CCRIF SPC
The Caribbean Catastrophe Risk Insurance Facility

Understanding CCRIF's Hurricane, Earthquake and Excess Rainfall Policies

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Background and Introduction

Governments are often challenged with the significant task of financing recovery efforts after a disaster. They must deal with the fiscal demands to undertake relief operations such as ensuring the availability of emergency assistance and sourcing funding for shelter, food and medical attention for displaced persons, and contend with the simultaneous challenges of mobilising enough resources to undertake the medium- to long-term recovery and reconstruction process. This process can include tasks that range from the clearance of debris to the restoration of critical services such as access to water and electricity for surviving populations to the reconstruction and rehabilitation of key public infrastructure.

CCRIF is a regional catastrophe fund for Caribbean governments designed to limit the financial impact of devastating hurricanes, earthquakes and extreme rainfall events by quickly providing financial liquidity when a policy is triggered.

In 2007, the Caribbean Catastrophe Risk Insurance Facility was created out of this recognition that natural catastrophes impose a significant burden on the financial ability of states to function after a disaster due to an unavailability of liquidity. The facility was structured as an insurance instrument to provide coverage similar to business interruption insurance in the event of losses from tropical cyclones (hurricanes) or earthquakes for 16 Caribbean member governments. In 2013 CCRIF began offering coverage for excess rainfall as well.

In 2014, the facility was restructured into a segregated portfolio company (SPC) to facilitate offering new products and expansion into new geographic areas and is now named CCRIF SPC. The new structure, in which products are offered through a number of segregated portfolios, allows for total segregation of risk.

CCRIF SPC now offers earthquake, tropical cyclone and excess rainfall policies to Caribbean governments. A segregated portfolio is expected to be established in 2015 for Central America to provide governments of that region with similar coverage.

Similar to a mutual insurance company, CCRIF is operated on behalf of its participating member countries, all of which pay a premium directly related to the amount of risk each transfers to CCRIF. Each country can purchase coverage up to a limit of US$100 million for each insured hazard (tropical cyclone, earthquake or rainfall event) within a given year. By pooling their risks, reinsurance fees are significantly lowered (See Figure 1). This in turn leads to a pricing reduction, estimated at more than half of

what it would traditionally cost if countries were to purchase identical coverage individually from reinsurance markets compared with buying the coverage from CCRIF.

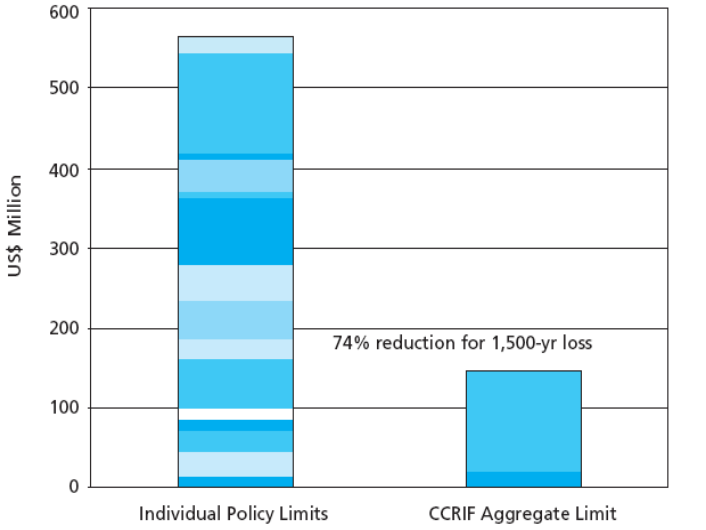


Figure 1: Insurance Costs

What is CCRIF's Parametric Insurance – How does it Work?

CCRIF offers parametric insurance which disburses funds based on the occurrence of a pre-defined level of hazard and impact without having to wait for an on-site loss assessment. This feature is quite different from traditional indemnity-based insurance products in which claims are paid based on formal confirmation of the amount of a loss through on-site verification.

For the CCRIF instrument, payouts are made on the basis of exceeding a pre-established trigger event loss. This trigger loss is derived from a simulated loss event set that is generated by a model. The model takes hazard inputs (wind speed and storm surge in the case of tropical cyclones, ground shaking for earthquakes and rainfall amount for rainfall events) from independently-provided input data. These hazard levels are then applied to pre-defined government exposure to produce a loss estimate.

Policies are triggered if the modelled loss is above a minimum value specified in the contract. Payouts above the trigger level increase with the level of modelled loss, up to a pre-defined coverage limit. Therefore payouts can be calculated and made very quickly because there is no need for an actual loss assessment to estimate damage after an event.

CCRIF makes payouts within 14 days after a hazard event triggers a country's policy.

Why Parametric Insurance?

The selection of a parametric instrument as the basis for the CCRIF policies was largely driven by the fact that parametric insurance is generally less expensive than an equivalent traditional indemnity insurance product as it does not require a loss assessment procedure in case of a disaster. Parametric insurance also allows for claims to be settled quickly. This is an important feature considering the urgent need for liquidity after a catastrophe. In addition, the instrument is also less exposed to moral hazard and adverse selection problems (which are costly to monitor) because the cost of insurance can be immediately related to the probability of an event, and the payout is independent of any mitigation efforts put in place after the policy is issued.

Despite these benefits, parametric products are exposed to basis risk, i.e., the possibility that a payout may be higher or lower than actual losses.

Although this is a significant challenge in terms of the development of the instrument, careful design of index insurance parameters as undertaken by CCRIF helps reduce the basis risk.

The development of the CCRIF catastrophe model is an important contribution to national and regional risk management institutions through its collection of a significant set of detailed databases on national catastrophe risk exposures in its member states. This is important specifically because prior to this initiative most member countries had for the most part never undertaken any major effort to collate this information which would be critical in understanding the catastrophe risks faced at a national and regional level.

A Closer Look at the CCRIF Catastrophe Models

In undertaking the development of the CCRIF parametric insurance coverage, significant investment went into developing the underlying catastrophe models. Catastrophe models are essential tools in assessing the risk associated with catastrophe events. For the most part they are based on robust datasets containing:

- **A hazard module**
- **An exposure module**
- **A vulnerability module**
- **A damage module**
- **A loss module**

The CCRIF models are no different, with the modules all developed within the context of the particular hazards of relevance to the client countries – tropical cyclones, earthquakes and excess rainfall.

The MPRES Model

The model for tropical cyclones and earthquakes is based on the **Multi-Peril Risk Evaluation System** (MPRES). This system, was developed for CCRIF and is supported by Kinetic Analysis Corporation (KAC), a risk modelling company with strong roots in the Caribbean. The MPRES can handle multiple hazards and hazard assessment methodologies, can accommodate a variety of input/output formats and detailed exposure classifications and produces accurate loss estimates with known statistical uncertainty.

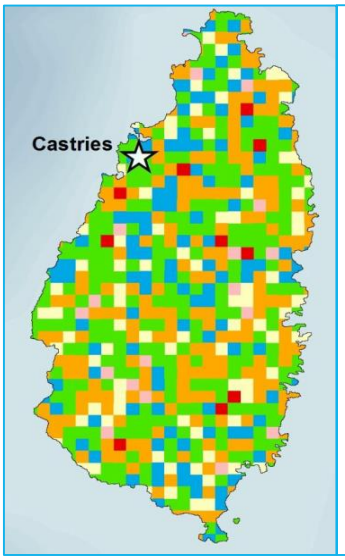
Hazard Module

The hazard module defines the frequency and severity of a hurricane or earthquake at a specific location. This is done by analysing the historical frequencies of the peril and reviewing scientific studies on the severities and frequencies in the region of interest. Using these historic data, simulated event sets are generated which define the frequency and severity of thousands of simulated cyclone or earthquake events in terms of their tracks/locations/intensities.

This hazard module then calculates the hazard intensity at each location for each event in the simulated set. This is done by modelling the attenuation/degradation of the event from its location to the site under consideration and evaluates the propensity of local site conditions to either amplify or reduce the impact.

Exposure Module

In developing the exposure module, the exposure values of "assets at risk" are estimated from available secondary data sources (including economic and satellite data) and from the population distribution. This "proxy" approach is used due to limitations in availability of site-specific asset data. Based on tested algorithms, the module computes the value of different asset types for each 1-km grid square across the entire country in question. Saint Lucia's exposure distribution below, provides an example.



Saint Lucia's exposure distribution. Each 1 x 1 km square shows the percentage of the country's total exposure in that area. Red squares show the highest exposure and pale yellow the lowest.

Vulnerability/Damage Module

In terms of the vulnerability module, the starting point is to quantify the damage caused to each asset class by the intensity of a given event at a site.

Estimation of damage is measured in terms of a mean damage ratio (MDR). The MDR is defined as the repair cost divided by replacement cost of the structure. The curve that relates the MDR to the hazard (earthquake shaking, wind or storm surge inundation) intensity is called a vulnerability function. Each asset class has a different vulnerability curve for each hazard.

Loss Module

To calculate the losses, the damage ratio derived in the vulnerability module is translated into dollar loss by multiplying the damage ratio by the value at risk. This is done for each asset class in each grid cell. Losses are then aggregated as required (e.g. at the administrative or national level). Government assets or assets that are likely to be financed with government resources can be isolated and an assessment of financial needs for reconstruction calculated.

The Rainfall Model

The Caribbean Rainfall model, developed by Kinetic Analysis Corporation and reinsurer Swiss Re, is used to calculate rainfall event loss. The current Excess Rainfall model is based on data from the Tropical Rainfall Measurement Mission (TRMM), which provides a satellite-based estimate of aggregate rainfall at quarter-degree (~25 km) resolution every 3 hours.

Using TRMM rainfall data, KAC produces enhanced rainfall estimates, or iTRMM ("improved" TRMM). iTRMM takes into account geographic details (topography) and is better than TRMM in capturing short, intense rainfall events.

The rainfall model will be changing for the 2015/2016 policies because of the termination of the TRMM mission in early 2016. Instead of reliance on TRMM data, a modelled precipitation approach is being developed. This approach allows for the use of multiple input data sources (including satellite) and it has higher spatio-temporal resolution than the current model. Also, it better addresses basis risk due to a more accurate modelling approach.

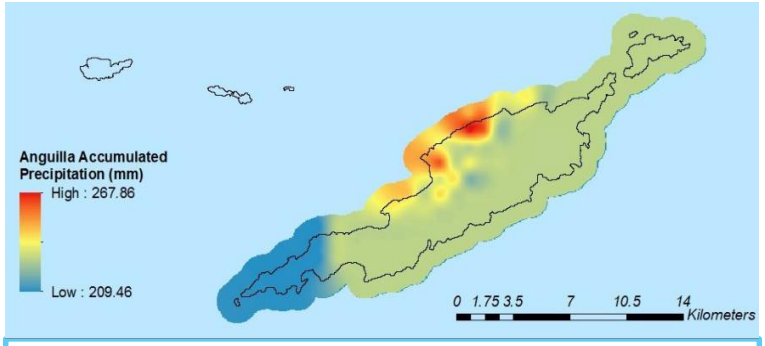
The current excess rainfall model uses the iTRMM data to compile a 2-day or 3-day (depending on the country) running aggregate of rainfall measurements (Aggregate Rainfall) at all of the iTRMM Grid Cells across a country.

As with the Tropical Cyclone and Earthquake products, the MPRES exposure database is utilised to map exposures across a country at 30 arcsecond (~1 km) resolution.

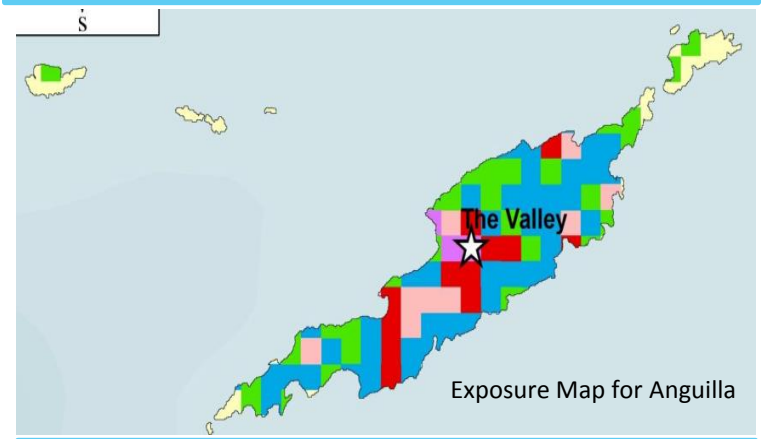
Since the iTRMM Grid Cells are at ~1 km resolution, the 1 km MPRES exposure data are mapped onto the iTRMM grid. This provides a distribution of the MPRES values between the rainfall measurement points covering each country.

Calculating index losses

To calculate index losses, the aggregate rainfall is calculated for each iTRMM Grid Cell using a moving window, which ensures that peak measurements are captured. An iTRMM Grid Cell Event (iGCE) occurs when the aggregate rainfall exceeds 75 mm and ends when aggregate rainfall falls below that level. For each iTRMM Grid Cell, the aggregate rainfall measurement is used to calculate the index loss rate via a damage function which maps loss percentage to rainfall amounts.



Accumulated precipitation data for Anguilla for a trough that occurred in November 2014



A grid of ~1km² iTRMM cells is created to cover each country. An exposure value is attributed to each iTRMM cell and each day an Aggregate Rainfall amount is attributed to those with an exposure value greater than zero.

The index loss for each grid cell (the iTRMM Grid Cell Event Loss) is calculated by applying the indemnity rate for each iGCE to the exposure value of the iTRMM Grid Cell. The next step is to calculate the total index loss for the rainfall event.

A **Covered Area Rainfall Event (CARE)** or national rainfall event is recorded when the total number of ongoing iTRMM Grid Cell Events exceeds a threshold (known as the active percentage) specified in each country's policy. For example, a country may be covered by 800 iTRMM cells of which 90% (or 720 cells) must be active to trigger a CARE. A CARE ends when the number of ongoing iGCEs falls below this threshold.

To calculate the Rainfall Index Loss for the CARE, the iTRMM Grid Cell Event Losses (for the iGCEs that contributed to the CARE) are aggregated. Therefore, the Rainfall Index Loss for a CARE can only be calculated once all iGCEs that contributed to it are finished, in other words, when the rainfall in those cells falls below 75 mm.

For any iGCE that spans two or more separate CAREs, the iTRMM Grid Cell Event Loss is allocated in full to the first CARE and forms part of the Rainfall Index Loss only for that first CARE.

How is a CCRIF Policy Triggered?

The trigger level is dependent on the coverage purchased by individual countries. Member governments may purchase coverage which triggers for a '1-in-15-year' hurricane, a '1-in-20-year' earthquake or a '1-in5-year' rainfall event, for example, with maximum coverage of US$100M available for each peril. The cost of coverage is a direct function of the amount of risk being transferred, ensuring no cross-subsidisation of premiums and a level playing field for all participants.

A policy is triggered when the modelled loss for a hurricane, earthquake, or event in a member country equals or exceeds the attachment point specified in the policy contract.

A CCRIF policy is triggered based on the government loss estimated in the loss model, which in turn is based on the characteristics of the hazard and the distribution and exposure of government assets at risk of being affected by the hazard (as described above). The trigger level (attachment point or deductible) specified in the policy contract is then applied to the modelled government loss. The policy is triggered when the modelled loss for a hurricane, earthquake or rainfall event in a member country equals or exceeds the attachment point specified in the country's policy contract.

How are Payouts Calculated?

Tropical Cyclones

In the case of tropical cyclones, a payout to a country would depend on the storm's intensity and track relative to the distribution and exposure of government assets and on the attachment and exhaustion points and coverage limit that the country has selected. Once the trigger level has been reached, the payout increases as the modelled loss increases, due to higher hazard intensity or a closer track (or both) for the storm (relative to the distribution and exposure of assets).

Payouts for tropical cyclones are determined based on government losses calculated using storm data from the National Hurricane Center (NHC) in the United States and parameters fixed within the loss estimation model used to underpin CCRIF's policies. The model calculates the level of wind and ocean hazards, such as storm surge, encountered across the affected area and uses the pre-fixed value and distribution of government exposures to those hazards to calculate a government loss.

Earthquakes

In the case of earthquake policies, a payout would depend on the source magnitude and hypocentre (location and depth) of the earthquake using data obtained from the United States Geological Survey (USGS). This is translated into a ground shaking intensity across each affected country which in turn drives generation of a modelled loss. The payout increases as the level of losses increases, and losses are directly calculated from the amount of ground shaking in the affected country and what assets are exposed to what level of shaking.

Excess Rainfall

In the case of excess rainfall policies, a payout to a country depends on the peak aggregate rainfall for the event, the distribution of high rainfall relative to exposure and the proportion of the country/ exposure impacted. As the index loss increases above the attachment point the payout increases as the Rainfall Index Loss increases, until the maximum payout (coverage limit) has been reached.

The specific payout totals are based on the level of coverage a country has. Each individual country chooses its own coverage options in terms of the attachment point (deductible), exhaustion point (which determines the coverage limit) and premium. The amount of the premium dictates how much of the risk between the attachment and exhaustion points a country is actually covered for.

Since its inception in 2007, CCRIF has made 12 payouts totalling approximately US$35.6 million to 8 member governments. All payouts were transferred to the respective governments within 14 days after each event. These payouts are shown in the table below.

Which Hazards are Included in the Tropical Cyclone and Excess Rainfall Payout Calculation?

Hazards that are included in computing the loss in Tropical Cyclone policies are: wind in all areas and storm surge in coastal areas where assets can be at risk from storm surge inundation. Rainfall is included only in Excess Rainfall policies. If a given tropical cyclone triggers both policies for a country then both payouts would be due.

CCRIF Policies and Coverage Selection

Regarding CCRIF policies and coverage selection, all countries are required to make three key decisions regarding their coverage selection. These are:

- **The selection of an attachment point**
- **The selection of an exhaustion point**
- **The selection of the coverage limit (which is tied to the ceding percentage and dictates the premium cost)**

Payouts made by CCRIF since 2007

Event	Country Affected	Policy Triggered	Payout (US$)
Earthquake, 29 November 2007	Dominica	Earthquake	528,021
Earthquake, 29 November 2007	Saint Lucia	Earthquake	418,976
Tropical Cyclone Ike, September 2008	Turks & Caicos Islands	Tropical Cyclone	6,303,913
Earthquake, 12 January 2010	Haiti	Earthquake	7,753,579
Tropical Cyclone Earl, August 2010	Anguilla	Tropical Cyclone	4,282,733
Tropical Cyclone Tomas, October 2010	Barbados	Tropical Cyclone	8,560,247
Tropical Cyclone Tomas, October 2010	Saint Lucia	Tropical Cyclone	3,241,613
Tropical Cyclone Tomas, October 2010	St. Vincent & the Grenadines	Tropical Cyclone	1,090,388
Tropical Cyclone Gonzalo, October 2014	Anguilla	Excess Rainfall	493,465
November Trough, 7-8 November 2014	Anguilla	Excess Rainfall	559,249
November Trough, 7-8 November 2014	St. Kitts & Nevis	Excess Rainfall	1,055,408
Trough System, 21 November 2014	Barbados	Excess Rainfall	1,284,882
Total for 2007 - 2014			**US$ 35,572,474**

Key Elements of CCRIF Policies and their Definitions

Attachment Point

The attachment point can be described as the minimum severity of the event loss which gives rise to a payment and therefore is the loss value at which the policy contract is triggered. The attachment point therefore functions like a deductible in a standard insurance policy.

Payouts are made on the policy when the modelled loss for an event in a member country equals or exceeds the attachment point specified in the contract. The policy holder, in CCRIF's case the specific country, covers all losses below the attachment point for any event.

The attachment point applies equally to each individual storm or earthquake. There is no accumulation of attachments (deductibles) from loss events for which the modelled loss was less than the attachment point. As the modelled loss increases above the attachment point, the corresponding payout increases up to the exhaustion point (see below for exhaustion point).

> ***The return period is the expected time between hazard events of a certain magnitude.***

For example, an attachment point selected at the 1-in-15-year loss level represents the loss amount (in dollars) which is likely to be exceeded only once in fifteen years. While countries generally select the attachment point as a return period, the policy includes the equivalent dollar value of loss which that return period represents in the country's risk profile.

For the 2014/2015 policy year, for example, CCRIF member countries typically selected attachment point return periods in the range 10 - 30 years for tropical cyclones, 20 - 100 years for earthquakes and 5 years for excess rainfall events.

Exhaustion Point

The exhaustion point refers to the severity of the event loss at or above which the maximum payment will be made. For the 2014/2015 policy year, CCRIF member countries typically selected exhaustion point return periods in the range of 75 - 180 years for tropical cyclones, 100 - 250 years for earthquakes and 25 years for excess rainfall events.

Ceding Percentage

The ceding percentage is the fraction of the risk between the attachment and exhaustion points that the country is transferring to CCRIF.

Once the attachment point and exhaustion point are chosen, there is a one-to-one relationship between the amount of premium paid and the ceding percentage – more premium means a higher ceding percentage.

Coverage or Policy Limit

The coverage/policy limit is the difference between the attachment and exhaustion points multiplied by the ceding percentage (the amount of risk between the attachment and exhaustion points that the country is transferring to CCRIF).

The coverage limit is the maximum amount that can be paid out under the contract in any one year for any one peril (tropical cyclone or earthquake). Payouts for events that have a modelled loss that exceeds the exhaustion point are paid out at the

coverage limit. The policy limit applies to the full term (one year) of the contract; the total amount paid out under the contract during the one-year period will not exceed the policy limit, whether that policy limit is due to payout from one large event or multiple smaller events that each trigger payments under the contract.

The coverage limit that is selected will depend on the capacity of the country to absorb losses and also on what premium the country wishes to pay.

Figure 2 shows the elements of a CCRIF policy with some example attachment and exhaustion point return periods.

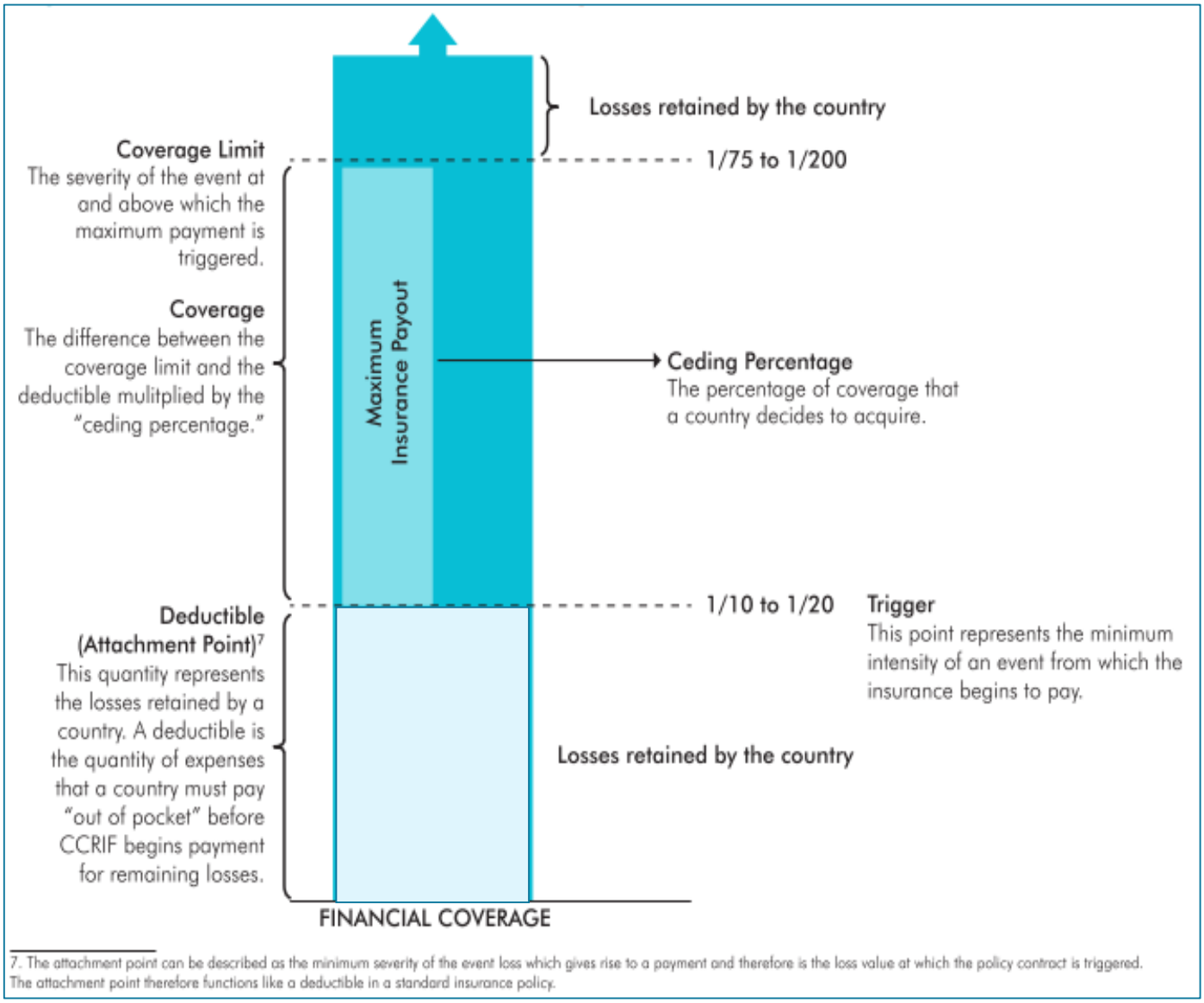


Figure 2: Elements of a CCRIF Policy[1]

[1] Adapted from *Caribbean and Central American Partnership for Catastrophe Risk Insurance*, World Bank, 2014

How is the Premium Cost Determined?

The premium is determined by the amount of coverage a country decides to take, the attachment and exhaustion points of that coverage, and the risk profile of the country. More specifically, a member country's premium cost is based on the frequency with which the hazard (hurricane, earthquake or excess rainfall event) exceeds the attachment point (as identified by the country-specific hazard profile) as well as the range between the attachment and exhaustion points and amount of risk being transferred (as encapsulated in the coverage limit).

Is there a Limit on the Number of Events Covered per Year?

Countries can purchase coverage up to US$100 million per peril. There is no limit in terms of how many events per year that a policy can cover. The real issue is the specific amount of coverage purchased relative to the impact of an event on a given country in a given year.

Assessing 2 Scenarios

Scenario 1:

What factors led to a payout of ~US$8.5M to Barbados as compared to ~US$3.2M for Saint Lucia after Hurricane Tomas in 2010?

In 2010, there was some concern expressed about the significantly lower payout received by the Government of Saint Lucia relative to their losses and in comparison to the payout received by the Government of Barbados. In the case of Saint Lucia, most of the damage that occurred was a result of the heavy rainfall and secondary induced hazards such as landslides.

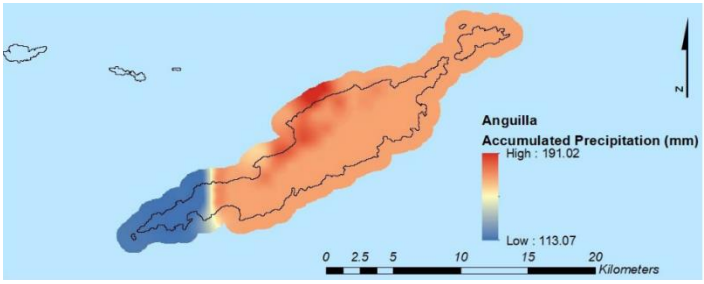
Neither rainfall nor landslides are included in the CCRIF Tropical Cyclone policies and therefore are not included in the pricing provided to countries for coverage. In the CCRIF policies, tropical cyclone coverage is priced based on damage from wind and storm surge and payouts are based on losses from wind and storm surge. Also, payouts countries receive are influenced not only by the hazard levels experienced but also the level of government exposure and the specific policy terms.

The coverage selections made by Saint Lucia and Barbados in terms of their attachment and exhaustion points and coverage limits played a significant part in determining the payouts that were received.

Policy parameters are selected by each country and are key determinants of if a policy is triggered or not and the level of payouts. Determination of payouts also depend on the value of assets insured which will have a major impact on the dollar value of damage experienced and level of modelled losses.

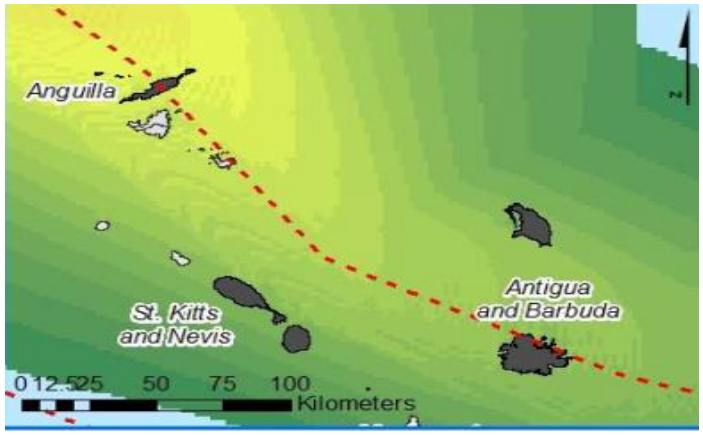
Scenario 2:
Why was Anguilla's Excess Rainfall policy triggered after Hurricane Gonzalo in 2014 and not the country's Tropical Cyclone policy?

Tropical Cyclone Gonzalo impacted Anguilla as a Category 1 hurricane in October 2014 and triggered the country's Excess Rainfall policy but not its Tropical Cyclone policy.



Accumulated rainfall for Anguilla during October 13-14 2014

A Covered Area Rainfall Event (CARE) resulted in Anguilla during Gonzalo (during the period October 13 - 14). For the CARE, the Caribbean Rainfall Model produced Maximum Aggregate Rainfall of 191.02 mm in the north of the island and the maximum number of ongoing iTRMM Grid Cell Events (iGCEs) was 114 which exceeded the required threshold (109) specified in Anguilla's Excess Rainfall policy to trigger a CARE. In fact, it was Anguilla's full complement.



Map showing the path and wind footprint of Tropical Cyclone Gonzalo

The Rainfall Index Losses calculated for Anguilla's CARE exceeded the attachment point on its Excess Rainfall policy and therefore a payout of $493,465 was due.

On the other hand, while preliminary runs of the CCRIF loss model generated government losses due to wind damage under the conditions of Anguilla's Tropical Cyclone policy, these losses were below the policy attachment point. Therefore no payout was due.

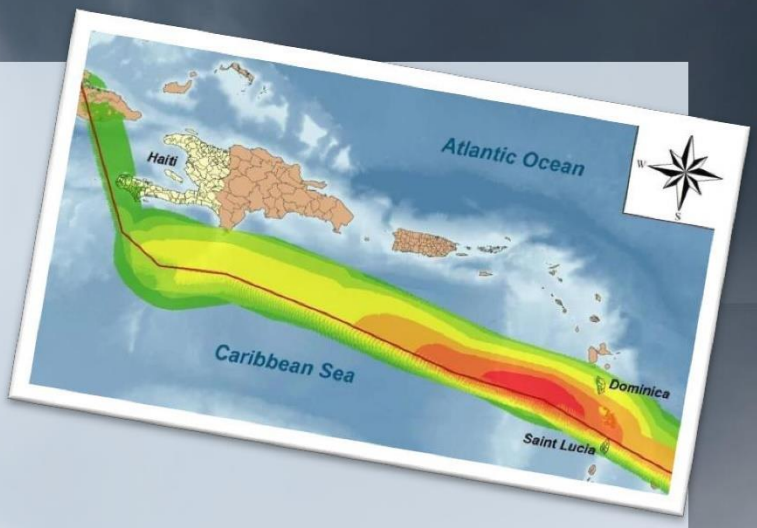
Conclusion

It is important to note that current CCRIF policies are not meant to provide full insurance of government assets but rather catastrophe insurance against loss of revenue and additional costs associated with disaster response and early recovery. Hence it is most efficient when used to cover those events which overwhelm the capacity of the state to respond effectively to high-intensity, low-frequency events.

Similarly, the insurance instrument is not meant to cover the entire risk profile of countries as a result of a catastrophe but instead is meant to ensure that there is some measure of liquidity available to governments quickly as resources are mobilised to assist with the longer-term recovery and redevelopment processes.

CCRIF SPC

The Caribbean Catastrophe Risk Insurance Facility



In 2007, the Caribbean Catastrophe Risk Insurance Facility was formed as the first multi-country risk pool in the world, and was the first insurance instrument to successfully develop parametric policies backed by both traditional and capital markets. It was designed as a regional catastrophe fund for Caribbean governments to limit the financial impact of devastating hurricanes and earthquakes by quickly providing financial liquidity when a policy is triggered.

In 2014, the facility was restructured into a segregated portfolio company (SPC) to facilitate offering new products and expansion into new geographic areas and is now named CCRIF SPC. The new structure, in which products are offered through a number of segregated portfolios, allows for total segregation of risk. CCRIF SPC is registered in the Cayman Islands and operates as a virtual organisation, supported by a network of service providers covering the areas of risk management, risk modelling, captive management, reinsurance, reinsurance brokerage, asset management, corporate communications and information technology.

CCRIF currently offers earthquake, tropical cyclone and excess rainfall policies to Caribbean governments and will soon offer similar coverage to Central American governments. Also, CCRIF offers loan portfolio coverage to financial institutions in Caribbean countries.

CCRIF helps to mitigate the short-term cash flow problems small developing economies suffer after major natural disasters. CCRIF's parametric insurance mechanism allows it to provide rapid payouts to help members finance their initial disaster response and maintain basic government functions after a catastrophic event.

Since the inception of CCRIF in 2007, the facility has made twelve payouts for hurricanes, earthquakes and excess rainfall totalling approximately US$35.6 million to eight member governments. All payouts were transferred to the respective governments within 14 days (and in some cases within a week) after the event.

CCRIF was developed under the technical leadership of the World Bank and with a grant from the Government of Japan. It 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 United Kingdom and France, the Caribbean Development Bank and the governments of Ireland and Bermuda, as well as through membership fees paid by participating governments.

Sixteen countries are currently members of CCRIF:

Anguilla, Antigua & Barbuda, Bahamas, Barbados, Belize, Bermuda, Cayman Islands, Dominica, Grenada, Haiti, Jamaica, St. Kitts & Nevis, Saint Lucia, St. Vincent & the Grenadines, Trinidad & Tobago and Turks & Caicos Islands