Climate Change Scenarios and Impact Assessments in the Caribbean: Agriculture and Water Resources

Methodologies, tools and constraints

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Adaptation to Climate Change

When most of us think and work about adaptation issues we usually assume implicitly that:

- Adaptation is possible totally within the system (agriculture or else)
- Actual agricultural systems are already adapted to our reference climate

Both assumptions are questionable…

Adaptation to What?

Vulnerability studies are usually made using climate change scenarios.

Adaptation projects and actions are constantly ongoing… but nobody seems to be adapting to 2020 or 2050 expected climate conditions.

It seems that the usual kind of adaptations is currently addressed to adapt ourselves to actual climate variability… climate change is not expected to be an abrupt event, but a continuously evolving process to which we'll have to be constantly adapting for many years to come.

We're we adapted to reference climate conditions?

Looking at the food security problems in developing countries and the long chain of adverse climatic conditions affecting our countries in the last 50 years… we could conclude that our agricultural and water management systems were never adapted to actual climate conditions.

We most do that now… in the new context of a constantly changing climate.

Data Needs and Tools

All our assessments in agriculture and water resources have been made with the following tools:

- Climate change scenarios based on coupled ocean-atmosphere global (GCM) and regional (RCM) climate models
- Climatic and bioclimatic indexes
- Process-based (biophysical) crop models

Data / Tools Relationships

Let's state here at the very beginning that data needs and constraints are largely conditioned by the tools to be used in V&A assessments.

Conversely, one would need to elect useful tools that can work with insufficient or incomplete climate datasets. This is not always possible because of the limited skill level of simple tools using simple or incomplete datasets as input.

Crop models data needs

Crop models as the Wofost and DSSAT versions require daily time series of climate variables for a specified time period (10 – 30 years). In the case of agriculture:

- Maximum and minimum temperature
- One atmosphere humidity parameter
- Precipitation
- Wind speed
- Global solar radiation
- Carbon dioxide atmospheric concentration
- Mean sea level (water resources assessments)

The case of actual reference climate

Complete datasets for this set of variables are very difficult to build in developing countries. This constitutes a constraint.

The problem is especially evident in the case of global solar radiation because of the lack of stations measurement of this parameter or some other parameter (sunshine hours) from which radiation can be inferred.

The case of future climate scenarios

In this case, the problem related to the inexistence of a complete dataset for reference climate is compounded by the fact that GCM and RCM based tools don't (generally) give us a complete future dataset for the necessary variables either.

This constraint compel us to resort to the so-called Bultot's type climate change scenarios. Some climate variables are obtained from GCM related tools as MAGICC/SCENGEN while others are specified according to general considerations requiring a lot of knowledge of the climate and climate change physical processes involved.

Cuban experiences in V&A assessments (1)

In the context of this presentation we'll be discussing only climate change scenarios based on numerical simulations experiments made with climate models, with or without downscaling. The way in what outputs from these numerical simulation models are used to generate the necessary input climate databases for feeding impact models in the two sectors involved, will be called the "standard procedure" (Parry and Carter, 1998; Benioff et al., 1996; IES / UNEP, 1998).

Cuban experiences in V&A assessments (2)

Impact assessments discussed here will deal only with the use of process-based impact models or with rational use of climatic and bioclimatic indexes. This approach to impact assessment could be named as the “recommended approach or pathway”.

No statistical assessment procedures based on relationships obtained in actual climate conditions will be discussed because they are only valid in limited contexts and must be redefined every 3 – 5 years (Gommes et al., 2006).

Period 1997 – 1999

A semi synthetic scenario (Bultot’s) based on the HadCM2 global climate model and the WOFOST 4.1 biophysical crop model were used given the complexity of crop’s responses to climate forcing. An autochthonous Forest Impact Model was also built.

Experiences obtained in this procedure were extended in 2000 - 2001 to the National Communication processes of Panama, Paraguay, Iran, Dominican Republic, Haiti and Saint Kitts-Nevis.

Period 1997 – 1999 (continued)

Output data from the HadCM2 climate model was obtained from internal files of the M/S 2.4 version as the whole set of **SIX** climatic variables necessary for running WOFOST 4.1 are no directly available through its user interface. As global solar radiation wasn't even available in these internal files the authors had to elaborate a final Bultot's type scenario for using the impact model in the assessment procedure.

Constraints are evident in this story.

Additional constraints

Some crop models tools lead to different results for cases in which the CO2 fertilization effect is included or not. This is not only an additional constraint but an additional source of uncertainty in V&A assessments.

That's why the assessment itself have to be made twice and not once. A final (expert judgment) has to be made at the end.

In addition, some models haven't got an explicit way in which to take account of the CO2 fertilization effect.

Period 1997 – 1999 (continued)

A second thrust in impact assessment was done through the rest of 1998 – 1999. Bultot's scenarios were constructed as to run biophysical (process-based) crop models contained in DSSAT 3.0 version. Simulations leading to different results were made taking (or not taking) into account the CO2 fertilization effect.

In the Water Resources sector combined use of a simple water balance scheme with indirect estimation of relevant non-climatic variables was made (Planos et al. 1999).

Results were surprising from the very beginning but confirmed using totally different calculating schemes by Rivero et al. (2005).

Period 1997-1999 (continued)

A thorough use was made of climatic and bioclimatic indexes, as well as the Forest Impact Model, to estimate the impact of climate change on aridity, drought frequencies, Life Zones, Net Primary Productivity and Potential Biomass Density of Forests and Terrestrial Ecosystems.

These efforts were later extended to the Dominican Republic, Haiti and Saint Kitts Nevis.

Period 1997 – 1999 (continued)

First quantitative assessment of hydrological potential (total annual expected runoff) was first evaluated in 1999 under the same climate change scenarios used in the agriculture sector. A water balance procedure was used for this end (Planos et al., 1999).

Surprisingly enough, a second assessment for a region not explicitly included in the first assessment and with **FOUR** different impact models, lead to similar results strengthening the confidence in calculations of expected hydrological potential (Rivero et al., 2005).

Integrated V&A Assessments

Integrated impact assessments have been widely discussed even if accomplished rarely in real impact studies. Maybe integrated assessments have been approached with too wide a perspective including socio-economical scenarios in regional and global contexts.

But not using cross - sectoral integrated assessment (agriculture – water resources) will lead to an **incomplete (erroneous) vision of the future** in relation with food security issues.

Period 1999 - 2001

A first effort was done in cross sectoral **integrated** assessment.

Total areal production (not monetary values) was the integrating output parameter. Agriculture and water resources were involved because:

- The impact of climate change will affect not only crop yields but the needed amount of irrigation water
- Irrigation is the first adaptation measure that comes to the mind of stakeholders and decision – makers, without even knowing if available water resources will be enough for that.

A first assessment was made using the MIIA 1.0 integrated model (Rivero, 2001). Afterward, this model was improved to a 2.0 version including irrigated and non-irrigated crops and livestock.

Period 2001 – 2005

A lot of effort was devoted in this period to confirm previous results in both sectors using alternative climate change scenarios, global climate models and different impact models including MIIA 2.0 and a second version of our Forest / Terrestrial Ecosystems Impact Model. Results obtained confirmed and extended to a wider area what was already found in our previous research enhancing credibility in those findings.

A second water resources assessment was done with totally different scenarios and a different set of impact models. This independent confirmation of previous results was used for new integrated cross – sectoral assessments.

Thermal human stress and climate change

Crop cultivation and agricultural production in our countries depends in a large measure of rural workers and hard manual work.

Even if thermal and comfort indexes are important for everyone of us, we should meditate about what climate conditions will be present in the future in our agricultural fields.

Thermal stress could be a factor leading to weak technological discipline and low production levels because of its impact on human workers in the open. Cows are no better than us and we already know that thermal stress leads to a sizable decrease in milk production and other bovine parameters. A simple approach to this problem was done by Rivero et al. (2005).

Moving on …

The next generation of V&A assessments and adaptation policies definitions are being developed on a wider … Caribbean perspective, with the collaboration and joint effort of the Hadley Centre, CCCCC and other CARICOM institutions including the University of West Indies.

They will include the creation of new high resolution climate change scenarios based on PRECIS RCM model and a joint forceful capacity building effort in the subjects of V&A assessments, allowing deeper studies of impacts on soil, livestock and watershed dynamics.

A Joint Capacity Building Effort

Our collaboration team has concluded that many previous capacity building efforts in our region have failed in training people for making a judicious and thorough use of available tools for V&A Assessments and for designing adequate Adaptation Measures and Policies. This author himself has participated in 20 workshops of that kind celebrated in 13 different countries.

A JCBE continued… 1

Causes that have been identified for this circumstance are …

Very general type of training workshops in which all the steps (seven or otherwise) are taught and many different impact sectors are addressed sequentially

The assumption of an inexistent previous basic knowledge in participants. Very complex tools are taught as “black boxes”

A JCBE continued… 2

Non suitable participants selection previous to the workshops… leading with practitioners of unrelated disciplines trying to understand the physics of climate change or plant physiology and agricultural meteorology concepts embedded in a sophisticated … highly sophisticated … climate or crop model.

A JCBE continued… 3

The lack of specific (sectoral) workbooks containing the theory, the results, the experience and the tools themselves … which are recommended to be used in the assessments to be done.

No follow-up activities after the initial sectoral training has been given.

A JCBE continued… 4

These constraints are being addressed in our joint Caribbean effort on capacity building already initiated in 2006 – 2007. Initially in agriculture … this effort will embrace all relevant impact sectors. In the following way …

A JCBE continued… 5

Sectoral (hands-on) training workshops are being organized. Its content guarantees:

- A previous selection of participants
- Climate change scenarios building and uses
- Basic (multidisciplinary) knowledge relevant to the tools to be used
- The recommended tools and a complete workbook containing basic theory, examples and exercises are provided with the training
- Follow-up activities will be ensured by the trainers themselves

Recapitulation… Data Needs and Constraints

IN REFERENCE CLIMATE

- Complete datasets for climate variables are very difficult to build in developing countries
- This is especially evident in the case of global solar radiation, the driving input variable for agricultural and water resources impact models.

IN FUTURE CLIMATES

In future climates (scenarios) this problem is compounded by the fact that GCM and RCM based tools don't (generally) give us a complete future dataset for the necessary variables either, especially solar radiation.

SPATIAL RESOLUTION

Low spatial resolution of available climate data is sometimes a constraint also in developing countries.

Recapitulation… Impact Models Related Constraints

Some crop models tools lead to different results whether the CO2 fertilization effect is included or not. This is not only an additional constraint but an additional source of uncertainty.

In addition, some models haven't got an explicit way in which to take account of the CO2 fertilization effect, so they have to be tailored by local experts.

Because of that the assessment itself have to be made two times instead of one. A final (expert judgment) has to be made at the end. This also applies to the assessment of adaptation options.

There is a lack of cross – sectoral integrated tools. **Not using cross sectoral integrated assessment** (agriculture – water resources) will lead to **an incomplete (erroneous) vision of the future** in relation with food security issues.

Validation of impact models is generally **impossible** within the limited human and technical **resources available in developing countries.**

Recapitulation… Knowledge Base Needs and Constraints

- In many developing countries there isn't enough knowledge base allowing them the use of advanced tools for generating adequate climate change scenarios or using sophisticated impact tools, as those used for assessing agricultural and water resources sectors responses to climate change such as, complex process – based crop and forest gap models or water evaluation and planning ones.
- Follow-up activities related to training efforts are almost never implemented so no feedback trainers – trained persons is allowed after the training.
- New strategies in capacity building should be established.
- A Joint Capacity Building Effort is on its way in the Caribbean region.

Concluding Remarks

Thanks to you all !