Ministry of
Agriculture & Fisheries
Government of Jamaica

CIB
Coffee Industry Board

Jamaica

Weather Insurance for the Coffee Sector
Feasibility Study

World Bank LAC
opportunities for all

Financed by:

Global Index Insurance Facility (GIIF)

All ACP Agricultural Commodities Programme

ACP GROUP OF STATES

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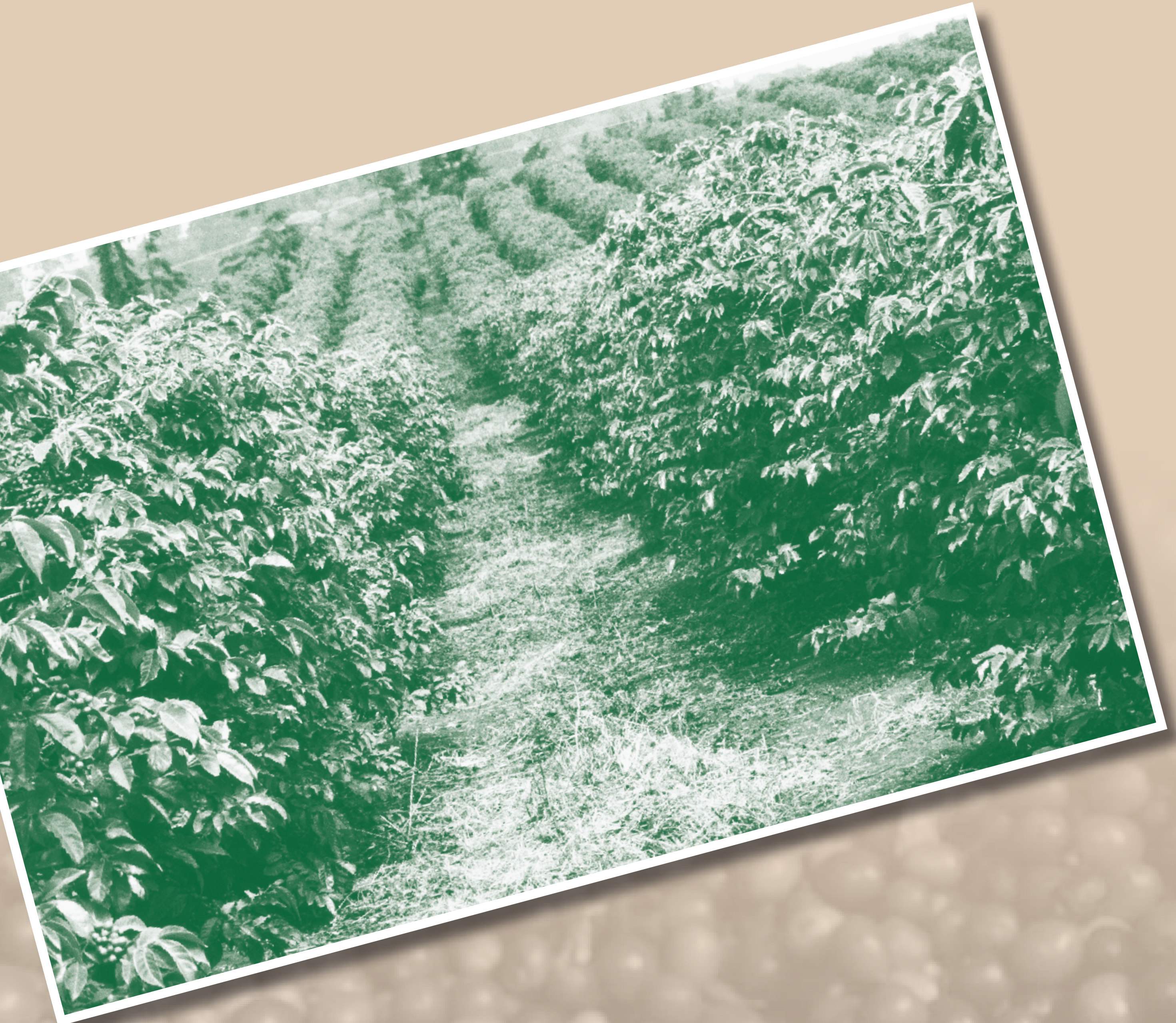

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Acknowledgements

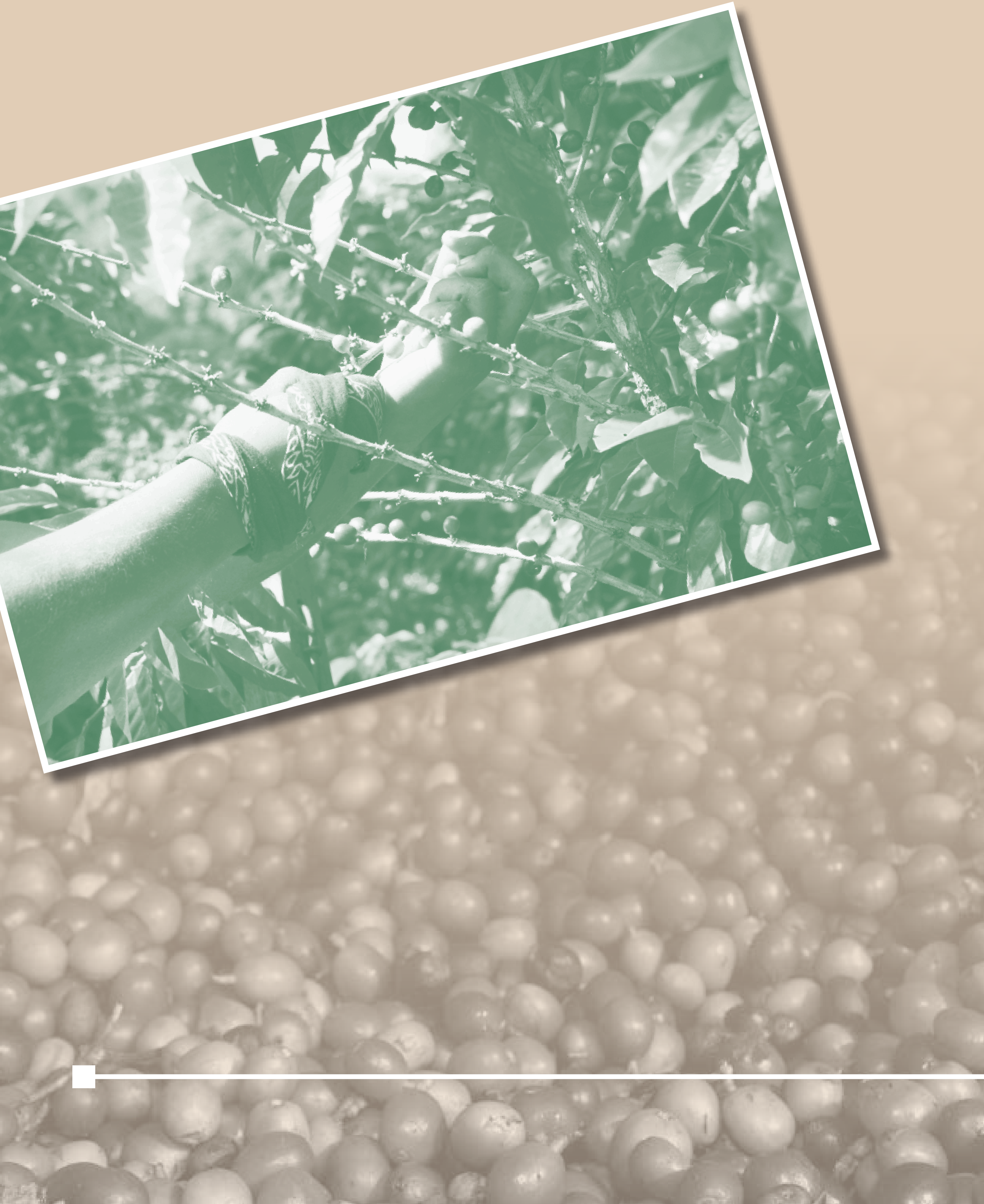
This report was authored by William Dick and Pablo Valdivia (Consultants, Agricultural Risk Management Team, ARMT, Agriculture and Rural Development Department, ARD) and Ramiro Iturrioz (Senior Agricultural Insurance Specialist, Insurance for the Poor Program, GCMNB), at The World Bank. The work was undertaken under the guidance of Carlos Arce (ARMT) and Diego Arias (Task Team Leader, LCSAR).

The authors would like to thank the Board, Management and Staff of the Coffee Industry Board (CIB), under the guidance of Christopher Gentles (Director General), with particular thanks to Gusland McCook, Damion Wedderburn and Dave Gordon, who had responsibilities as technical counterparts to the World Bank team, and to many other members of the CIB's staff who contributed. The authors would also like to thank coffee farmers who attended meetings organized at the Mavis Bank Coffee Factory convened by Senator Norman Grant, CEO, and at meetings organized in Morant Bay and in Portland Districts. The authors acknowledge the input of Dr. Simon Young, CEO, Caribbean Risk Managers Ltd., in facilitating the risk modeling work undertaken by CGM Gallagher Group Ltd.

Funding support for this study was provided by EU's All ACP Agricultural Commodities Programme (AAACP) and the Global Index Insurance Facility (GIIF).

Abbreviations

ARMT	Agricultural Risk Management Team
CIB	Coffee Industry Board
CCRIF	Caribbean Catastrophe Risks Insurance Facility
CGM-KAC	CGM Gallagher Group Ltd – Kinetic Analytics Corporation
EP	Excedance Probability
FAC	Financial Services Commission
FAO	Food and Agriculture Organization (United Nations)
FRATS	Farmer Registration and Activity Tracking System
GoJ	Government of Jamaica
IADB	Inter-american Development Bank
MOA	Ministry of Agriculture
NOAA-ATCF	National Oceanic and Atmospheric Administration – Automated Tropical Cyclone Forecasting
TSI	Total Sum Insured
WB	The World Bank



Executive Summary

1. **Coffee grown by farmers in the Blue Mountain region of Jamaica is subject to damage from high winds and heavy rains associated with major tropical cyclones (hurricanes and tropical storms).** A coffee insurance scheme was operated by Trustees of the Coffee Industry Board (CIB) until 2006, since when there has been no insurance in place. The previous program suffered from several difficulties, due to lack of farmers' registration, difficulties of field assessment after major losses, and due to the insurance/reinsurance policy operating only at an aggregate industry level. The legal basis of Trustees operating an insurance scheme was also questioned.

2. **The present study investigates the feasibility of wind index-based insurance,** using an approach where payouts are based on the output of a model which is able to simulate the winds associated with cyclones occurring over Jamaica during the hurricane season, from July 1st to November 30th. The model considers the spatial distribution of winds associated with past storm events held in the National Oceanic and Atmospheric Administration (NOAA) Caribbean basin database, including storm characteristics as well as physical features such as topography. **Farmers are grouped into 16 zones, according to districts and altitude bands, for the purpose of payouts.** Vulnerability functions according to the stage of growth, and exposure patterns based on monthly expected reaping of coffee, were prepared by the CIB and used to correlate, as closely as possible, the payout levels against the expected loss of coffee. The generated payouts from past major events were compared with known industry losses, as a method of validating the parameters within the model.

3. **Even though rainfall is a risk of concern for the coffee industry, it was not possible within the timeframe and budget of this feasibility work to derive a basis for simulating rainfall associated with cyclone events.** Whilst this type of rainfall risk modeling work is also continuing as part of wider efforts of the Caribbean Catastrophe Risk Insurance Facility (CCRIF), it has not been possible to include rainfall within the findings of this feasibility study. However, preparatory work has been carried out which would allow rain hazard outputs to be incorporated as and when this type of risk modeling is available.

4. **The report lists advantages and disadvantages associated with the wind index-based insurance approach, and compares it to the previous insurance program.** Advantages include its objectivity and lack of moral hazard, the absence of field loss assessment, the direct contract made possible to the farmer, the expected feasibility of placing the risk with the international reinsurance market, and the possible rapid payout after a major event. **The report also considers that there is a major disadvantage that Basis Risk levels will be high.**

5. **The Basis Risk** (variances in the payout amount compared to actual yield loss) for this insurance product arises from: (a) localized differences in crop damage which are expected and well known because of the chaotic nature of wind storm events; (b) the complex topography of the Blue Mountain region, leading to modeling challenges, and of phenology, leading to challenges in estimating coffee vulnerability to different windspeeds; and (c) because the model only simulates winds, and not rainfall or other causes of loss. The validation against previous specific major wind events seems reasonable; however **there remains a significant Basis Risk** particularly from damage caused by rainfall related events where there is limited or no wind. The potential for Basis Risk has been apparent from the outset of discussions and conduct of this study with the CIB, and led to the proposal that an insurance scheme such as this could best be described

as an "income supplement" triggered by major wind events, rather than a "proxy for crop insurance". **Thus, it is important for the CIB to assess the impact of marketing a scheme with potentially high Basis Risk.**

6. **Chapter 2 provides a technical description of the model, and how the modeled winds could be used within a wind index-based insurance product.** It is noted that this type of downscaled wind hazard modeling to a local scale, and then applied to an insurance product, is innovative. Whilst the "hazard module" (estimation of wind speeds associated with specific events) uses well established modeling techniques, the "coffee vulnerability module" (estimating percentage damage according to growth stage) relied heavily on the expert opinion of the CIB's technicians, whose knowledge of coffee production stages and estimated impacts according to coffee phonological stages was needed to derive the profiles. The "coffee exposure module" (estimating the quantities of coffee remaining unharvested according to the date of a wind event) relied on historical information about the reaping schedule. Since the ripening schedule of coffee is slower at high altitudes, it was decided to divide farms into three altitude categories: High, Medium and Low. Overall **zoning** of the Blue Mountain coffee areas was achieved in order to provide **payout zones** within which farmers would be grouped and all farmers would receive a payout at the same rate applied to their sums insured (captured within the final "damage module").

7. **The second part of Chapter 2 assesses the accuracy of the wind index-based insurance model** by comparing the generated winds and the percentage payouts derived from the model, with known coffee damage arising from 9 major loss events starting with Hurricane Allen in 1980 to the present day, highlighting that the model seems to capture damage from major events but that where rainfall is more relevant to damage, it cannot do so.

8. **Calculations of Probable Maximum Loss (PML) and expected Commercial Premium Rates** are presented. The PML is calculated as 50.4% (of total sum insured for the seasonal production). PML is calculated as the highest payout expected in 250 years, based on simulations of many modeled events. Intuitively, this estimate seemed low, but it is derived using the parameters selected for the model, some of which are based on the the CIB's expert opinion, for example in the vulnerability estimates. The highly catastrophic profile of the wind risk demonstrates, as expected, the need for reinsurance. The estimated overall commercial rate is 9.16% but the rates vary for each zone from 7.26% to 12.12%.

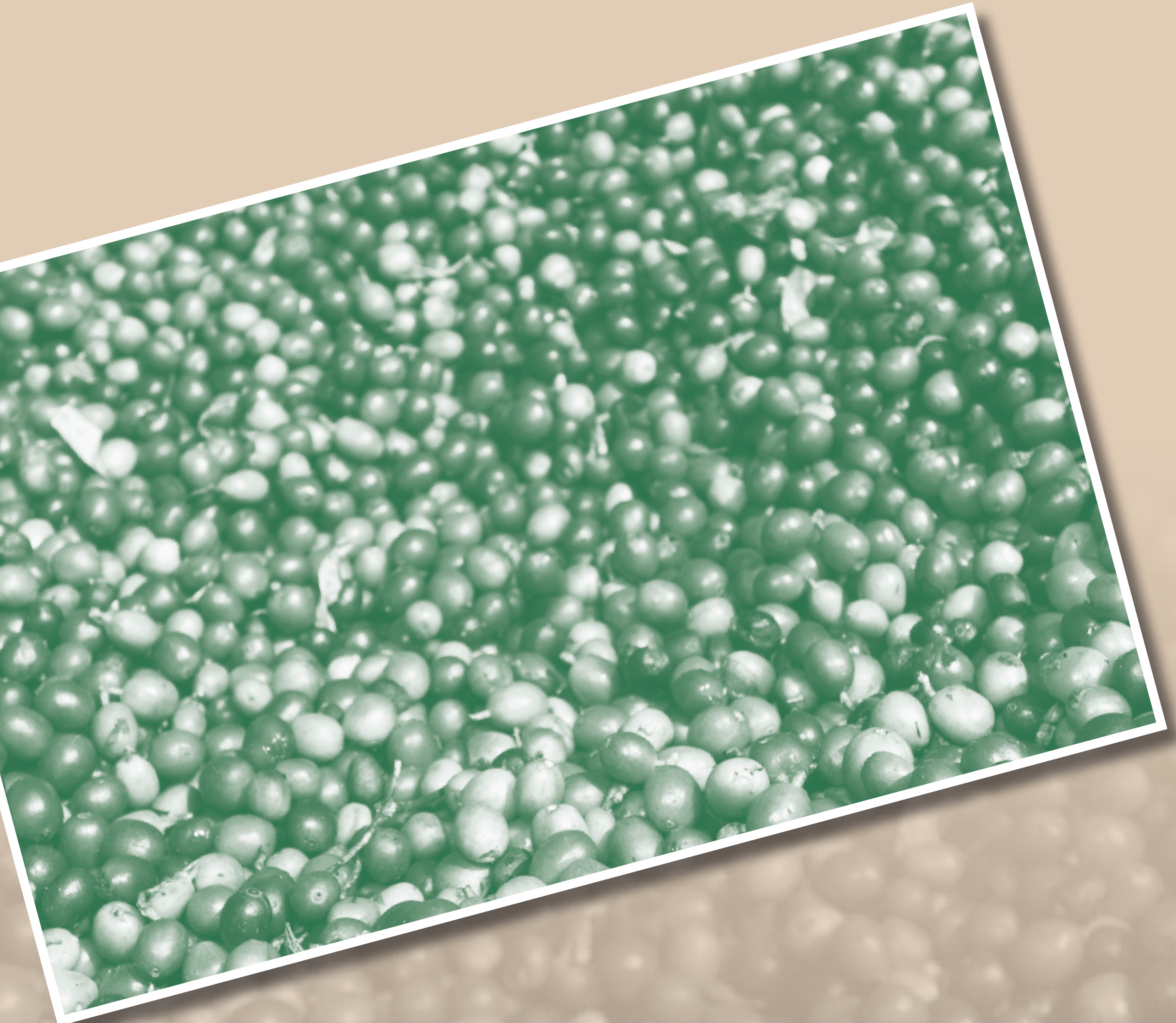
9. **If such a scheme was implemented, an ongoing contract would be needed with the modeling firm,** to ensure the ability to model specific storms arising during the period of insurance. This contract would be made with the insurers. Costs would need to be determined and budgeted into the overall premium costs of the insurance product.

10. **Chapter 3 describes the coverage which would be provided by a wind index-based insurance product, and describes the most important points relevant to its operation.** In particular, the concept of a Compulsory Basic Cover, and optional Top-Up Cover, was developed between the team and the CIB. The idea would be that the Basic Cover would be paid for from a uniform cess, collected, as at present, on all delivered boxes of cherry coffee. It is pointed out that whereas a cess could be a uniform premium rate provided that the scheme was compulsory or automatic, the Top-Up Cover would need differentiated premiums related to the risk in each zone, in order to avoid anti-selection. The options of which parameters could be adjusted are described in this Chapter. In particular, since premium is proportional to sum insured, the variation of sum insured is the main variable which could be adjusted in order to vary premium; in particular, reducing sum insured under Basic Cover so that it could be covered by the existing cess level (estimated to cover 56% of the sale value of coffee cherry).

11. **Section 3.3 describes the organizational and delivery options.** A conclusion of the product design is that (as anticipated and discussed at the outset) the product would be most suited to be marketed as an individual farmer insurance contract to farmers in a particular zone (a micro-level index product), rather than an industry-level or aggregate (meso-level) coverage. As already noted, Basis Risk remains as a key consideration. Although there are options of marketing this product to coffee processors as the insured party (a meso-level scheme), it was recognized at the outset that few formal contractual arrangements exist, such as seasonal input packages and credit, which have allowed meso-level schemes to be implemented in a few countries (allowing coffee processors to set rules under which individual farmers would be compensated). However, processors could play an important part in Farmer Registration for insurance. Registration is considered a vital part of such an insurance scheme, and would be developed from the existing Farmer Registration and Activity Tracking System (FRATS).

12. **Section 3.4. describes the ways in which the risk could be "layered" so as to involve the insurance market, reinsurers and possibly the highest level of protection being taken by the Government.** The possible top layer being taken by the Government, resulting in a loss approximately one in 25 years, is investigated because this top layer of loss tends to be relatively very expensive for reinsurers to supply, since capacity must still be reserved even though events are highly infrequent. This could be one way to limit premium cost to farmers, but would still need the Government to budget payment for such events (which, by definition, occur at times of very major events which would likely affect other sectors of the economy).

13. **Chapter 4** describes legal and regulatory issues, the structuring of a pilot, and possible next steps for evaluation of the study.



1. Introduction

1.1 Background

Agricultural insurance in Jamaica

There is a long history of agricultural insurance in Jamaica, originating with the statutory insurance schemes for some permanent crops such as banana and coconut, the insurance program for coffee, which is the subject of this report, as well as insurance for sugar cane. However, with the demise of the banana export sector, and the cessation of coffee insurance in 2006, there is now extremely limited volume of agricultural insurance in the country.

In part, the lack of sustainable agricultural insurance coverage has been blamed on high catastrophic exposure (and lack of reinsurance capacity), but in reality it has also been the result of various factors, including: (i) the technical difficulty of designing appropriate insurance products and delivery mechanisms for small farmers, (ii) the diversity of tropical crops produced in the country (multi-cropping systems), (iii) technical difficulties in modeling (correlating) hurricane, rainfall, and flood damages to agricultural production (yields), and (iv) a generally uninvolved local private insurance market (with some exceptions). Only for a few examples has traditional named-peril insurance[1] worked or nearly worked in the island (e.g. bananas,[2] coffee and coconuts), plus fire insurance on sugar cane. These agriculture supply chains have apex marketing arrangements or are at an industrial scale, facilitating organization of insurance delivery. At present, almost the entire agricultural sector, including farmers and supply chains, is effectively uninsured by public or private sector insurance and reinsurance.

A brief history of coffee insurance in Jamaica

In 1988 Hurricane Gilbert devastated the coffee industry and was a driver for the implementation of the Coffee Industry Board (CIB) insurance programme, which operated between 1992 and 2006. The insurance program was established under a private Deed of Trust, administered by four Trustees, with the premium paid from an industry cess (deduction per box of delivered cherry coffee) and mandatory participation for farmers. In this respect, and aligned with the the CIB's privatized status, the insurance scheme differed from the statutory schemes for bananas and coconuts. The scheme was administered by Trustees for the CIB. Essentially the trust acted as insurer, purchasing commercial reinsurance, and managing the program. The commercial insurance policy (with risk almost entirely ceded to reinsurers) was on an aggregate production shortfall basis. This policy, therefore, differed from the cover intended to be provided under the trust deed (i.e. individual farmer insurance), which meant that claims response was not properly defined, and farmers did not understand the basis of the insurance actually provided. A major shortcoming was that the Trust was not able to implement normal insurance management procedures (for example, a claims management unit, or provide certificates or evidence of insurance to farmers, or provide adequate information). A particular problem was that, after an event, farmers had to estimate production loss on their own farms ("number of boxes lost"), leading to inevitable over-estimation, with subsequent loss adjustment and verification challenges for the CIB. There were

1 Named-peril insurance are contracts based on on-farm loss verification, but tied to a specific risk (i.e. wind, fire).

2 From 1987 to 2002 one major banana producing and exporting company in Jamaica was buying a catastrophe named-peril insurance from Lloyd's, and in 2006 purchased catastrophe index insurance.

considerable efforts to implement an improved basis of registration and establish sum insured based on a 3 year rolling average production per farmer, following Hurricane Michelle in November 2001 (the first claim to involve commercial insurers). **Difficulties in mobilizing individual-farmer in-field loss adjustment following a major event proved almost insurmountable, given the small farm size, logistic disruptions, claims numbers, and difficulties of measuring damages in the coffee crop.** Dissatisfaction with the insurance program was cited as the most important single concern of farmers in a CIB's customer perception survey.

In 2004, following revisions to the Insurance Act, the Trust was legally obliged to obtain a license from the Financial Services Commission (FSC). These difficulties coincided with major problems surrounding damage caused by Hurricane Ivan in September 2004, when farmers declared losses which were 110% of the sum insured under the policy, leading to a highly problematic loss adjustment process. It showed the structural constraint of an aggregate reinsurance policy and the need for effective insurance registration and procedures linking claimed boxes to insured boxes. Difficulties were compounded when the insurance company, Dyoll, was declared insolvent. In 2006, reinsurers withdrew support for the programme and no insurance has been in place since that time.

The divergence of the insurance structure and the reinsurance policy, linked to difficulties in implementing loss adjustment, the high exposure to catastrophe losses, and the legal constraints of the CIB's Trustees acting as a *de facto* insurer, all contributed to the demise of the CIB's insurance scheme.[3]

Context of the present study

The Ministry of Agriculture (MOA) has recognized the need to implement a new strategy for managing all agricultural weather-related risks. Currently, agricultural weather hazards are managed by farmers resorting to individual savings, selling of livestock, borrowing, and through additional funding from the Government and international donors following major events. There are no readily available risk financing instruments, such as contingent lines of credit or insurance, which farmers or the Government can access when faced with extreme weather events. As a result, the Government of Jamaica (GoJ) is currently in the process of designing a new framework to move from an ex-post unplanned system of managing risks to an ex-ante financial risk management strategy. The MOA is proposing a new framework that will address the different categories of weather hazards (and their associated risk levels) with specific financial instruments and government policies.

Following discussions between the CIB, MOA and the World Bank (WB) in 2008 and 2009, the present feasibility study was proposed, in parallel with a study on risk management and insurance needs related to disaster risk management, focusing on two parishes.[4] A national risk assessment contributed to the findings of this work,[5] involving risk mapping, assessment of industry damage and creation of a database.

1.2 Purpose and organization of the report

The present report is intended as a technical, organizational and financial summary of the feasibility study to review options and to make decisions on whether or not this programme meets the needs of the industry. It

3 Detailed information is provided in Dunkley, G. (2008): *Crop insurance: The Jamaican coffee industry experience and recent global trends.* Discussion paper prepared for the CIB.

4 World Bank (2010): *Introducing innovative agriculture weather risk management mechanisms for small farmers. Pre-feasibility assessment for St. Elizabeth and Portland parishes.*

5 CGM Gallagher (2009): *Jamaica: weather risk management in the agricultural sector – pre-feasibility study.* Consultant report to The World Bank.

is recognized that decisions on whether or not to proceed towards a future insurance program will require significant consultation with farmers and processors, and an agreement on an implementation plan, including decisions on pilot testing.

Chapter 2 describes the risk modeling undertaken during the study and the outputs. These outputs are used to define key elements of a parametric insurance product, such as zoning of coffee farmers within the Blue Mountain area, the frequency and severity of the wind hazard, and how the expected impact of those hazards was estimated by division into altitude bands to create vulnerability profiles. Finally the outputs can be used to price different insurance options.

Chapter 3 considers the organizational options and requirements to deliver a parametric insurance product to coffee farmers, and some financial implications including structuring insurance and reinsurance protection.

Chapter 4 considers the issues and steps which would be needed for implementation, including options for piloting and scaling up, and legal and regulatory requirements.

The **Annex** provides supporting information.

2. Risk Modeling

2.1 Coffee model key features

During early stages of the project, strong winds and heavy rainfall were identified as the risks which cause the greatest losses on the coffee sector in the Blue Mountain area. Based on technical discussions held with coffee specialists from the Coffee Industry Board (CIB) and farmers, it is known that different levels of impact on coffee production can be experienced depending on several factors, such as: magnitude of the weather event that is impacting the production area, the period of the year (which determines the vulnerability of coffee plants to weather events) and the level of exposure of coffee cherries still to be harvested, and others.[6]

Despite of the fact that the Blue Mountain coffee is listed as a world-class product and contributes with foreign exchange earnings to the country, up to date there is no financial instrument in the market that can transfer risks faced by the coffee sector to international markets. In an attempt to design an insurance product that provides protection to farmers in the Blue Mountain region against strong winds and heavy rainfall, the World Bank (WB), in conjunction with the CIB, worked on the design of an index insurance product.

Assessment of the historical wind and rainfall data availability in Jamaica, and specifically in the Blue Mountain area, showed the constraints of station-based measurement and indexation, particularly for wind, where no ground stations and limited data exist. A decision was reached that modeling provided an approach with wider potential for an indexed product, recognizing that this did not preclude any decision that a network of weather stations would likely play a role in validation of, and adjustment to, future model design, apart from other benefits of support for advisory and agriculture extension work.

The process followed for the design of this product was divided into two stages: the first stage consisted on hiring a modeling firm (CGM) that could simulate wind speed and rain amounts in the Blue Mountain. During this phase, the CIB's specialists and WB's consultants also worked on the definition of vulnerability of curves which could best estimate the percentage of loss which are expected to occur at given levels of intensity of wind speed and cumulative rainfall; and on the estimation of the production-at-risk for different altitude bands. It is important to note that, because of absence of historical wind and rainfall recording in the Blue Mountain area, and lack of scientific evidence showing the levels of wind speed and rainfall amounts at which no damage or maximum possible damage is expected for different phenological stages, the construction of the vulnerability profiles was based on expert opinion, input obtained from farmers during focus group exercises, and on historical production data registered by the CIB since 1959.

Since the CGM model could not perform reliable modeled rainfall values on an event basis as it was conducted for wind hazard, the rainfall simulated database could not be generated by the end of the project. The modeling exercise conducted by the specialized firm had the following objectives: (i) generate a high spatial resolution (1 Km^2 grid) wind speed and rain database for the design of a parametric contract for the Blue Mountain area; (ii) use the simulated database as an alternative data source from which compensation payouts would be defined due to the occurrence of specific cyclonic events that cause negative impacts on the

6 The model addresses loss of coffee whilst in formation on coffee trees. Damage to coffee trees (including effects on rooting systems) and the impact on coffee in subsequent seasons is well known following extreme storms, and can also lead to the need for rehabilitation and even replanting, but was considered too complex to model, and less of a priority in the design of this scheme.

insurance zones. On the other hand, during the second phase of the project, the modeling firm and both the WB team and the CIB's specialists worked on tidying up the coffee model which is comprised by simulated wind speed, estimated production curves and crop vulnerability curves for different homogeneous zones within the Blue Mountain region. The definition of uniform areas is a critical process for the implementation of the proposed parametric insurance model as all policyholders within the same homogeneous region will receive a payout based on an index which will be measured objectively and transparently (further details with regards to delimiting homogeneous zones are provided later in this Chapter).

2.2 Product design

The proposed parametric wind speed model for the coffee grown in the Blue Mountain region is comprised of the following four modules:

1. Hazard Module:

This module contains the simulated values of wind speed per month (July to November) and per homogeneous zone (10 zones) within the pilot area. The simulated wind speed values were generated based on historical events recorded in the Atlantic Basin[7] for the three altitude bands[8] (Low 350-600m, Medium 600-900m, High 900-1500m) where coffee trees are planted. Due to the high correlation found in the modeling between the different homogeneous zones, the model made the assumption during the simulation analysis that all zones are perfectly correlated in relation to the frequency and intensity of the wind. However, it is important to note that for future hurricane events, wind speed footprint maps will be generated from the model which differentiates the winds speeds for that event for each zone.

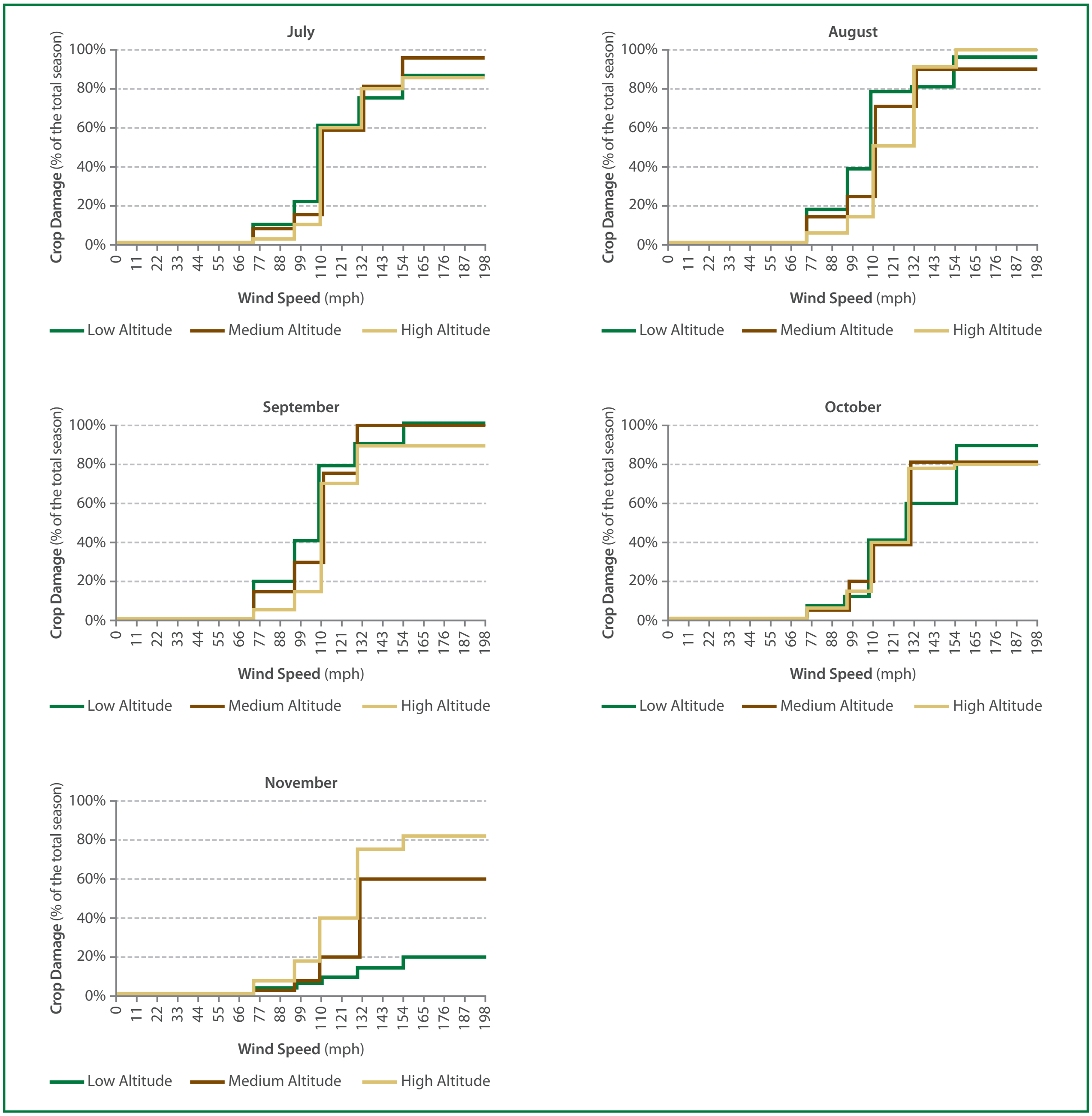
2. Vulnerability Module:

This module shows the percentage of loss that is expected to occur at given levels of wind speed and during a specific period of the year. The development of the vulnerability curves was based on: (i) the CIB´s specialist best knowledge on coffee susceptibility to wind speed on different phenological stages; and on (ii) the experience and knowledge of the CIB on levels of losses incurred in the past by coffee plants per month during the hurricane season (July to December). Vulnerability curve details per month are shown in Figure 2.1 from the final model.

7 The modeling used the NOAA-ATCF database to conduct the analysis on the frequency of events. The NOAA´s database is comprised by 1644 storms registered during the period between 1851 and 2009.

8 It is known that coffee exposure varies between the altitude bands, being the highest areas the ones where coffee ripens more slowly in comparison to lower and medium zones.

Figure 2.1. Wind Vulnerability curves provided by the CIB



3. Exposure Module:

The sums insured which are exposed for different periods of the year among the zones are shown in this module. This module estimates the sum insured as the product of the 3-year average production by the total area per zone by the reference price of coffee. The exposure module contains the following inputs:

(i) **"Production curves" for each altitude band:** The production-at-risk per month is defined as the maximum production which could be lost (expressed as a percentage of the whole season´s expected production) if a loss event occurred in that month.

(ii) **Coffee ripening distribution between July and December:** Such distribution was estimated based on historical harvesting calendars registered by the CIB.

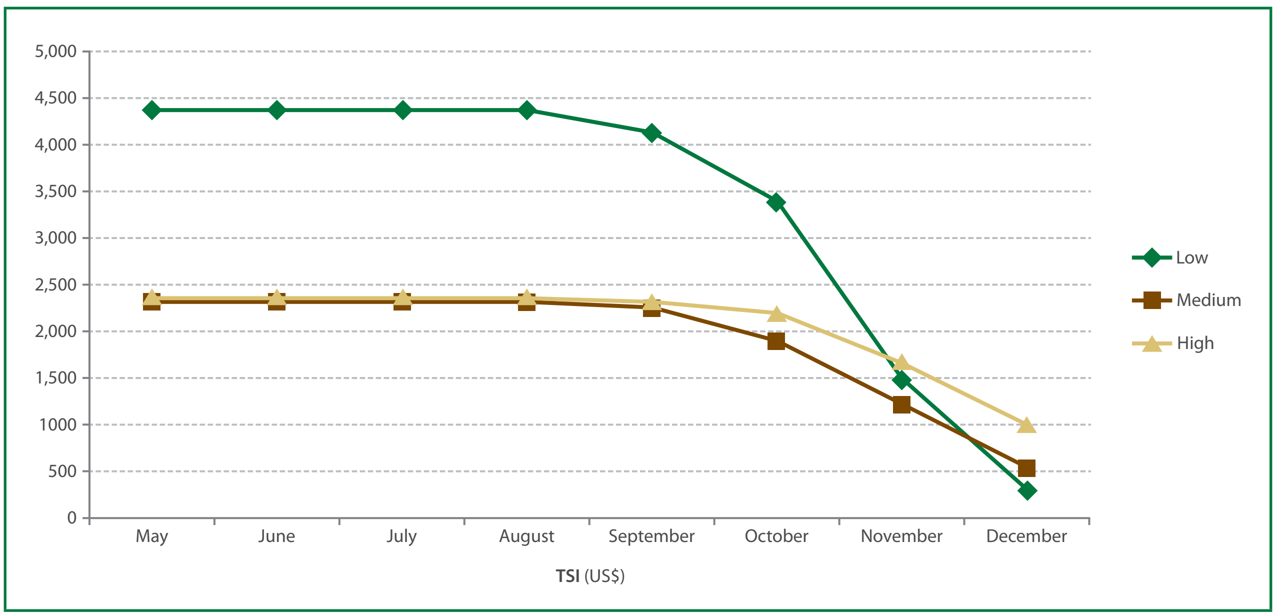
(iii) **Number of farmers per homogeneous zone:** Based on the information registered in the 2004 farm census for the Jamaica Blue Mountain region, it was estimated that the current number of individuals (5,797 farmers) who grow coffee is 17.56% less than in 2004 (7,032 farmers). For the purposes of the risk analysis, it is assumed that all farmers are similarly distributed among the homogeneous zones (see Table 2.1 for further details). Since the total sum insured (TSI) per zone is linked to this input and, thus, has direct implications on the risk analysis and contract implementation, it is advised that these figures be corrected once the geo-reference location of all farmers is known and registered by the CIB on the Farmer Registration & Activity Tracking Systems (FRATS).

(iv) **Reference price per box:** The reference coffee price per box is assumed to be J$1730.

(v) **Sum insured per zone:** Value estimate based on the sum of the production values of all farmers registered in each zone. The production value is calculated as the average of actual coffee production for the past 3 years. According to the information provided by the CIB, the coffee average yield for the past 3 years is equivalent to 27.29 boxes/acre.

(vi) **Size of coffee farms:** Based on the data analyzed from the 2004 Census. It is assumed that each farmer has 2.29 acres. Further work must be conducted by the CIB in order to better estimate the total area that is actually allocated for coffee production in the Blue Mountain area.

Figure 2.2. Remaining sum insured (US$'000) and percentage of harvested coffee per month



Altitude	May	June	July	Aug	Sep	Oct	Nov	Dec
Low	0.00%	0.00%	0.00%	5.59%	22.55%	66.02%	93.05%	97.25%
Medium	0.00%	0.00%	0.00%	2.96%	18.80%	47.42%	76.67%	85.74%
High	0.00%	0.00%	0.00%	1.47%	6.19%	28.14%	52.53%	63.14%

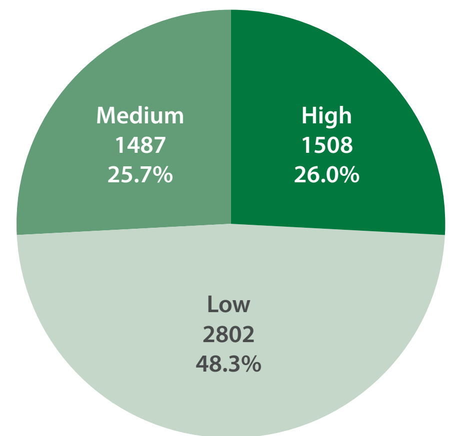
Source: CIB.

Table 2.1. Exposure distribution per altitude band and homogeneous zone

Altitude	Zone	No. of Farmers	Area (acres)	Production (boxes)	TSI (US$)
Low	1L	379	868	23,684	473,671
Medium	1M	360	824	22,496	449,925
Medium	2M	379	868	23,684	473,671
High	2H	369	845	23,059	461,173
Low	3L	340	779	21,246	424,929
High	4H	369	845	23,059	461,173
Low	5L	364	834	22,746	454,924
Medium	5M	379	868	23,684	473,671
High	5H	384	879	23,996	479,920
Low	6L	374	856	23,371	467,422
Low	7L	326	747	20,372	407,432
Low	8L	333	763	20,809	416,180
Low	9L	319	731	19,934	398,683
Low	10L	367	840	22,934	458,673
Medium	10M	369	845	23,059	461,173
High	10H	386	884	24,121	482,419
Total		**5,797**	**13,275**	**362,252**	**7,245,035**
Low	**8**	**2,802**	**6,147**	**175,096**	**3,501,913**
Medium	**4**	**1,487**	**3,405**	**92,922**	**1,858,438**
High	**4**	**1,508**	**3,453**	**94,234**	**1,884,684**

Source: Authors and CIB.

Figure 2.3. Distribution of farmers per altitude range



Source: Authors and CIB.

4. Damage Module:

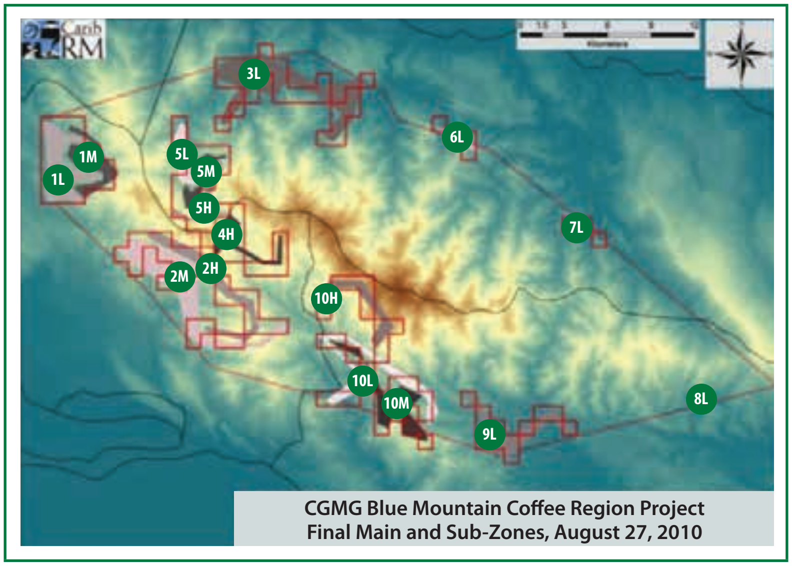
Based on simulated wind speed data of events generated in the Atlantic Basin, this module calculates the percentage of damage suffered on coffee annual production per homogeneous zone due to the occurrence of a covered event. This module combines the data recorded in the Hazard Module, Vulnerability Module and the Exposure Module.

2.3 Delimiting of risk zones

Homogeneous zones were defined based on the probability of occurrence and magnitude of the impact of strong winds in the Blue Mountain region. The purpose of the definition of homogeneous areas is focused on delimiting narrow geographic areas that show similar conditions during the occurrence of an extreme wind event. The following information was used in order to delimit the areas: (i) location of "coffee estates", (ii) geographic location of farmers and clusters of coffee estates, (iii) elevation, (iv) general topographic settings (including general facing direction (aspect)), and (v) probabilistic risk levels of wind.

The modeling of future events (strong winds) will be generated on specific geographic points (centroid locations) within each homogeneous zone. The process of clustering homogeneous zones in the Blue Mountain region resulted in a total of 10 zones, which in turn were subdivided into one, two or three sub-areas according to the level of elevation where they are located. These sub-zones (16 in total) are represented by a code that comprises numbers and letters: the number represents the point area and/or sub-area; the letter indicates the elevation of the area according to the CIB's altitude band classification ("L" stands for Low band, "M" for Medium band; and "H" stands for High altitude band). In Figure 2.4 it can be appreciated that all sub-zones were established as non-overlapping free-form polygons which were as small as possible to include all farms within each sub-zone. In addition, for each homogeneous area, a centroid has been defined. The centroid location has been selected to best-represent the zone as a whole and to be used for real-time modeled hazard levels for triggering policies.

Figure 2.4. Homogeneous risk zones (16 sub-zones) in the Blue Mountain pilot area



Source: CGM Gallagher.

2.4 "As If" analysis and Basis Risk

Even though the CIB has been registering production losses since 1959 to present, a precise analysis to determine the level of accuracy of the proposed coffee model cannot be conducted with a high statistical confidence level due to the following reasons: (i) there is insufficient ground data in the Blue Mountain area (i.e. wind speed measures at weather stations) to evaluate the accuracy of modeled winds for past events on each homogeneous zone; (ii) the historical production data and percentage of production losses been registered by the CIB does not show disaggregated data per homogenous zone, and neither indicates the reasons why such losses were experienced (i.e. wind speed, rain, pests and diseases, external shocks, etc.); (iii) it is known that there is significant local variation in damage caused by wind, as all storms show different characteristics (i.e. wind speed, rainfall, closer point of approach). Such variation is also experienced in severe events.

Knowing the limitations of conducting an analysis that could compare the difference between simulated losses and actual losses registered by the CIB in the past, the CIB asked the WB team to show examples of the crop model outputs (payouts) at aggregated level for specific storms. In this regard, simulated wind speed on a month-by-month basis was generated by a modeling firm in order to use it to build a set of events.[9]

9 For the analysis of historical events in the Atlantic Basin, the modeling firm used the NOAA-ATCF database, which comprises 1644 storms for the period 1851-2009. The monthly event wind excedance probability (EP) curves take into account any and all storms in the Atlantic Basin, whether or not they have any impact at all on the pilot area.

Based on the occurrence distribution (probability distribution) per month of storms in the Atlantic Basin, event excedance probability (EP) curves for each month (July to November) were generated to establish the severity of selected events. As a result, the wind speed of 15 historical storms was estimated for each zone centroid. Out of these events, six storms were selected by the CIB since they caused great impact on the coffee national production. The selected storms were Hurricane Allen, Hurricane Gilbert, Tropical Storm Gordon, Hurricane Ivan, Hurricane Dean and Tropical Storm Gustav. The modeled wind speed of these storms, in conjunction with the Vulnerability Module, Exposure Module and with the Damage Module, was used in order to compare simulated coffee losses with actual losses registered by the CIB.

Table 2.2. Modeled wind speed (mph) at each zone centroid for 9 historical events

Zone ID	1980 Allen	1988 Gilbert	1994 Gordon	2001 Iris	2004 Charley	2004 Ivan	2005 Dennis	2007 Dean	2008 Gustav
1L	70 - 75	90 -95	< 30	35 - 40	< 30	60 - 65	55 - 60	55 - 60	55 - 60
1M	70 - 75	85 - 90	30 - 35	35 - 40	< 30	60 - 65	60 - 65	55 - 60	45 - 50
2M	65 - 70	90 - 95	35 - 40	40 - 45	30 - 35	65 - 70	55 - 60	65 - 70	55 - 60
5M	45 -50	110 - 115	< 30	35 - 40	< 30	55 - 60	40 - 45	55 - 60	70 - 75
10M	65 - 70	125 - 130	40 - 45	40 - 45	< 30	65 - 70	55 - 60	60 - 65	45 - 50
2H	70 - 75	85 - 90	35 - 40	40 - 45	< 30	60 - 65	60 - 65	55 - 60	45 - 50
3L	65 - 70	125 - 130	< 30	55 - 60	< 30	85 - 90	55 - 60	85 - 90	70 - 75
4H	80 - 85	145 - 150	40 - 45	50 - 55	40 - 45	90 - 95	70 - 75	85 - 90	85 - 90
5H	80 - 85	130 - 135	40 - 45	50 - 55	40 - 45	85 - 90	65 - 70	80 - 85	80 - 85
5L	65 - 70	130 - 135	< 30	60 - 65	< 30	95 - 100	50 - 55	90 - 95	75 - 80
6L	70 - 75	120 - 125	< 30	55 - 60	< 30	85 - 90	60 - 65	80 - 85	70 - 75
7L	65 - 70	125 - 130	< 30	45 - 50	< 30	75 - 80	55 - 60	70 - 75	65 - 70
8L	65 - 70	125 - 130	40 - 45	40 - 45	< 30	65 - 70	60 - 65	55 - 60	65 - 70
9L	45 - 50	95 - 100	< 30	60 - 65	35 - 40	95 - 100	40 - 45	90 - 95	55 - 60
10H	80 - 85	90 - 95	40 -45	40 - 45	< 30	65 - 70	70 - 75	60 - 65	50 - 55
10L	70 - 75	135 - 140	30 - 35	60 - 65	40 - 45	100 - 105	60 - 65	95 - 100	75 - 80

Source: **CGM Gallagher.**

From the selected storms, the "as if" analysis shows that the proposed coffee model would have generated a payout of a maximum of 56.5% (Hurricane Gilbert) and a minimum of 0.1% (Hurricane Gordon) of the sum insured at the end of the period of coverage. Conversely, the range of standard deviation of total losses modeled for the selected group of storms goes from 17% to 0.2%, for Hurricane Gilbert and the Tropical Storm Gordon, respectively. Table 2.3 presents the results of the coffee model in different zones (16 sub-zones) over the pilot area.

Table 2.3. Summary of total payouts per homogeneous zone for six storms

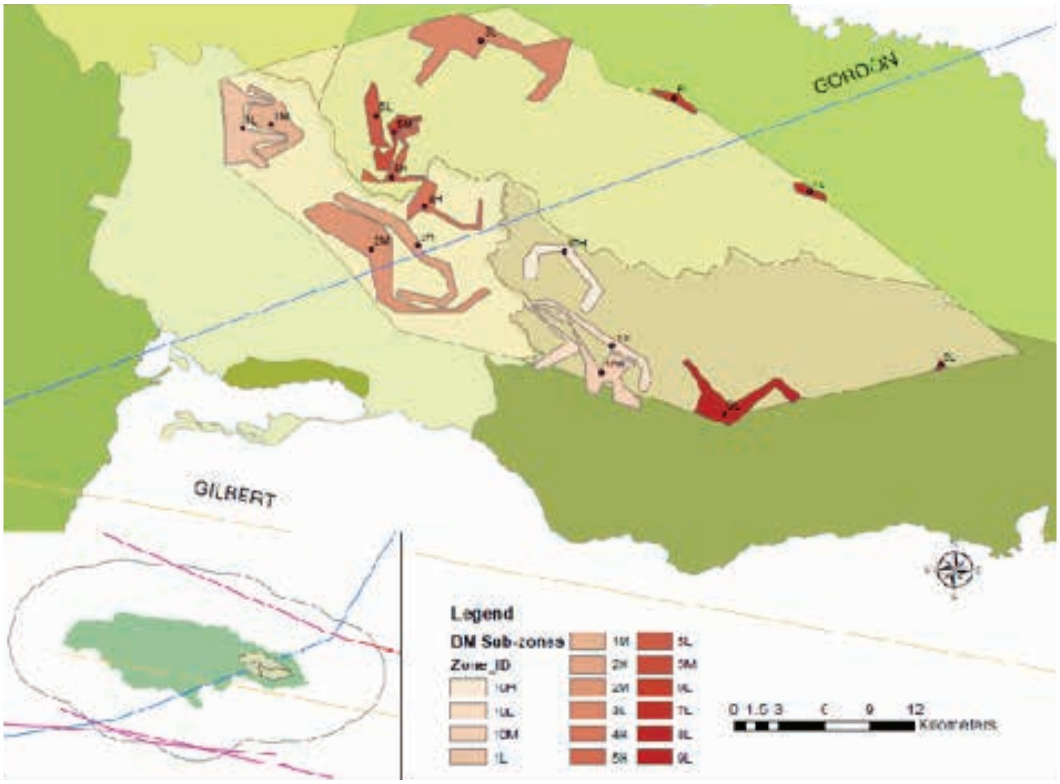
Zone/ H. Event	Allen Jul, 1980	Gilbert Sep, 1988	Gordon Nov, 1994	Ivan Sep. 2004	Dean Aug, 2007	Gustav Aug, 2008
Total 1L	19.4%	47.2%	0.0%	24.6%	21.5%	21.5%
Total 1M	18.2%	38.6%	0.0%	18.1%	14.6%	8.8%
Total 2M	14.6%	43.1%	0.0%	21.9%	21.4%	14.6%
Total 2H	14.9%	30.5%	0.0%	10.7%	6.3%	0.7%
Total 3L	16.1%	74.4%	0.0%	43.3%	43.1%	31.9%
Total 4H	22.4%	81.7%	0.0%	34.9%	29.0%	29.0%
Total 5L	16.1%	78.0%	0.0%	51.2%	46.9%	35.5%
Total 5M	2.7%	61.3%	0.0%	14.5%	14.6%	25.0%
Total 5H	22.4%	70.3%	0.0%	30.5%	24.7%	24.7%
Total 6L	19.4%	70.7%	0.0%	43.3%	39.3%	31.9%
Total 7L	16.1%	57.5%	0.0%	21.6%	19.4%	16.1%
Total 8L	16.1%	57.5%	0.9%	15.2%	10.0%	16.1%
Total 9L	4.8%	35.6%	0.0%	35.6%	33.9%	10.0%
Total 10L	19.4%	64.4%	0.0%	39.3%	37.7%	20.7%
Total 10M	14.6%	62.1%	0.2%	14.2%	11.3%	2.7%
Total 10H	22.4%	30.0%	0.0%	11.2%	8.1%	2.3%
Total (US$ 000)	**1,477.81**	**5,133.03**	**5.45**	**2,422.01**	**2,148.89**	**1,651.61**
% of SI	**16.3%**	**56.5%**	**0.1%**	**26.7%**	**23.7%**	**18.2%**
Avg	16.2%	56.4%	0.1%	26.9%	23.9%	18.2%
Max	22.4%	81.7%	0.9%	51.2%	46.9%	35.5%
Min	2.7%	30.0%	0.0%	10.7%	6.3%	0.7%
Sd	5.6%	17.0%	0.2%	13.0%	13.1%	11.2%

Source: Authors and CIB.

Based on the vulnerability curves, developed in conjunction with the CIB's specialists, the simulated results seem to follow a logical pattern of what would be the percentage of loss if an event would have occurred during the same period of time and with a similar strength. For example, Gordon and Gustav, both tropical storms, show noticeable differences with regards to total payouts (0.1% and 18.2%, correspondingly). Differences could be explained due to the period of time when both natural phenomena made landfalls in the Blue Mountain area: whereas Gordon struck Jamaica during a period of the year (November 13th) when almost all the coffee cherries had already been harvested, Gustav wiped out the area when almost all cherries of all altitude bands were exposed (August 29th).

Another important case of discrepancy in total simulated losses that still, however, seems to follow a logical pattern, is Hurricane Gilbert (56.4%) and Hurricane Dean (23.9%). Although both were major hurricane phenomena (Category 3 and Category 4, respectively), the greatest losses on Gilbert could be explained - despite it was a less powerful storm - due to the proximity to the pilot area. While Gilbert´s path was ≈20 Km of the Blue Mountain area, Dean´s closest point of approach from the same area was greater than ≈70 Km.

Figure 2.5. Schematic presentation of Gordon´s and Gilbert´s tracks



Note: **In the lower left corner of the figure, the corresponding tracks of Hurricanes Allen and Gilbert, Tropical Storm Gordon, Hurricanes Ivan and Dean, and Tropical Storm Gustav can be appreciated. A buffer of 50 Km from Jamaica intersects the storms mentioned above.**

Source: **Map created by the authors based on Historical Hurricane Tracks from NOAA.**

Despite of the apparent consistency of the model performance, there are considerable differences between the modeled percentage of loss and CIB's records. For example, CIB's records show greatest losses at the end of the crop season due to the effects of Hurricane Dean (40%) than during Hurricane Gilbert (27%). This is probably explained by the fact that the index-based model for coffee farmers only simulates losses caused by wind events and, therefore, is not reflecting any individual or combined effect of other perils (i.e. excessive rain, pests and diseases, landslides or drought). In this regard, and despite of the fact that the CIB's values are the reverse of that obtained from the model, the level of Basis Risk may be acceptable for the coffee sector and the insurance industry if the principle of an "income supplement payout for major events" is established. However, extreme caution is adviced with farmers who are not familiar with index insurance principles, and may distrust of the methodology from which payouts will be determined. The model shows that whilst major wind events lead to payouts, the fact is that Basis Risk remains, and that the model outputs can never precisely be related to loss, and that other causes of loss will also impact farmers. One of the largest issues for the CIB in evaluating this product remains one of whether, even if maximum efforts are made to explain the product and the Basis Risk, how an event would be managed with farmers where losses have occurred but payouts are either small or not triggered (see section 2.6). The assessment of how this "Basis Risk" is presented and managed is a critical factor in the assessment of whether this product meets the needs of the industry. Planning of extension workshops with groups of farmers is essential in order to reduce to a minimum the number of doubts that may negatively affect the level of acceptance of the product during the introduction and operation of such an insurance scheme.

Table 2.4. Comparison of simulated loss with CIB's records of six storms

Saffir-Simpson Scale	Date	Year	Name	Model (% of boxes, BM)	CIB (% of boxes, BM)	CIB (% of boxes, CNP)
H4-H5	Jul 31-Aug 11	1980	Allen	-16.2%	30.0%	-40.0%
H3	Sep 8-20	1988	Gilbert	-56.4%	-27.0%	-50.0%
TS	Nov 8-21	1994	Gordon	-0.1%	50.0%	70.0%
H4-H5	Sep 2-24	2004	Ivan	-26.9%	-55.0%	-46.0%
H4-H5	Aug 13-23	2007	Dean	-23.9%	-40.0%	-40.0%
TS	Aug 25-Sep 5	2008	Gustav	-18.2%	29.0%	30.0%

Source: Authors and CIB.

2.5 Probable Maximum Loss (PML) & pricing

The analysis of twenty thousand simulated wind speed events for different altitude bands in the Blue Mountain area shows that the estimate of the Probable Maximum Loss (PML)[10] that might be suffered in the pilot area in 1/250 years is 50.4% (US$3.65 million) (see also section 3.4).The same analysis shows the sub-zones 6L (64.59%) and 9L (46.29%) as the areas that present the highest and the lowest level of losses, respectively. Working with less conservative figures (1 in 100 year-event), on the other hand, would result in an estimated maximum loss of 46.18%. The very high estimated maximum loss in both cases, 1/100 and 1/250 year-event, suggest the need to underwrite this risk with reinsurance protection.

An indicative rating exercise for the proposed coffee model in the Blue Mountain region indicates that the weighted average loss cost for this contract would be 2.77% of the total sum insured. After applying a security loading of 30% of the standard deviation of the loss cost, the weighted average technical rate would be 5.5%, while the indicative average commercial premium rates rise up to 9.16%. By observing the results per altitude band, it can be inferred that the results agree with the level of exposure and vulnerability of

Table 2.5. Coffee index model: Results of indicative technical rates per zone

Altitude Band	Grid	Average Loss (%)	Technical Rate (AEL+0.3 STDEV AEL)	Estimated Commercial Rate
Low	1L	3.54%	6.87%	11.44%
Medium	1M	3.35%	6.48%	10.79%
Medium	2M	2.71%	5.38%	8.96%
High	2H	2.37%	4.80%	8.00%
Low	3L	3.27%	6.40%	10.67%
High	4H	2.54%	5.09%	8.48%
Low	5L	3.20%	6.31%	10.52%
Medium	5M	2.89%	5.71%	9.51%
High	5H	2.39%	4.85%	8.08%
Low	6L	3.78%	7.27%	12.12%
Low	7L	3.08%	5.91%	9.86%
Low	8L	2.28%	4.56%	7.60%
Low	9L	2.16%	4.35%	7.26%
Low	10L	2.37%	4.67%	7.79%
Medium	10M	2.39%	4.78%	7.96%
High	10H	2.04%	4.43%	7.39%
Total		**2.77%**	**5.50%**	**9.16%**

Source: Authors.

10 The PML estimate is the maximum loss that the portfolio comprised by the coffee zones under analysis might incur in a single event for different return periods (i.e. 1 in 100 years, 1 in 175 year-event, etc.).

the different zones due to negative effects of wind speeds caused by hurricane and/or tropical events. The cumulative relative proportion of annual Atlantic storms for the period July-September represents around two thirds of the total, period during which above 80% of the cherries remain on the trees. The weighted technical rates per altitude band decrease from the Low altitude (5.85%) to the High altitude band (4.79%).

Although farmers state the need for purchasing an insurance contract, coffee farmers have also expressed that under the current production costs and coffee cherries low prices there is not enough business margin to purchase an index-based contract. During interviews sustained with farmers, they expressed concern with regard to the current situation in which they are not obtaining enough gross margin from coffee production to invest on the following crop cycle and to recover from past weather events. According to the information received from farmers during the focal groups performed for this study, many of them have abandoned the coffee business as it by itself does not even cover household's expenses.

2.6 Advantages and disadvantages of the proposed coffee model

The proposed coffee index model embraces many advantages in comparison to the former indemnity based, individual-farmer, traditional crop insurance program. The main advantages that can be mentioned are:

(i) **Objectivity and lack of moral hazard:** Based on a previously agreed contract structure, both the policyholder and the insurance company will have access to the data base (modeled wind speed) on which the payouts will be calculated. In addition, and given that a modeling firm will provide simulated wind speed values, the chance of an individual to increase the level of losses to be claimed as a result of purchasing an insurance contract is minimal.

(ii) **No field loss assessment and rapid payment:** Given that the contract payouts will be based on an index (e.g. measurement of modeled wind speed) at each homogeneous zone, all farmers within the same area will receive identical payouts. For this reason, the need to make individual loss adjustments is omitted, therefore speeding the process of delivering payouts to coffee farmers.

(iii) **Direct contract between farmer and insurer:** Unlike the former insurance scheme, where there was not a clear evidence of insurance to farmers, the index-based insurance program aims to provide legal support to farmers by delivering individual insurance certificates.

(iv) **Transfers weather risks to international markets:** Nowadays, there is no existing insurance product available for the coffee industry that allows farmers to transfer weather risks to international markets. As mentioned before, the proposed coffee model aims to provide coverage against strong wind speed that have a negative impact on the coffee production in the Blue Mountain area.

(v) **Rapid payout:** Rapid payouts should be possible to farmers after an event, since there is no field loss assessment.

Despite the visible advantages of the proposed coffee index insurance program, there are also important shortcomings that need to be taken into account before and during the implementation of the program in the Blue Mountain pilot area. For example:

(i) **Reliance on model to determine payout:** Due to the lack of ground historical information to design and operate an index-based insurance contract, the proposed coffee product relies entirely on modeled wind speed. Without having a proper educational program where farmers can learn about the operational aspects of this product, the level of product acceptability from farmers will be limited due to lack of confidence in the methods being used for the measurement of the index.

(ii) **Basis Risk:** Given that the payout mechanism of the proposed product will only be based on modeled wind speed in the pilot area due to extreme events registered in the Atlantic Basin, it is expected that the distribution of percentage of actual losses of coffee will vary in comparison to the ones provided by the coffee model as the cause of loss and wind characteristics are affected by various factors. For example: in 2004, the Blue Mountain area registered a reduction of coffee berries equivalent to 55% in comparison with the former crop season due to the impact of Hurricane Ivan, which was accompanied by strong winds and heavy rains. According to estimates of the CIB, hurricane winds destroyed around 5% of the coffee trees and surrounding forest. However, the coffee production loss during the occurrence of that particular event was magnified when heavy rains caused landslides which impeded farmers to harvest coffee cherries that remained on their plantations. On the other hand, wind speed and direction, which are affected by topography and vegetation, can change in short distances and periods of time. Narrow valleys and steep slopes in the Blue Mountain area accelerate the wind and produce erratic direction. Last but not least, the vulnerability curves may also entail Basis Risk due to errors in estimating the percentage of loss that is caused by different magnitudes of wind speeds.

2.7 Conclusions from modeling for insurance design

The proposed model is technically limited in many aspects. Although there is enough room to greatly improve the crop model in order to reduce mismatches between actual losses and model outputs, there are many factors that determine the level of productivity of coffee plants (i.e. altitude, topography, temperature, rainfall, wind speed, coffee varieties, crop management, market, others). As a result, these factors may preclude any attempt on our part from being able to accurately isolate and quantify the negative impacts of the varied major factors that influence coffee productivity in the Blue Mountain region. As a result, it is believed that increasing the crop model level of complexity will not necessarily make great improvement on risk protection, and hence, makes infeasible any attempt to conduct a systematic analysis of the contract. For this reason, the team considered that an "income compensation" product would recognize the existence of Basis Risk, and that such a product could still respond to major shock events from wind (see section 3.1).

The proposed model does not consider the possibility of having two events in a same month. Even though the frequency of occurrence of two events in a same month is very low, this possibility does exist in the pilot area. In this case, the coffee industry and the insurance sector will need to agree on which of the events the estimation of total losses will be calculated.

The PML for both 1/100 (46.18%) and 1/250 (50.4%) year-event seem to be lower than intuitive expectations which underwriters would have for the Blue Mountain region. The CIB's historical production records show that in the past decade alone, two major hurricane events have almost reached above 40% and 50% of the total coffee production in the Blue Mountain region. By comparing the results of the PML loss cost analysis for a 1 in 10 year-event with the CIB's historical records for the past two decades, great differences can be observed: whereas the expected PML 1/10 year-event barely reaches 8% of the total value of the Blue Mountain coffee production (US$579,602.80), in the period 2000-2008 there were 9 storms which caused in average 37% of the total production loss. If the decade of the 90's is included in the period of the analysis, the total number of storms increases to 10 and the average total production loss was above 20%. The difference in the results shown above confirms, once again, the high level of Basis Risk implied by this product.

An agreement between the insurance industry and the modeling firm is needed for the operation of the proposed "wind index-based income compensation insurance scheme". The estimation of payouts due to the effect of tropical storms registered in the Atlantic Basin will only be possible if a specialized firm models storms' wind speed at each risk zone. The use of weather stations to measure wind speed for the operation of the proposed insurance scheme does not seem to be a feasible option from the financial and technical point of view because of the following: (i) purchasing new weather stations does not solve the issue of historical data based on which the risk analysis for different geographic points within the Blue Mountain region should be conducted: (ii) due to steep slopes in the Blue Mountain region, a great amount of weather stations will probably be needed to ensure that they are representative of the area of interest. Since the location of many of these weather stations will be in areas of difficult access, the cost of maintenance and operation will be prohibitive, thus increasing the cost of the insurance premium.

The proposed coffee index model has left an empty rainfall hazard module where technically sound simulated rainfall values of weather events can be integrated (in the case these values are to be generated in the future) as part of the model to estimate payouts to be received by farmers under an income compensation program for the coffee sector. Nevertheless, it is important to mention that the estimation of the final payout would be based on the highest loss caused during an event. In other words, if there were two events (e.g. rainfall and wind speed) that generate payouts over an insured area, the index-based coffee model will take the highest lost incurred by either of the two phenomena.

3. Insurance Feasibility

3.1 Income compensation concept for catastrophe events

The high frequency of natural events threatens the sustainability of coffee production in the Blue Mountain region. Over the last ten years, the coffee sector has been affected by nine major tropical storms which have caused, not only a reduction on coffee yields, but also a dramatic decrease on the amount of coffee berries that qualify for export. For example, in 2006 only 23% of the coffee berries passed the quality test for export, while that amount was above double in 2001. According to CIB's figures, the area under Blue Mountain coffee production fell about 40% over a period of 4 years because of weather impacts. Having such frequency of events causing great damage to the industry and farmers as a whole, if factored as an average annual loss, it represents a drain on the average profitability of coffee production. Insurance can only smooth the financial impact of extreme years by translating cost of extreme years into an annual premium. Such annual premiums are dependent on sufficient margin of coffee prices over costs. The CIB advised the team that some ability to transfer the impact of major events to the market is highly necessary if farmers are to remain in coffee production.

It is recognized that index-based insurance contracts seek to address several technical and operational problems of traditional insurance products. Contrary to traditional insurance schemes, where there are high administrative costs associated with loss adjustments and slow disbursement of payouts to insurance contract beneficiaries, index-based insurance products define a trigger which determine payout amounts due to the occurrence of an insured and pre-agreed event. Due to index insurance products flexibility, they can be designed to facilitate rapid loans and to recover crops productivity in the aftermath of a catastrophic event.

In these types of products, where the indemnity payment is based on predetermined index triggers, triggers should correlate as far as possible with damages to crops (i.e. wind speed at which crop losses are experienced by farmers). One way of reducing a potential mismatch between the losses of the insured and the payouts is focusing on extreme events where the relationship among the trigger and actual loss is expressed more strongly. **Nevertheless, large variations on crop losses, even in an extreme event, are anticipated to be registered in the Blue Mountain region.** The inability to set triggers, which can accurately correlate with loss of coffee berries, can be attributed due to several variables, including the steep slope of the terrain and vegetation cover (i.e. trees used for shade control), issues that influence both the direction and speed of the wind during a hurricane and/or tropical storm. Despite the fact that the Basis Risk would be very high, it is believed **that setting an income compensation scheme (not related with actual losses) will be beneficial for farmers, and thus for the coffee sector in the Blue Mountain region as they will have access to a financial mechanism to manage the negative effects caused by strong winds during the hurricane season.** In this regard, payouts triggered by this coffee index program scheme can be used by farmers either to meet some of their immediate needs or to invest on their land to get back in business in the shorter period of time.

Due to the importance of the Blue Mountain coffee for Jamaica, any insurance scheme that could be implemented in the pilot area will both be protecting farmers as well as having wider economic benefits. According to discussions with the CIB, the proposed program, which would work as income compensation for farmers, should be compulsory, where all farmers located within the same homogeneous zone are enrolled in the program in order to guarantee enough premium volume to become a financially and operationally viable program in the medium term. Premium volume is important for the scheme's eventual financial viability, firstly since insurers have to cover administrative costs (including the fee for the modeling firm) out of a percentage of the premium and, secondly, because reinsurers will be interested and competitive if the transaction size is significant.

Nevertheless, the sustainability of a compulsory index-based insurance program will be greatly influenced by the level of profit margins farmers are obtaining from their coffee trees. According to the information obtained from the focal groups, coffee farmers expressed their willingness to purchase an index-based insurance contract. However, they also expressed that extreme caution should be taken by the CIB if they decide to implement a compulsory insurance scheme under the current situation where profits from a box of coffee have declined by 30% over the last year due to coffee demand issues and the increase of the costs of inputs. Assuming a coffee price per box of J$1730, a coffee yield per acre of 27.29 box/acre and production costs (variable plus fixed cost) above J$84,600, farmers are achieving a very poor return on their labor input to grow coffee.[11] Under this situation, it is unlikely that the coffee sector in the Blue Mountain region escapes from a vicious circle where farmers will prefer to retain the risk and produce, to a certain extent, more profitable crops rather than coffee. As a result, any chance to increase either coffee yield per acre or coffee price per box is unlikely to happen since coffee plantations are using less and less inputs given decreasing profit margins.

3.2 Insurance coverage and options

3.2.1 Summary of hurricane index insurance cover

In this section, 3.2.1, the key features of the proposed insurance coverage are summarized (Box 3.1), and are described in more detail in section 3.2.2. In section 3.3, the options in terms of program management and organization are presented. Financial structuring of risk transfer is considered in section 3.4.

Box 3.1. Draft summary of coverage

Title	Wind Index-based Insurance
Insured	Coffee Farmers who are registered under Farmer Registration & Activity Tracking System (FRATS) as per the schedule attached to the policy
Geographical range	*Insurance zones* within the Blue Mountain coffee region
Insurance zones	Coffee farmers will be allocated to one of the following *insurance zones* (Altitudes L: Low; M: medium; H: High): 1L; 1M; 2M; 2H; 3L; 4H; 5L; 5M; 5H; 6L; 7L; 8L; 9L; 10L; 10M; 10H. *Insurance zone* boundaries are defined in the Master Policy.
Insured event	Wind events where the modeled winds exceed thresholds established within the wind hazard module of the CGM model
Period of insurance	July 1st to November 30th
Average production	The *average production* of cherry coffee in boxes delivered by the *Insured* in the 3 previous seasons as stated in the schedule
Valuation per box	An agreed value of J$ *XXXX* per box
Sum insured	The *sum insured* of each *Insured* is the 3 year *average production* multiplied by the *valuation per box* as stated in the schedule

11 Coffee profitability estimation was based on CIB´s Farm Profitability and Financial Modeling Tool.

Box 3.1. Draft summary of coverage (cont.)

Basis of insurance payment	A payment under this policy arises solely when the agreed model (operated by CGM) is applied to an *insured event* under agreed parameters based on: (a) the wind hazard generated for each *insurance zone*; (b) agreed vulnerability parameters within the model; (c) the *sum insured* adjusted to reflect the month in which the event occurs; and (d) less any previous insurance payments already made during the policy period. The model output will provide a "payout rate, expressed as a percentage of the *sum insured*". Payments in any *insurance zone* will be done at the same payout rate applying the *sums insured* shown in the schedule of insurance to all insured coffee farmers.
Premium	The premium is calculated for each *Insured* as the premium rate (expressed as a percentage) for the relevant *insurance zone* applied to the *sum insured*. [See 3.2.3 for comment on Basic Cover versus optional Top-Up Cover]
Conditions	The following points need to be incorporated into the policy: • This is an agreed value income supplement policy and no assessment of crop loss or damage will be made after an *insured event*. • Payments made under this policy are based solely on the maximum modeled wind speeds during an *insured event* applied to an agreed scale of vulnerability factors for each zone and an agreed scale of decreasing *sum insured* per month according to the altitude of each *insurance zone*. • It is accepted by the *Insured* that any payment made under this insurance may be of lesser value or greater value than the actual loss of coffee berries sustained on any individual farm or in the *insurance zone*. • A Master Policy is held by a central body [to be specified, e.g. the CIB], with an attached schedule listing the *Insured*, location of the holding, and *sum insured*. [*Certificates of Insurance from that Master Policy could be issued to each farmer; see section 3.3)*]. • [*Certain basic parameters within the CGM-KAC model may also be named in the policy, e.g. the decreasing sum insured per month*] [*Further policy conditions and exclusions are likely to be relevant and would be finalised in an implementation stage, and would include the regulator of insurance's involvement*]
Information	The following information is not part of the Terms and Conditions but would be incorporated as information on the program, in a separate document: • The *sum insured* per month is a decreasing percentage of the *total sum insured* on an agreed scale, reflecting the expected harvest schedule according to the altitude band of the *insured zone*, which is incorporated into the CGM-KAC model. • There is no deductible because payouts are based solely on the CGM-KAC model which incorporates a modeled wind threshold below which payouts will not be triggered. • The Policy may also list roles of insurer, the CIB, broker and any other parties, as established for scheme implementation, or refer to a separate document confirming the organizational arrangements. • "Deductions" (% of gross premium) established during scheme implementation, and agreed with insurers, for scheme administrative functions may also be shown in the schedule (see section 3.4).

3.2.2 Description of key features of cover

Compulsory Basic Cover and optional Top-Up Cover

During discussions with the CIB, the concept of a Basic Cover and Top-Up Cover was developed. This approach was established because there is a consensus amongst all parties that, for such an insurance scheme to be viable, there needs to be obligatory participation by all farmers. However, since cost of insurance is a major issue for farmers operating in such a high risk area, and because of affordability within poor profit margins, the concept of a Basic Cover being provided on a compulsory level, and the availability of a voluntary Top-Up Cover, was agreed. This could also allow for a continuation of central collection of the premium by means of a cess, for Basic Cover. The cess currently collected could not pay for the "full value" of the sum insured.

The most important difference between Basic and Top-Up Cover relates to premium. The cess is a central collection of funds at an agreed levy per box on all boxes of coffee cherry delivered. In a year of a major loss, there is a smaller overall cess collected due to production shortfall. Since insurers will require a premium precisely related to sums actually insured for the insurance period, management of cess (possibly with premiums paid out of a cess retained from the previous season) is a specific issue to be addressed. Further, as noted, where a farmer's premium is not exactly related to the sum insured in that season (as in the case of cess), the farmer will have an incentive to maximize his or her sum insured during the registration process. However, for Top-Up Cover, the premium would be calculated specifically for that farmer.

Insured

A key feature of the proposal is that the "insured" is the individual coffee farmer. In this respect it overcomes a major shortcoming of the previous insurance scheme, where CIB's Trustees were "the insured", and coverage arrangements between the Trustees and the coffee farmers were not fully specified.

Even for compulsory Basic Level Cover (section 3.1) **it is considered essential that there is an active enrollment process for farmers,** who need to agree on the details of their registration for insurance purposes, their sum insured and other information, which will be demonstrated in the schedule of insurance, confirming the contract of insurance between the insurer and the insured. Operational details are discussed in section 3.3.

Geographical range and insurance zones

The definition of the insurance zones is based on technical parameters (primarily altitude) and the location of main coffee areas, and involved significant work by the CIB and the modeling firm. Unless revised at a future date, these parameters are fixed within the model.

Each farmer enrolling for insurance must be allocated to one of the 16 insurance zones, based on the location of the coffee plantation, irrespective of the marketing channel and/or processing location for his or her coffee.

Insured event

In past traditional insurance programs, there has often been a written description of an insured wind event: for example "a hurricane or tropical storm, as designated by NOAA, passing within 50 nautical miles of any point on the island of Jamaica". Such a definition is not considered necessary in the current proposal, since the winds associated with any event tracking through the Caribbean basin can be modeled within the CGM model, and the wind strength modeled for each insurance zone within the Blue Mountain area. The modeling of past events takes all the official NOAA events within the storm catalogue, and an identical approach is undertaken in an actual insurance period, so as to maintain the integrity of the index model. However, in finalizing the insurance policy, reference can be made to definitions used within the CCRIF policies which operate using the same modeling process to trigger payouts to the Government. It is noted that "localized windstorm" is not an insured event as such winds are not of a tropical cyclone origin. Whilst localized windstorms occur (particularly in Jan/Feb), after harvest is completed, the intention of the proposed cover is to provide protection from major damaging events, which are originated by tropical cyclones.

Period of insurance

The period chosen for modeling needed to have a start and end date, coinciding with the hurricane season, so the period of July 1st to November 30th was agreed upon by the team and the CIB. Events falling outside this period are not covered. It is also noted that the main period of vulnerability of coffee, due to phenology of growth stages, is August to October. Unless revised at a future date, these parameters are fixed within the model.

Sum insured

The sum insured of each insured farmer is established as:
Sum insured = (average number of boxes produced during the last three years) x (agreed value per box).

Average production

The average number of boxes produced is a statistic which is dependent on the accurate recording of coffee deliveries under an individual farmer FRATS number. Establishment of such a database by the CIB has been one of its long term objectives and is a core strategy needed by the industry in order to establish traceability and management of the sector as a whole. To date, the FRATS database is incomplete because there continues to be sales of coffee through dealers, or to processors, who are not always willing to provide information on sources of coffee, or may not record this information. A cornerstone of any agricultural insurance scheme is that (a) farmers are registered for insurance and (b) that the production history, related sum insured, and corresponding premium, of each farmer is established **in advance of the insurance period, and recorded on the schedule of the policy.** The establishment of the sum insured is based on "productivity" of the coffee harvest (for which the three year production history provides a pragmatic time period – being long enough to average out annual differences, but not too long to be onerous in terms of data collection and management at the farmer level). A procedure to develop a production history linked to farmers' number was introduced in 2005 under the "Request for Coverage" (RFC) system, asking farmers to confirm their production level to be insured.

It should be noted that, in theory, there is no major "moral hazard" related to the average production under the wind indexed scheme, since payouts are calculated by the model and there is no field loss adjustment. For a farmer, a higher sum insured means paying proportionally more premium, and receiving proportionally higher payout during a triggered loss event. **However, there may be a moral hazard where premium is collected under an industry cess, where the amount of cess is not directly linked to each farmer's sum insured.** Under these circumstances, farmers have an incentive to maximize their production history.

Since this scheme would be marketed as an "income compensation" and not a "crop insurance", the use of the 3 year production history should be seen as a benchmark to establish a sum insured that is related to the level of economic activity of each farmer in coffee production.

Valuation per box

As noted above, the intention is to create a sum insured which will provide an "income compensation". The best estimate of "expected income" (revenue from coffee sales) is to value expected average production (reflected in a 3 year average) valued at the farm gate expected coffee price per box. **The maximum sum insured should be equal to the expected farm gate price of per box,** which the CIB calculates is around US$20 (J$1,730) per box. The wind model (and related vulnerability functions) is designed to reflect as accurately as possible, the expected loss of coffee associated with a specific event. **However, the wind index product allows a high degree of flexibility** in selecting lower box values and therefore lower sum insured per farmer, to provide a partial income supplement, but at proportionally lower premium (see section 3.1).

Basis of insurance payment

As described in Box 3.1, the payout is calculated by running the coffee model, as indicated in section 2.1, for the particular storm event, to calculate the payout rate in each insurance zone. All farmers in that insurance zone receive payments which are calculated by applying that payout rate to their individual sums insured.

The potential for **more than one event during the insurance period** (July 1st to November 30th) means that it is necessary to allow for previous payments already made, in the event of a second or subsequent event occurring. The simplest and most pragmatic way to incorporate this is to deduct payments made from the first payout from subsequent payouts (noting that the coffee model will calculate payouts as if the first event had not happened, i.e. the sum insured will not be reduced when running the coffee model for the second event in a season).

Premium

The methodology for derivation of the premium rates per insurance zone are described in Chapter 2.

During discussions with the CIB it was proposed that a **uniform premium rate** should be provided **for the basic coverage** level for all 16 zones. This approach implies a level of internal cross-subsidisation (mutualisation) between coffee farmers in the Blue Mountain area, and is only feasible if there is compulsory participation; otherwise, there will be a tendency for only farmers in higher rated areas to decide to insure. Essentially, compulsory participation allows a collective pool of premium to be collected, using the cess system for the Basic coverage. The creation of a uniform premium rate would have to be discussed with insurers, who would certainly wish to be satisfied over the adequacy of this rate and, in particular, about the overall rate reflected the sums insured in each zone, given the differences in premium rates (Chapter 2, Table 2.5). This issue could still be overcomed by calculating the commercial premium (to be paid from the aggregate cess) exactly based on sums insured in each zone and the related zone premium rate. For farmers, it is less of a concern since they are not individually responsible for the premium and this is centrally managed. For additional ("Top-Up") coverage, if made available, **the premium rate applicable to that zone should be applied**, and not a uniform rate, in order to maintain the rating integrity of the overall insurance scheme.

Other terms and conditions

The design of the policy for an indexed payout based on a model has the benefit that the payout calculation is mechanical, based on the operation of the coffee model. However, it is recognized that this approach is new, at least for a micro-level (individual farmer) product, and the dissemination of information to coffee farmers will be critical. The existence of Basis Risk (Chapter 2) and the fact that there is no field loss assessment, is the most critical message which will require education; this applies even before farmers, dealers and the CIB can reach agreement on whether or not to proceed with the scheme.

Drafting of the contract of insurance, would need to involve insurers, the regulator of insurance, and the CIB.

3.3 Programme organization and distribution

3.3.1 Farmers' registration for insurance

The registration of farmers into the insurance scheme is the cornerstone of the programme administration. A registration database of farmers is needed: (a) to confirm those farmers who have a contract of insurance, stated on the schedule of insurance prior to the start of the period of insurance; (b) to allow the data on production history to be collected (and if necessary validated) in order for the sum insured per farmer to be calculated; and (c) to allow the correct and rapid payment to insured farmers, following an insured event.

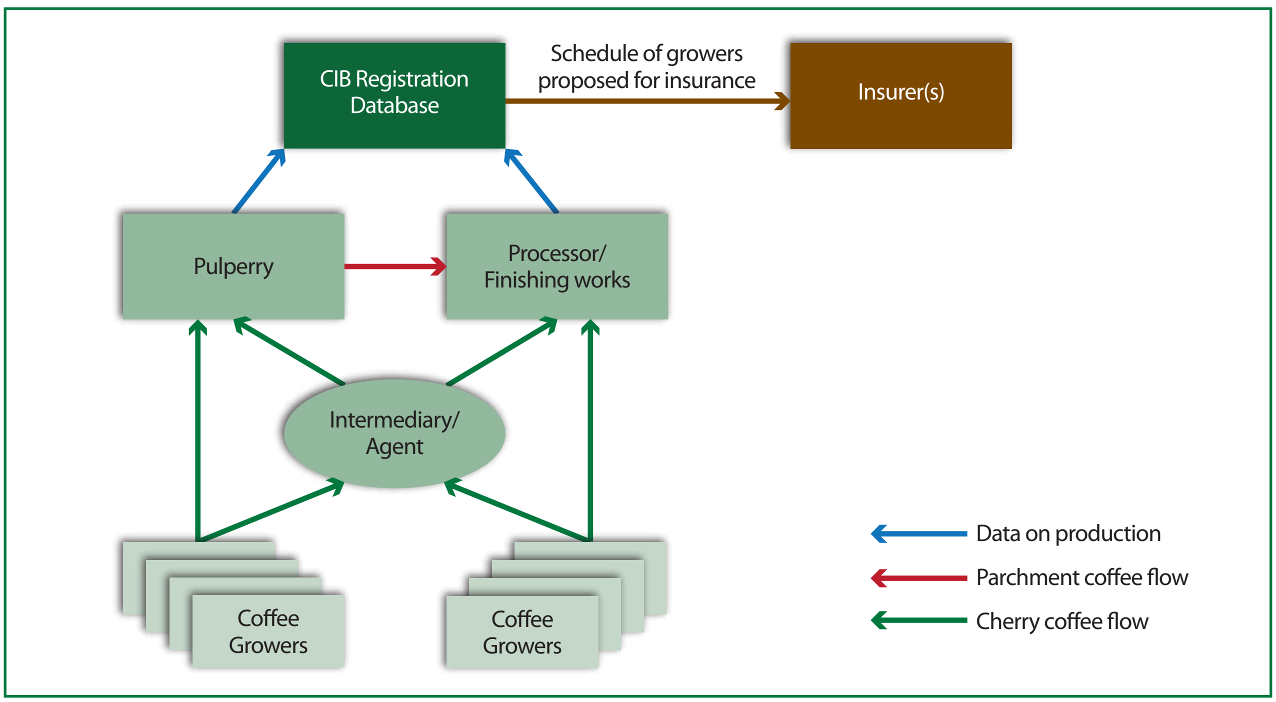
Actual data needed for the insurance database include a farmer registration number (and name, address, general production area (GPA) area, main group number, etc., already associated with the farmers' registration), plantation location, insurance zone, and three year production history for that farmer.

Discussions with the CIB on the current status of the FRATS registration system show that the objectives of an insurance scheme are very much in line with the needs of the CIB, in its statutory role as a regulator of the industry, to be able to establish a database which traces coffee back to specific registered farmers and their plantations. The present system of registration relies on dealers (licenced to purchase coffee cherry, being pulperies or combined pulping and processing entities) providing data to the CIB. As there are also other intermediaries (purchasing agents), this process is difficult to control and coffee grown on plantations may be sold through other registered family members or third parties. Further, there may be unwillingness, for trading or financial reasons (including cess calculation), for coffee dealers to provide centralized information.

The licenced pulperies and processors **will need to be actively involved and participate in the signing up (enrollment) of farmers into the insurance programme,** as they are the interface between farmers and the CIB. Such a campaign would best be organized district by district, and need a collaborative effort between the CIB and processors. A point to be resolved with insurers (and the regulator) would be whether such "enrollment" is limited to an "application (proposal) for insurance", or whether a Certificate of Insurance could be issued as part of the same registration process.

In contrast to the previous CIB's insurance scheme, which did not have a register of coffee farmers, an index insurance programme with the insurance contract provided to each farmer makes it essential that each coffee farmer is formally enrolled in the first year. Subsequently, automatic renewal of insurance based on updated delivery data of coffee cherry in the previous year, can be considered. Figure 3.1 shows the flow of information to allow registration and creation of the schedule of insured farmers.

Figure 3.1. Flow chart for data collection and registration of insured farmers



Source: Authors.

An example of this process was undertaken in the first year's operations of the Windward Island Crop Insurance Company (WINCROP), a specialist banana windstorm insurance company. Insurance premium was levied on all export bananas (and volumes of exports used to determine a 3 year delivery to establish the sum insured).

However, farmers were only eligible to receive claims once they had formally registered for insurance. This provided a high incentive for farmers to register, since premium was deducted at source, and the database soon became the most complete farmer database on the Windward Islands.

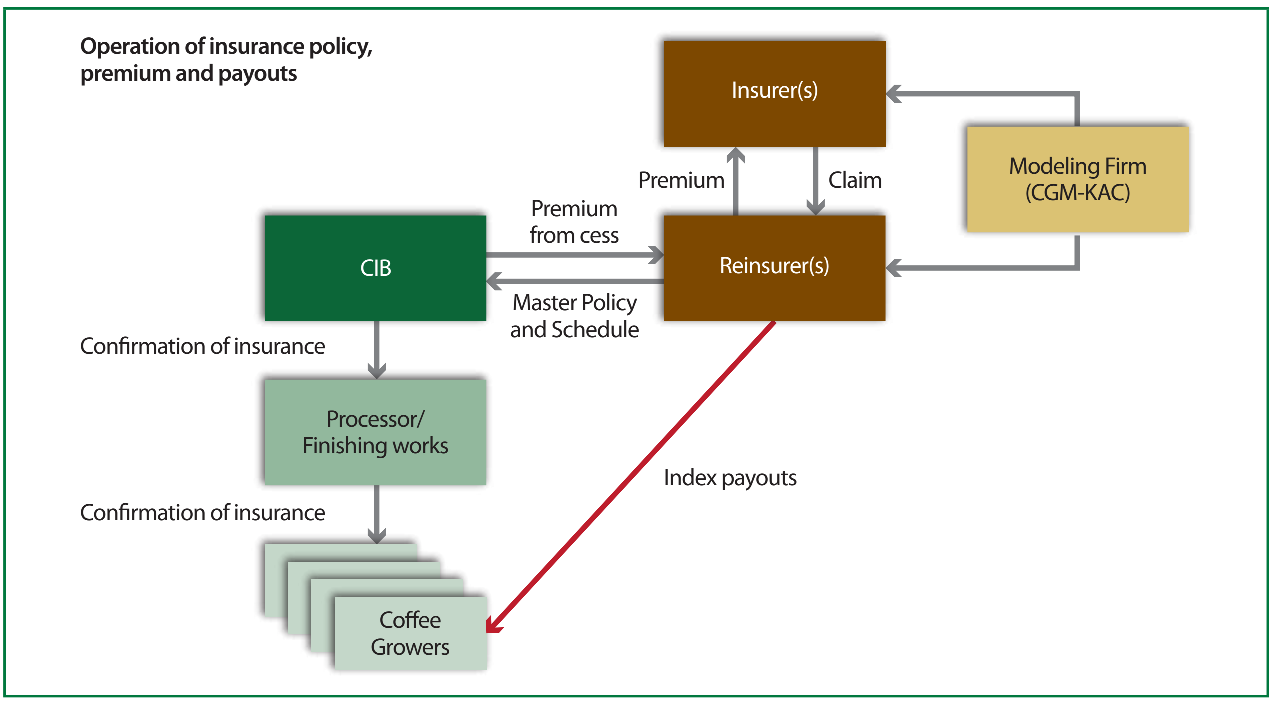
3.3.2 Premium collection, index payments and confirmation of insurance

Whilst no formal discussions have been held with insurers before this feasibility study for wind index-based insurance was determined, some comments are relevant to a future programme.

The most important objectives for the CIB were confirmed as avoiding the problems associated with the previous scheme. The main identified difficulties are: the *de facto* role of the CIB's Trustees acting as insurers, and the difficulties this situation gave the CIB in dealing with the the farmers' trust; the lack of clarity in the cover offered to farmers; lack of loss adjustment procedures to cope with measurement of losses; and lack of register of farmers. The combination of these factors led to the non-renewal of the scheme.

The proposed index programme can overcome the constraints mentioned above, notably because of the direct contractual arrangement between farmers formally enrolled into the insurance program, and the lack of loss adjustment in the field. However, disadvantages in the index approach are Basis Risk, and the potential this brings for reputational risk for the CIB and for insurers, if the coverage is not adequately understood and its shortcomings accepted. An organizational chart showcasing the index insurance mechanism is shown in Figure 3.2.

Figure 3.2. Organisational chart for wind index-based insurance, Base Cover



Source: Authors.

The arrangements shown in Figure 3.2 could be adjusted in several ways by agreement between the stakeholders. The chart considers the proposed arrangements for **Base Level Cover**, whereby automatic insurance would apply based on the payment of premium to commercial insurers as collected by cess.

The **premium** would be paid by the CIB to insurers from the cess collected centrally. For this Cover, no individual premium accounting is necessary directly with the farmers.

Index payouts, arising from a triggered wind event, should flow from the insurance company directly to the farmers, in an acceptable format that does not involve intermediaries, to allow immediate payment. Given that distribution of individual payments directly to farmers is costly, then payments could be made to farmer accounts held by processors, if this was acceptable to farmers. In the future, payments could be made via innovative means such as mobile phones, which have proved to be a possible alternative in a few insurance schemes. The ability to release payments very soon after an event directly to farmers is a major advantage compared to conventional crop insurance, where field assessment is necessary. Payouts should be able to be released by insurers (and their reinsurers) soon after the model has been run for the event. Data is available to do this immediately after the event has taken place.

Confirmation of insurance could take several forms. At its simplest (in terms of documentation and policy issuance), a Master Policy would be issued by the insurer(s) and lodged with the CIB. Copies of this Master Policy could be lodged with each processor. An attachment to the Master Policy would have a schedule of insured farmers for that season, showing their registration details and sum insured. Farmers could check that their names are on such a schedule at any time. A more onerous, but possibly necessary procedure, would be for Certificates of Insurance to be issued. Legally, a Certificate serves as confirmation that coverage has been granted under a Master Policy. An intermediate measure could be that “evidence of insurance” is provided to groups of farmers by means of a copy of the schedule relevant to that group. The precise methodology depends on local organization, farmer groupings, and could also be organized around the location where the farmer registered for insurance.

For **Optional (“Top-Up”) Cover**, a different approach would be needed for premium collection. The premium amount for a farmer buying Top-Up Cover would be specific to that farmer (selected sum insured x premium rate applicable to that insurance zone) and would need to be paid by the farmer in advance, or paid to insurers by processors under a credit arrangement with that farmer. One discussed option would be for farmers to agree to hold back funds from coffee sales from a previous season, to pay Top-Up premium for the following season.

Similar considerations apply for confirmation of Top-Up Cover, and for index payouts for Top-Up Cover following a triggered event, as for Base Level Cover.

3.3.3 Role of organisations to implement wind index-based insurance

Insurers

Apart from the obvious role of the insurer in accepting the insurance risk, and the insurance premium as “consideration” for the contract, the insurer will also need to be satisfied on all aspects of the legal and regulatory issuance of such a policy; to work with other stakeholders to put the administrative procedures in place; to negotiate any commissions for administrative functions; and to ensure that all aspects of the policy are operationally viable. Initially, the insurer would need to accept participation in the scheme, propose pricing, and finalise terms and conditions. The insurer plays a central role within the programme, even if other parties are responsible for functions as described.

The insurer should also be actively involved in the extension and education effort for an index policy (section 3.3.4), and to be satisfied that there is proper understanding of the product by the insureds (the farmers), in particular with regard to the potential for Basis Risk. There is potential for reputational risk in the event that the operation of the policy is not properly understood; however the product is considered much more transparent and objective compared to the organization of the previous insurance scheme.

In view of the innovative nature of the insurance product, the insurance sector should consider forming a co-insurance pool so that the insurance market can respond to the initiative more widely than it would with a single insurance company. This can have advantages in increasing the capacity of the market retention (section 4.2) and for reinsurance. If a pool is formed, experience shows that it is essential that a lead company is responsible for underwriting decisions, and that these are not disbursed to a committee structure of pool members.

Reinsurers

Reinsurers have a vital role to play in accepting the majority of the financial risk (Chapter 4). Reinsurers operate internationally and have valuable experience they can bring to the Jamaican market in supporting and formalizing an innovative programme such as this. Their ability to validate the proposed insurance contract and arrangements can add confidence and act as an additional due diligence to the transaction, including the pricing.

Brokers

The appointment of a broker is a decision for the "client", (in this case, the CIB) and is likely to involve a tender process. The tender would also consider the value added services which a broker could bring in program implementation and administration. These services can either be financial, in terms of negotiating insurance and reinsurance, or administrative, in terms of designing and implementing administrative procedures. A distinction is normally required between an insurance broker ("direct broker") and a reinsurance broker. The direct broker intermediates between the client and the insurer. The reinsurance broker negotiates reinsurance for the insurer. The roles could be played by a single broker, given the integration needed to finalise an overall scheme implementation.

Modeling firm

The index programme is reliant on the continued technical application of the same model used to derive the product, to be operated during the forthcoming periods of insurance. This ability is obviously central to the operation of wind index-based insurance based on modeled winds.

Confidence in the integrity of the modeling firm, and its ability to replicate the same modeling basis in the future as for the past analysis of events, is critical to the confidence of all parties. Index insurance in the Caribbean is not new as it is being operated under CCRIF, so there are precedents for the necessary measures to link a modeling firm to insurance contracts.

Third party review of the outputs of a modeling firm may well be a necessary step in order to satisfy the coffee farmers, who may well be suspicious of any "black box" in the model that could mask transparency. There is a past history of insurance failures in the previous scheme which is likely to affect perceptions by farmers of the insurance sector.

CIB

The CIB wishes to distance itself from the role as "principal" (as was the case with the CIB's Trustees management role in the previous scheme), and to become a facilitator.

The CIB has a role in initiating developments which should benefit the coffee sector. The CIB has an obvious and central convening role to any new insurance scheme, as demonstrated by their pivotal role in the present feasibility study. The CIB will need to lead the evaluation of the index insurance proposal and review demand from farmers. The database of farmers for insurance purposes, linked to FRATS, is a cornerstone of the index insurance scheme, but is only a part of the overall design of procedures to manage insurance.

The extension and representation staff of the CIB provides a resource to allow dissemination of information on the new insurance scheme.

The status of the Trust Deed established by the CIB in 1992 has not been researched in relation to this feasibility study.

Processing firms

The processing firms, and the pulperries which supply the processing firms, are the primary interface with coffee farmers as buyers of their coffee cherry. They also have financial accounts with the farmers to make payments to them for coffee purchases, and in some cases for supply of inputs.

Processors would have a role as focal points for organization of farmers in the registration process, and in promoting the insurance programme. Although not the beneficiaries of the insurance policy, they stand to benefit from the financial security of the farmers, on whom they depend for ongoing coffee supplies in the years following a shock event.

Farmers and farmer groups and co-operatives

Generally, the Blue Mountain coffee farmers are independent and the industry is not well organized in terms of formal farmer groups or co-operatives, which contrasts with low-land coffee. This emphasizes the need for processors and the CIB to play a lead role.

3.3.4 Extension and education

Experience in the implementation of index insurance shows that a key in the initial education effort is to ensure that the persons who have commercial or advisory relationships with farmers are themselves properly informed on details of the insurance scheme. These persons act as the first point of contact in communication with farmers.

For the wind index-based coffee insurance, this applies to officers of the CIB, processing companies, pulperies, co-operatives and government officials.

The preparation of explanatory materials (leaflets, presentations, etc.) would be needed. This material will be required as part of the process of disseminating the insurance proposal, to allow farmers and industry stakeholders to evaluate whether or not this is a program which the industry choses to proceed with.

Responsibility for extension would fall on the CIB, but would need to be supported by both processors and insurers.

To facilitate the overall implementation (if a decision is taken to proceed), would require the formation of a team of individuals with assigned responsibility. Leadership of this process is critical. Other insurance programs demonstrate the need for an assigned "champion" with the ability and interest to coordinate and motivate the persons within and outside such a team.

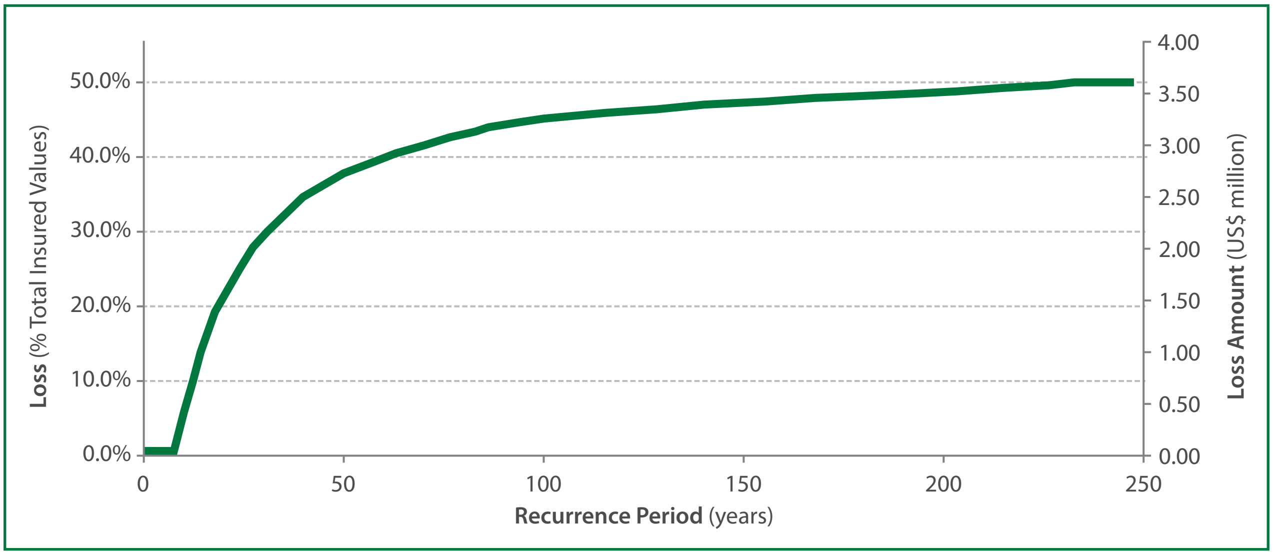
During farmer meetings held in May and June 2011, there was a good understanding of the concept of wind index-based insurance, from a presentation and ensuing discussion, and feedback was positive. The farmers are aware of their vulnerability to major wind events, and sensitized to the problems associated with the previous scheme (difficulties of loss adjustment and cover definition, bankruptcy of the insurer leading to delays in settlement of claims from Hurricane Ivan). They expressed concerns over the profit margin from coffee production and their ability to afford premiums. There was agreement that such a scheme needed to be compulsory.

3.4 Risk financing and reinsurance

3.4.1 Maximum probable losses

If modeled wind index-based insurance is introduced for Blue Mountain coffee in Jamaica, insurers would face several liabilities. Owing to this reason, a detailed analysis has been conducted in order to estimate the probable maximum losses for the Blue Mountain coffee modeled wind index-based insurance program. The analysis suggests that for this program, covering hurricane/tropical storm modeled wind speeds over 50 mph, the expected losses that might occur every 10 years could be in the order of US$582,000 (8% of the total insured values under the scheme – TSI), rising to US$1.98 million or 27.3% of the TSI for a recurrence period of one in twenty five years, 42.7% of the TSI for a recurrence period of 75 years, and US$3.65 million or 50.3% of the TSI for a recurrence period of 250 years. Figure 3.3 summarizes the estimation of expected losses on Blue Mountain aggregate coffee production due to the occurrence of different wind speeds for different return periods.

Figure 3.3. Blue Mountain coffee modeled wind speed index insurance. Loss excedance curve for different return periods



Recurrent Period	10 years	25 years	75 years	150 years	250 years
Losses (% TSI)	0.00%	0.00%	0.00%	5.59%	22.55%
Losses (Amount – US$ million)	0.00%	0.00%	0.00%	2.96%	18.80%

Source: Authors.

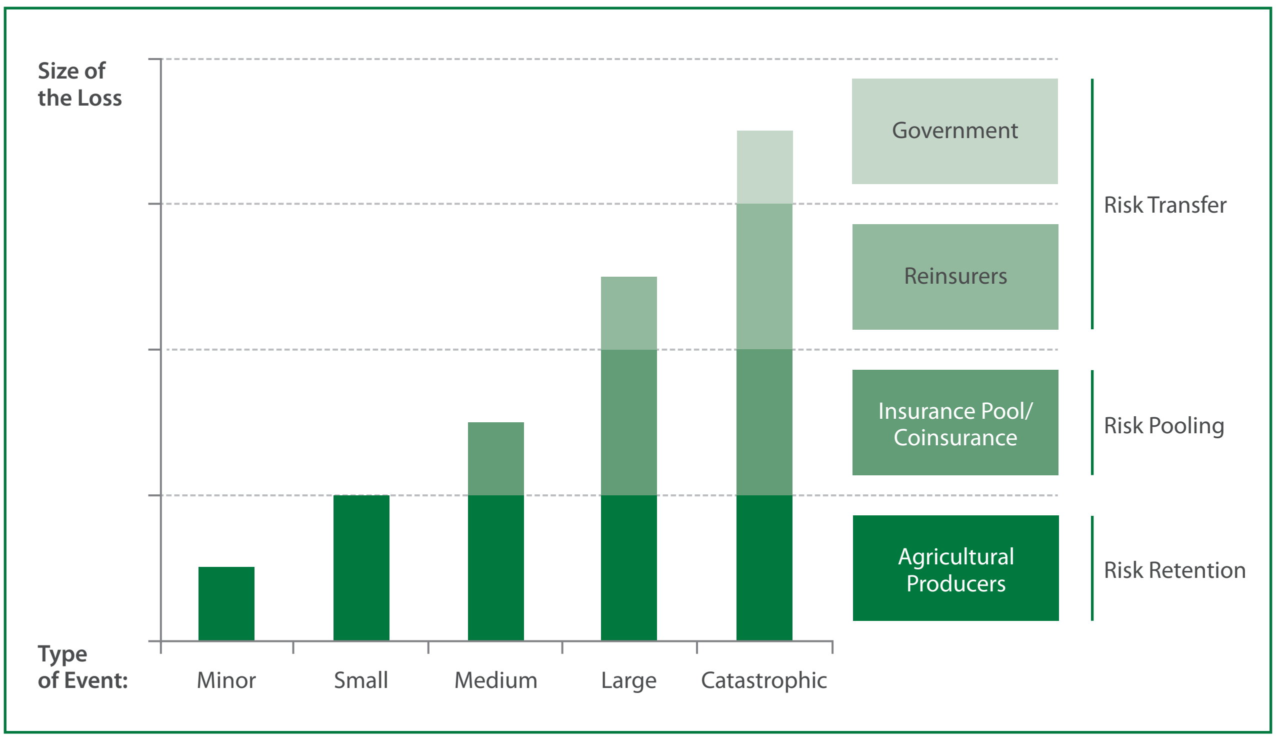
3.4.2 Risk layering

The successful development of a wind speed index-based insurance for coffee production in the Blue Mountain area will depend on the implementation of an efficient risk financing strategy. The risk financing deals with the residual risks that cannot be mitigated with cost-effective risk management measures.

They can be financed through farmers' self-retention, private commercial insurance and reinsurance markets, governments and international donors through an appropriate layering of risks.

A successful risk financing strategy is based on an appropriate risk layering. Conceptually, agricultural risks can be divided over three layers. The bottom layer of risk includes high frequency but low severity risks that affect farmers from a variety of mainly independent risks. These losses may be caused by inappropriate management decisions and are thus exposed to moral hazard and adverse selection problems. These losses should not be insured and should be retained by the farmers. The mezzanine layer of risk includes less frequent but more severe risks (that affect several farmers at the same time). The private insurance industry has demonstrated its ability to cover these losses. However, mezzanine (meso) level risks, depending on the financial capacity of the local industry, may expose insurance companies to aggregate insured losses and, thus, they may want to transfer these excessive losses through reinsurance. The top layer of risk includes low frequency but high severity risks. These catastrophic risks are by definition not well documented, and the probable maximum loss can be very large. The cost of transferring these high level risks, i.e., the insurance or reinsurance premium, can be high compared to the annual average loss, making (re)insurance a costly risk financing mechanism. On such cases, government intervention providing protection on the catastrophic layer is justified. Innovative financial products (e.g., catastrophe bonds, catastrophe options, contingent debt) may offer new risk transfer opportunities to the insurance markets and governments. Figure 3.4 conceptualizes how the risk transfer strategy can work to transfer liabilities arising out of the eventual implementation of modeled wind speed index-based insurance for coffee production in the Blue Mountain area in Jamaica.

Figure 3.4. Example of agricultural risk layering for coffee production in the Blue Mountain area



Source: Authors, adapted from Mahul & Stutley 2010.

In Jamaica, it is extremely unlikely that the local insurance industry would be willing to assume significant portions of the liability implied on the implementation of a modeled wind index-based

insurance coverage for Blue Mountain coffee in the short term. The reasons for the expected low levels of domestic risk retention are multifold. First, owing to the fact that Jamaica is in the middle of the North Atlantic hurricane corridor, wind risks are extremely catastrophic, and major losses would aggregate with property insurance losses. Second, the domestic market lacks both technical and financial capacity to write agricultural insurance in general and modeled wind speed index-based insurance in particular. In this context, the modeled wind index-based insurance scheme, as a new line of business, may expose the local insurance industry to an unacceptable level of risk that may affect their financial viability.

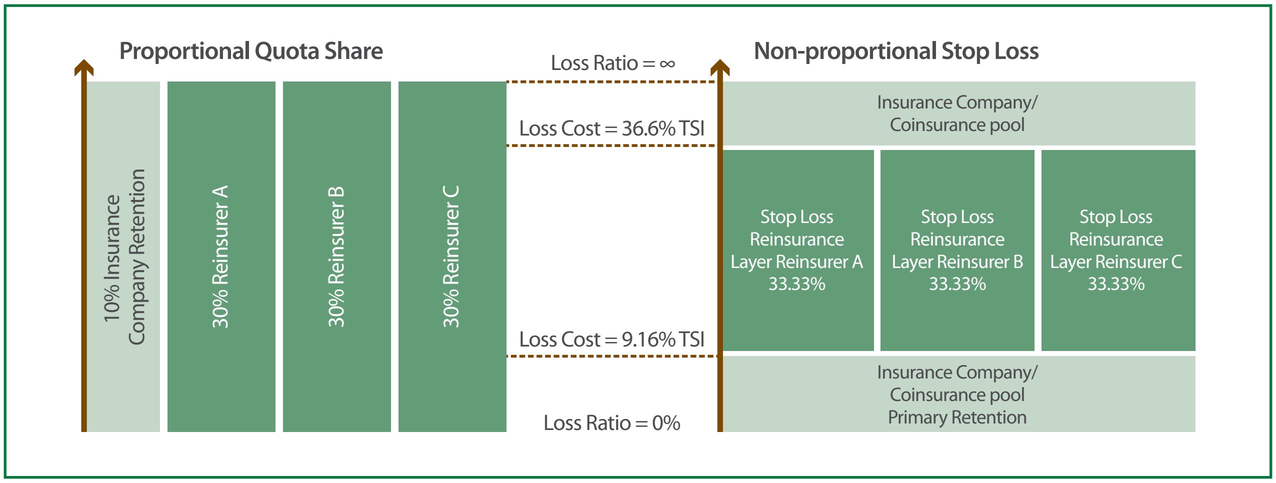
3.4.3 Co-insurance pools

Agricultural co-insurance pools should be promoted. The promotion of co-insurance pools can partly overcome the problem of low levels of risk retention in the domestic insurance market for the implementation of modeled wind speed index-based insurance for coffee production in the Blue Mountain coffee region. Under a co-insurance pool, the insurers associate to share particular risks. Each of the insurers belonging to the co-insurance pool is liable for a portion of each and every loss, and –concomitantly– share a similar portion in the premium. Under a co-insurance pool, insurance companies can combine individual financial capacities in order, either, to increase risk retentions in the domestic market or to share risks among the industry, which are not yet well known but represent potential future growing business opportunities for the industry. Co-insurance pools also allow insurance companies to reach economies of scale in the operation of agricultural insurance. The investments in infrastructure, capacity building, and human resources necessary to underwrite agricultural insurance and to launch the scheme can be shared among the pool. Co-insurance pools improve the power of negotiation of the domestic insurance industry at the moment of negotiating a reinsurance agreement.

3.4.4 Reinsurance

The participation of the international reinsurers in the program would be critical. It is recommended that, in the eventual implementation of the modeled wind speed index-based insurance program for coffee in the Blue Mountain region, the insurers participating in the program purchase reinsurance protection from international reinsurers in order to protect the program against catastrophe losses. The support from international reinsurers may include both proportional and non-proportional reinsurance. A proportional reinsurance is an agreement whereby the insurer agrees to cede and the reinsurer agrees to accept a proportional share of all reinsurances offered within the limits of the treaty, as specified on the slip, in exchange of participating with similar shares on the premiums. A non proportional reinsurance is an agreement whereby the reinsurer agrees to pay all losses which exceed a specified limit arising from an insured portfolio of business in exchange of a reinsurance premium. On the initial stages of the modeled wind index-based insurance scheme for coffee in the Blue Mountain coffee region, It is probable that reinsurers will be more likely to offer non proportional reinsurance in order to limit their liability to catastrophe claims. The access to the international agricultural reinsurance markets will benefit the local industry by having access to the expertise and services of specialized reinsurers. The service and expertise that the international agricultural reinsurers can provide is critical for the development of agricultural insurance schemes, particularly during the first years of operations. International agricultural reinsurers can provide their expertise and services to the local industry in the fields of agricultural insurance product research and development, pricing and underwriting, and claims management. Figure 3.5 provides a schematic characterization of the most popular forms of reinsurance used in the agriculture sector: the proportional quota share reinsurance, and the non-proportional aggregate Stop Loss reinsurance.

Figure 3.5. Comparison of proportional (quota share) and non-proportional (Stop Loss) reinsurance treaty structures



Source: Authors.

A rating exercise has been conducted in order to establish the indicative reinsurance prices for a non-proportional aggregate Stop Loss reinsurance protection for the modeled wind index-based insurance scheme. The pricing exercise has been conducted over nine Stop Loss reinsurance structures resulting from the combination of three options of aggregate indemnity limits[12] (9.16%, 18.32%, and 27.42% of the total sum insured, respectively) and three options of attachment points or priorities[13] (9.16%, 18.32%, and 27.42% of the total sum insured, respectively). The annual aggregate Stop Loss pricing analysis has been conducted assuming the terms and conditions presented for the modeled wind speed index-based coverage for coffee production in the Blue Mountain coffee region in Jamaica, and following the international reinsurance practice. The results of the analysis show that in no case the cost of reinsurance non-proportional Stop Loss coverage will be cheap. This is because of the high risk exposure of coffee production in the Blue Mountain area. The indicative commercial rates for the different coverage structures of an annual aggregate Stop Loss resulting from this analysis are presented in Table 3.1 below.

Table 3.1. Indicative reinsurance commercial rates for different options of priorities and annual aggregates indemnity limits for a non-proportional aggregate Stop Loss pricing exercise

Stop Loss Priorities	Stop Loss – Aggregate Limits		
	9.16% of TSI	18.31% of TSI	27.48% of TSI
9.16% of TSI	**2.1% of TSI** (US$148,547)	**3.5% of TSI** ((US$251,302)	**5.1% of TSI** (US$367,000)
18.32% of TSI	**1.5% of TSI** (US$107,606)	**2.5% of TSI** (US$178,753)	**3.2% of TSI** (US$231,000)
27.48% of TSI	**1.0% of TSI** (US$75,271)	**1.6% of TSI** (US$118,464)	**1.8% of TSI** (US$131,584)

Source: Authors.

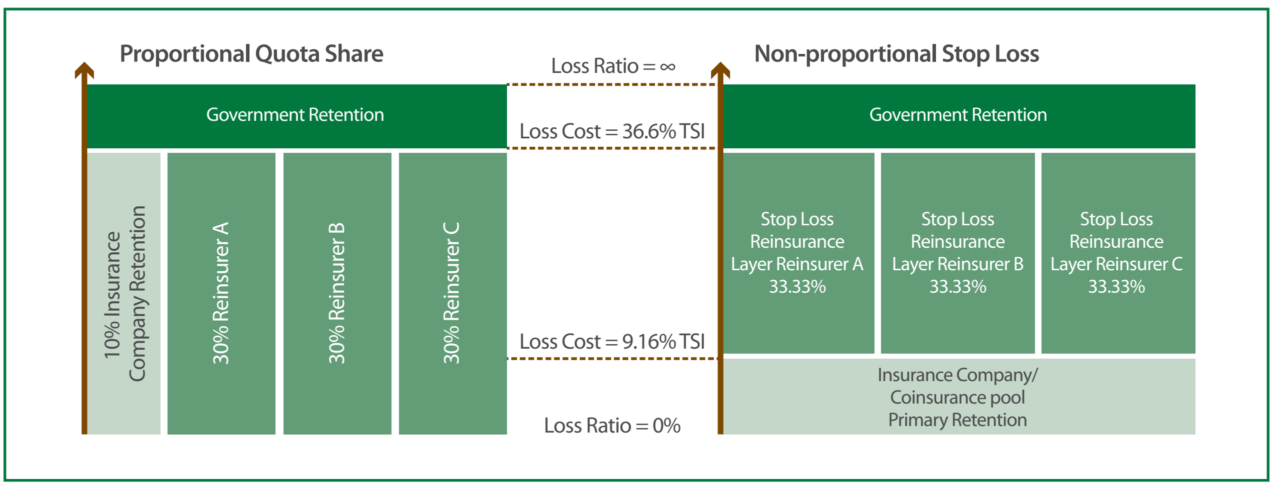
12 Maximum limit of liability to be assumed by reinsurers.

13 Attachment point or amount of losses from which the Stop Loss coverage is activated.

3.4.5 Role of government in reinsurance

The Government of Jamaica (GoJ) may assume the key role of reinsurer of last resort for the catastrophic layers of risks. The GoJ may consider participating in the structured risk financing program by retaining the low frequency but high severity losses of the top layers of the risk. The GoJ participation on the top layers of the risk, would cap the catastrophic losses that arise out of the scheme. This mechanism will bring several positive externalities. The first externality is that the existence of the loss cap, since it will limit the liability of the participating risk takers, would attract more insurers and reinsurers to participate in the scheme. The second externality is that the existence of the loss cap, since it cuts the low frequency and high severity risks, should be reflected in a decrease on the original gross rates of the coverage. The third externality is that having the Government participating on the catastrophic layers should allow insurance companies to build up reserves and to retain larger layers of risk over time. The resulting risk exposure for the GoJ because of assuming the catastrophic layer of risks should be adequately financed through an appropriate country risk financing strategy including, e.g., reserve funds, reinsurance, and contingent debt facilities provided by international institutions like the WB (see below). Figure 3.6 is aimed to provide a brief description on what would be the risk transfer structure for a strategy with Government participation on the top layers of risks under a proportional quota share and/or an annual aggregate Stop Loss reinsurance cession. For the purposes of this exercise, it is considered that the top layer of risk goes from liabilities in excess of 36.64% of the total sum insured (which is equal to 400% of the estimated gross net premium income in the scheme).

Figure 3.6. Comparison of proportional (quota share) and non-proportional (Stop Loss) reinsurance treaty structures



Source: Authors.

The GoJ participation on the catastrophic layers of risks of the modeled wind speed index-based coverage for Blue Mountain coffee should reduce the price of direct premiums. An "As If" analysis was performed under the study for two scenarios of the GoJ risk retention in catastrophic risk layers of the scheme. The objective of the "As If" analysis was two fold: The first objective was to assess the cost for the GoJ for participating on each of these layers. The second objective of the "As If" analysis was to estimate the average reduction on the direct insurance premiums as result of the eventual GoJ assumption of the liabilities in excess of the priorities. The "As If" analysis was run assuming two scenarios. The first scenario consisted of assuming GoJ participation on losses above 27.3% of the total sum insured which, according to the model developed for this study, would take place –approximately – every 25 years. The second scenario for the "As If" analysis consisted in assuming a GoJ participation on losses above 38.2% of the total sum insured. This scenario –according to the model–

would occur one every 50 years. The results of the "As If" analysis indicates that if the GoJ decides to retain all the liabilities of the scheme in excess of 27.3% of the total sum insured, this would represent a technical cost of US$100,000 per year (1.4% of the total insured values in the scheme). The results of the "As If" analysis also show that the cost of the GoJ participation retaining full liability in excess of 38.2% of the total sum insured in the scheme would represent an annual cost for the Government of US$40,000 (0.6% of the total insured values in the scheme).

The "As If" analysis also shows that both considered scenarios for government retention of catastrophic losses would generate a reduction on the average direct insurance premiums of the scheme. The analysis shows that while the scenario of the GoJ participation in losses above 38.2% of the total sum insured will generate a reduction on the average direct insurance premium of 9.7%, this reduction in the average direct insurance premium would be increased to 24.3% if the GoJ participates on liabilities in excess of 27.3% of the total sum insured. Table 3.2 presents the indicative cost for the GoJ participation on layers above 27.3 and 38.2% of the total insured values and the potential impact of each of these scenarios on the reduction of direct insurance premiums under the scheme.

Table 3.2. Indicative reinsurance commercial rates for different options of priorities and annual aggregates indemnity limits for a non-proportional aggregate Stop Loss pricing exercise

GoJ retention of risk	Recurrence period of affectation	Indicative cost for GoJ	Expected reduction on average direct insurance premium for the scheme
In excess of 27.3% of TSI	25 years	**1.4% of TSI** (US$100,000)	24.2%
In excess of 38.2% of TSI	50 years	**0.6% of TSI** (US$40,000)	9.7%

Source: Authors.

The "technical costs" indicated in the previous paragraph (US$100,000 or US$40,000 respectively) are the calculated annualized cost of the GoJ making the infrequent payments estimated at once every 25 or 50 years respectively. The reserve fund needed for such layers (from the excess point up to the PML) are approximately US$1.67 million or US$0.885 million respectively. For such infrequent but significant catastrophe payments, forming a fund reserved specifically for this purpose does not represent a cost efficient allocation of capital. At the same time, using the commercial reinsurance market may not be appropriate as the cost of the reinsurance premium will be relatively very high compared to the annualized technical cost, as reinsurers also incur in costs in reserving capacity to meet infrequent claims. For this reason, the WB has developed an instrument, a CAT Deferred Drawdown Option (CAT DDO) which is a pre-negotiated loan facility to drawdown funds under specified circumstances. Other options with catastrophe bonds (securities sponsored by reinsurers of governments and placed in the capital market, and triggered by defined modeled events) might be feasible. It is beyond the scope of this report to detail such arrangements. However it illustrates that financial protection options may be opened up in a parametric insurance scheme such as the proposed, compared with a conventional insurance indemnity based policy.

3.4.6 Program administrative costs

At this stage the program administrative costs cannot be estimated, as they are dependent on the organizational arrangements and, in particular, the methods through which each organization either retain the cost of the inputs they provide for their own account, or receive some payment in recognition of these inputs.

In almost all insurance programs, the costs of administration are met out of a commission negotiated with insurers. Insurers themselves have to build sufficient margin in their quoted prices to allow for their internal overheads (including staff time allocated to the product) and a margin for profit.

For third parties, a commission is payable to those parties which contribute an administrative or management function. Depending on the roles undertaken, this can include broker, distributer for policy sales, program manager or program administrator. In relation to the wind index-based product, it is useful to consider these functions and to compare with a conventional crop insurance policy.

In the case of **"policy sales"** there is a difference between the Base Level Cover, where there would be no formal sale as the product would be compulsory. In the case of Top-Up Cover, there is a sales function: farmers will need to be "sold" the policy by processors or agents, and the specific premium for the Top-Up option would be accounted or collected. Instead, the main workload relates to (a) **registration** of farmers for insurance and (b) **extension and education**. Linked to this is the cost of establishing and maintaining the **insurance database**.

Under typical crop insurance, overall parties involved in the above functions are typically remunerated by commissions of around 15% of gross premium. It is stressed that the costs structure for a completely new product such as index insurance should be based on budgeted costs of delivering services, and not on a level of "typical" commission for other classes of insurance. In the end, commissions are paid by the original insureds, who pay increased premium to accommodate the margin. The real costs of administering the program, and transparency of the pricing process, are important.

A further factor to be built in is the **fee of the modeling company** for providing the service of modeling the storms.

In terms of costs of **loss adjustment**, clearly there are major savings involved with the index product, since no in-field adjustment is carried out. Under traditional crop insurance, costs of field assessment can be around 5% of the premium. There will be some costs associated with settling an index claim.

4. Issues and Steps for Implementation

4.1 Regulatory approval

Index insurance differs from conventional indemnity insurance in two main ways, and these differences are relevant to the insurance regulator, who has responsibility to approve an index insurance contract.

The first main difference is that insurance law generally requires that there is an "insurable interest" in the property which may be lost or damaged, and against which an insurance claim may become payable. In the case of index insurance, the policy provides an agreed value payout, based on a proxy measurement (in this case, modeled wind speeds, applied to a formula within the model, generating a payout). The insurance regulator is likely to want to be satisfied that registration procedures demonstrate that genuine coffee farmers are being enrolled into the insurance scheme. Under the registration arrangements proposed, this would be the case, given the need to demonstrate a coffee production history.

The second main difference is that general insurance law may require that there is demonstration of loss or damage, in other words that the insured has suffered a financial loss. In index insurance, this is not the case, since the payout is made based on a proxy, and not on field measurements. Index insurance recognizes that Basis Risk exists and that payments are based on the index, and not in measurement of loss. In the present proposal, there is recognition from the outset that it is not possible to create an index which precisely correlates to coffee losses at the individual farmer level, and that such a product should be explained to farmers as an "income compensation" and not as a proxy for crop loss. The fact is that hurricanes are a well understood catastrophic event causing widespread damage and disruption to all households. The objective of "income compensation" is more readily understandable than would be the case for losses arising from less identifiable "events".

In practice, index insurance follows the principle that it is a "valued" insurance policy, where an agreed value is paid out in the event that defined circumstances occur.

It is recognized that the insurance regulator will need to examine the specifics of the proposed product and its procedures, in the event that there is a decision to implement wind index-based insurance. Training and capacity building in relation to the principles of index insurance have been provided to the insurance regulator (and the insurance market) by IADB. An initiative for collaborative development of policy for microinsurance regulation, including index insurance, is being undertaken by a working group of the MicroInsurance Network.[14]

4.2 Structuring a pilot and capacity building

Should there be a decision by the CIB to proceed to the next stage, following evaluation of this feasibility study and consultations with stakeholders (including a demand assessment), a pilot test would be necessary, rather than full scale implementation.

The purpose of a pilot would primarily be one of testing procedures which are developed for registration, developing the FRATS database, and informing stakeholders (both farmers, and particularly processors and those in the CIB who interface with farmers). This implies a significant effort to develop the educational materials

14 http://www.microinsurancenetwork.org/workinggroup/Regulation-Supervision-and-Policy/10.php

needed. The purpose of the pilot is to have a concentration of effort in a defined geographical area, in order to ensure that the task is fully carried out within this area considering the available human resources, and that the results can be monitored.

A difficult aspect of any insurance pilot is that there is no guarantee that there will be a loss event during the pilot period. Hence, it may not be possible to test all the procedures associated with a payout. Testing the reaction of farmers to a payout is the final test of the insurance scheme.

The proposed wind index-based product, based on a model, is a unique development at a micro-level (with individual farmers as the insured) and, in this respect, there is limited international comparison to be made with procedures in other schemes. Examples of materials used in index insurance for educational materials are available. Further, insurance professionals can bring insurance product launch and management skills to the effort, even if not related to crop insurance. However, coordination of piloting requires a structure, workplan and budget.

The CIB's role in this process involve the following steps:

Step 1. Evaluation of the feasibility study:
- Evaluation of the technical, organizational and financial implications of wind index-based insurance, as an income compensation product as proposed in this report;
- Determining demand (demand assessment) for such a product and forwarding the proposal to farmers;
- Determining whether costs and benefits justify moving to a piloting phase;
- Detailed discussion of the proposal with the insurance market; possible appointment of a broker to intermediate this function;
- Forming agreements between the CIB, farmer representatives, insurers (and modeling firm), the Government and the regulator.

Step 2. Designing a pilot (*if findings from step 1 are to proceed*):
- Appointing a team responsible for pilot implementation, including appointing a lead insurer and appointing individual(s) allocated from within the CIB (see 4.3);
- Development of the workplan and timeframe for the pilot;
- Budget, and finding sources of funding specifically to fund the pilot workplan (later the pilot needs to become self sustaining from overall premium).

Step 3. Operating the pilot:
- Registration, education, etc. in the pilot area;
- Establishing the insurance database;
- Payouts from an insured event (if any);
- Monitoring and evaluation.

4.3 Pilot design and budget

The following need to be considered in relation to pilot design, *if there was a decision to proceed in step 2*:

Selection of area(s) to be piloted: A selection of a parish would provide a representative cross section of growers in terms of altitude, commercial and subsistence farmers, buyers, processors, etc. The CIB has already identified Portland parish as a potential pilot area.

Time length of a pilot: Typically, a period of 3 years is used to pilot test an index insurance program. However, within this time frame, a decision can be made in the second and third year to modify, scale up, or adjust the process, depending on findings. (As noted, there may be no loss event during this period, and therefore no opportunity to test feedback from a payout, which is one of the most important aspects of a pilot test in a scheme such as this).

Appointment of the insurer: The appointment of an insurer will need to be made by the CIB, representing the insured farmers. The insurer will need to commit to the pilot, and to issue the cover, finalise reinsurance as necessary and to prepare the insurance policy. In addition the insurer will need to be actively involved in developing the farmer enrollment procedures. The insurer would be responsible for relations with the insurance regulator and with reinsurers.

Organisational structure: Evaluation of the feasibility study as above (step 1) will also involve consideration of the required operational structure for a pilot. The question of how formalized such a structure needs to be has to be considered, and clearly defined roles in the **implementation team**, including assignment of a lead organization have to be considered. This team is primarily involved in setting up the dissemination of information and enrollment of farmers into the scheme. More specifically, a good manager (a "champion") can make a large difference to the success of a pilot. The identification of such a person would be a key position, and preferably reporting or employed by to the insurer. Other persons would be identified in the implementation team attached part time to assigned tasks. For some major crop insurance pilots, a specialist unit ("Technical Support Unit") has been justified, normally attached to the insurer, and with a project budget for the duration of the pilot.

To facilitate and guide the implementation team, a steering committee can be formed. This steering committee has the function of overall direction and meets periodically. The steering committee needs to include the CIB, a farmers representative, a processors representative, the insurers (and probably a representative of the insurance association), and possibly the insurance regulator.

Workplan for the pilot: The workplan needs to be formulated for step 2 above, by the implementation manager and needs to include at least the following activities and assignation of tasks:

- Procedures: Defining the procedures to be adopted and stakeholder responsibilities.
- Materials: Develop explanatory materials/presentations for farmers and for other parties.
- Database: Develop (with the CIB) the farmers' registration database for insurance.
- Processor and the CIB's field staff awareness: The first stage of dissemination requires that all persons who intermediate with farmers are themselves fully aware of the details of the insurance programme. Unless this is the case, there will be misinformation at farmer level.

Basic and/or Top-Up options: An issue for consideration would be whether to pilot initially solely a Basic Level Cover (section 3.2.2) or whether to additionaly offer the option of Top-Up Cover. Generally, the purpose of a pilot is to test all aspects of the scheme design and operational needs on a controlled area, so the inclusion of the Top-Up option would be logical. However, such an introduction could be phased if a decision was to roll out Basic Cover as a first step.

Budget for the pilot: Although each party is likely to need to allocate some staff time to the pilot project implementation, there will be core tasks which are dedicated to the insurance scheme. For the long term, these need to be absorbed into the margin of commission negotiated with the insurers for administrative purposes.

However during implementation, not only are development costs higher, but premium volumes are lower. Hence, a pilot project budget is needed which will differ from the long term operational budget. Agreement to arrangements with the modeling firm will need to be made under a contract. In this respect, CCRIFF can be consulted, since it is operating on a similar basis for payouts in the Caribbean region at a national level.

Annex: Wind Index-based Insurance Methodology to Calculate the Total Net Loss (TNL) & Rating Methodology

1. The Total Net Loss (TNL) formula is given by:

$$TNL: \quad NL_{1L} + NL_{1M} + NL_{2M} + NL_{2H} + NL_{3L} + NL_{4H} + NL_{5L} + NL_{5M} + NL_{5H} + NL_{6L} + NL_{7L} + NL_{8L} + NL_{9L} + NL_{10L} + NL_{10M} + NL_{10H}$$

Where:
TNL: Total Net Loss, expressed in monetary units.
NL_i: Net Loss per insurance zone "i", expressed in monetary units.

1.1. For the proposed coffee model, the Net Loss formula per insurance zone is given by:

$$NL_i: \quad Loss(\$)_{Jul\,(i)} + Loss(\$)_{Aug\,(i)} + Loss(\$)_{Sep\,(i)} + Loss(\$)_{Oct\,(i)} + Loss(\$)_{Nov\,(i)}$$

Where:
$Loss(\$)_{Jul(i)}$: correspond to the simulated loss in July for insurance zone "i", expressed in monetary units.
$Loss(\$)_{Aug(i)}$: correspond to the simulated loss in August for insurance zone "i", expressed in monetary units.
$Loss(\$)_{Sep(i)}$: correspond to the simulated loss in September for insurance zone "i", expressed in monetary units.
$Loss(\$)_{Oct(i)}$: correspond to the simulated loss in October for insurance zone "i", expressed in monetary units.
$Loss(\$)_{Nov(i)}$: correspond to the simulated loss in November for insurance zone "i", expressed in monetary units.

Since the *sum insured* per month is a decreasing percentage of the *sum insured*, the calculation of the simulated loss per month must consider the *expected harvest schedule* (EHS) according to the altitude band of the *insured zone*. The simulated loss for each month that comprise the *period of insurance* is calculated using different algorithms:

1.1.1.

$$Loss(\$)_{Jul\,(i)} : Loss(\%)_{Jul\,(i)} * SI_i$$

Where:
$Loss(\%)_{Jul(i)}$: July simulated loss for insurance zone "i", expressed in percentage.
SI_i: Sum Insured for insurance zone "i", expressed in monetary units.

1.1.2.

$$Loss(\$)_{Aug\,(i)} : if \begin{bmatrix} (SI_{Jul\,(i)} - Loss(\%)_{Jul\,(i)}) * EHS_{Aug\,(i)} < 0,0 \\ (SI_{Jul\,(i)} - Loss(\%)_{Jul\,(i)}) * EHS_{Aug\,(i)} * Loss(\%)_{Aug\,(i)} \end{bmatrix}$$

1.1.3.

$$Loss(\$)_{Sep\,(i)} : if \begin{bmatrix} (SI_{Aug\,(i)} - Loss(\%)_{Aug\,(i)} - Loss(\%)_{Jul\,(i)}) * EHS_{Sep\,(i)} < 0,0 \\ (SI_{Aug\,(i)} - Loss(\%)_{Aug\,(i)} - Loss(\%)_{Jul\,(i)}) * EHS_{Sep\,(i)} * Loss(\%)_{Sep\,(i)} \end{bmatrix}$$

1.1.4.

$$Loss(\$)_{Oct\,(i)} : if \begin{bmatrix} (SI_{Sep\,(i)} - Loss(\%)_{Sep\,(i)} - Loss(\%)_{Aug\,(i)} - Loss(\%)_{Jul\,(i)}) * EHS_{Oct\,(i)} < 0,0 \\ (SI_{Sep\,(i)} - Loss(\%)_{Sep\,(i)} - Loss(\%)_{Aug\,(i)} - Loss(\%)_{Jul\,(i)}) * EHS_{Oct\,(i)} * Loss(\%)_{Oct\,(i)} \end{bmatrix}$$

1.1.5.

$$Loss(\$)_{Nov\,(i)}: if \begin{bmatrix} (SI_{Oct\,(i)} - Loss(\%)_{Oct\,(i)} - Loss(\%)_{Sep\,(i)} - Loss(\%)_{Aug\,(i)} - Loss(\%)_{Jul\,(i)}) * EHS_{Nov\,(i)} < 0,0 \\ (SI_{Oct\,(i)} - Loss(\%)_{Oct\,(i)} - Loss(\%)_{Sep\,(i)} - Loss(\%)_{Aug\,(i)} - Loss(\%)_{Jul\,(i)}) * EHS_{Nov\,(i)} * Loss(\%)_{Nov\,(i)} \end{bmatrix}$$

Where:
$EHS_{Jul(i)}$: July expected harvest schedule for the insurance zone "i", expressed in percentage.

The estimation of the Loss of month "i", value is expressed in percentage, will be obtained from the modeled wind speed that exceed thresholds of the month of interest that is established (vulnerability curves) within the wind hazard module of the CGM-KAC model.

Technical Rate & Commercial Premium Rate estimation

For the calculation of the Technical Rate (TR) for each insurance unit, first it is needed to calculate the Total Net Loss (TNL) of 20,000 simulated events that considered the possibility of occurrence of having insured events in more than one area within the Blue Mountain region. Second, the average estimated loss obtained from all simulated events are loaded up by 30% of the standard deviation of all simulated events and then, the result is divided by the sum insured of the insurance unit.

1.1.6.

$$TR: \frac{\sum TNL}{20{,}000} + (30\% * DESVEST)$$

Where:
TR: Technical Rate, expressed in percentage.
TNL: Total Net Loss, expressed in monetary units.
DESVEST: Standard Deviation.

The Standard Deviation is calculated by the given formula:

1.1.7.

$$DESVEST: \sqrt{\frac{\sum_{i=1}^{n} (x_i - x)^2}{n - 1}}$$

Where:
X is the mean of the sample, and n is the sample size.

Finally, an additional loaded factor is applied to the TR in order to derive estimated commercial premium rate (ECR):

1.1.8.

$$ECR: \frac{TR}{60\%}$$

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