Potential Impact of Climate Change on Agriculture in Jamaica:

Case Study of Sugar Cane, Yam, Escallion

Presentation to SALISES 50-50 Conference,
"Globalization, Climate Change and Rural Resilience",
Pegasus Hotel

Michael Witter

May 10, 2012

Background

- **One of more than 30 studies for ECLAC-DfID project on impact of climate change on selected sectors of selected Caribbean countries**
- **Studies have been synthesized into a UNECLAC document, “The Economics of Climate Change in the Caribbean – Summary report”, September 2011**

Review of several analytical approaches

Production function model

- Use **empirical or experimental production functions**, which include climate variables as inputs, to estimate the impact of climate change by examining the yield of specific crops under different climate scenarios.

Ricardian model

- cross sectional analysis of the impact of climate on land value or farm revenue. The model uses a **multiple regression approach** where the farm value/land revenue is regressed on climatic variables such as temperature, rainfall and rate of runoff of rainfall, geophysical variables such as soil type, soil erosion, salinity, flood probability and wind erosion and economic variables

Review of several analytical approaches

Agronomic-economic model

- Assess the relationship between crop productivity and environmental factors using **simulation modeling**. The results of the simulation models are then fed into **economic models** in order to predict the impact on the economy in general.
  - Examples of software programmes include: **SOYGRO** used for soy bean, EPIC model used for maize, millet, rice, cassava, sorghum**, DSSAT** used for wheat, corn, potato, soybean, sorghum, rice and tomato and **CENTURY** used for hay and grassland crops including cane
  - require detailed weather and farm management data, and omit the effects of crop pests and diseases.

Agro-ecological zones model

- In the AEZ model land is divided into smaller units, which have similar characteristics such as climate, soil, terrain constraints to crop production, potential productivity and environmental impact. Crops are then assigned to different zones and yields are calculated under different climatic and zonal conditions.

.

Review of several analytical approaches

Integrated assessment model

- models try to analyse how changes in the climate system will impact the economy.
- **DICE and RICE** models are the most popular of the Integrated Impact Assessment Models.
  - DICE model focuses on the global economy
  - RICE model examines the economy at the regional/national level

Methodology

- Chose Leontief method – least data requirements
- Approach was to compare yields of selected crops estimated with this method on three climate scenarios – BAU, A2, B2 – for the decades between 2010 and 2050
- Estimate the difference between the yields under these scenarios as a percentage of GDP in a base year, 2008

Climate Scenarios

- **BAU –** major problems of agreement
- ***Approaches***
  - **Projecting historical trend of variables assuming historical trend of climate variables**
  - ***Projecting climate with assumptions on emissions***
  - **Projecting historical variables without taking account of climate change –** ***final agreement***
- **A2, B2 scenarios adopted from the SRES by IPCC**
- ***A2 faster build-up of greenhouse gases than B2***

A2 scenario

A2

- The A2 scenarios are of a more divided world than the A1. The A2 family of scenarios is characterized by:
- A world of independently operating, self-reliant nations.
- Continuously increasing population.
- Regionally oriented economic development

B2 scenario

- **B2**
- The B2 scenarios are of a world more divided, but more ecologically friendly than B1. The B2 scenarios are characterized by:
- Continuously increasing population, but at a slower rate than in A2.
- Emphasis on local rather than global solutions to economic, social and environmental stability.
- Intermediate levels of economic development.
- Less rapid and more fragmented technological change than in A1 and B1

A2, B2

A2	B2
Increasing population	Increasing population, but slower than A2
Regionally rather than globally oriented development	Local rather than global solutions to economic, social and environmental stability
A world of independently operating, self-reliant nations	Less rapid and more fragmented technological change than A1 and B1

General Data requirements

- **Inputs –** water, seed, chemicals, capital, labour etc, including soil type
- **Climate data - *temperature, rainfall and rate of runoff of rainfall, geophysical variables such as soil type, soil erosion, salinity, flood probability and wind erosion, hours of sunshine, humidity***
- ***Economic variables-*** *basically, prices*

Selected Crops

- **Sugar cane, yams, escallion**
- **Sugar cane –** export, data availability because of the scientific tradition of the industry
- **Yam, escallions** because of their **importance in domestic agriculture and their characteristic climate conditions** – hills of Manchester, Trelawny and St. Ann for yams, and the hot plains of St. Elizabeth for escallion

Climate Data

Data Used

- ***Temperature – high, low, average***
- ***Rainfall – high, low, average***

Data Not used

- **Hours of sunshine**
- **Wind speed**
- **Moisture**
- ***Sea level rise – needed in Guyana study***

Selection of Crops for Case Study

- **Structure of the agricultural sector**
  - Subsectors vs other ways of classifying – farm size, location, organization etc
- **Domestic agriculture contributes about 3 times as much as export agriculture to GDP => had to select representatives of export and domestic subsectors**
- **Sugar**, more than a third of export subsector
- **Yam –** root crops more than 40% of domestic subsector
- **escallion –** staple in Southern St. Elizabeth, the breadbasket parish

Selection of Crops

- **what we ignored**
  - **Forestry and fishing because their contribution to GDP is so small**
  - **production on vulnerable lands and production by vulnerable households**
  - **Impacts of extreme events, singularly and collectively**
  - **many climate variables, primarily because of lack of data**

Sugar cane

- The data for the estates were aggregated into the **five main climatic regions** used by SIRI: Central, Dry North, Irrigated, Wet West and Wet East.
- **A Generalized Least Squares (GLS) model** was estimated on the basis of the data from the panel of 5 regions.
- The model used the **price of cane, the cost of production, monthly average maximum temperature, precipitation for three (3) periods (April-July, August-November and December-March), soil types and regional trend dummies as independent variables that determine the yield of cane output**. The climate variables were included in both linear and quadratic forms.

Sugar cane model – basic results

- According to the model, for sugar cane production to be maximized, rain in the growing season (April to July) must be **greater than or equal to the optimal minimum of 189.93. mm per month. By the contrast, in the ripening season (August to November) rain must be less than or equal to the optimal maximum of 195.76 mm per month**. Additionally, in the reaping season (December to March), rain of at most 101.77 mm per month is optimal.

Sugar Cane model – basic results

- Deviation around the mean temperature in Jamaica has a negative impact on sugar cane yield. **Increases in temperature above the average temperature of 29.43 °Celsius have a negative impact on sugarcane yield, while decreases below the average increases the yield**.

$$y_{it} = \frac{p_{it}}{c_{it}} + pr_{it} + pr_{it}^{2} + \max t\_mean_{it} + \max t\_mean_{it}^{2} + D_{it}$$

where,

- y_{it} - represents the output of cane per year in tonnes per hectare
- c_{it} - represents the average cost of production per tonne in Jamaican dollars (J$), in a given year
- p_{it} - represents the average sale price in Jamaican dollars per tonne of cane, in a given year
- pr_{it} - is a vector of period specific precipitation in millimetres. April-July is the planting and germination season; August-November is the ripening period; and December-March is the harvesting period. For each period it is average monthly rainfall that is entered in the model.

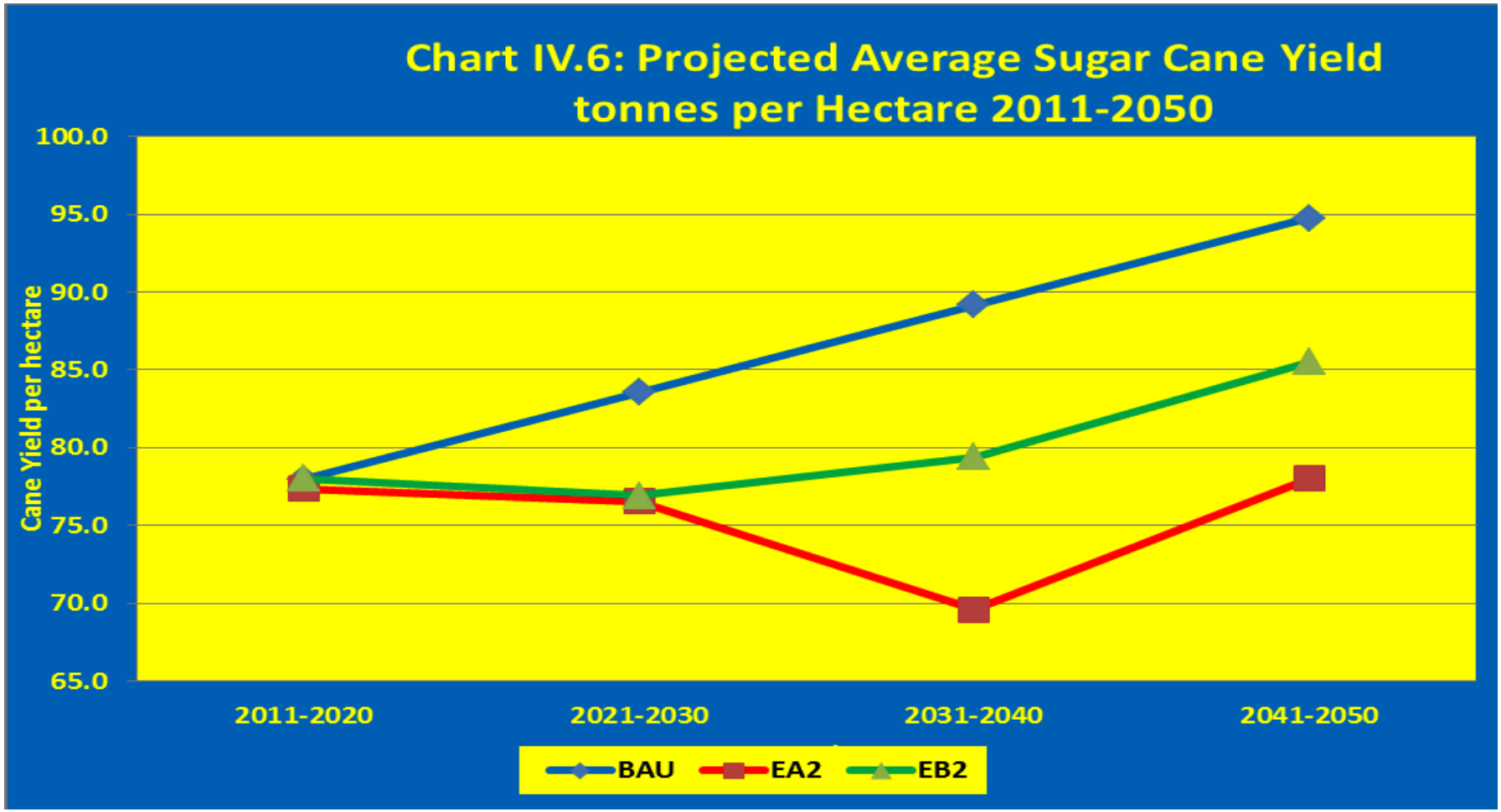
Chart IV.6: Projected Average Sugar Cane Yield
tonnes per Hectare 2011-2050
100.0
95.0
90.0
85.0
80.0
75.0
70.0
65.0
Cane Yield per hectare
2011-2020
2021-2030
2031-2040
2041-2050
BAU
EA2
EB2

Yam and Escallion

- Similar model for yam and escallion, but the results were ambiguous – little difference between the BAU and A2 and B2 scenarios
- Data for estimating these models was much weaker than for sugar cane.

Basic Recommendations

- **Support for climate modelling –** need to bring projections down to local levels to be able to deal with locally specific vulnerabilities
- **Building modeling capabilities** for resilience
- **Data requirements –** climate data, production data, socio-economic data, at least at the regional levels
- **Data collection methods** – expensive traditional methods have to be augmented using technology as well cheaper man-power, such as students
- **Incomplete data and analytical approximations mean GoJ must maintain high priority on**
  - No regrets policies
  - Precautionary principle

Adaptations

- ***Better management of water*** =>irrigation, which is costly in terms of energy; hence, the importance of sustainable development practices, such as rainwater harvesting, and tapping into renewable energy sources
- ***new varieties*** that are more suitable to warmer climate
- ***Insurance***
- ***Research*** into more heat-resistant plants
- ***Education*** of the farming community on the global, regional, and where possible, the national trends in climate change

Adaptations

- ***More and improved irrigation practices – energy issue***
- Jamaica as a whole, and the agriculture sector in particular, needs *better* ***water management*** *practices*. The principal elements of this are:
  - *Management of the forests,*
  - *Harvesting rainwater*
  - *Improved management of pests and diseases* will be mandatory.
- ***Adjusting the planting cycle*** to changing rainfall patterns has occurred in the past
- The practice of ***protecting cultivation*** *with natural windbreaks* of trees and shrubs

Adaptations

- Commercial agriculture in Jamaica is committed to ***protected agriculture***
- A lot of scientific work has been done on ***managing the temperature in chicken houses***
- Indeed, the ***ventilation of all animal houses***, such as barns for cows and horses, will have to be improved to minimize the risk of heat stress to animals. The complement to this will be ready *access to clean water* both for drinking and for washing down the animals and their facilities
- **Popular knowledge and practices**

Future

- Beginning of regional research on climate change and its impacts
- Scholars 50 years from now will need more and better data and more and better modeling techniques
- Building regional capabilities is integral to building resilience