Assessment of alternative agricultural insurance Designs suitable to nutmeg and cocoa production in Grenada

By

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Summary

The Agricultural Economics Research Institute (LEI) of Wageningen University and Research Center in collaboration with the United Nations Food and Agriculture Organization is assessing pre-feasibility of agricultural insurance schemes in Grenada. The objectives are to define insurance scheme for crops accounting a large share of households' income, primarily nutmeg and cocoa, to access performance of the contract, and willingness to pay. As part of this project, the objective of the present study was to evaluate effectiveness of indemnity-based (farm yield) insurance, and index insurances: area yield and weather index insurances. Yield, price, and weather data of both crops and household income derived from cocoa and nutmeg farming were retrieved from a field survey result and additional data and assumptions were taken from literature.

Fair premiums of farm yield, area yield and weather index based insurances were first estimated at coverage levels ranging from 65% to 85% (for farm and area yield designs) and probabilities of hurricane of 1/75, 1/50 and 1/25. For weather index insurance, an index that results in pay out of one-year loss only in the events of hurricane was developed since rainfall was a very poor pay out indicator. For farm and area yield insurances a 5-years coverage was considered. One-year coverage and indemnifying replanting cost were also considered as alternative indemnities.

To assess effectiveness of the insurance designs in trsnsfering risk, percentage of reduction in variance of net yield was calculated as the framework in Barnnet et al (2005). Potential impact of the insurance schemes on farm revenue was also assessed using coeffiecent of variance analysis. To assess basis risk of area yield insurance, correlation analysis between individual farm and country level yields were undertaken. The results, at 85% coverage level (for farm and area yield, 100% for weather index) and 1/50 probability of hurricane are summarized in the next table.

To determine premium and make sound performance analysis, pre and post-hurricane production per acre of the farms are required. For perennial crops, age of the trees and number of trees per acre are also important since yield is dependent on its age. In our case, since farm level pre-hurricane production per acre of cocoa and size of nutmeg farms were not available, we determined them indirectly based on assumptions.

Had these limitations were solved, the premium computed could have been more accurate and the performance of farm and area yield based schemes could have been more consistent in both analyses. Furthermore, assuming that risks are normally distributed, the possibility of excluding extreme values from the analysis of variance of net yield is higher, as it takes squared deviations. Therefore, CV analysis was undertaken and the result was reversed, where in the former farm yield based scheme performed better. On the other hand, both analyses assume that lower risk is preferable than higher risk. Therefore, cost of insurance (pure premium plus loading) and basis risk need also to be considered while adopting the insurance schemes.

Apart from these limitations, however, we have shown that weather index insurance is not effective scheme, while the other two can be considered for further analysis during implementation. Specially, a major concern among policy makers in implementing farm yield insurance is existence of moral hazard, adverse selection and high premium loadings. In such cases, area based insurance can be adopted.

Summary of premium and performance of insurance designs

Description		Cocoa			Nutmeg		
Insurance schemes		Farm yield	Area yield	Weather index	Farm yield	Area yield	Weather index
Premium[1]	Indemnity[2]	8.55	8.30	2 .00	29.92	7.32	2 .00
	Replanting	38.54	-	-	3.00	-	-
	Alt. indemnity[3]	1.70	-	-	1.70	-	-
Variance reduction[4]		63	48	11	60	44	-1
Farm	Mean	2990	2954	2330	2855	3117	2609
Revenue	Std. dev	905	567	875	1265	976	1890
(EC$)	CV[5] (%)	30	19	38	44	31	72

[1] Ratio of premium to value of pre-hurricane production (%)

[2] Multi-year coverage (for farm and area yield base)

[3] One-year coverage in the event of hurricane.

[4]Percentage of reduction in variance of net yield,

[5] coefficient of variance

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List of Abbreviation

BCMOAL - British Colombia Ministry of Agriculture and Land

CV - Coefficient of Variance

FAO - United Nations Food and Agriculture Organization

GCA -Grenada Cocoa Association

GCNA - Grenada cooperatives of Nutmeg Association

GRP-Group Risk Plan

LEI -The Agricultural Economics Research Institute of Wageningen University and Research Center

MPCI - Multi-Peril Crop Insurance

MOA - Granada Ministry of Agriculture

OECS - Organization of Eastern Caribbean States

Std dev - standard deviation

CHAPTER I

INTRODUCTION

1.1. General background

Grenada is an island in the Caribbean region, comprises of seven parishes: St. George's, St. John's, St. Mark's, St. Patrick, St. Andrew's, St. David's and Carriacou. Its population reaches 102, 632 (OECS, 2005). It is situated south of the historical paths of most tropical storms and hurricanes. During 1955–2005, three major hurricanes directly affected Grenada: Janet in 1955, Category 3 Ivan in 2004 and Category 1 Emily in 2005 (Roberts et al., 2007). It was also directly hit by at least four major storms between 1990 to 2006 including Hurricane Lenny in 1999 (Peters, 2006 as cited by Roberts et al., 2007). This vulnerability to weather events have damaged its agricultural sector and limits engagement of banks in the sector.

A set of stakeholders' consultations and preliminary assessments on risks management and access to finance are already undertaken by the United Nations Food and Agriculture Organization (FAO). Farmers and financial institutions indicated the need to develop insurance products covering the main cash crops, such as nutmeg and cocoa, to expand lending in these sectors. The Agricultural Economics Research Institute (LEI) of Wageningen University and Research Center in collaboration with FAO is undertaking a project aimed at pre-feasibility assessment of agricultural insurance schemes in Grenada. As part of this on going project, the present study focuses on identifying suitable insurance schemes for cocoa and nutmeg farming.

1.2. Objective of the study

According to Organization of Eastern Caribbean States, OECS, (2004) cocoa and nutmeg are the leading export crops in Grenada's agriculture. The nutmeg sub-sector employs approximately 30,720 persons either directly or indirectly and cocoa sub-sector employs approximately 7,500 active farmers throughout the parishes of the country (OECS, 2004). This paper aims at evaluating performance of alternative crop insurance schemes suitable to nutmeg and cocoa production and identifying the best fit in the context of Grenada. It is part of the pre-feasibility assessment of agricultural insurance schemes in Grenada. The pre-feasibility study has three objectives: to define insurance schemes for crops accounting a large share of households' income, primarily nutmeg and cocoa, to assess their performance, and willingness to pay. Within this framework, the main objective of the present study is to evaluate the effectiveness of:

a. Indemnity-based insurance (farm yield insurance), and
b. Index insurances: area yield and weather index insurances.

1.3. Organization of the chapters

The paper is organized in five chapters. The first chapter is about the general background and objective of the study. The second chapter comprises literature about types of crop insurance designs, nature and yield function of perennial crops, mainly cocoa and nutmeg loss indemnification of perennial trees, and insurance experience of perennial crops. In chapter three the methodology in detail is included: source and description of data, additional assumptions considered and methodology for the alternative insurance designs are explained. The results, which include calculated premiums and performance of the alternative insurance designs, are explained in chapter four. The conclusion and discussions are finally included in chapter five.

CHAPTER II

PERENNIAL CROPS AND INSURANCE

2.1. Impact of hurricane on cocoa and nutmeg production

Hurricane history of the country shows Grenada had three main devastating hurricanes; in 1955 (Janet), 2004 (Ivan), and 2005 (Emily). Hurricane Emily occurred just after 10 months of hurricane Ivan.

A study by Marcelle (1995) shows, in Grenada, there were 400-450 thousand estimated number of nutmeg trees with the majority assumed to be under age of 40 years, while the rest were 100 years and over but were productive. Except only few locations with pure stance of nutmeg trees in moderate acreage, most fields are heavily intercropped and there are variations in the number of trees planted per acre (Marcelle, 1995). In Grenada nutmeg tree has no serious insect pest except few diseases of varying significance (Cruickshank, 1973 as cited by Marcelle, 1995). However, because of the shallow root system its tree can be easily uprooted or blown down by high winds (Marcelle, 1995). Hurricane reports of the island show that during hurricane Janet (1955), 80% of nutmeg tree population was damaged (Muller et al., 1980 as cited by Marcelle, 1995). Moreover, a report by OECS (2005) show hurricane Ivan (2004) has damaged 70% of the trees (i.e. 8,400 acreage equivalents out of the 12,000 acres) and hurricane Emily damaged 11.6 acreage equivalents out of the left over 3,200 acres. The nature of damage ranged from toppling of trees to loss of matured nutmeg and set blossoms (OECS, 2005).

According to the OECS (2005) report 4,496 acreage equivalents out of the 6,602 acres (i.e., 68%) of cocoa trees were damaged by hurricane Ivan and 115.8 acreage equivalents out of the 2,106 left over acres were damaged by hurricane Emily. Damage of the cocoa industry included toppling of trees, destruction of the apical part of the stem, leaf tissue desiccation caused by the high winds, mature pod and flower drop, the destruction of infrastructure at Mount Horne and the nurseries at Boulogne, Ashden, Maran and the germplasm bank at Mount Horne.

2.2. Crop insurance designs

2.2.1. Farm yield insurance

Indemnity-based insurance, also called Multi-Peril Crop Insurance (MPCI) (or farm yield from now on in the present report) insurance, provides indemnities when crop yield falls below a specified level from variety of natural causes. It provides protection against yield losses at the farm level. Adverse selection, moral hazard and higher administrative costs are challenges related to implementation of this insurance scheme. Adverse selection arises when farmers with higher relative risk purchase insurance at the same cost as farmers with lower relative risk, which ultimately forces the insurer to raise premium (Skees and Reed, 1986). Moral hazard exists when insured entities change their behavior after having bought insurance in a manner not predicted by the insurer (e.g. by becoming more careless) (Arrow, 1996). The administrative costs are higher due to record keeping and other manpower requirements needed to verify individual production histories and to adjust individual yield-loss claims, which raise insurer expenditures and impose transaction costs on participating producer (Miranda, 1991).

Barnett et al., (2005) while comparing risk transfer effectiveness of MPCI and area yield insurance (or Group Risk Plan, GRP) contracts, estimated premium for alternative deductible levels. Assuming that indemnities are paid in units of production (pounds) per acre, for insurance unit *i*, they used the following MPCI indemnity function:

$$\tilde{n}_i = \max(y_{ic} - \tilde{y}_i, 0) \quad (1)$$

Where, $\tilde{n}i$ is the indemnity per acre, $\tilde{y}_i$ is the realization of the stochastic yield, and y_{ic}, is the critical yield calculated as:

$$y_{ic} = \mu_i * (1 - deductible) \quad (2)$$

with the deductible expressed in percentage of the loss. For MPCI, predicted yield (μ_i) is normally calculated as a moving multiple-year average of historical yields for the insurance unit. They empirically estimated actuarially fair premium at 65%, 75%, and 85% coverage levels.

2.2.2. Area yield insurance

Area yield insurance contracts provide farmers with an indemnity only when average yields across all farms in the area fall below a critical yield and it is under the assumption that the individual farm's yield will have only a small impact on area yield and therefore area yield crop insurance contracts do not provide such large incentives for moral hazard or adverse selection (Smith et al., 1994). The holder of an area yield insurance policy receives an indemnity whenever the realized area yield falls below some specified critical yield (i.e., strike); regardless of the realized yield on his or her farm (Barnett et al., 2005). Miranda (1991) described area yield plan as a hedging instrument, specifically, like a put option in which the critical yield plays the role of the strike price. He used the following indemnity function of area yield insurance, which is similar to that of MPCI, except yield is now defined at area level rather than at farm level:

$$\tilde{n} = \max(y_c - \tilde{y},0) * scale \tag{3}$$

$$y_c = \mu * (1 - deductible) \tag{4}$$

Where, $\tilde{y}$ is the realization of the stochastic area yield, μ is the predicted area yield, and scale is according to Barnett et al. (2005), a choice variable that allows a policyholder to increase or decrease the amount of protection per acre.

Skees et al. (1997) identified basis risk as an important factor affecting the efficacy of area yield insurance. That is, farmers may experience farm-level yield losses when area yield shortfalls are not sufficient to trigger an indemnity payment under an area yield policy. The higher (lower) the positive correlation between the farm and county yield, the lower (higher) the basis risk (Barnett et al., 2005). Therefore, lowering the basis risk is an important objective while designing an area yield policy (Skees et al., 1997).

2.2.3. Weather index insurance

Weather index insurance is a type of weather risk management that has been recently developed as a potential tool to reduce weather risk in agriculture. The payout for index insurance for a specific weather event, (such as rainfall deficits or hurricanes) has the following properties:

$$y = \begin{cases} 0 & if\ x < strike \\ \dfrac{x - strike}{strike} * \lambda & if\ \lim it > x > strike \\ \lambda & if\ x > \lim it \end{cases} \tag{5}$$

where strike and limit are choice variables, x is realized value of the underlying index (e.g., cumulative precipitation or maximum wind speed) during the contract period, and λ is the liability.

High correlation between weather index shortfalls and farm yield shortfalls is an important precondition for introducing a successful weather-based index insurance to reduce farmers' crop yield risk (Bokusheva, 2007). An important limitation of index insurance is that policyholders are exposed to basis risk, which refers to the imperfect correlation between the index and the losses experienced by the policyholder (Barnett and Mahul, 2007). According to Barnett and Mahul (2007), losses may be caused by disease, insect infestation, or any number of factors other than the weather variable on which the index is based. The other cause of losses is the weather variable used to drive the index may not be highly spatially covariate; thus, the measure of the weather variable at the farm or household may be quite different than the measure at the weather station (Barnett and Mahul, 2007). Unless the index is based on a weather variable, that is the dominant cause of loss in the region, basis risk will be unacceptably high and continuing availability of accurate historical weather data is critical for its implementation (Barnett and Mahul, 2007).

Regarding hurricanes, Roberts (2005) mentioned three problems as causes of basis risk in the Caribbean region: i) hurricanes vary greatly in size, this means that defining a trigger as being activated when the hurricane eye passes within 100 km of a coupon zone will be fair for some, but if the hurricane is a large one, then there will be coupon holders who will not be compensated since they fall outside of the100km band; ii) the tendency for wind strength (and therefore damage) vary along the track of the hurricane which can impact categorization of the event, including the crucial shift from tropical storm to hurricane, and vice versa. These relatively quick shifts are not always recorded in the official reports due to incomplete network devices; and iii) the track recorded by meteorologists coordinated in the Caribbean area by the National Hurricane Center in Miami, is only an approximation of the real path, in effect it is a best fit curve through a series of points recorded at intervals of six hours. On the other hand, Roberts (2005) recommended it is possible to reduce basis risk to some extent by introducing: declaration of hurricane for a given zone, and documenting evidence of storm damage gained from aerial photography soon after the passage of the hurricane.

2.2.4. Performance of insurance designs

Barnett et al. (2005) evaluated the performance of insurance contracts by how much they reduce the variance of net yield. They used the following framework while measuring performance of farm yield and area yield based insurances:

$$\tilde{y}_i - \mu_i = \beta_i(\tilde{y} - \mu) + \tilde{\varepsilon}_i \quad (6)$$

$$\beta_i = \frac{\text{cov}(\tilde{y}_i, \tilde{y})}{\text{var}(\tilde{y})}, \text{ and}$$

$$E\tilde{\varepsilon}_i = 0; \quad Var(\tilde{\varepsilon}_i) = \sigma^2_{\tilde{\varepsilon}_i}; \quad Cov(\tilde{y}, \tilde{\varepsilon}_i) = 0 \quad (7)$$

$$E\tilde{y}_i = \mu_i; \quad Var(\tilde{y}_i) = \sigma^2_{\tilde{y}_i}$$

$$E\tilde{y} = \mu; \quad Var(\tilde{y}) = \sigma^2_{\tilde{y}}$$

This framework decomposes the farm yield deviation from expectation into a systemic component, measured by β_i times the area yield deviation from expectation, and an idiosyncratic component, $\tilde{\varepsilon}_i$. The coefficient β_i measures how sensitive the farm yield deviations from expectation are to area yield deviations from expectation. Abstracting away from price risk and assuming that farmers are mean variance utility maximizers, the performance of each insurance contract can be evaluated by its impact on the variance of net yield, $\tilde{y}_{ij}^{net}$, where

$$\tilde{y}_{ij}^{net} = \tilde{y}_i + \tilde{n}_{ij} - \pi_{ij}.$$

The variance of net yield is measured as:

$$Var(y_{ij}^{net}) = \sigma^2_{\tilde{y}i} + \sigma^2_{\tilde{n}ij} + 2Cov(\tilde{y}_i, \tilde{n}_{ij}) \quad (8)$$

where, $\sigma^2_{\tilde{y}_i}$ is as defined in equation (7), and $\sigma^2_{\tilde{n}ij} = Var(\tilde{n}_{ij})$ is the variance of the indemnity for farm *i* and insurance contract *j*. Purchasing insurance contract *j* reduces the farmer's yield risk by:

$$\Delta_{ij} = Var(\tilde{y}_i) - Var(\tilde{y}_{ij}^{net}) = -\sigma_{\tilde{n}ij}^2 - 2Cov(\tilde{y}_i, \tilde{n}_{ij}).$$

Converting this into percentage terms, the variance reduction due to the insurance contract is:

$$\theta_{ij} = \frac{\Delta_{ij}}{\sigma_{\tilde{y}_i}^2} \tag{9}$$

$$\bar{\theta}_{lj} = \sum_i \frac{w_i \theta_{ij}}{\sum_i w_i} \; \forall i \in l = state, cooperative \tag{10}$$

2.3. Loss indemnification

2.3.1. Annual crops

Annual crops include, wheat, maize, rice, soybeans, sorghums, cotton, beans and any loss or damage is just to one season's crop (Roberts, 2005). The indemnity functions explained in the above insurance designs' literature were applied to annual crops. The authors empirically estimated premiums for various annual crops.

2.3.2. Perennial crops

According to French and Matthews (1971) perennial crop production is distinguished from that of annual crops by i) the long gestation period between initial input and first output, ii) an extended period of output flowing from the initial production or investment decision, and iii) eventually a gradual deterioration (usually) of the productive capacity of the trees. This indicates if perennial trees are damaged, yields of the subsequent years are also affected depending on severity of the damage.

Nutmeg and cocoa are perennial crops with distinct yield production patterns. Nutmeg starts to bear fruit after 7-10 years, increase production for about 25 years and maintains this peak level twice a year till age of 65-70 years (McCarthy, 2000). According to Marcelle (1995) production may start in 5-8 years, gradually increases to 25-30 years, where it peaked to its maximum level, and production starts to decline after 70 years of age. These numbers are in line with observations from Grenada since after hurricane Janet in 1955, which is one of the strongest Atlantic hurricanes on record, it took the nutmeg industry approximately 25 years to rehabilitate to pre-hurricane production levels (GCNA). In the context of Grenada, a good producing tree may give on average a yearly production of 30-50 lbs (14-22 kg) green nutmegs (15-25 lbs or 7-11 kg of shelled, dry nutmegs) Marcelle (1995).

According to Wood (1975) the first crop of cocoa is gathered in the 3rd year, and yield keeps increasing for the following 3 or 4 year until it reaches peak yield in the age of 8-10 years. The tree is expected to maintain this maximum yield till age of 20 years and starts to decline then after, and its economic rotation is estimated 25-30 years (Ryan et al., 2009). Obiri et al., (2007), on the other hand, considered 80 years traditional rotation age of cocoa in estimating yield in Ghana. In traditional farms like in Costa Rica, where average age of cocoa is beyond 30 years, production per tree reaches 0.75-0.98 kg per tree per year and about 243 kg per hectare per year (Cruz, 1991).

Figure 1 shows the relative yield for nutmeg and cocoa yield pattern over 50-years productive period. The functional form was taken from Ryan et al. (2009) and parameter values estimated on the basis of literature review presented in the previous paragraph.

$$y_{nutmeg} = \frac{e^{-2.828+\ln(t)-0.024*t}}{0.9063} \quad \text{If t>5, else 0} \quad (11)$$

$$y_{cocoa} = \frac{e^{-1.501+\ln(t)-0.083*t}}{0.9880} \quad \text{If t>2, else 0} \quad (12)$$

where, *y* is the relative yield and *t* is age of the tree in years.

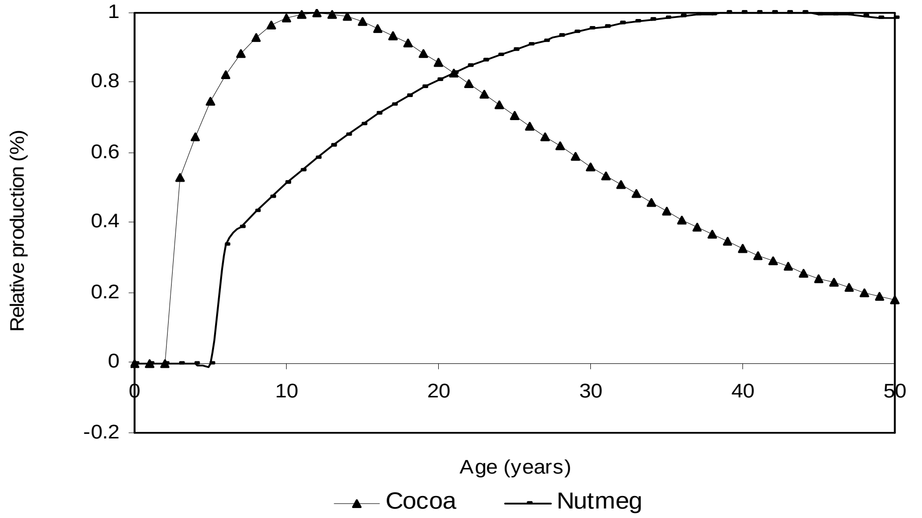

Figure 1 Relative nutmeg and cocoa yield curve over a 50-year period.

Nutmeg fruit: the inner most is nutmeg and the red-laced tissue surrounding it is what becomes mace (Beaton, 2009)

Cocoa fruits

Figure 2. Nutmeg and cocoa fruits

Loss indemnification of perennial crops needs special approach unlike annual crops (where only the annual yield loss is indemnified). According to Roberts (2005) loss may be calculated based on only current season's expected production or may include next season's reduced production due to damage of the tree. Three common approaches are suitable for different circumstances: i) when a peril such as windstorm causes damage to tree crops (i.e. when losses are severe), longer term losses might be considered to be eligible for compensation too and it could include cost of replanting; ii) if the loss is less sever but still sufficient to mean a diminishing in the following season's crop, including only the current season's lost production is appropriate; or alternatively iii) formulating wording such that harvest (e.g., fruit or nut) and trees are parts of the same policy.

In contrary to property insurance, covering damage to buildings, the loss is more difficult to ascertain because of the typical production function of trees. Ryan et al. (2009) quantified loss in cocoa trees production, for example in an event of uprooting, compared to a scenario with discounted revenue and cost stream if the same cocoa trees were left undamaged and yield remained on the normal growth curve (Equation 13).

$$l_{cocoa} = \frac{e^{-1.1+\ln(t)-0.125*t}}{0.9797} \qquad (13)$$

where, l is the relative loss and t is age of the tree in years.

For nutmeg production the optimal economic lifespan is longer than for cocoa, and more close to the biological lifespan of the tree since it has a more persistent yield curve at maturity.

2.4. Insurance experience of perennial crops

In this section practical experiences of insurance for perennial crops are assessed. One approach recommended by Roberts (2005) is to calculate loss based on current season's expected yield. Miller et al. (2000) estimated actuarially fair premium rates (achieved when the expected indemnity (loss) equals the insurance premium) for yield insurance of peaches. They estimated the expected loss measured in commodity terms *E(L)*, for an individual yield guarantee product using:

$E(L) = \text{probability of } (y < Y_g) * [Y_g - E(y / y < Y_g)]$,

where, y denote farm yield, $E(y)$ expected farm yield, and Y_g is the yield guarantee given by $coverage * E(y)$. They considered coverage level of 50% to 75% and calculated the pure premium rate, R, as the ratio of the expected loss to the maximum loss: $R = E(L)/Y_g$

Wei-ping et al. (2009) also designed a weather-based indemnity index for insurance against freeze damage to citrus orchards and considered varying yield depending on the age of the tree.

Another approach recommended by Roberts (2005) is to formulate wording such that fruit and trees are separate parts of the same policy, which is practiced in the British Columbia Ministry of Agriculture crop insurance programme. Crop (production) insurance in British Colombia is supported by both the federal and provincial governments and is delivered by the British Columbia Ministry of Agriculture and Lands (Government of British Colombia). Cost of insurance is shared among federal and provincial governments, and the producers (Government of British Colombia). Participation is voluntary at coverage levels of 60, 70, 80 and 90% (Abbaspour, 1994).

The production insurance policy for tree fruit includes four types of coverage: *coverage for yield loss*, *minimum coverage for quality loss a type of tree fruit*, *optional coverage for quality loss of a crop,* and *loss of fruit trees* (BCMOAL, 2005). Farmers who obtained *coverage for yield loss* are indemnified for any reduction (yield loss) in total yield of a crop below the production guarantee for yield loss purposes caused by various natural causes (listed in the contract), and poor pollination due to adverse weather; or uncontrollable deer or elk. Farmers who obtained *minimum coverage for quality loss for a type of tree fruit* are indemnified for a reduction in value of a crop caused by a 'quality peril' specified in the contract and the reduction in value must exceed a threshold level. The other coverage farmers can obtain is *optional coverage for quality loss of a crop* that indemnifies for a reduction in value of the crop on each separately covered lot caused by a 'quality peril'. Similarly, the reduction in value must exceed a threshold level. Farmers can also obtain coverage for *loss of fruit trees* that indemnifies for damage (fruit tree loss) to a fruit tree, and renders when the fruit tree is incapable of producing at least 60% of the previous crop year's yield in the crop year following the loss, caused by various natural causes (as listed in the contract) sufficient to destroy the tree. In this case, farmers are required to provide list of all those fruit trees by type, variety, age, planting date, and spacing and a map showing their location before the crop year starts.

To our best knowledge there is no literature related to loss indemnification of cocoa and nutmeg trees. Moreover, the fruit tree loss indemnification experience presented above does not show how the tree values are appraised. The study by Miller et al. (2000) was mainly for yield loss only, it doesn't say anything if there is loss due to damage of the tree it self. One approach that might be adopted is the yield loss estimation based on level of cocoa tree damage, which was undertaken by Ryan et al. (2007). Chen and Moss (2007) also suggested, since expected yield of perennial crops depends on age of the tree, data related to the number of trees by variety, county and year, and the total production by county and variety is required to estimate expected production. Generally, data related to detail history of trees is a pre-requisite to determine tree loss indemnification.

CHAPTER III

MATERIALS AND METHODS

3.1. Sources and description of data

Data on annual yield, average price of nutmeg and cocoa, household income derived from cocoa and nutmeg, and meteorological data were taken from a field survey report of the overall project. The nutmeg yield in pounds, price in East Caribbean dollars (EC$), and respective household incomes were collected from Grenada Cooperatives Nutmeg Association (GCNA); while the cocoa yield and price data, and respective household incomes were collected from Grenada Cocoa Association (GCA). The meteorological data (i.e. monthly rainfall) was collected from national meteorology station of Grenada. The type, characteristics and sources of data are summarized in table 1.

Data collected for cocoa crop include time series production of all farms (i.e., 2820 farmers) for the period covering from 2006-2009, country-level production for the period covering from 1998-2009 and price data from year 2005 to 2009. 1489 of the individual farm data include farm size ranging from 0.032 to 398.43 acre, out of which on average 75% have size of four acres or lower while the 25% are one acre or lower. However, data related to number of trees per acre, age of trees, and yield per tree were not available.

Data collected for nutmeg include yield in pounds of 200 randomly selected farms for the period covering from 1998-2008, country level time series yield data in pounds for the period covering from 1998-2009, number of nutmeg farmers in each year (1998-2009), and average price in dollar for 1998-2009. However, data related to size of farms, number of trees per acre, age of trees, and yield per tree were not available. Regarding to weather, data related to wind speed was not available.

Table 1. Type and characteristics of data collected during field survey.

Data type	Parameters	Crops	
		Cocoa	Nutmeg (equivalent shelled)
Farm-level yield[1]	Mean	184.37	1,070
	Std. deviation	417.40	5,665.88
	Minimum	0	2.63
	Maximum	10,772.80	79,326.72
Country-level yield	Mean	1,423,840	3,722,517
	Std. deviation	929,911	2,598,377
	Minimum	11,859	501,086
	Maximum	2,699,608	6,614,732
	Pre-hurricane Ivan mean yield	2,087,845	5,756,714
Farm gate price[2]	Mean	2.85	3.66
	Std. deviation	0.50	1.21
	Minimum	2.13	2.00
	Maximum	3.24	5.43
Annual rainfall[3]	Minimum (Mean, Std. dev)	(5.63, 0.93)	(5.58, 0.81)
	Maximum (Mean, Std. dev)	(8.37, 1.19)	(8.43, 0.81)

[1]Yield in pounds per year of each: cocoa (2004-2009), nutmeg (1998-2008)

[2] Average price per pound in dollars: cocoa (2005-2009), nutmeg (1998-2009)

[3] Rainfall in inches (1998-2009)

3.2. Additional Assumptions and derived data

i. Number of trees for both crops was assumed to be constant through out the periods covered in this analysis, i.e., steady state of farm size was considered.

ii. Average replanting costs were EC$200 and EC$160 per tree for cocoa and nutmeg, respectively (MOA, 1995).

iii. Only the cocoa farms with recorded acre size (i.e. 1489 farms) were considered for analysis.

iv. The estimated total numbers of acres covered with cocoa trees were 6,602 (OECS, 2005), therefore, the pre-hurricane Ivan mean production per acre equals 316.24 lbs (i.e. 2,087,845 lbs divided by 6,602 acres).

v. Cocoa production per tree was taken 3.10 lbs (Owen). Therefore, average number of trees per acre was 102 (i.e., 316.24 lbs per acre/3.10 lbs per tree).

vi. Nutmeg production per tree was 24.79 lbs (Owen). Therefore, number of trees per farm equals the pre-hurricane individual farm yields divided by 24.79.

3.3. Insurance designs

Actuarial fairness occurs when the expected indemnity (loss) equals to the insurance premium (Miller et al., 2000). If insurance contracts are actuarially fair, then according to Miranda (1991):

$$\pi_{ij} = E\tilde{n}_{ij} \;\forall\, i, j \tag{14}$$

where π_{ij} is the per acre insurance premium for farm *i* and insurance contract *j*, and $\tilde{n}_{ij}$ is the per acre insurance indemnity. Therefore, fair premiums of farm yield, area yield and weather index insurances for both crops were first estimated. The expected loss at alternative coverage levels ranging from 65% to 85% at 5% increase (for farm and area yield designs) and with alternative probabilities of hurricane, i.e., 1/75, 1/50 and 1/25 were calculated. Covergaes were constrained to be the same for all cocoa and nutmeg farms. For farm and area yield based insurances a multi-year coverage of 5 years was calculated, and one-year coverage and indemnifying replanting cost were considered as alternative indemnities.

3.3.1. Farm yield insurance

Fair premiums of farm yield (indemnity based) insurance for nutmeg and cocoa were estimated at alternative deductible levels and probabilities of hurricane as in equation 1. Assuming constant number of acres, trees, and yield per tree through out the years since 1955 (assuming all the plantation took place in 1955, just after hurrican Jannet), the predicted yields (μ_i) of both crops were determined as simple averages of pre-hurricane Ivan productions. The detail procedures are presented below.

i. Cocoa

Since there were no pre-hurricane farm-level production data of cocoa, a single predicted yield (μ_i) was first estimated from the pre-hurricane Ivan country-level production (1998 to 2004) data and multiplied by the farm's size to come up with predicted yiled of each farm. Critical yields (y_{ic}) were calculated for the alternative coverage levels as in equation 2. The OECS (2005) report show that 68% of cocoa farms were damaged during hurricane Ivan. Therefore, we believe that the 65% will be on the safe side to reflect the minimum loss incurred by the farmers. Young (1994) as cited by Ryan et al. (2009) stated that cocoa starts to bear fruit within age of 3 to 5 years. Accordingly, 5-year yield loss was considered as an impact of hurricane at the alternative probabilities, and added up to the pre-hurricane annual expected indemnity to come up with the amount of premium. The per-hurricane premium was calculated from the country-level production data.

ii. Nutmeg

The predicted yields (μ_i) of each farm were estimated from the pre-hurricane Ivan farm-level production (from 1998 to 2004) then critical yields (y_{ic}) were calculated at the alternative coverage levels as in equation 2. The OECS (2005) report show that 70% of the nutmeg farms were damaged during hurricane Ivan. Therefore, the range 65% to 85 % will be more safe to reflect the minimum and maximum losses incurred by the farmers.

The country level field survey data show that pre-hurricane Janet (1955) production level was achieved after 20 years. On the other hand, the study by McCarthy (2000) shows nutmeg starts fruiting at an age of 7-10 years and increases production for about 25 years, which is its peak level. The OECS (2004) study also estimated that five years reduction of nutmeg production as a negative consequence of the disaster. Therefore, to avoid overestimation of expected loss, an impact of 5-years yield loss at the alternative probabilities of hurricane was considered and added up with the pre-hurricane expected annual indemnity to reach at the amount of premium.

3.3.2. Area yield insurance

Fair premiums were determined using the indemnity function in equation 3 assuming scale equal to one (i.e., 100% scale) for all farmers of both crops, and the whole country were considered as a single area. Moreover, since as with any option, basis risk is an important factor affecting the efficacy of area yield insurance, correlation analysis between individual farm yield and population of both crops were also undertaken.

3.3.3. Weather index insurance

As mentioned above rainfall was the only data collected in relation to weather index insurance. First correlation analysis between rainfall and yield was undertaken. However the result was very low as shown in figure 2 and 3, and table 7, indicating rainfall as very poor weather pay out indicator. Therefore an index, based on hurricane, was developed which results in pay out of one-year yield loss only in the events of hurricane.

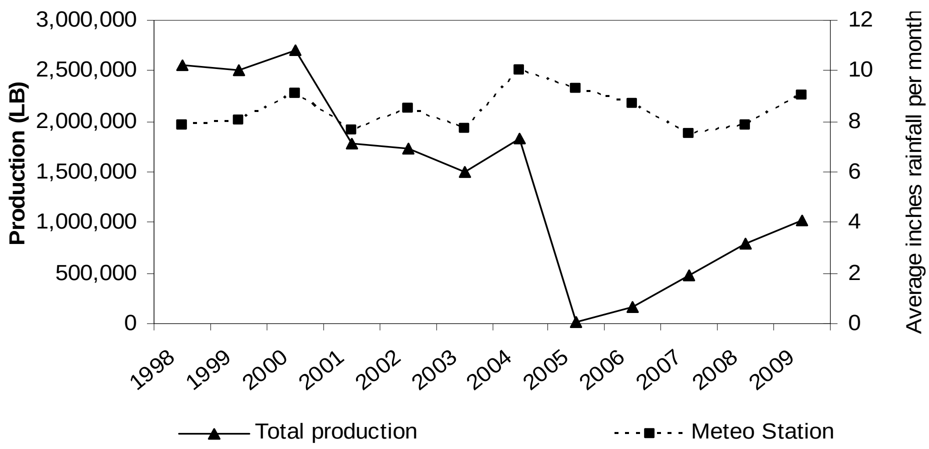

Figure 2. Yearly cocoa yield and weather measure

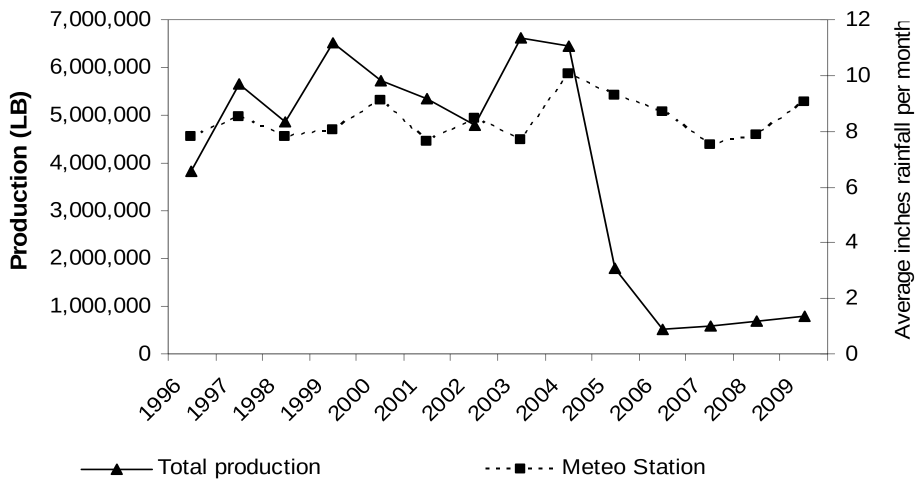

Figure 3. Yearly nutmeg yield and weather measure

3.4. Assessing effectiveness in risk transfer (reduction)

The performance of insurance designs interms of their effectiveness in risk trsnsfer, percentage of variance of net yield reduction was calculated using the framework in Barnnet et al (2005). First $\sigma^2_{\tilde{y}_i}$ was estimated as in equation 7, $\sigma^2_{\tilde{n}ij}$ was estimated as variance of $\tilde{n}_{ij}$, variance $\tilde{y}^{net}_{ij}$ was calculated as in equation 8, and percentages of variance reduction θ_{ij} and $\overline{\theta}_{lj}$ were then calculated as in equation 9 and 10, respectively.

In order to access the potential impact of the alternative insurance contracts on farm revenue, the insurance choice was evaluated for the three alternative contract designs and compared with the non-insurance option. In each of these scenarios the farm revenue was computed for each year from 1998 to 2009 with 85% coverage level for the farm and area yield insurances, both for a multi-year coverage, while the payout of the weather index insurance comprised only the hurricane exposure at a level of one-year revenue, at 1/50 probability of hurricane. No transaction cost (premium loading) was considered. The analysis focused on mean values of farm incomes, standard deviation, and coefficient of variation (CV). The CV was calculated as the standard deviation of all empirical outcomes of an individual farm divided by the mean of those outcomes to measure the vulnerability of a farming system to revenue variation.

CHAPTER IV

RESULTS AND ANALYSIS

4.1. Estimated premiums under the alternative insurance designs

In this section risk premiums expressed in terms of percentage of pre-hurricane average value of production for the three alternative insurance designs are included. Risk premium in terms of dollar value are also included in table A-1, A-2, A-3 A-4 and A-5. The standard deviations of dollar value premiums are also included in the annex tables.

4.1.1. Farm yield Insurance

Fair premiums of farm yield insurance for cocoa and nutmeg at alternative coverage levels and probabilities of hurricane are presented in table 2. A multi-year coverage for cocoa, with probability of hurricane once in 50 years and coverage level of 65% has risk premium ratio (ratio of premium to value of production) of 4.65%. Indemnifying replanting cost (assuming matured trees) for the mentioned probability and coverage level amounts to premium ratio of 29.47 %. Indemnifying only one year production reduces premiums considerably, which amounts to 1.30%.

For nutmeg, assuming probability of hurricane once in 50 years, a multi-year coverage, for example with coverage level of 65%, has a mean risk premium ratio of 20.01%. Indemnifying replanting costs, with the assumption of matured trees, amounts to mean risk premium ratio of 2.30% (for the given example). Indemnifying only one-year production reduces premiums to 1.30%.

The multi-year coverage risk premium of nutmeg is considerably higher than that of cocoa. One reason is the pre-hurricane indemnity for cocoa was zero; the other is almost 12% of the cocoa farms included in the analysis had post-hurricane production above the critical yield (indemnity is zero). However 100% of the sample nutmeg farms had post-hurricane production below critical yield, which could be due to randomness of sample data and/or due to the shallow rooting system of nutmeg which makes it easily uprooted or blown down by high winds during hurricane (Marcelle, 1995).

The risk premium ratio based on one-year yield loss indemnification is equal for both crops since in effect it indemnifies the critical yield of each farm the crop (i.e. the ratio of premium to average production equals to coverage level multiplied by probability of hurricane). Indemnifying cost of replanting for cocoa is considerably higher than for nutmeg because of the higher replanting cost per cocoa tree relative to its lower yield per tree and lower price per pound. The increase in risk premiums if farmers opt for a higher coverage levels can also be deducted from Table 2.

Table 2. Mean risk premium ratios of indemnity based insurance for cocoa and nutmeg.

Description	**Cover age levels**	**Ratio of premium to value of pre-hurricane production (%)**					
		Cocoa			**Nutmeg**		
		1/75	**1/50**	**1/25**	**1/75**	**1/50**	**1/25**
Indemnities	65%	3.10	4.65	9.30	18.13	20.01	25.65
Replanting		19.65	29.47	58.94	1.53	2.30	4.59
Alternative ind.[1]		0.87	1.30	2.60	0.87	1.30	2.60
Indemnities	70%	3.39	5.08	10.16	20.22	22.26	28.40
Replanting		21.16	31.74	63.47	1.65	2.47	4.94
Alternative ind.[1]		0.93	1.40	2.80	0.93	1.40	2.80
Indemnities	75%	3.67	5.91	11.42	22.45	24.66	31.28
Replanting		22.67	34.00	68.01	1.77	2.65	5.30
Alternative ind.[1]		1.00	1.50	3.00	1.00	1.50	3.00
Indemnities	80%	5.08	7.06	13.00	24.81	27.19	34.31
Replanting		24.18	36.27	72.54	1.88	2.82	5.65
Alternative ind.[1]		1.07	1.60	3.20	1.07	1.60	3.20
Indemnities	85%	6.42	8.55	14.93	27.39	29.92	37.54
Replanting		25.69	38.54	77.07	2.00	3.00	6.00
Alternative ind.[1]		1.13	1.70	3.40	1.13	1.70	3.40

[1] premium based on indemnifying one-year yield loss in the event of hurricane

4.1.2. Area yield Insurance

Fair premiums of area yield insurance for cocoa and nutmeg at alternative coverage levels and probabilities of hurricane are summarized in Table 3. For cocoa, assuming a probability of hurricane once in 50 years, a multi-year coverage, for example with a level of 65% coverage, has a mean risk premium of 4.13% (ratio of premium to average pre-hurricane production). With same probability of hurricane and coverage level, nutmeg has risk premium of 4.98%. Risk premiums under area yield insurance, specially, for nutmeg are considerably lower than under indemnity based since only systemic risks are covered.

Table 3. Mean risk premium ratios of area based insurance for cocoa and nutmeg.

Coverage levels	**Ratio of premium to value of pre-hurricane production (%)**					
	Cocoa			**Nutmeg**		
	1/75	**1/50**	**1/25**	**1/75**	**1/50**	**1/25**
65%	2.76	4.13	8.27	3.32	4.98	9.96
70%	3.09	4.63	9.27	3.65	5.48	10.96
75%	3.82	5.53	10.67	3.99	5.98	11.96
80%	4.87	6.75	12.38	4.32	6.48	12.96
85%	6.26	8.30	14.43	4.99	7.32	14.30

4.1.3. Weather-index based Insurance

Fair premiums of a weather (hurricane)-index insurance for nutmeg and cocoa at alternative probabilities of hurricane are given in Table 4. Assuming probability of hurricane once in every 50 years both crops has risk premium ratio of 2%. Both crops have equal premium ratio since all farms are indemnified their pre-hurricane average indemnity (i.e. equally 100% of their expected production for all farms multiplied by probability of hurricane). Risk premiums under hurricane-index based insurance are considerably lower than under indemnity and area based insurance contracts since the indemnity pay out is only in the events of hurricane which covers loss of only one year yield.

Table 4. Premium on weather index based insurance of cocoa and nutmeg.

Crop	**Ratio of premium to value of pre-hurricane production (%)**		
	1/75	**1/50**	**1/25**
Cocoa	1.33	2.00	4.00
Nutmeg	1.33	2.00	4.00

4.2. Effectiveness of the insurance designs

4.2.1. Reduction of variance of net yield

In this section performance of the three insurance designs interms of their effectivenss in risk transfer, as measured by percentage of reduction in variance of net yield is evaluated. Table 5 presents the weighted average percentages of reduaction in variance of net yield of cocoa and nutmeg. For all coverage levels of the area yield insurance design, scale was assumed to be 100%. It is shown that farm yield insurance has greater percentage of risk reduction than area yield and weather-index insurances contracts. Weather-index based insurance has the lowest percentage of risk reduction. Its result in nutmeg shows negative due higher variance of net yield than variance of actual yield. This shows risk will not be reduced as a result of having weather-index insurance.

For cocoa, the farm yield insurance with 50% coverage level generates, for example, as equal risk reduction as the 95% covergae level of area-yield insurance. For nutmeg the farm yield insurance with 50% coverage generates as equal risk reduction as the 70% covergae level of area-yield insurance. For both farm and area yield insurances, the percentage of risk reduction increases with the coverage levels. These results are broadly consistent with the notion that area yield insurance works better in relatively homogeneous production regions, as there is higher correlation in cocoa than nutmeg (table 7). Table 6 presents correlations between farm and country of cocoa and nutmeg yields for the data used in the analysis. Results show that, in both cases there is no such a strong correlation, indicating lack of systematic risk which makes the area based insurance increase basis risk.

Table 5. Percentage of reduction in variance of net yield under farm yield, area yield and weather-index based insurance designs of cocoa and nutmeg.

Coverage Level	**Variance reduction of cocoa (%)**			**Variance reduction of nutmeg (%)**		
	Farm yield	**Area yield**	**Weather - index**	**Farm yield**	**Area yield**	**Weather index**
50%	53	32	11	40	32	-1
55%	56	36	11	43	35	-1
60%	59	39	11	47	37	-1
65%	61	42	11	50	39	-1
70%	62	44	11	53	41	-1
75%	63	46	11	56	43	-1
80%	63	47	11	58	44	-1
85%	63	48	11	60	44	-1
90%	62	51	11	63	45	-1
95%	60	53	11	65	46	-1
100%	58	54	11	67	46	-1

Table 6. Correlation between Farm and Country-level Yield; and between yearly country-level yield and rainfall.

Crop	**Between farm and country yield[1]**	**Between country yield and rainfall**
Cocoa	0.59	-0.24
Nutmeg (farm & country average)	0.56	-0.27
Nutmeg (farm & sample average)	0.72	

[1]For cocoa farm level data includes only post-hurricane

Table 7 shows value of correlation between individual farms and average country yield of both crops. Only 13% of the sample nutmeg farms had correlation below 0.25, 23% of them 0.25-0.50 and 64% of them had correlation of above 0.50. for cocoa 73% of the farms had correlation value of more than 0.50. The correlation between farm level yield and the sample avearge yield, on the other hand, shows 0.72 (table 6) indicating better homogenousity among the sample farms.

Table 7. Correlation between farm-level and country-level yield of nutmeg an cocoa.

Correlation value	Cocoa[1]		Nutmeg	
	No of farms	%	No of farms	%
Below 0.25	568	21%	26	13%
0.25-0.50	131	5%	46	23%
0.50-0.75	299	11%	86	43%
Above 0.75	1645	62%	42	21%

[1] The correlation is before detrending

4.2.2. Reduction in coefficient of variation of farm revenue

The coeffiect of varriation (CV) of farm reveue under no insurance and the three alternative insurance designs is given in table 8. It shows the no insurance senario has the highest CV. The ability of insurance to reduce CV, and standard deviation demonstrates the effectiveness of insurance to reduce risk on farm revenues. When we compare the risk reduction measured by CV and reduction in variance of net yield, indemnity and area based contracts have different result. Weather-index contract had lowest result in both methods. However, area based insurance has better performance when it is measure by CV.

Table 8: Impact of alternative contract designs at farm level

Farming system	**Senario**	**Farm revenue**		
		Mean (EC$)	**Std dev. (EC$)**	**CV (%)**
Cocoa	No Insurance	2043	1004	49
	Indemn. based Insurance	2990	905	30
	Area based insurance	2954	567	19
	Weather index insurance	2330	875	38
Nutmeg	No Insurance	2403	1893	79
	Indemn. based Insurance	2855	1265	44
	Area based insurance	3117	976	31
	Weather index insurance	2609	1890	72
Nutmeg and Cocoa	No Insurance	4446	2579	58
	Indemn. based Insurance	5846	1321	23
	Area based insurance	6071	850	14
	Weather index insurance	4939	2483	50

CHAPTER V

DISCUSSIONS AND CONCLUSIONS

5.1. Conclusions

The objective of this study was to evaluate performance of farm yield, area yield and weather-index based insurance schemes for nutmeg and cocoa production and identifying the best fit in the context of Grenada. It is part of the pre-feasibility assessment of agricultural insurance schemes in Grenada addressing three aspects: defining insurance schemes for crops accounting a large share of households' income, primarily nutmeg and cocoa, accessing performance of the contract, and willingness to pay. Yield, price and weather data of both crops were retrieved from a field survey result and additional data and assumptions were considered from literature.

Fair premiums of both crops for the three insurance schemes were calculated, and their risk transfer effectiveness in reducing variance of net yield was assessed. Their potential impact on farm revenue was also measured by coeffient of variation (CV). The overall findings are summarized below:

- Assuming a multi-year coverage, for both crops at alternative coverage levels and probabilities of hurricane, an area yield insurance had lower risk premium than farm yield insurance contract.
- Weather/hurricane-based insurance, which was based on 100% of average one-year production loss indemnifying only in the events of hurricane, had the lowest premium, for both crops.
- Assuming one-year coverage in the event of hurricane as an alternative indemnity, the farm yield insurance scheme for both crops had equal risk premium and was considerably lower than the multi-year coverage alternative.
- Assuming indemnifying only replanting cost in the event of hurricane, for cocoa tree, it was considerably higher than all the alternative insurance schemes due to the higher replanting cost considered in our calculation. Whereas for nutmeg, it was lower than the multi-year coverage of both farm and area yield insurance schemes.
- According to the performance measurement based on risk transfer effectiveness as reduction in variance of net yield, farm yield insurance scheme had better

performance than area yield. Whereas according to the CV method area yield insurance scheme had better performance. In both performance measurement methods, weather-index insurance scheme had the lowest performance.

- Correlation between farm-level and country-level production was low in both crops amounting to 0.59 for cocoa and 0.56 for nutmeg. However for nutmeg 64% and for cocoa 73% of the farms had correlation value of more than 0.50.

5.2. Discussion and recommendation

Our risk performance analyses were undertaken under the assumption that risks are normally distributed. Therefore, extreme values in both sides might not be covered. This makes the possibility of excluding extreme value from the variance of net yield higher as it considers squared deviations. Considering this, we undertook the CV analysis and the result was reversed, where in the former farm yield insurance scheme performed better while in the later area yield scheme had better performance. On the other hand, both analyses assume that lower risk is preferable than higher risk. Therefore, cost of insurance (pure premium plus loading) and basis risk have to be considered while adopting the insurance schemes.

In order to determine premium and make sound performance analysis, pre and post-hurricane production per acre of the farms are required. For perennial crops, age of the trees and number of trees per acre are also important since yield is dependent on tree age. In our case, farm-level pre-hurricane production per acre of cocoa was not available. So the average pre-hurricane production was derived indirectly from the country level production. For nutmeg since the size of farms (in acre) was not available, the pre-hurricane production was derived as per tree level. Therefore, had the mentioned limitations were solved, the premium computed would have been more accurate. Moreover, the performance of farm and area yield insurance schemes based on both methods adopted in our analysis would have been consistent.

The yearly yield of perennial crops depends on the age of the tree among others. Assuming re-planting was taken place after 1955 (after hurricane Janet), the yield trend of cocoa tree is expected to fall down (section 2.2.2. above). For nutmeg, the yield curve shows that 2004/2005 was its peak production period. Therefore, detrending the data in order to separate hurricane effect from the growth effect of cocoa would have been important. We were not able to model this effect due to lack of post-hurricane farm level data. With detrended data, the risk premium of cocoa would have been decreased.

The replanting costs per tree of both crops were taken from a recommended crop compensation schedule from Grenada Ministry of agriculture (1995) which considers a maximum of EC$160 for a bearing or matured nutmeg tree (15 years or more) and EC$ 200 for a bearing or mature cocoa tree (10 years or more). Even though these values were subject to review after five years, we couldn’t find updated data. Looking at the cost relative to production per tree of both crops, indemnifying replanting costs for cocoa tree is more expensive of all alternative schemes. With updated replanting cost the result could have been different.

Apart from these limitations, however, we have shown that weather-index insurance is not effective scheme, while the other two can be considered for further analysis during implementation. A major concern among policy makers in implementing farm yield insurance is existence of moral hazard, adverse selection and high premium loadings. In such cases, area yield insurance scheme can be adopted.

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Pictures

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Appendix I

Table A.1. Premium for indemnity based insurance of cocoa

Description	Coverage levels	Mean loss Indemnity at alternative probabilities of hurricane (EC$/tree)					
		1/75	Std. dev[1]	1/50	Std. dev.[1]	1/25	Std. dev.[1]
Indemnities	65%	0.27	0.10	0.41	0.15	0.82	0.30
Replanting		1.73		2.60		5.20	
Alternative ind.[2]		0.03		0.04		0.08	
Indemnities	70%	0.30	0.11	0.45	0.16	0.90	0.32
Replanting		1.87		2.80		5.60	
Alternative ind.[2]		0.03		0.04		0.09	
Indemnities	75%	0.32	0.11	0.52	0.17	1.01	0.33
Replanting		2.00		3.00		6.00	
Alternative ind.[2]		0.03		0.05		0.09	
Indemnities	80%	0.45	0.12	0.52	0.17	1.15	0.35
Replanting		2.13		3.20		6.40	
Alternative ind.[2]		0.03		0.05		0.10	
Indemnities	85%	0.57	0.12	0.75	0.18	1.32	0.36
Replanting		2.27		3.40		6.80	
Alternative ind.[2]		0.04		0.05		0.11	

[1] The standard deviation of indemnities include only the post hurricane indemnities
[2] premium based on indemnifying one year yield loss in the event of hurricane

Table A.2. Indemnity based insurance premium of Shelled nutmeg

Description	Coverage levels	Mean Indemnity at alternative prob. of hurricane (EC$/tree)					
		1/75	Std. dev	1/50	Std. dev.	1/25	Std. dev.
Indemnities	65%	16.43	14.00	18.14	14.07	23.25	14.28
Replanting		1.39		2.08		4.16	
Alternative ind.[1]		0.79		1.18		2.36	
Indemnities	70%	18.33	15.02	20.18	15.08	25.74	15.29
Replanting		1.49		2.24		4.48	
Alternative ind.[1]		0.85		1.27		2.54	
Indemnities	75%	20.34	16.15	22.35	16.05	28.35	16.44
Replanting		1.60		2.40		4.80	
Alternative ind.[1]		0.91		1.36		2.72	
Indemnities	80%	22.49	17.09	24.64	17.15	31.09	17.38
Replanting		1.71		2.56		5.12	
Alternative ind.[1]		0.97		1.45		2.90	
Indemnities	85%	24.82	17.94	27.12	18.00	34.02	18.23
Replanting		1.81		2.72		5.44	
Alternative ind.[1]		1.03		1.54		3.08	

[1] premium based on indemnifying one year yield loss in the event of hurricane

Table A.3. Indemnity based insurance premium of nutmeg

Description	Coverage levels	Mean Indemnity at alternative probabilities. of hurricane (EC$/tree)					
		1/75	Std. dev	1/50	Std. dev.	1/25	Std. dev.
Indemnities	65%	16.43	14.00	18.14	14.07	23.25	14.28
Replanting		1.39		2.08		4.16	
Alternative ind.[1]		0.79		1.18		2.36	
Indemnities	70%	18.33	15.02	20.18	15.08	25.74	15.29
Replanting		1.49		2.24		4.48	
Alternative ind.[1]		0.85		1.27		2.54	
Indemnities	75%	20.34	16.15	22.35	16.05	28.35	16.44
Replanting		1.60		2.40		4.80	
Alternative ind.[1]		0.91		1.36		2.72	
Indemnities	80%	22.49	17.09	24.64	17.15	31.09	17.38
Replanting		1.71		2.56		5.12	
Alternative ind.[1]		0.97		1.45		2.90	
Indemnities	85%	24.82	17.94	27.12	18.00	34.02	18.23
Replanting		1.81		2.72		5.44	
Alternative ind.[1]		1.03		1.54		3.08	

Table A.4. Area based insurance premiums of cocoa and nutmeg

Coverage levels	Mean loss Indemnity at alternative probabilities of hurricane (EC$/tree)					
	1/75		1/50		1/25	
	Cocoa	Nutmeg	Cocoa	Nutmeg	Cocoa	Nutmeg
65%	0.24	3.01	0.36	4.51	0.73	9.03
70%	0.27	3.31	0.41	4.97	0.82	9.93
75%	0.30	3.61	0.45	5.42	0.91	10.84
80%	0.33	3.92	0.50	5.87	0.99	11.75
85%	0.36	4.82	0.54	6.63	1.08	12.96

Table A.5. Premium on weather index based insurance of cocoa and nutmeg

Crop	**Mean loss Indemnity at alternative probabilities of hurricane (EC$/tree)**		
	1/75	**1/50**	**1/25**
Cocoa	0.12	0.18	0.35
Nutmeg (shelled seed)	1.21	1.81	3.63