime	Unfamiliarity
Future Climate	Higher temperatures Drying trend Intense extremes Higher sea levels	Entrenchment of the new climate regime	Unprecedented

The 2013–16 Caribbean multiyear drought is most severe and extensive period of dry conditions in the Caribbean and Central America since at least 1950. Appears to be related not only to El Niño–driven precipitation deficits, but also to temperature- driven increases in PET

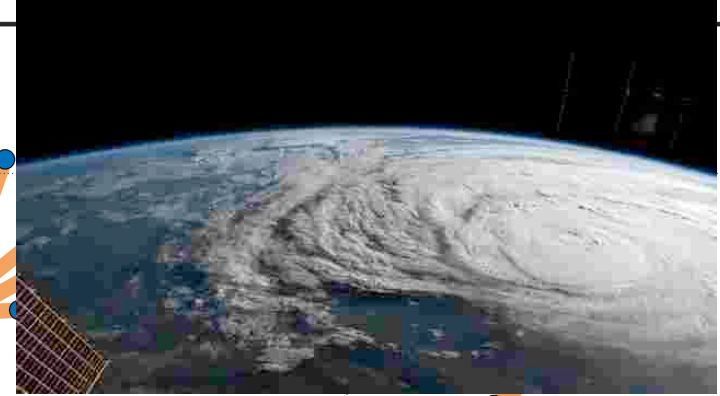
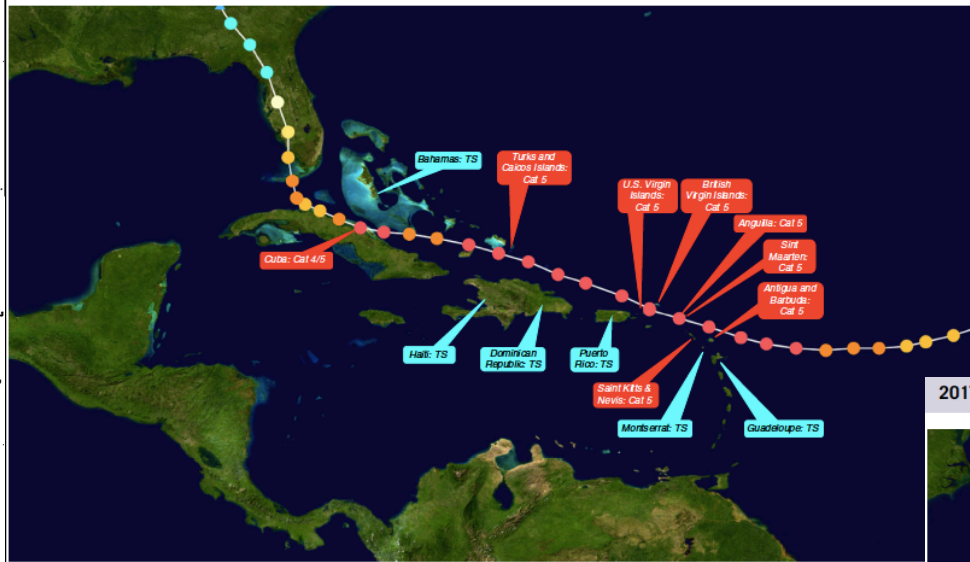
Critical Transitions

The Caribbean 1.5 project reported that 2.0 degrees will result in even further significant changes (over 1.5) in regional climate which take us close to climates we have not experienced to date

Tropical Storms



2017 Atlantic Hurricane Season: Hurricane Irma Impacts on 14 Caribbean Region SIDS



2017 Atlantic Hurricane Season: Hurricane Maria Impacts on 16 Caribbean Region SIDS



2017

Twenty-two of 29 Caribbean SIDS were each impacted by 1 to 3 named storms
 Maria was the fourth storm in a month to undergo rapid intensification, tying Hurricane Wilma (2005) for the most rapid intensification, strengthening from tropical depression to a Category 5 storm in 54 hours



Regional News

GlobalMedic Team from Canada Arrives In St Maarten With Relief Aid for Hurricane Irma Victims

GlobalMedic's Bill Alie, some of the images, and also drone footage of the level of damage in St Maarten

Related stories

- Healthcare donor Canadian Organization GlobalMedic to help 3000
- Alleged Kill for Hurricane Irma Victims in the Caribbean

■ Maria's toll on Puerto Rico
■ Bravest, Finest to help with relief

'OUR ISLAND DESTROYED'

PAGE 3

ST. MARTIN

BREAKING NEWS

ISLAND OF ST. MARTIN LEFT IN SHAMBLES AFTER HURRICANE IRMA

CATEGORY 4	WIND SPEED 155 MPH	WIND GUSTS 190 MPH	DIRECTION/SPEED MOVING W @ 12MPH	199 MI OF NA
------------	-----------------------	-----------------------	-------------------------------------	-----------------

FRIDAY, SEPTEMBER 5, 1959. TWO CENTS

SANTO DOMINGO WRECKED BY HURRICANE 800 DEAD, HUNDREDS HURT IN CITY ALONG WASHINGTON RUSHING RELIEF TO ISLAND

THE CITY OF SANTO DOMINGO AS SEEN FROM THE AIR.

RED CROSS, MARINES AND NAVY RUSH AID

STORM HEADS NORTH FOR THE BAHAMAS

20 MORE DIE IN DOM

Roseau, Dominica

Before Maria

After Maria



IRMA WREAKS HAVOC IN ST. THOMAS; SINCLAIR HOSPITAL SUFFERS 'CATASTROPHIC FAILURE'

Breaking News / Featured / News / Top Stories / Virgin Islands / September 6, 2017

Princess Margaret hospital compound in Dominica



Fisheries Division building
Dominica after Maria



Cascading public health consequences during and after the events

Mortality

Physical Injury

Heat-Related Injury

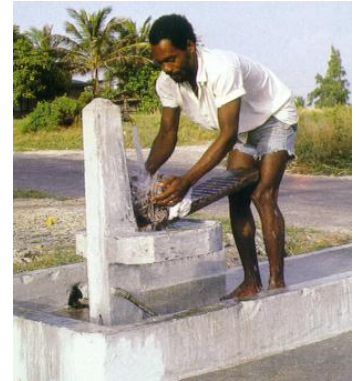
Vector-Borne Diseases

Decompensation of Chronic Disease Symptoms

Vector-Borne Diseases

Diseases Related to Contaminated Water

Mental Health



Population Displacement

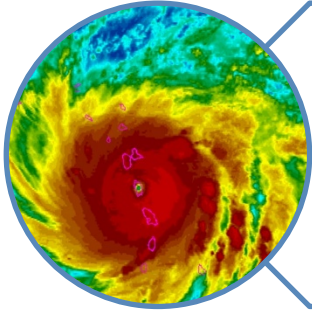


**Total payouts since 2007:
US\$123.5 million to 12 member governments**

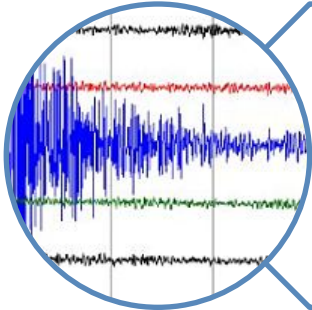
Recent Events	Countries Affected	Payouts (US\$)
Tropical Cyclone Erika, August 2015	Dominica	2.4 million
Tropical Cyclone Matthew, September 2016	Barbados, Haiti, Saint Lucia, St. Vincent & the Grenadines	29.2 million
Tropical Cyclone Irma, September 2017	Anguilla, Antigua & Barbuda, St. Kitts & Nevis, Bahamas, Turks & Caicos, Haiti	31 million
Tropical Cyclone Maria, September 2017	Dominica, Anguilla, Antigua & Barbuda, St. Kitts & Nevis, Turks & Caicos, Barbados, St. Vincent & the Grenadines, Saint Lucia	23.8 million

All payments made within 14 days

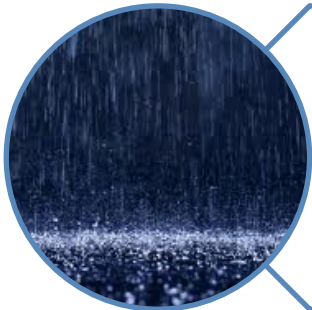
CCRIF Products



Tropical Cyclone
wind and storm surge



Earthquake



Excess Rainfall
since 2013
TCs or non-cyclonic
systems

**CCRIF primary country contacts:
Ministries of Finance**

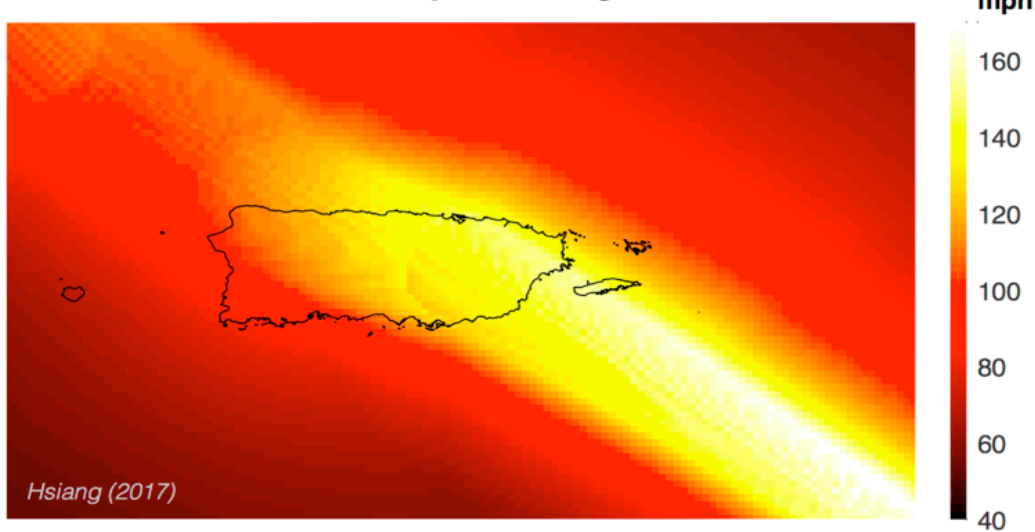
17 CCRIF members:
16 Caribbean, 1 Central America

Policy pricing based on country risk
profiles

Many countries do not have
“adequate” coverage

Basis risk
**CCRIF was not designed to cover
all losses on the ground**

Maximum surface wind speed during Hurricane Maria

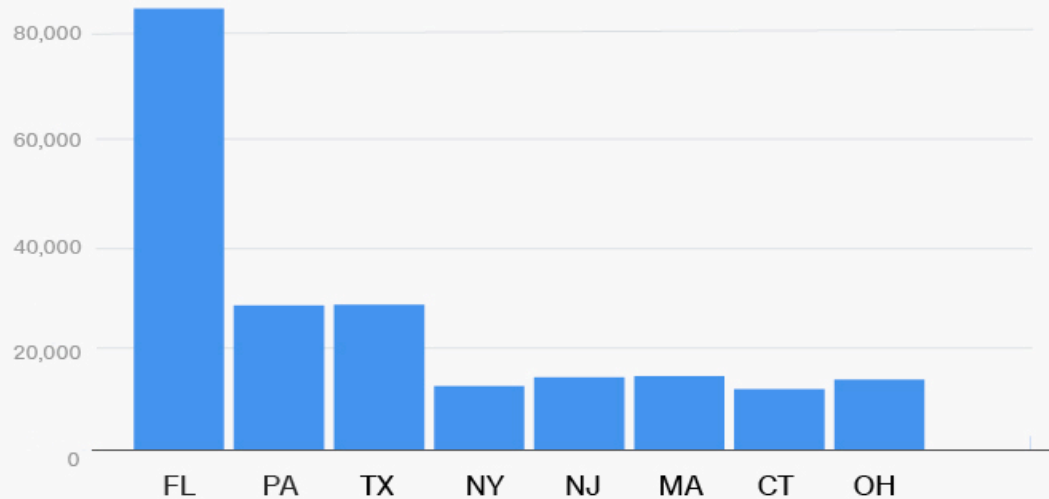


[Opinion](#) Op-Ed Contributors
Don't Let Puerto Rico Fall Into an Economic Abyss

New York Times Sept. 29, 2017

Post-Maria Exodus from Puerto Rico

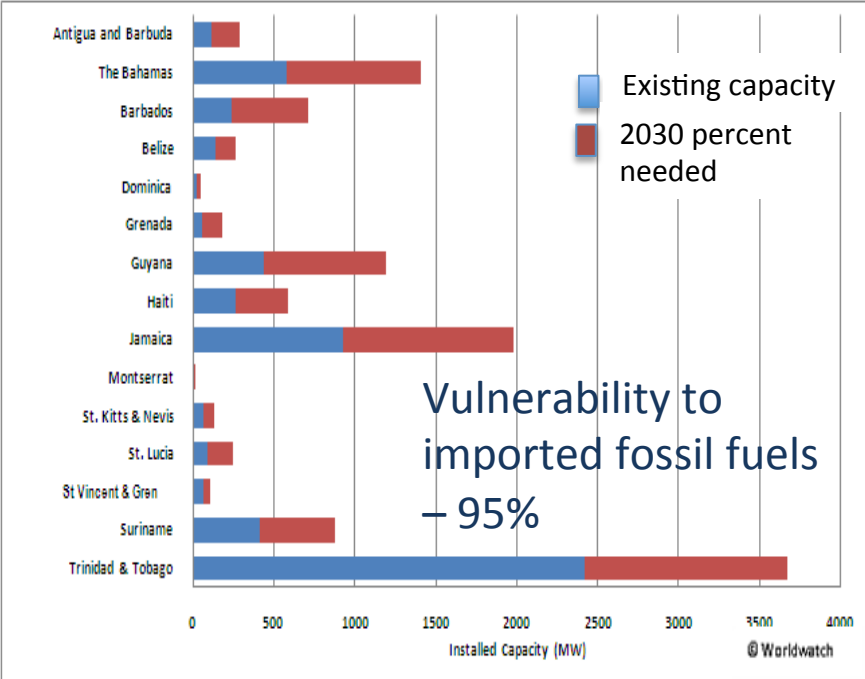
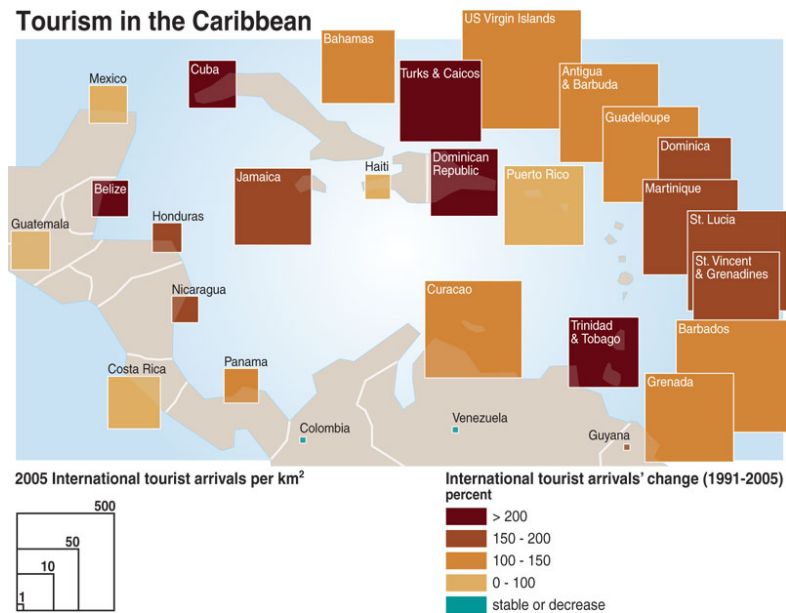
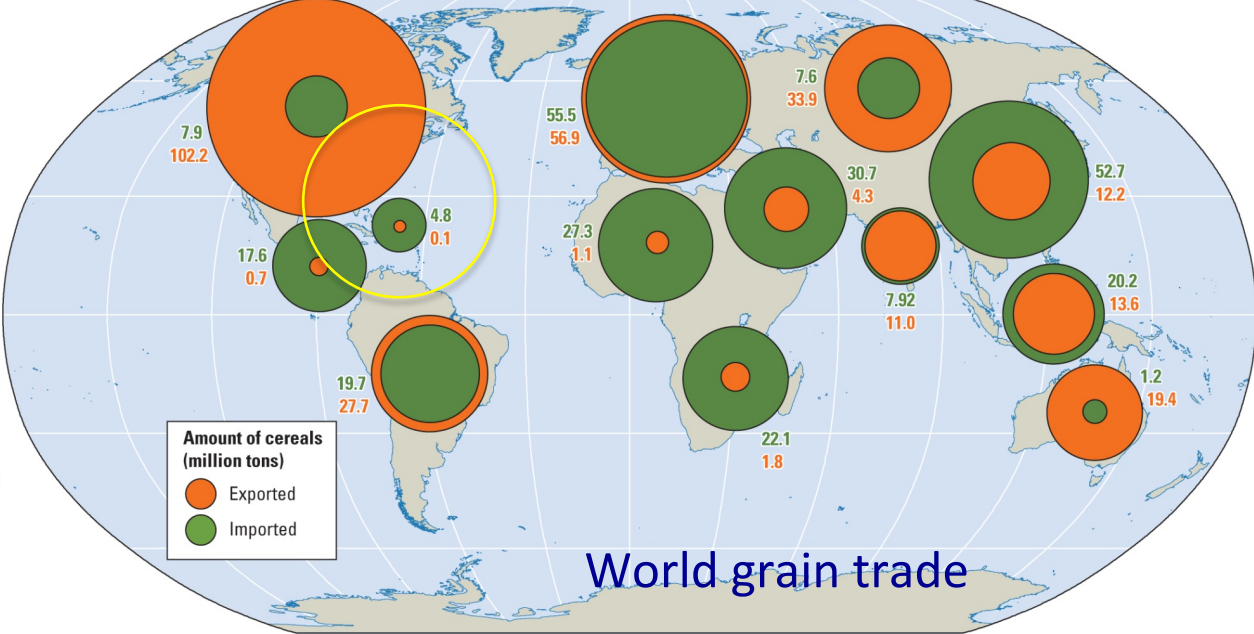
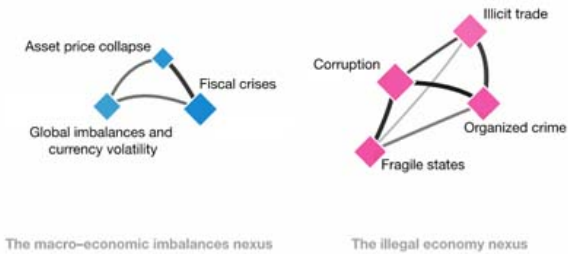
Based on recent migration trends, here's how many Puerto Ricans could flow to each state as a result of Hurricane Maria.



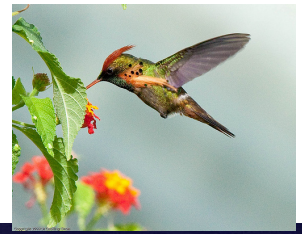
SOURCE: THE CENTER FOR PUERTO RICAN STUDIES AT THE CITY UNIVERSITY OF NEW YORK

Maria could lower Puerto Rican incomes by 21% over the next 15 years, undoing roughly 26 years of economic development (Hsiang 2017)-provided there are no other storm impacts

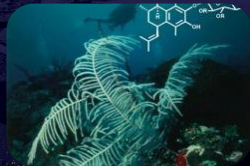
Globally networked risks



Adaptation spans multiple activities and scales



Life and Property



Health



Agriculture



Energy



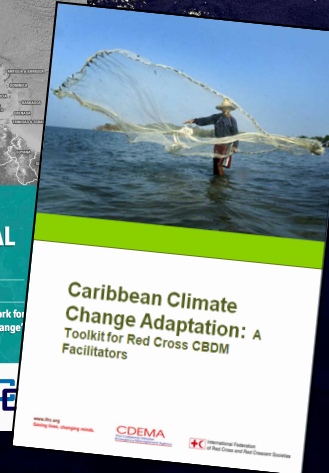
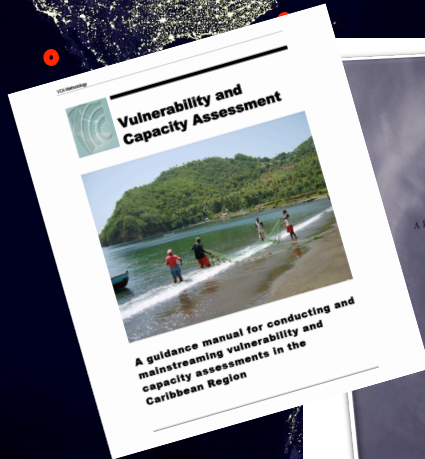
Hydropower



Emergency Management



Construction



Forests



Infrastructure



Earth at Night
More information available at: p001127.html



Ecosystems



Aviation



Reservoir Management



Maritime Commerce

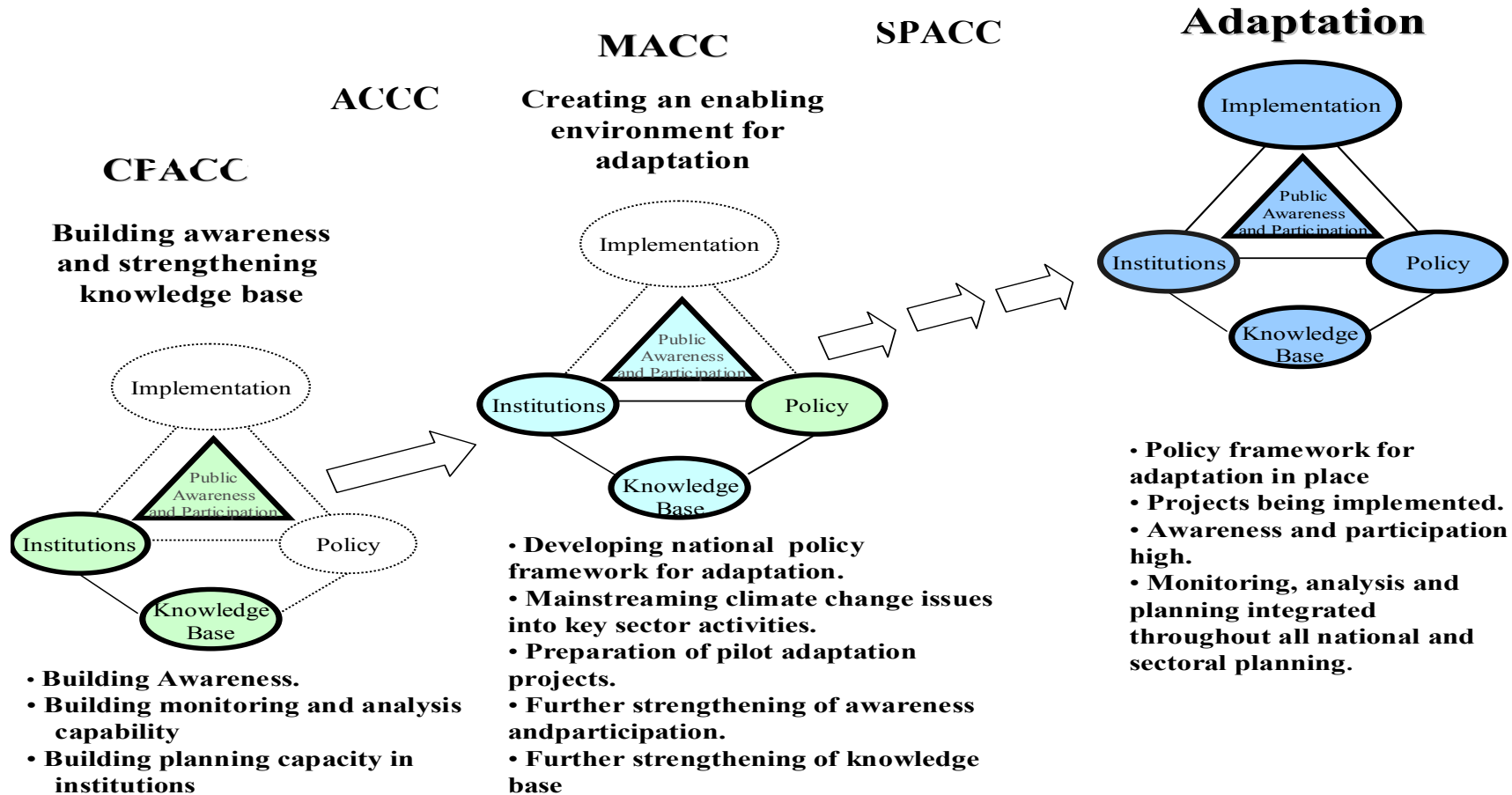
Astronomy Picture of the Day
2000 November 27
<http://>



Environment

Summary of the CARICOM Programme of Adaptation (1997 – 2011)

(1997 – 2001) (2001- 2004) (2004 – 2008) (2007 – 2010) →



2050 ALTERNATIVE FUTURES

**RCP 2.6, 4.5, 6.0
SSP 2**

COOL RUNNINGS

PPP, Moderate Growth,
Individualism, Consumerism,
Energy Mix

**RCP 2.6
SSP 1**

ISLAND IN THE SUN

Renewable Energy, Collectivism,
Health and Wellness

**RCP 4.5, 6.0, 8.5
SSP 3**

HARDER THEY COME

High Debt Levels, Income
Inequality, Obsolete Sectors,
Environmental Degradation

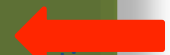
**RCP 2.6, 4.5, 6.0, 8.5
SSP-**

PIRATES OF THE CARIBBEAN

- **Pathway 1**
- **Pathway 2**

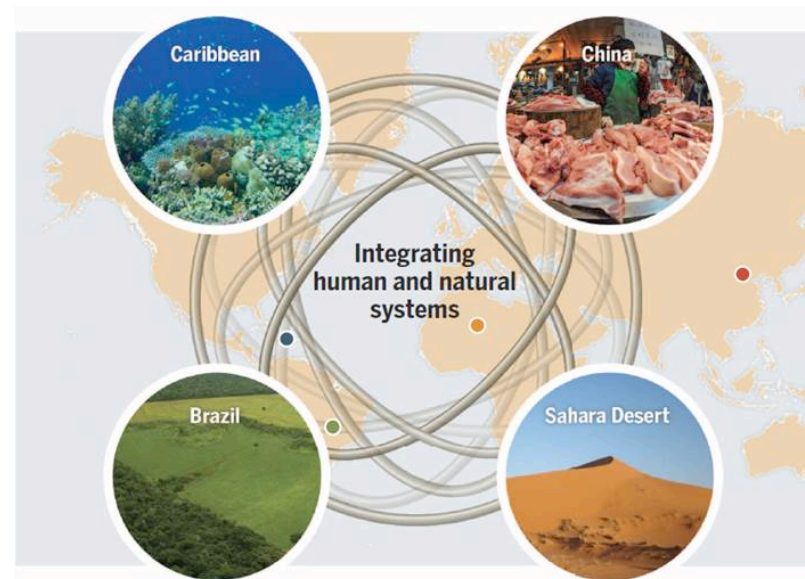
Global Economic
Collapse, Arms & Narcotic
Trade, Crime, Corruption,
Poverty

**WILD
CARD**



2014-2024

- Results based Strategy and Programming Framework that emphasises the nexus of Climate Change and Disaster Risk Reduction in building resilience in the Caribbean.





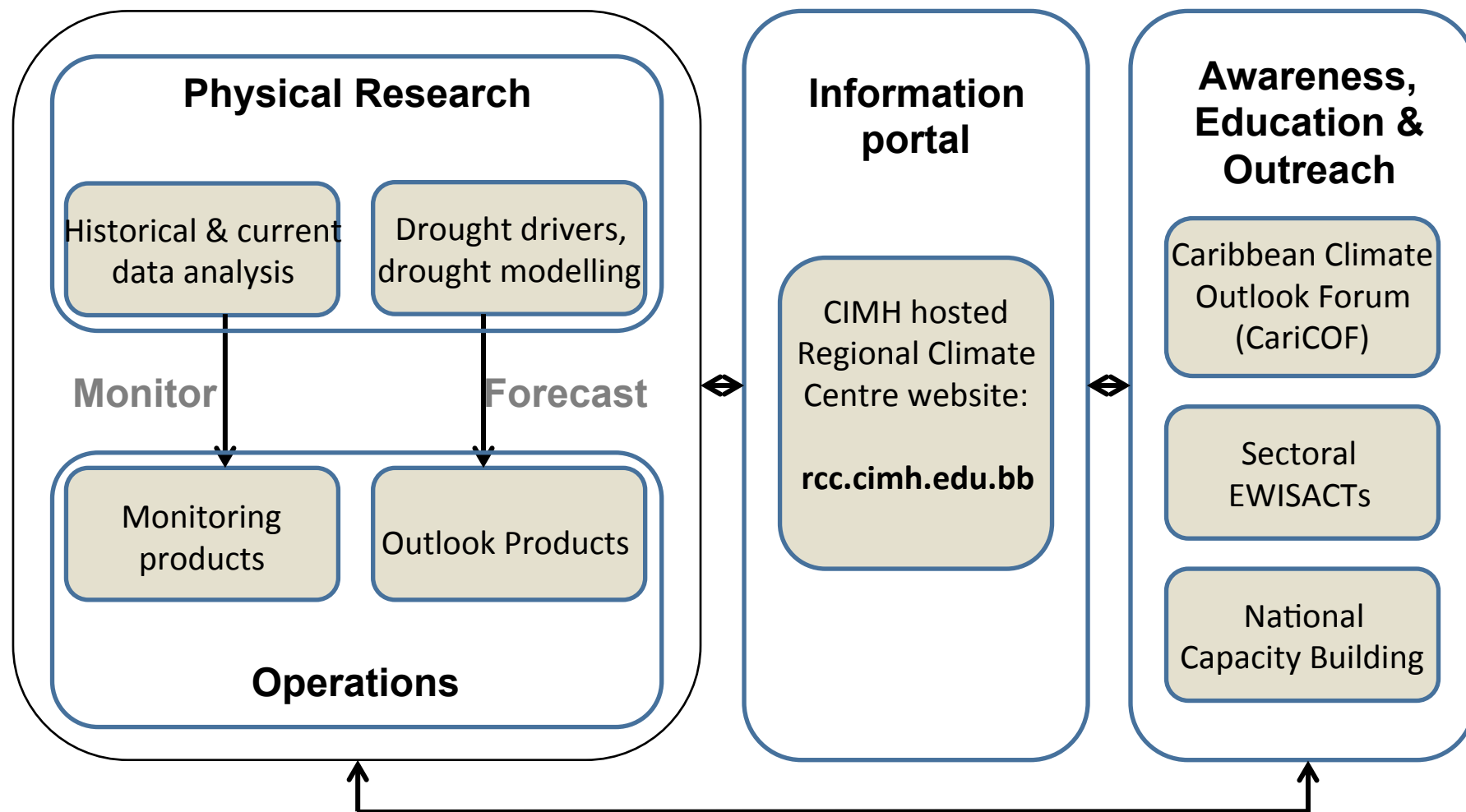
Promoting Implementation of Specific Adaptation Interventions

Solar Powered Reverse-Osmosis Systems in Bequia and Grenada





Caribbean Institute for Meteorology and Hydrology

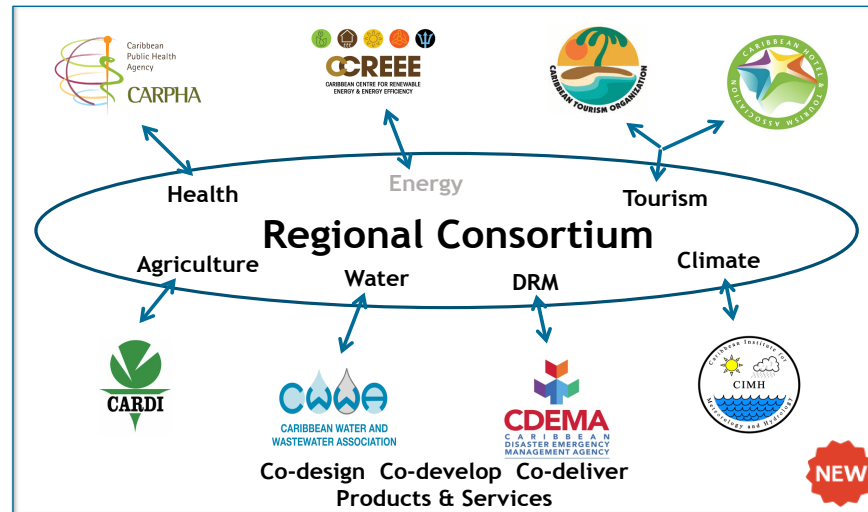
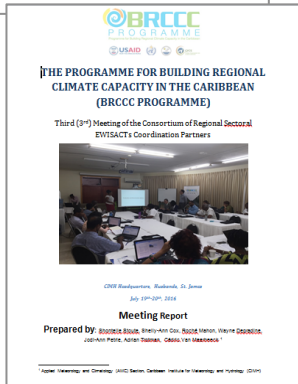
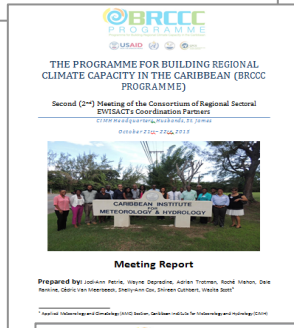
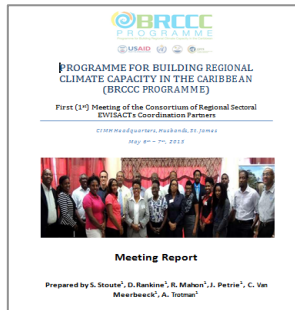


Regional Climate Center Drought Early Warning Information System

Early Warning Information Systems Across Climate Timescales

EWISACTs Partners

The Consortium is a key regional mechanism to champion the design, development and delivery of tailored climate products and services in the agriculture and food security, disaster risk management, energy, health, tourism and water sectors.



Co-development of sector-specific climate indices

- Facilitates broader dialogue and sustained engagement with regional and national stakeholders;
- Facilitates the identification and sharing of textual and georeferenced sectoral datasets;
- Facilitates the identification and sharing of historical climate-related impact data;
- Supports the conduct of research that examines associations between climatic variables and relevant sectoral productivity outcomes; and
- Promotes the dissemination of climate information.



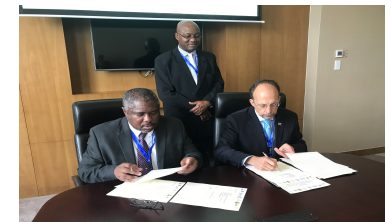
CTO and CHTA sign the LoA, September 16th, 2016



CWWA signs the LoA, October 26th, 2016



CARDI and CDEMA sign the LoA, December 6th, 2016



CARPHA and CIMH sign the LoA, April 26th, 2017

Caribbean Public Health Agency

CARPHA Partners



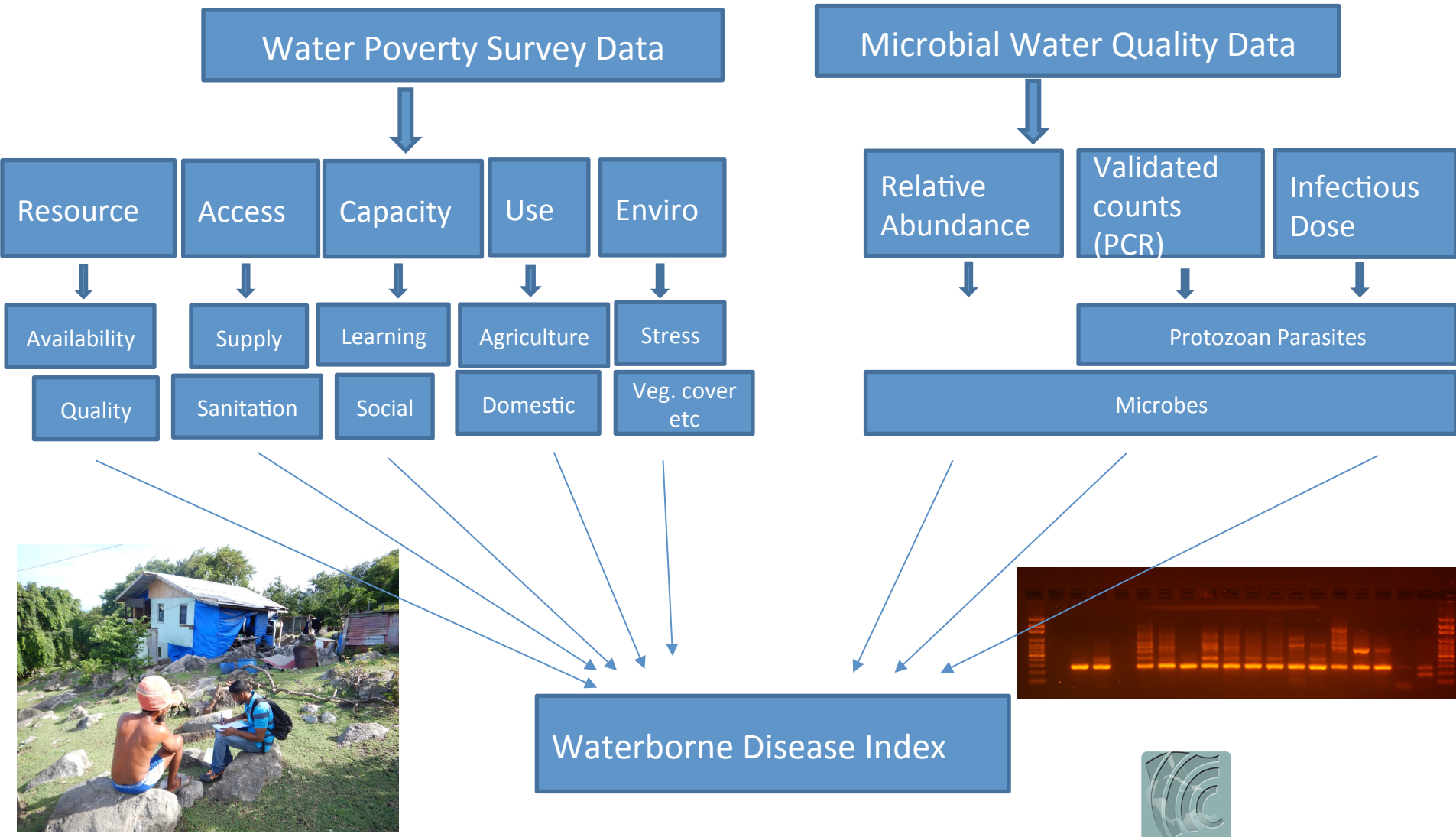
Established in 2013: Integrating 5 regional agencies



Concept for Regional Proposal on Built Environment, Climate Change & Health

- CARPHA, Public Health Agency of Canada, 5Cs and Town and Country planners to work on health- promoting and environmentally sustainable communities
- Characteristics of a health-sustaining built environment similar to those which support environmental and economic sustainability, and quality of life
- A significant health promoting component is whether urban design enables people to transport themselves with options beyond single occupant vehicle, espec:
 - design to support active transportation (walking and cycling, wheelchairs)
 - public transportation
- Built environment changes being advocated by public health community are the same as those being called to mitigate climate change

Develop a waterborne disease index for rural communities in the Caribbean





↓ 64% perceived quality
↓ 61% perceived quantity



44% HH



11% HH

Environmental Capital

0.630

NARIVA

0.460

**Natural Disasters &
Climate Variability**

0.413

Physical Capital

0.351

Social Capital

0.556



Economic Capital

0.398

Human Capital

0.412



PAHO Smart Hospital Initiative

(5 new hospitals to date)

SMART HOSPITALS

SMART = SAFE and GREEN

A hospital is considered "SMART" when it links structural and operational safety and disaster resilience with resource reducing interventions (less energy, water efficiency and reduced costs) at a reasonable cost-benefit ratio and reduces greenhouse gas (GHG) emissions.

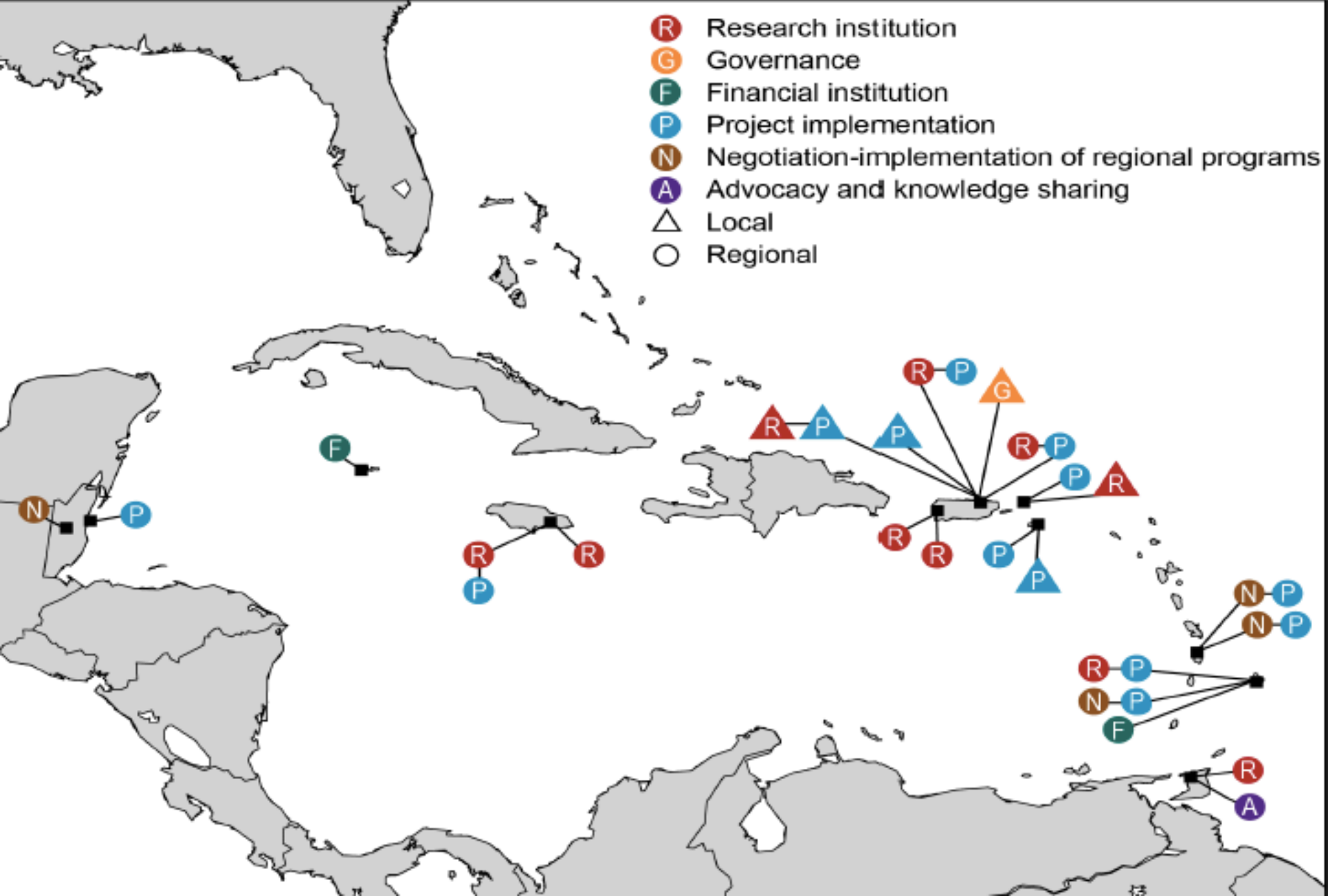
In "green" hospitals, air quality improves, water and energy costs decline, and people's working conditions improve thru enhanced physical access to hospitals, improved access to safe water and improved safety conditions.

Read more and see a video on SMART Hospitals at:

http://www.paho.org/HQ/index.php?option=com_content&view=article&id=11225%3A%20paho-promotes-safe-green-and-smart-hospitals-in-the-caribbean&Itemid=1926&lang=en

SMART HOSPITAL INTERVENTIONS *includes*

1. Improve access for all weather conditions;
2. Reduce vulnerability to relevant disasters;
3. Emergency response plans, teams and training;
4. Replace all incandescent (waste of energy) and Fluorescent (Hg) light with LED;
5. Solar water heaters!
6. Collect rainwater for flushing and washing (dual plumbing system, preventing mosquito breeding);
7. Wastewater re-use: toilet flushing or irrigation;
8. Improve to more efficient AC and HVAC!
9. Improve natural ventilation (reduced cost for HVAC and better indoor air quality).



Climate Risk Management –Regional Actor Network

Climate Risk Governance: Broadening the “Actor Network”

When might co-production become co-optation ?



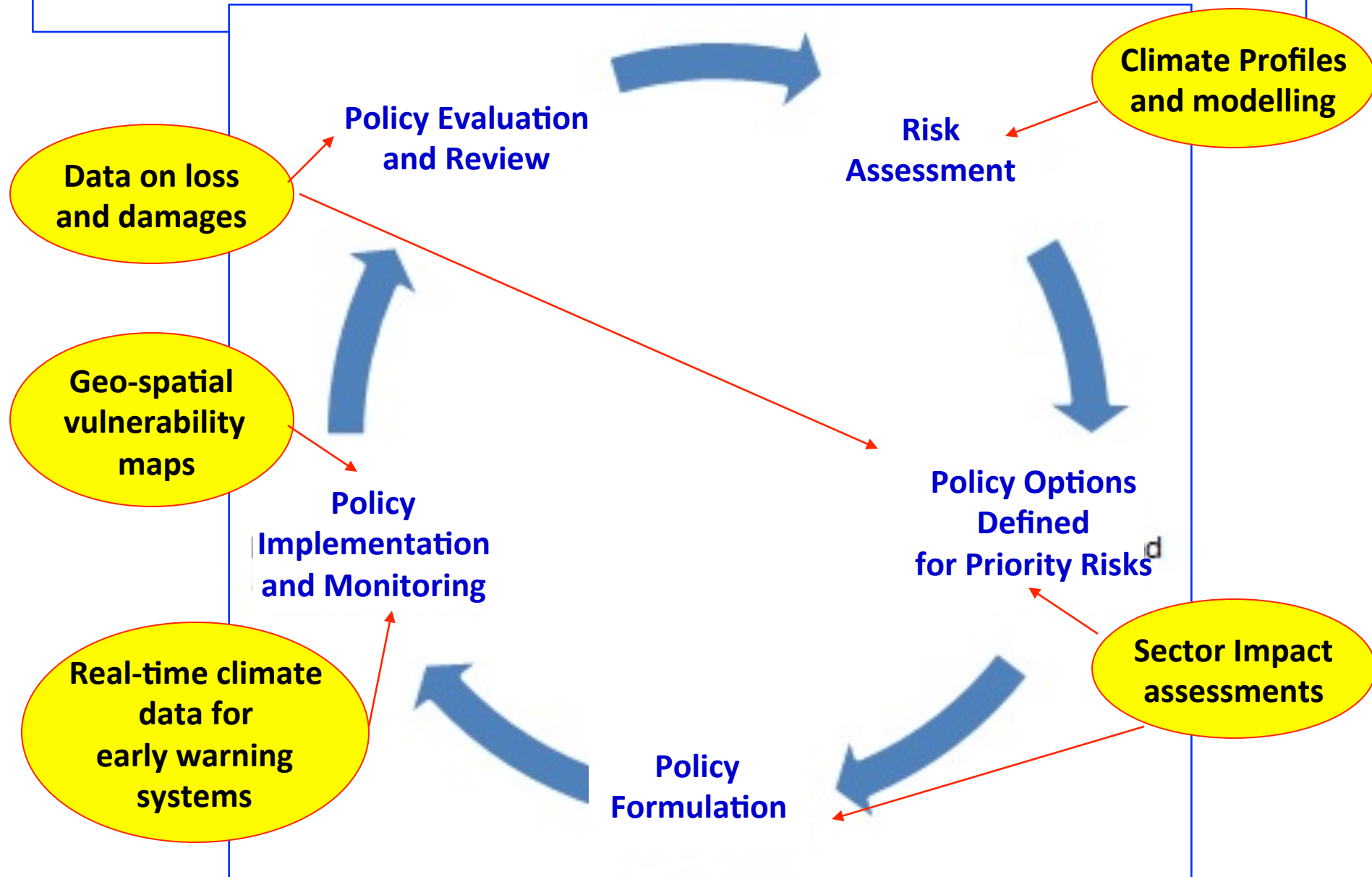


Professional MSc Program in Natural Resources-Climate Change Stream (1.5 years)
Over 90 people around the region in DRR, Water, Tourism, Agriculture, NGOs, Ecosystems



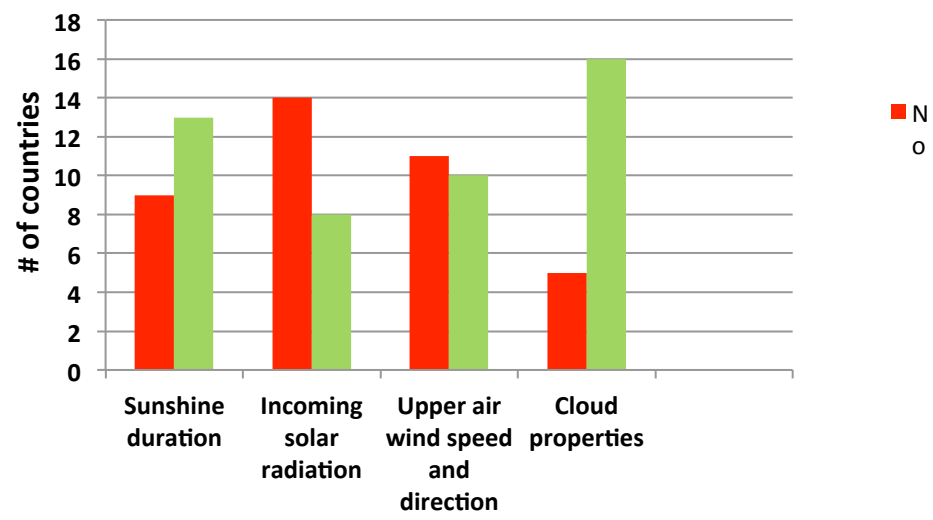
THE UNIVERSITY OF THE WEST INDIES
AT CAVE HILL, BARBADOS

Science/ Information Needs to Support National Climate Change Adaptation Policy Process (5 year Cycle)

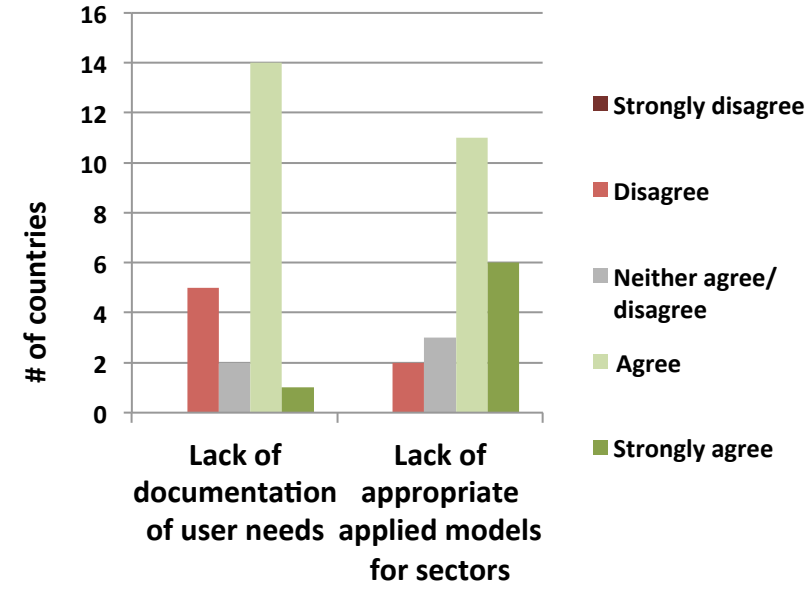


Many barriers to the development of sector-specific climate information and indices exist

Climate observation program gaps



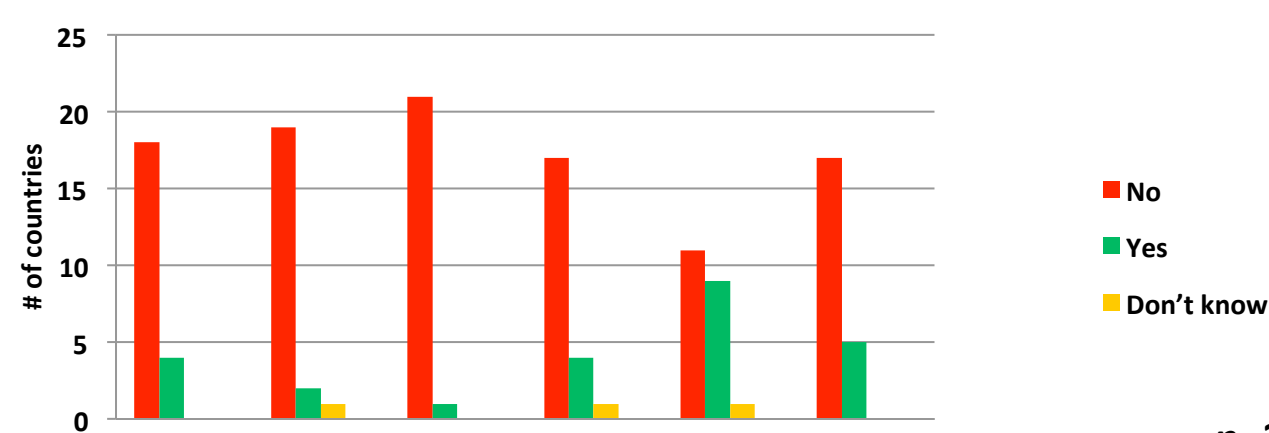
RMP gaps 1



Sector data needs to be rigorously collected and managed as like the climate data – and compatible format

Caribbean Climate Impacts Database (CID) developed to support research and modelling for sector specific impacts-based forecasting

RMP gaps 2



A research partnership for the Caribbean climate change adaptation and resilience planning through partnerships

nt Initiative by
OM UNITED NATIONS

CARICOM-UN HIGH LEVEL PLEDGING CONFERENCE BUILDING A MORE CLIMATE RESILIENT COMMUNIT

21 NOVEMBER 2017
UN HEADQUARTERS, NEW YORK

<http://resilientcaribbean.caricom.org>

#ResilientCaribbean

ELEGANT ST. CROIX CARIBBEAN WEDDINGS MAGAZINE

*We wish
speedy
recovery
to our sister
islands in
the Caribbean!*



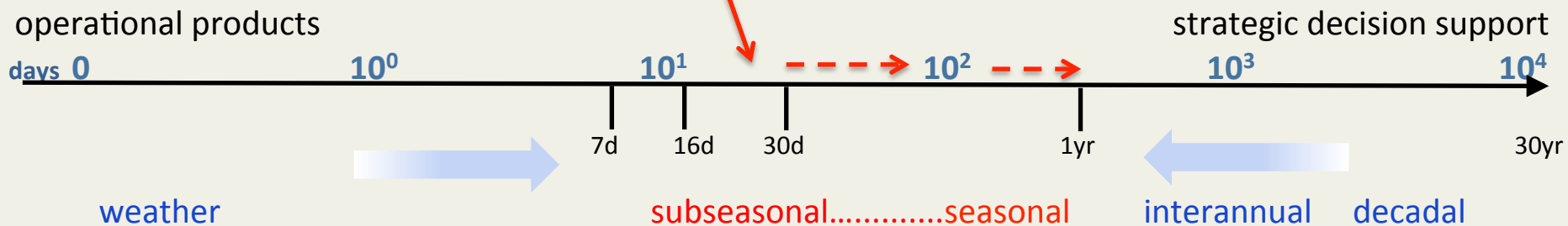
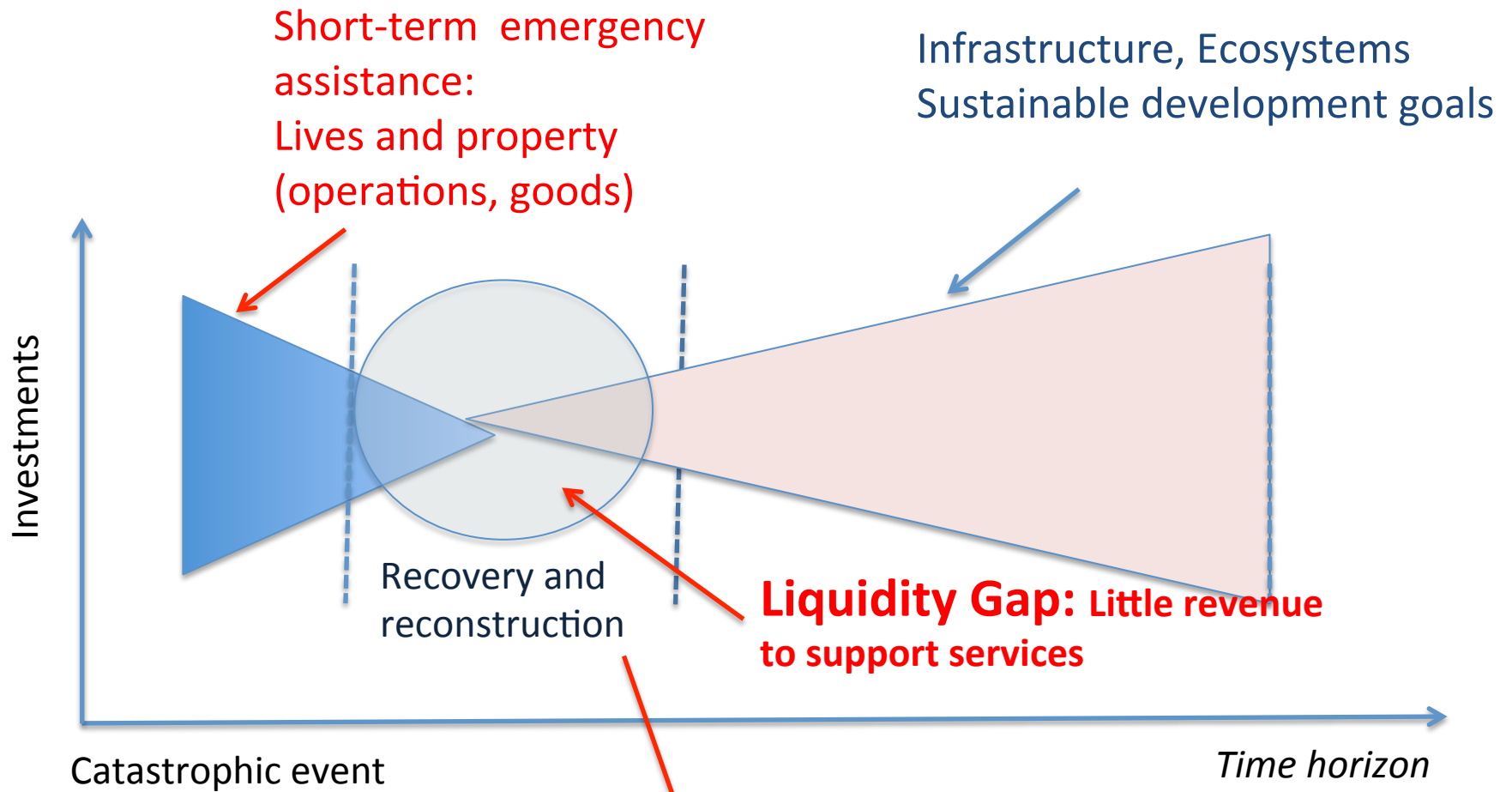
Royal Caribbean partnered with the Mogens Bay Authority and USVI local government undertook major restoration effort, working with local contractors and businesses restore the white sand coastline

Tourism Cares™

CARIBBEAN WEDDINGS

CARIBBEAN

CARIBBEAN TOURISM RECOVERY FUND



Strong risk of underestimating the complexity of adaptation

- Increasing recognition of adaptation buffers arising from ecosystems, but little commensurate action to support this awareness: critical transitions-system decompensation
- Limited coordination on investment and implementation across the scales of governance- unclear responsibilities of actors, conflicting timescales of interventions, response
- Level of community acceptance of needed adaptations: Co-benefits of addressing multiple threats and opportunities- Alistair/Kris' cyclist

Early Warning Signs of Critical Transitions

Globally Networked Risks

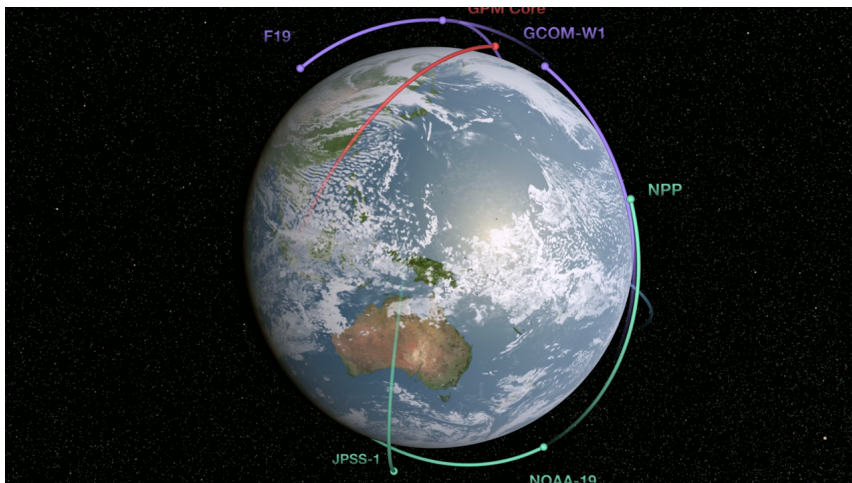
Broadening characterization of the “Actor Network”

Facilitating decision-making: Resourcing the analytical AND the deliberative processes

Five questions

- **How does transformation relate conceptually to research on vulnerability and resilience?**
- **What areas of land/coastal use have the potential to transform development negatively and positively in the context of other drivers (climate extremes and change, disaster risk management)?**
- **How can incremental steps of improved risk management over the next 5 years inform policy transformations and practice over the long-term? How should learning take place?**
- **What are concrete environment and development benefits and resource requirements of risk management? in the near (5-10 years) and the long-term**
- **How can progress in disaster risk reduction and land use choices form a basis for collaboration?**

Sustaining collaborative networks across research, observations, services and decision-making



Thank you!
roger.pulwarty@noaa.gov



Coordination



Uses of CCRIF Payouts

- Humanitarian support
- Provision of food and shelter for displaced persons
- Immediate recovery e.g. clearing silty rivers, unblocking major roads, stabilizing drinking water plants
- Stabilization of government processes
- Provision of civilian security
- Purchase of medication
- Assistance to agriculture sector
- Repairs to roofs, bridges, roads
- Capitalization of a special recovery fund
- Acquisition of building materials for affected persons



Insurability requires

1) 'Risk Landscape'
information by which to
apply technical pricing and
diversification strategies

2) High quality data on
the risk to be insured

How risk transfer links with risk reduction

3) Customers'
appreciation for how
insurance works

4) Active government
engagement in risk
management and
regulation

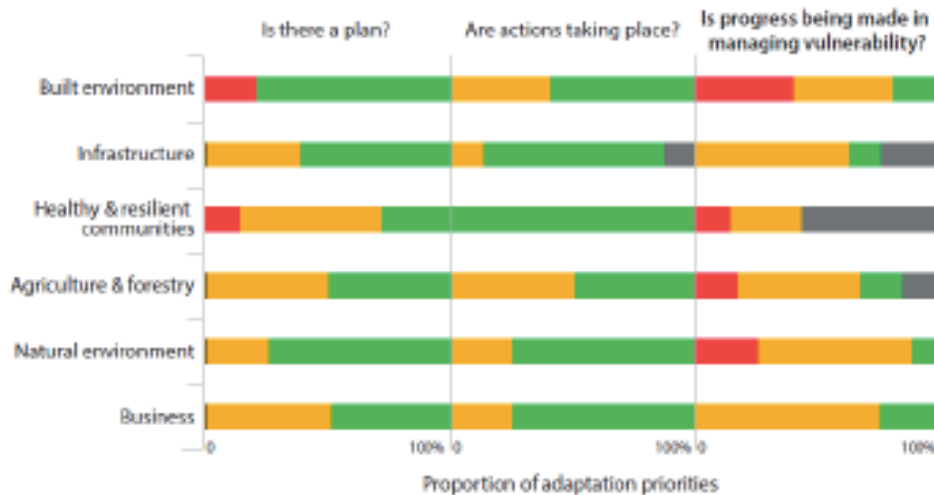
Monitoring of adaptation- Examines, on an on-going basis, one or several of the following:

- i) progress made in implementing planned initiatives that directly or indirectly affect the level of climate resilience or the capacities to develop and implement adaptation policies, plans and strategies, known as adaptive capacity
- ii) changes in the enabling environment in place for adaptation actions and adaptive capacity,
- iii) trends in exposure and vulnerability to climate-related hazards, or realised impacts of climate events, iv) tracking financial or non-financial resources spent on adaptation initiatives.

Evaluation of adaptation-A periodic assessment to answer one or several of the following:

- i) Are adaptation action(s) on track to meet pre-defined objective(s) and why/why not?
- ii) Are resources spent efficiently allocated?
- iii) Are these actions effectively reducing climate risks and how are they doing so?

Evaluations are partly based on the information monitored, but also draw on other relevant information such as stakeholder consultations and expert reviews.



(Example OECD 2017)

What are your monitoring and evaluation indicators?

Red: plans and policies, delivery of actions or progress in addressing vulnerabilities, are lacking

Amber: Adaptation priority has been partially addressed, some evidence of progress in some areas

Green: plans are in place, actions are being delivered, progress is being made

Grey: insufficient evidence to form a judgement

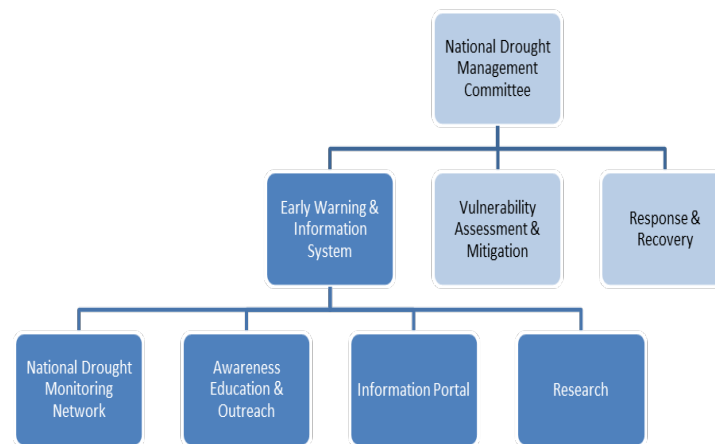
Framework for National Drought Management

Focus on Drought Early Warning & Information Systems

Phase 1—CARICOM/Brazil/FAO Cooperation Programme on Disaster Risk Reduction (DRR)
 — training in drought monitoring and planning, and development of national drought management framework.

Phase 2—USAID-funded OECS Reduce Risk to Human & Natural Assets Resulting from Climate Change (RRACC) Project

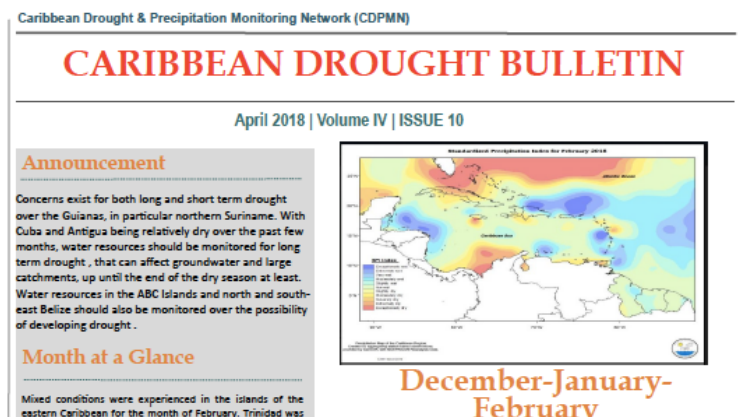
Phase 3—USAID-funded Building Regional Climate Capacity in the Caribbean Programme



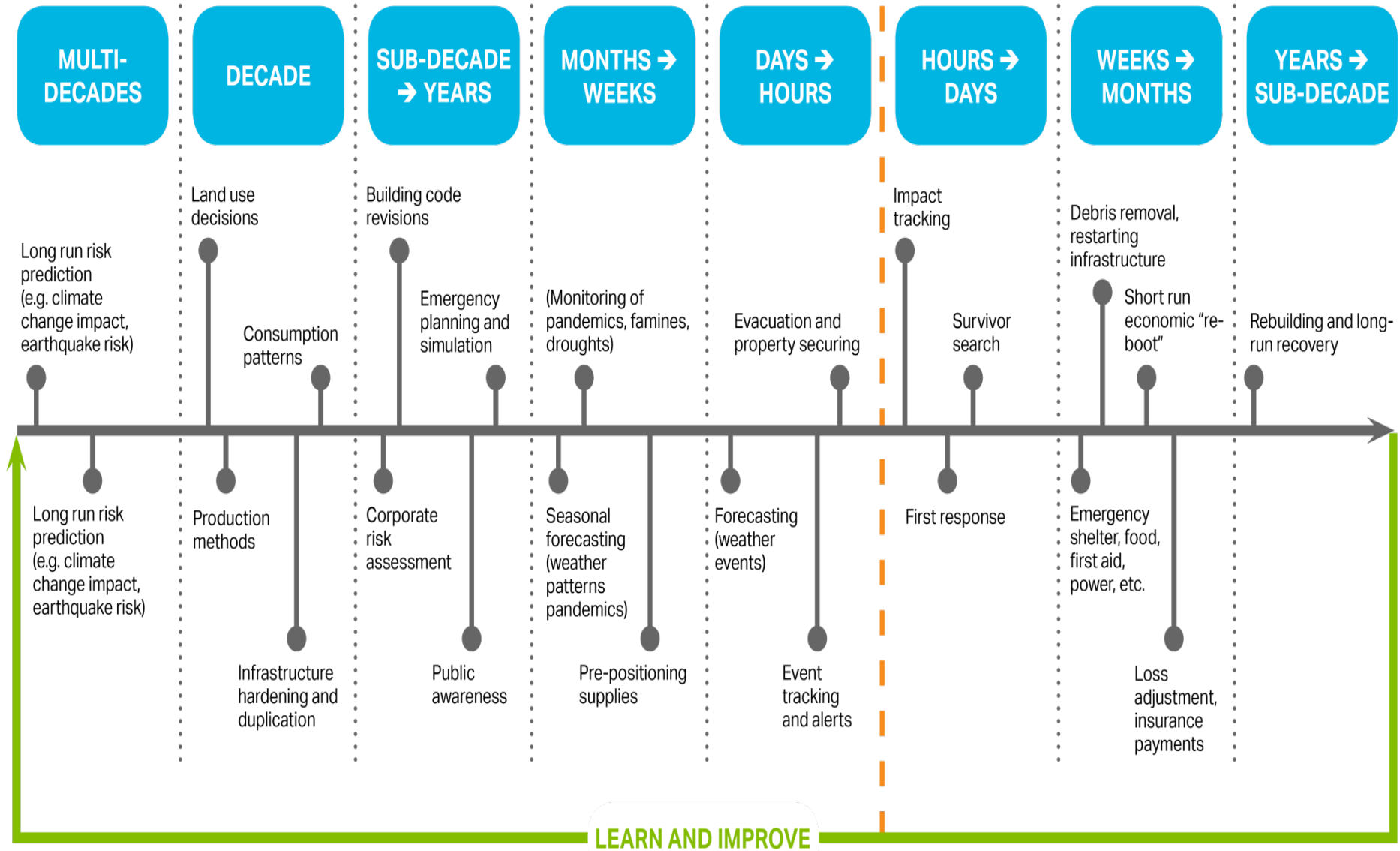
National Drought Management Framework

Thematic Area	Agency	Responsibility/Contribution
Early Warning Information Systems	St. Kitts Meteorological Services	To monitor and report relevant available climate parameters and information, to provide seasonal climate outlooks for St. Kitts and Nevis; and advise the NDMC
	Nevis Meteorological Service	
	Water Services Department	To monitor built and natural hydrologic conditions, as well as, to provide water demand trends and forecasts as the drought situation evolves; and advise the NDMC
	Department of Agriculture	To monitor for signs of crop and vegetation water stress and water availability for livestock and crops; and advise the NDMC
	Ministry of Finance	To budget internal resources and mobilize external resources in support of drought early warning; and advise the NDMC

Excerpt, SKN TOR – Role of Committee Members



"Resilience" spans multiple activities and time-scales



Sources UNISDR, UNFCCC: IBM, AECOM, National Agencies agencies.. others

Early Warning Information Systems Across Climate Timescales (EWISACTs) Roadmap

Draft 1: Shared Logic Model: Sectoral EWISACTs Roadmap and Plan of Action

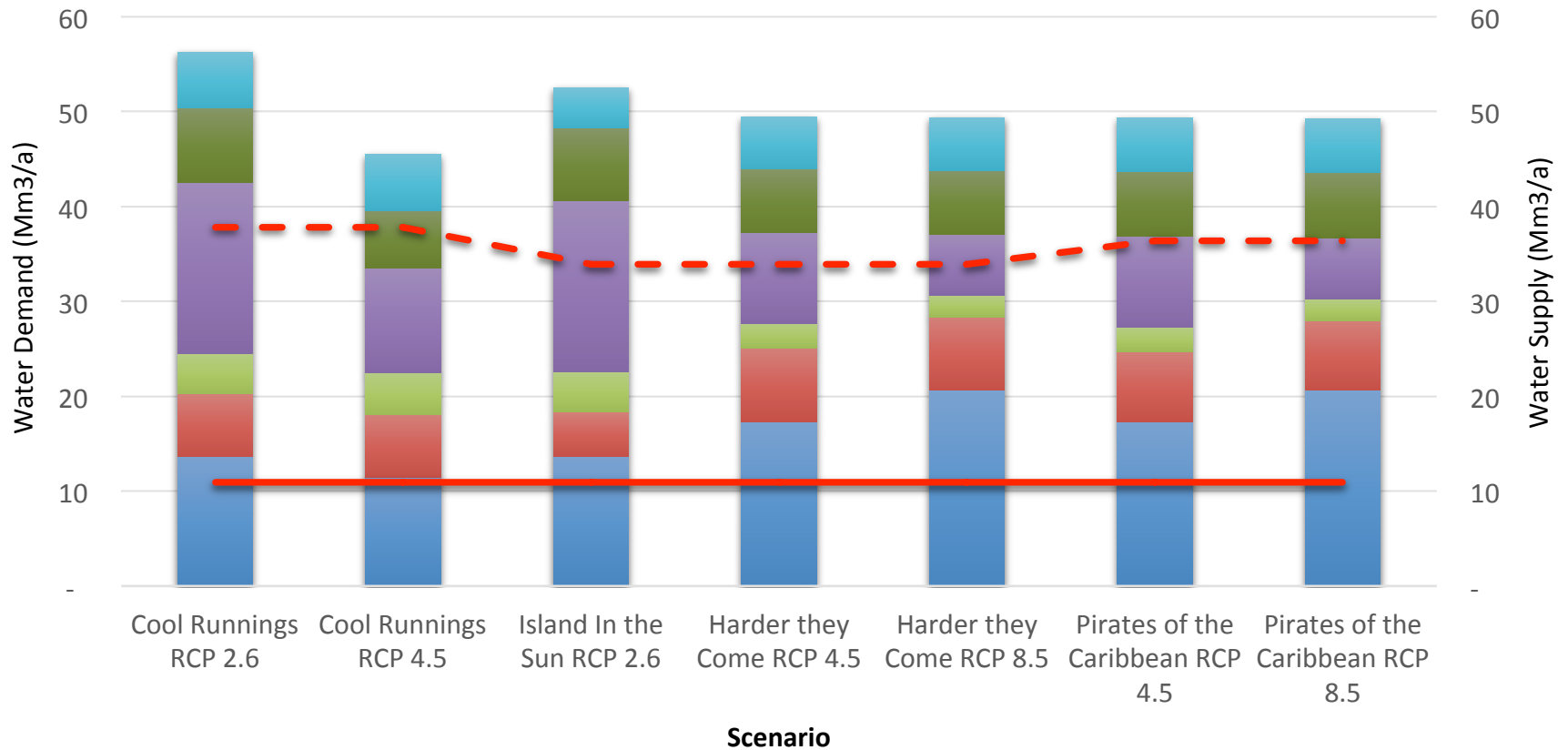
DRAFT GOAL, ULTIMATE OUTCOMES, INTERMEDIATE OUTCOMES

LEVEL	RESULTS		
Paradigm shift objective (30 year change)	To reduce and halt the incidence of weather and climate-related losses in key socio-economic sectors in the Caribbean.		
Consortium mission	Inter-institutional alliance for climate resilience among the agriculture, water, DRR, health, tourism and energy sectors.		
Roadmap guiding principles	<ul style="list-style-type: none">□ Better use of existing meteorological/climate services and information platforms;□ Synergy across sectoral activities, structures and initiatives to implement the climate services agenda;□ Consultation and partnership to identify, co-produce, co-implement and evaluate services; and□ Inform and influence the regional and national resilience agenda.		
Roadmap goal (10 year change)	Increased climate resilience of sectoral infrastructure, activities and outcomes.		
Roadmap Ultimate Outcomes (10 year change)	Strengthened institutional arrangements for climate risk management (CRM) at regional, national and sectoral scales	Harmonised production systems for the generation of tailored, sector-specific climate information at regional and national scales	Improved sectoral decision-making for CRM at regional and national scales

Nine of 17 named storms brought tropical storm or hurricane force winds to 1 or more Caribbean Region SIDS.

- Twenty-two of 29 Caribbean SIDS were each impacted by 1 to 3 named storms:
- Four SIDS were affected by 1 storm, 13 by two storms, 5 by three storms.
- For 11 Caribbean SIDS, maximal wind speeds were tropical storm force.
- For 11 Caribbean SIDS, maximal wind speeds were major hurricane force.
- Nine of 29 Caribbean SIDS experienced direct landfall of a major hurricane.

Barbados Water Availability 2050



Domestic water demand

Government water demand

System Losses @ 20%

Desalination existing

Tourist water demand from public system

Commercial water demand

Agricultural & Golf water demand

Plus Groundwater safe yield RCP2.6

CARPHA and climate change

- Overall objective: **Foster regional resilience**
- Serve as health coordinator for a Caribbean-wide strategic plan
 - In collaboration with key existing stakeholders such as 5Cs, CDEMA CIMH PAHO/WHO
 - Facilitate implementation with focus on most vulnerable/disparities
 - Monitor outputs and outcomes
 - Disseminate evidence-based practices



a roadmap for the Caribbean