ICWALPA: Integrated Carbon, Water and Land Management for Poverty Alleviation

A collaborative project funded under the ESPA programme

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Outline

• Introduction to the project and study areas
• Growing sugarcane in JULES – Brazil and Ghana
• The effect of higher temperatures and elevated CO$_2$ on yield and irrigation requirements
• The hydrological and economic context
The environmental and economic implications of exporting biofuel technology from Brazil to Ghana

- The feasibility and sustainability (economic and physical of sugarcane cultivation for biofuel cultivation in a changing climate, and the capacity of such activities to alleviate poverty in the long term
- The long term impact of land management on ecosystem services, with a particular focus on water availability
- Land surface – climate feedbacks and their impact on the sustainability of different land use strategies

Cultivating C4 crops in a changing climate: sugarcane in Ghana
Emily Black, Pier Luigi Vidale, Anne Verhoef, Santiago Vianna Cuadra, Tom Osborne and Catherine Van den Hoof
Published in ERL download from http://iopscience.iop.org/1748-9326/7/4/044027
Regional relevance:
Environmental impact of growing sugarcane in West Africa (particularly on water)

Sugarcane cultivation in Africa

Wider relevance:
The behaviour of vegetation under climate change affects the evolution of the global water cycle and land carbon sink

Vegetation response to raised CO₂ (Knohl and Veldkamp (2011) Nature)
Study areas

Sugarcane cultivation regions in Brazil (red)

Sao Paulo study area

Daka River region Ghanaian proposed cultivation
ICWALPA modelling framework
ICWALPA modelling framework
Set up of JULES-Sugarcane (JULES-SC, which is based on JULES Crop)

Set up

- Meteorological driving data: 3-hourly; 1 degree resolution Sheffield dataset
- Soils: ISCLP2 satellite based soil textures (1 degree resolution)

Supplementary information in: Cultivating C4 crops in a changing climate: sugarcane in Ghana
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Cultivation of sugarcane
Application of model to Ghana

As expected, irrigation increases yield and reduces interannual variability.

Expected yields under irrigation (courtesy of Northern Sugar Resources)
Idealized climate change scenario

Idealised climate scenario: 4° increase in temperature uniformly imposed; consistent change in humidity (based on statistical model of observed temperature/humidity relationships and theoretical constraints); local water balance maintained
Hydrological setting

[Map showing the hydrological setting with locations of Daka and Oti]

[Bar chart showing long-term mean monthly flow for different basins]

Legend:
- Red: Ekumdipe-Daka
- Blue: Sabari-Oti
- Green: Mango-Oti
Pitman hydrological model
PITMAN was used to simulate damming of the River Daka. Two models were developed – with seepage (left) and without seepage (right).

Location of dams and subcatchments shown bottom right.
ICWALPA modelling framework
The Nexus Land-Use: a model articulating biophysical potentials and economic dynamic

Biophysical parameters
- Potential yields of 11 crop functional types (1999-2003 mean on a 0.5x0.5° grid)
- Feed composition & feed conversion into livestock outputs (2000)

Scenario
- Population
- Calorie consumption per capita
- Animal calories in food diet
- Agrofuel production
- Deforestation area
- Fertiliser and pesticide price

Nexus Land-Use
Cost minimisation under Supply/Demand equilibrium on food and agrofuel markets

Outputs
- Cropland area
- Intensive pasture area
- Extensive pasture area
- Crop yield
- Fertiliser and pesticide consumption in agriculture
- Trade of food
- Calorie/Land prices

Data for calibration and initialisation
- Actual yields of 11 crop functional types (1999-2003 mean on a 0.5x0.5° grid)
- Global land cover (2000)
- Production, trade and uses of edible calories (2001)
- Consumption of fertiliser and pesticides by the agricultural sector (2001)
Calorie price evolution in the three food scenarios
The impact of bioenergy production on agricultural price

Yearly evolution of the world calorie price

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(1) Production of 50 EJ bioenergy
(2) Potential crop yield are increased by 100% to 2050
Summary and Conclusions

• JULES-Crop has been extended to included sugarcane with some skill for Brazil and Sudan

• Applying JULES-SC to Ghana suggests that ~75% of the Brazilian yield is achievable – provided there is sufficient irrigation.

• Hydrological modelling suggests that damming the River would (just about) provide enough water for irrigation, and that it might have other benefits to the local population [note these are preliminary results from an idealized study]

• Work is underway to use these results to inform an economics case study of the profitability of sugarcane production in Ghana and the wider impact of biofuel cultivation on food prices

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