CLIMATE VARIABILITY: AN ESSENTIAL INGREDIENT IN THE GECAFS CARIBBEAN FOOD SYSTEMS PROJECT

By

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GECAFS is an international research programme involving a wide range of social, physical and biological scientists, investigating the vulnerability of human food systems to, and interactions with GEC. It is sponsored by the international GEC research community (IGBP, IHDP and WCRP[1]) and is being developed in active collaboration with FAO, WMO and the CGIAR. The GECAFS International Project Office is based in the United Kingdom. Initial GECAFS regional projects are proposed for (i) the Indo Gangetic Plain; (ii) the Eastern Pacific Fisheries (iii) Southern Africa and (iv) the Caribbean.

Regional projects include research on all three inter-related GECAFS Science Themes:

Theme 1: Vulnerability and Impacts: Effects of GEC on Food Provision
Theme 2: Adaptations: GEC and Options for Enhancing Food Provision
Theme 3: Feedbacks: Environmental and Socio-economic consequences of Adapting Food Systems to GEC

Research is aimed at determining strategies to cope with the impacts of GEC on food provision and to analyse the environmental and societal consequences of adaptation. This will allow analyses of tradeoffs between socioeconomic and environmental goals to be made in a systematic and quantitative manner.

The GECAFS Caribbean Food Systems project looks mainly at elements of climate variability and change (see Annex) as they may affect the accessibility to food and the social well-beings of the inhabitants of the territories of the Caribbean.

CLIMATE VARIABILITY: AN INSIGHT INTO THE FUTURE

There is much concern as to what will happen in the food sector with our globally changing climate, in particular the changes expected in the Caribbean region. Many territorial, regional and international bodies have been in the recent pass, and will continue in the future, looking at measures to adapt to these changes. One way to know where we are going in the future in adaptation to climate change, is to take a look at where we came from and where we are. We ought to look back at what has worked and

[1] International Geosphere-Biosphere Programme; International Human Dimensions Programme on Global Environmental Change; and World Climate Research Programme

what has not particularly at the times we experienced more extreme conditions, because what will become mean conditions in the future due to climate change would have been experienced on occasions in our recent history due to our variable climate. One thing we do know about our climatology in the Caribbean region is that it is very variable (both interseasonally and interannually), particularly parameters like rainfall. With that in mind, an attempt is being made here to show how:

1. Through our climatic variability, we have experienced, to some degree what, might be in the future mean conditions
2. Trying to improve our food availability by coping with what we know as anomalies about a current mean we may have had initial test runs of workable adaptation strategies or some insight (even if not adopted) into strategies whose implementation can make our food sector(s) in the Caribbean a bit more robust.

As examples of these we will take a look at the variability of our land-based rainfall and sea conditions as they impact our land- and sea-based agriculture, respectively. The land-based strategies would involve adaptation measures that would have been tried and tested in many Caribbean territories, whereas the sea-based would (for which there is much uncertainty of the relationships between environment and fisheries) have been much less tested as adaptation measures in this sector have been less adopted (at least at a policy level).

ASPECTS OF VARIABLE RAINFALL AS IT IMPACTS ON LAND-BASED AGRICULTURE

In the Caribbean region, the most limiting climatic factor on land-based agricultural production is water availability. Caribbean rainfall by nature is highly variable with much concern about the distribution of rainfall. SRES A2 predictions suggest a reduction of rainfall in the Caribbean by the period 2070-2100 range of 0.25 mm day^{-1} in the C. basin and up to 0.5 mm day^{-1} (IPCC SYR). The region has often experienced totals of this magnitude below the mean. Rainfall distribution (annual) varies spatially across the Caribbean region and within individual territories (due mainly to orographic effects).

The Caribbean region can be characterised as dry-winter tropical, with the months of the boreal winter and early spring (i.e. from December/January to May/June) being dry with the rest of the year being wet. Essential the wet season accounts for about 70 to 80 % (Enfield and Alfaro, 1999) of the region’s rainfall. In general, the wet season of Central and Northern South America and the Greater Antilles run from about May to November while in the Eastern Caribbean (in particular the southern islands) the season runs from June to December. Countries like The Bahamas and Guyana do not follow this trend. The Bahamas, which is influenced by the warm Gulf Stream with frontal systems coming of the southeastern USA more frequently in the winter, has its rainy season during November to April. Guyana is influenced by the passages of the ITCZ during its northward and southward treks. This results in two rainfall peaks in its capital Georgetown in May and December (Riehl 1954).

Temporally, the distribution concern is as a result of dry winters and early springs with a deficit in water availability with the remainder of the year being wet with a surplus in available water. The high variability in Caribbean rainfall during the wet season suggest that in some years there is less rainfall with some intense enough dry-spells during the wet season which can be limiting to crop yield unless irrigation (note that Caribbean agriculture is mainly rainfed – however in more recent times there has been an increase in irrigation acreage) is available. Trotman (1994) found that dry spells of two weeks or more well into the wet season for stations in Barbados are not uncommon. Also not uncommon is rainfall of 2 to 4 inches and more during the dry season (Trotman 1994) which results in more run-off and erosion than usual on uncultivated land and increased flooding. Peterson et. al 2002 has shown that there is a trend of increasing rainfall intensities in the region. Another major cause for concern realized from Trotman's work is the variability of start, end and ultimate length of the growing season (based on rainfall, evaporation and soil moisture budgeting). This has great influence on the planning of farm activities.

Table showing the 20, 50 and 80th percentiles of the start, and length (Julian dates) of the growing season for stations in Barbados. Stations listed are Canefield (CAN), Orange Hill (ORA), Husbands, CIMH (HUS) and Grantley Adams Airport (ADA). Note that at times the end of the growing season can be in the year following the start, as expressed in low Julian dates.

	Start			End			Length		
	20	50	80	20	50	80	20	50	80
CAN	92	139	182	34	54	91	240	287	320
ORA	127	164	191	363	16	41	177	225	263
HUS	151	184	219	344	4	20	140	178	225
ADA	151	185	225	342	358	16	115	168	221

ASPECTS OF VARIABLE SEA CONDITIONS IMPACTING CARIBBEAN FISHERIES

The patterns of fertility, migration and survival of Caribbean species of demersals and pelagics are highly correlated with Sea Surface Temperatures, fresh water influx (due to local run-off after heavy rains and discharge from rivers like the Orinoco, Amazon and Magdalena in South America) and intense weather systems like tropical storms (in particular hurricanes).

The variability of SST has very strong links to the ENSO and the NAO. During a positive ENSO the eastern Pacific is warmer than normal. By the mature phase of a positive ENSO, a positive tongue of warm waters extends from the eastern pacific in to the Caribbean western Atlantic basin from November (0) to February (+1) (Taylor et. al. 2002, Giannini et. al. 2001, Giannini et. al 2000 and Enfield et. al. 1999). During the ENSO weakened NE Trades reduces evaporation and reduces upwelling from cooler waters below thereby increasing SSTs in the Atlantic. The positive SSTA in the Atlantic then peaks in the boreal spring (thereby lagging the mature ENSO by about a season. During a La Nina this all reverses. Increased SST of just only a 3^{o}C rise above normal can cause damage to coral reefs which serve as habitats to many reef fish species and spiny lobsters (Mahon 2002). The SST in the Caribbean region are expected to rise about 2 to 3 ^{o}C by the period 2070-2100 relative to 1960-1990 (IPCC SYR). Seasonal anomalies in SST due to ENSO (like that of 1997-98) and NAO (which will both influence winds and upwelling) variability have caused damage, in some case irreparable, to coral reefs. The seasonal anomalies can cause the death and/or migration of marine species with the introduction of others. The extent to the seasonal increases can be compounded by climate change and can at least provide an initial insight into potential impacts of climate change.

In the eastern Caribbean, buoyant freshwater plumes, which also bring with them potentially dangerous pathogens) intrude from both the Amazon and Orinoco River (in particular) watersheds. In the western Caribbean, discharge from the Magdalena River extends north and eastward under the influence of the Colombian gyre. These river plumes extend to very shallow depths in the southern Caribbean (less than 10 m) but under the influence of wind and current, slowly entrain into the underlying higher salinity water masses achieving depths of 40 to 60 m in the NE Caribbean. Meso-scale eddies traversing the Caribbean Sea further modulate freshwater transport. All this would influence migratory and stock patterns which will consequently affect the availability to local fishing fleet (Mahon 2002). The near coastal salinity is also influenced by freshwater in river and streams outflow due to heavy rains and subsequent run-off in the individual territories themselves. The variability in wind (which influence the sea currents) and rainfall in both South America and the Caribbean

Certainly, extreme weather events such as tropical cyclones can be very damaging to the fisheries industry. Damage to fishing gear, fishing vessels, and coral reefs act as a major setback to the fishing community and by extension the general population. On top of this with the damage to coral reefs, which act as protective barriers for our coastlines, the door is now open for more destruction as a result of storm surges that can inundate and thereby displace fishing villages.

ADAPTATION STRATEGIES

LAND-BASED AGRICULTURE

- Irrigation water is important for the extension of the growing season into the dry season as well as for the elimination of the potential damage of long dry spells during the wet season. Ways of harvesting water for at times of low availability is well documented. The construction of dwelling houses with a minimum water storage capacity is encouraged and in some territories legislated. In Barbados a dwelling house of at least 1500 ft^2 must have a collection and storage facility of rainfall of at least 3000 gallons for lawn, garden and backyard farming.
- Like harvesting, measures to conserve soil are also well documented and are used to varying degrees in the Caribbean (terracing, contour farming, vegetative barriers, planting of trees etc.)
- Improving the drainage a flood prone areas

- Introduction of more drought tolerant species
- Introduction and increased use of more efficient irrigation devices (e.g. drip irrigation)

FISHERIES

Mahon made the following recommendation for adaptation to climate change. These same strategies can be investigated now to adapt to our variable environment. Once an appropriate data collection and research framework is developed the suitability of these measures in a changed climate can be investigated.

- One adaptation strategy in adapting to climate variability is to improve the conditions of habitats to, by extension, improve their resilience. These measures will conserve species habitats both in quantity and in quality and may involve restoration of damaged habitats so as to increase the possibility of maintaining threshold levels under the variability. Such measures can include reduced input of toxic waste into the sea agricultural chemical applications, cruise ship waste. These measures will provide other benefits such as shoreline protection (reefs).
- Fishermen can adjust to the unavailability of fishing stock in traditional areas due to variability by adopting multipurpose vessels and gears that can pursue the resources in their new habitats and can also harvest demersal species when pelagics are seasonally unavailable. These can be combined with fishing agreements between countries that allows legal entry of fishermen into foreign waters.
- Measures that can reduce the infrastructural, vessels , the use of larger vessels (for higher catch and greater degree of safety) and implements damage and displacement of the fishing population would include improving the design and construction of facilities, the provision of facilities and preparedness plans for the removal of vessels from the sea and securing and removal of fishing gear. Fishing villages that are often inundated by storm surge waters can be relocated.

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ANNEX

GLOBAL ENVIRONMENTAL CHANGE AND THE FOOD SYSTEMS OF THE CARIBBEAN
DEVELOPMENT OF A REGIONAL RESEARCH PROJECT

OVERVIEW

Changes in climate and other important environmental factors pose a major concern to food security throughout the Caribbean. This is because such changes not only directly threaten the production of food from land and sea for local consumption, but also threaten revenue generation from export crops and other industries which is needed to import food. Together, both factors will bring added complications for food provision in the region.

To prepare and plan for food security within a changed Caribbean, a new, interdisciplinary Caribbean research project is being launched which aims to determine strategies to cope with the impact of environmental change on food provision and to determine the environmental and societal consequences of possible adaptation alternatives. Results will help policy-makers at both national and regional levels analyse the socioeconomic and environmental tradeoffs of alternative natural resource management policies designed to respond to the additional challenges environmental change will bring.

THE CARIBBEAN REGION: A NET IMPORTER OF FOOD

The food systems of the Caribbean are highly dependent on imports, amounting to about US$3 billion in 2000. Food imports are dominated by cereals (wheat & corn), oils (soybean & corn) and meat products. Although the majority of these imports form an integral part of the diet of Caribbean people , these crops are either not adapted to grow in the region or are not cultivated on a commercial basis.

This major reliance on imported foods requires raising revenue from the exports of traditional commodities (sugar, bananas, rice, coffee beans and cocoa beans) which, until recently, have been largely sold under preferential markets. However this source of revenue is now under threat as trade liberalisation under the WTO is dismantling market preferences under the ACP/EU protocol, lowering tariffs on imports and is removing support for agriculture. Attempts at agricultural diversification has faced many challenges due to the difficulty of achieving economies of scale, the sloping and hilly terrain characteristics of many islands limiting mechanisation, declining availability of water resources, constraints in market access and weak R&D support. Many small island states have therefore turned to tourism as an alternative/additional source of revenue. This has brought about rapid conversion of the best arable lands to building developments. It is also having a negative impact on coastal ecosystems on which the industry largely depends.

In an attempt to limit the economic damage of changing international markets, balanced in part by the tourism sector, regional policy priorities include:

- Higher levels of food security and self-sufficiency through increased productivity and diversification of agricultural and fisheries production.
- Improved trade policies and competitiveness through greater export of high quality produce and processed products.
- Enhanced sustainability of the food and agricultural sector and poverty alleviation in rural communities, through greater opportunities for rural employment.

GLOBAL ENVIRONMENTAL CHANGE: AN ADDED COMPLICATION FOR REGIONAL FOOD PROVISION

Global environmental change (GEC) is happening. Human activities, including those related to food, are now recognised to be partly responsible for changing the world's climate and giving rise to other, globally- and locally- important environmental changes. These include alterations in supplies of freshwater, in sea conditions (affecting fisheries and sea-level rise), in the cycling of nitrogen, in biodiversity and in soils. There is also concern that meeting the rising demand for food will lead to further environmental degradation.

GEC will bring additional complications to many aspects of the Caribbean's food systems, both directly (in terms of impacts on locally produced commodities) and, even more importantly, indirectly in terms of reducing export revenues. Sources of foreign exchange earnings from export crops and tourism are both highly vulnerable to many aspects of GEC, but of particular concern are potential changes in the frequency, intensity and tracking of tropical storms and hurricanes and sea-level rise. Potential environmental consequences of adapting the local food provision systems in response to reduced export earnings are also of concern as such strategies may further undermine the natural resource base.

In the short-term it is clear that climate variability and changes in extreme weather events are the most important aspects for the Caribbean region. Research is needed to understand the disruptive effects of hurricanes and other extreme weather events (resulting in floods and drought for example) on food systems, but it must also consider GEC impacts on land and water resources and availability, and vulnerabilities of different sections of societies and countries. Better projections are also needed of sea and atmospheric temperatures and precipitation trends, of hurricanes and other severe weather systems, ENSO teleconnections and intra-regional variability, sea-level rise and length and timing of growing season in relation to rainfall.

Policies need to be formulated that enable Caribbean societies to adapt to the added complication GEC will bring to food provision, while promoting socio-economic development and limiting further environmental degradation. Such policy formulation needs to be built upon an improved understanding of the links between GEC and food provision. The international research project “Global Environment Change and Food Systems” (GECAFS) is designed to meet this need.

LINKING GECAFS TO THE CARIBBEAN

Over the last year Caribbean scientists and policy makers have been in consultation with the GECAFS Executive Committee to develop and customise a GECAFS project for the Caribbean. The development of the GECAFS project was approached on a vision that the project will be composed of three phases:

Phase I: Preparation and scoping – identifying the issues
Phase II: Project start up – synthesis and assessment of existing information, development of prototype models
Phase III: Main analysis – major science and policy contributions

An Interim Steering Group comprising representatives from the Caribbean Agricultural Research and Development Institute (CARDI), CARICOM Fisheries, United Nations Economic Commission for Latin America and the Caribbean (UNECLAC), Caribbean Institute of Meteorology and Hydrology (CIMH), Food and Agriculture Organisation (FAO), the University of the West Indies (UWI) and GECAFS Executive Committee oversaw the development of the Phase I.

ACCOMPLISHMENTS TO DATE

Phase I, which is now complete, consisted of a series of scoping discussion meetings which identified a number of issues of concerns and ultimately developed methods and research approaches to address GECASFS research questions.

Theme 1: *How will GEC (especially land degradation, variability in rainfall distribution, sea surface temperature, tropical storms and sea-level rise) affect vulnerability of food systems in the Caribbean?*

Theme 2: *What combinations of policy and technical diversification in food harvested and traded for local consumption, in export commodities and in tourism would best provide effective adaptation strategies?*

Theme 3: *What would be the consequences of these combinations on national and regional food provision, local livelihoods and natural resource degradation?*

As the region comprises many independent states, each with their own set of priorities and conditions, research needs to look at both the local- and regional-levels. GECAFS approaches were developed for these two spatial levels:

1. Applying the GECAFS approach at the national level

Target: Food systems in resource-poor communities based on fishing and locally produced food crops.

Aim: To reduce food system vulnerability, especially in relation to changes in climate variability.

Theme 1 How would changes in climate variability and water availability affect food systems of communities on different islands?

Theme 2 How would current national and regional policy instruments (e.g. access to markets, insurance schemes, Exclusive Economic Zones EEZs) best be adjusted to enhance the effectiveness of technical options for diversifying cropping systems and fisheries so as to reduce vulnerability to GEC?

Theme 3 To what extent would these strategies affect food provision by altering the proportional reliance on local vs. imported commodities, and how would changed land management and associated changes in runoff affect coastal fisheries and other aspects of coastal zone ecology and tourism income based on this?

2. Applying the GECAFS approach at the regional level

Target: Caribbean regional food provision.

Aim: To develop regional-level strategies to reduce the *additional* complications GEC would bring to regional food provision, given changing preferential export markets.

Theme 1 What additional factors would GEC bring to destabilise the region's food system, and in particular what would be their impact on revenue generation from different cash commodities?

Theme 2 How could regional institutional changes best be introduced to sustain regional food provision by maximising diversification options and inter-island trade?

Theme 3 How would changes in intra-regional trade, and in policy and technical development at a regional level affect development in individual islands, and how could such changes be promoted to conserve the natural resource base of the region?

Phase I was successfully completed in February 2003 by the Interim Steering Group charged with its oversight. A 4-person Phase II Proposal Preparation Committee has now been established comprising active scientists from a range of regional research organisations (Caribbean Institute for Meteorology and Hydrology, the Caribbean Regional Fisheries Mechanism (CRFM) and the University of the West Indies) and joined by a representative from the GECAFS Executive Committee. Planning coordination will be provided by CARDI.

The major outputs expected from Phase II are:

1. The characterisation of food provision for a series of Case Studies representing the range of regional characteristics.

2. A synthesis and assessment of stresses on Food Systems which can also be of value to IPCC assessments. This is to be presented as an Overview Report with a set of Country Reports as appendices.

3. An initial assessment of the vulnerability of the CFS and to identify appropriate policy responses to encourage the development of adaptation / mitigation strategies

4. Prototype models of Caribbean Food Provision and examples of their applications as proof of concept.

5. An assessment of information needs to guide further national and international research.

6. A research proposal for follow-up activities (Phase III).

In addition Phase II will also:

- Consolidate links between national and regional policymakers and scientists, and potential donors and thereby maintain project momentum within the region.

- Consolidate links between regional research and the international GEC programmes.

- Produce a Science/Implementation Plan based on the Phase III proposal to attract broader international scientific collaboration for the main research effort.