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

A collaborative project funded under the ESPA programme

NCAS: Emily Black, Pier Luigi Vidale, Tom Osborne
University of Reading: Anne Verhoef, Andrew Wade, Attila Lazar
CIRED, Paris: Patrice Dumas
Federal University of Viscosa, Brazil: Sandiago Cuadra
Northern Sugar Resources, Ghana: Kojo Fosu
Soil Research Institute, Ghana: Bosiake Antwi

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
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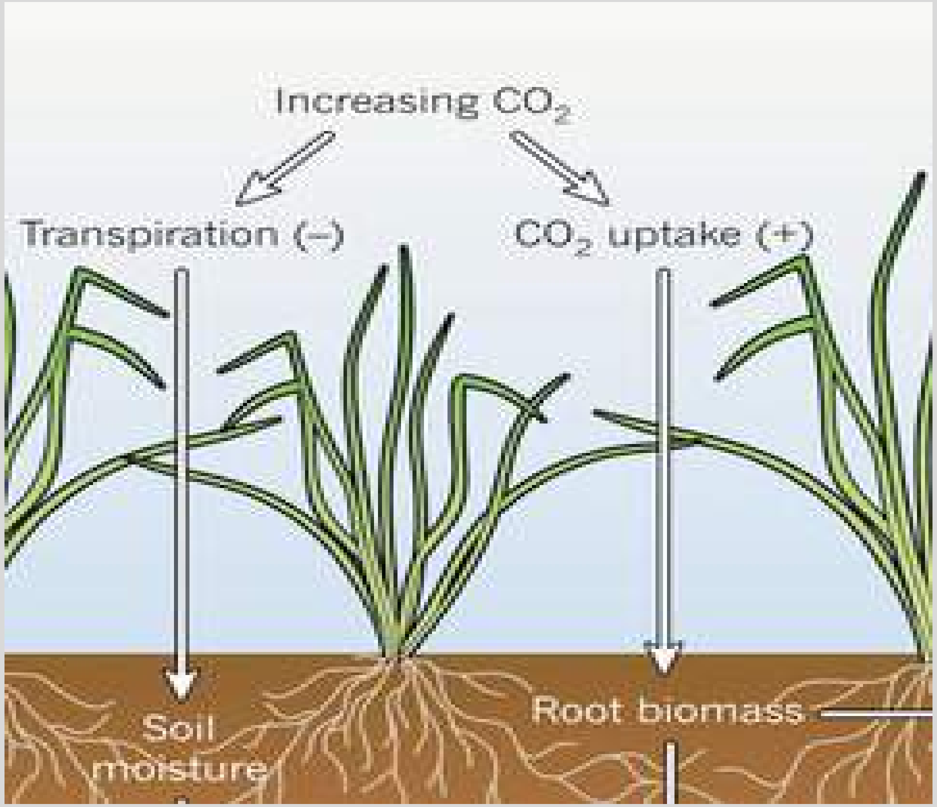
Regional relevance:

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

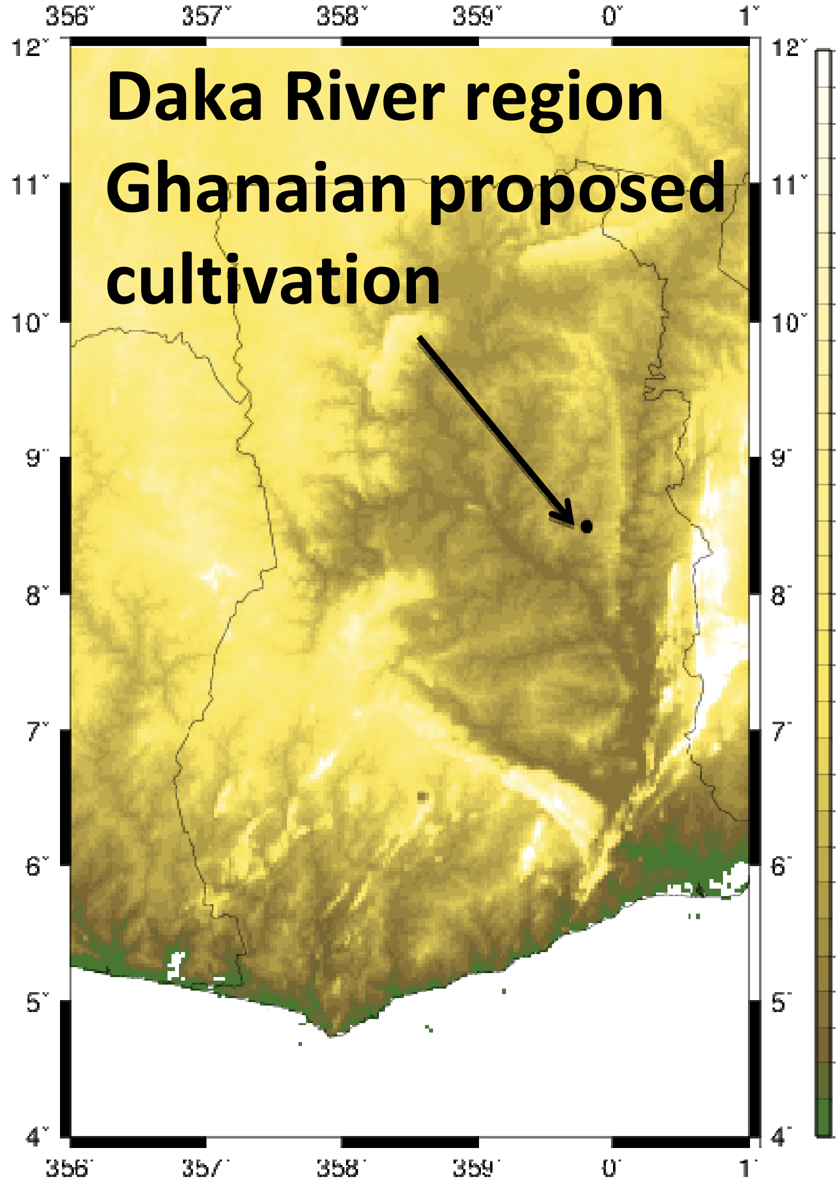


Vegetation response to raised CO_2 (*Knohl and Veldkamp (2011) Nature*)

Study areas

Sugarcane cultivation regions in Brazil (red)

Sao Paulo study area

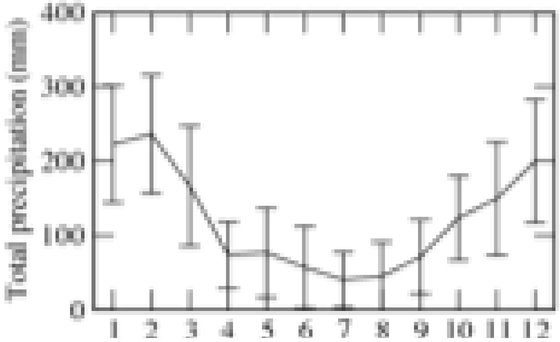


Climate of Brazil and Ghana

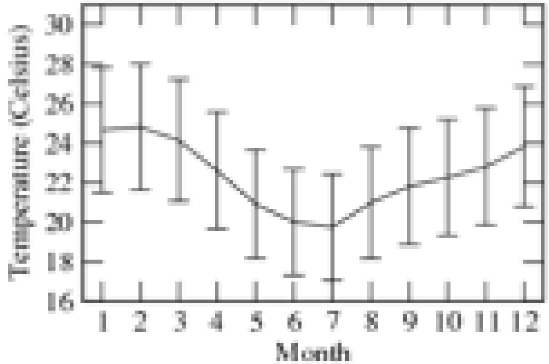
Brazil to Ghana

Brazil

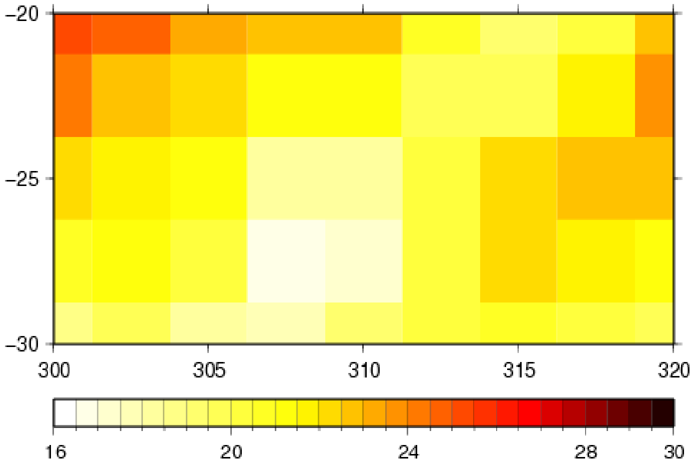
Precipitation seasonal cycle



Temperature seasonal cycle

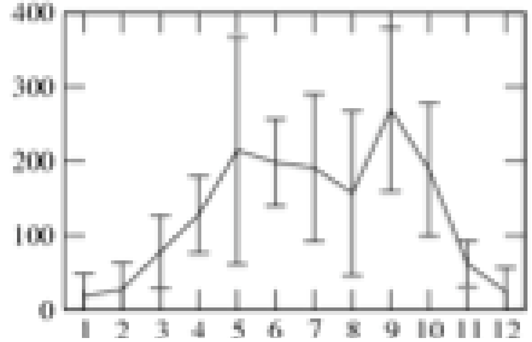


Mean annual temperature

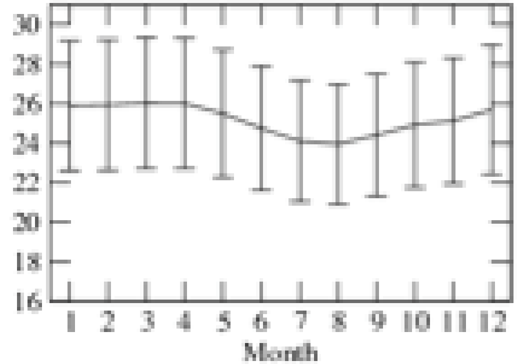


Ghana

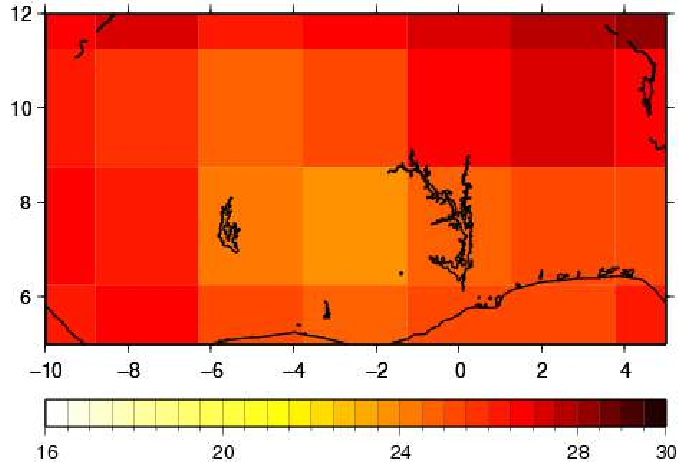
Precipitation seasonal cycle



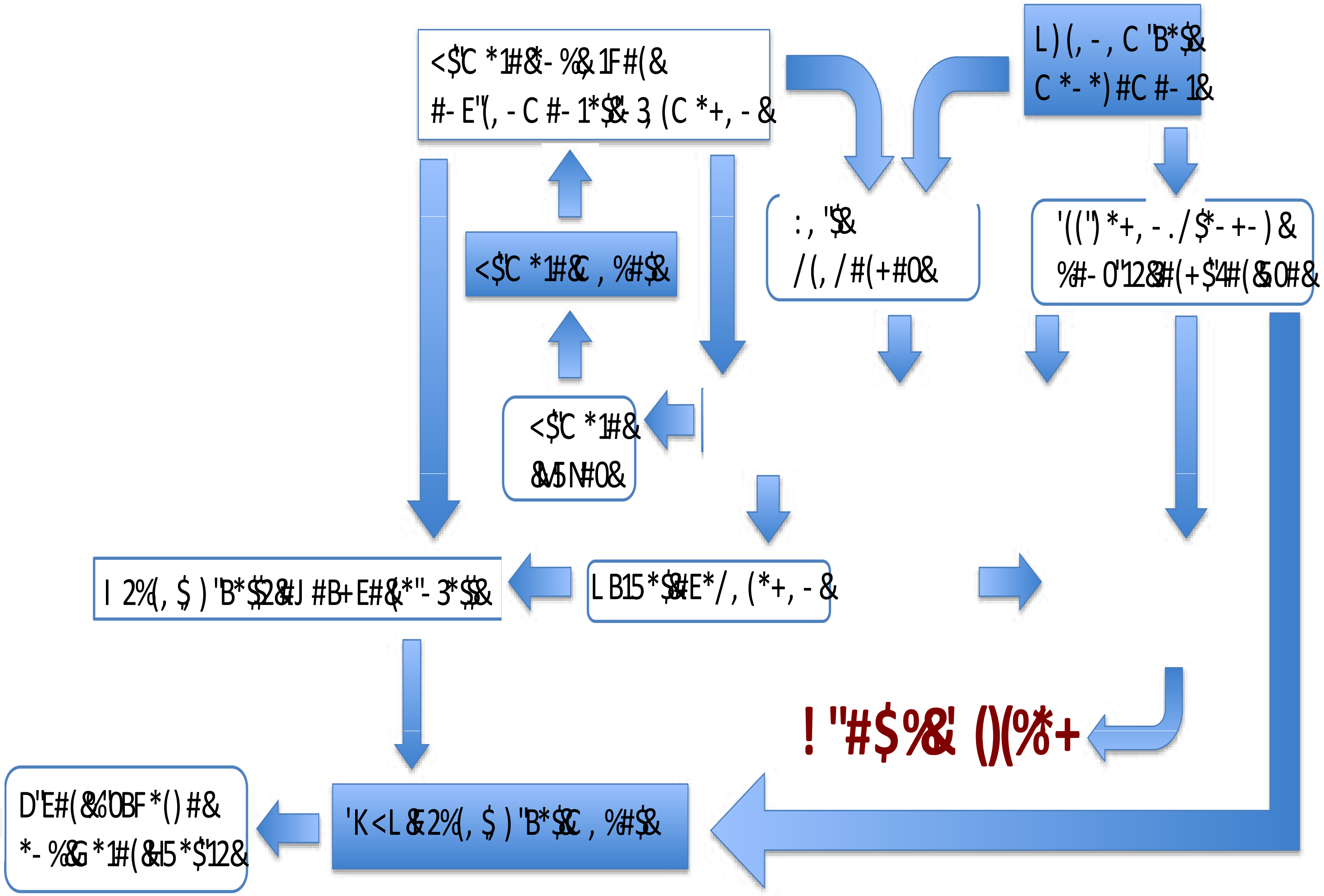
Temperature seasonal cycle



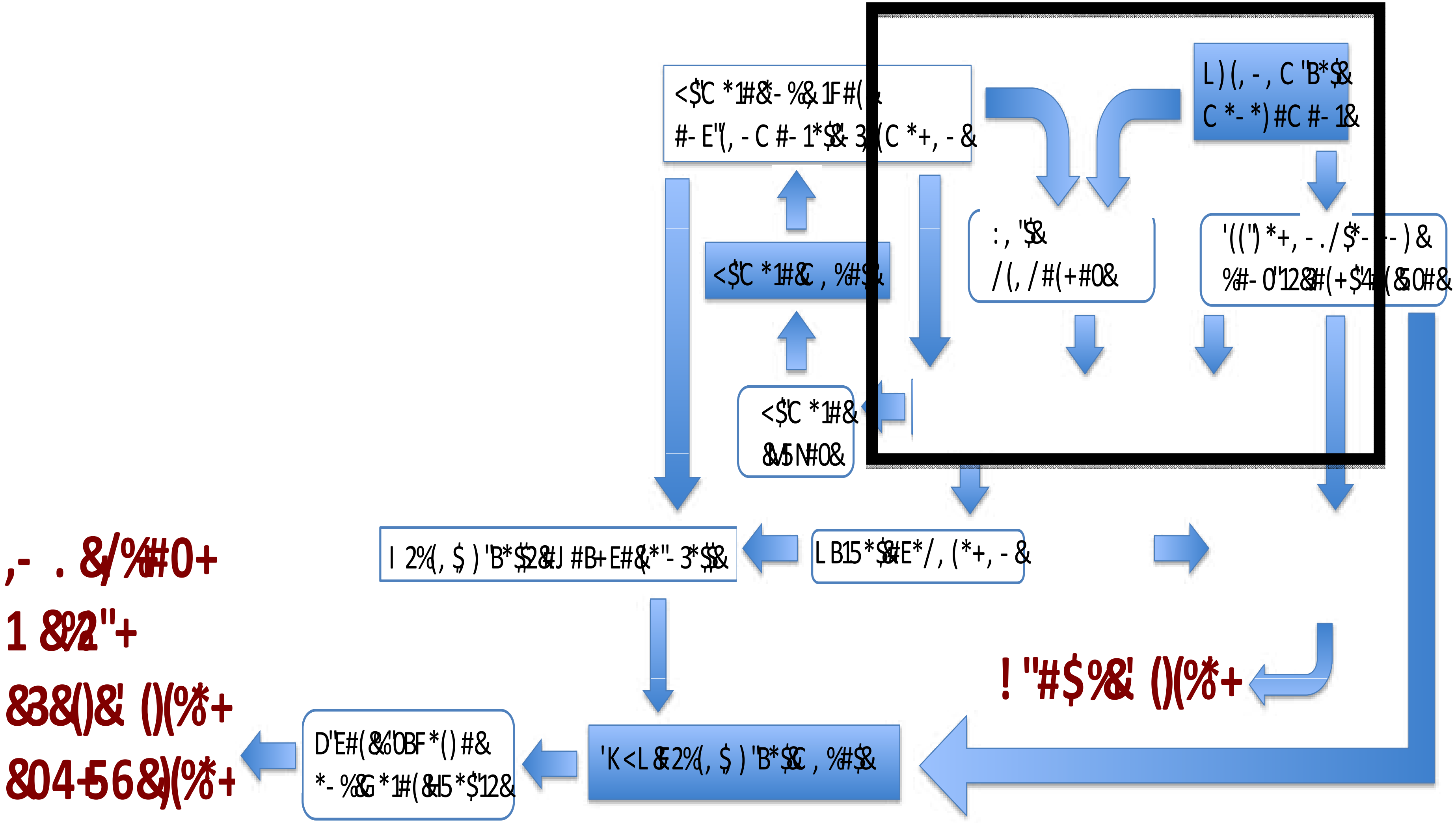
Mean annual temperature



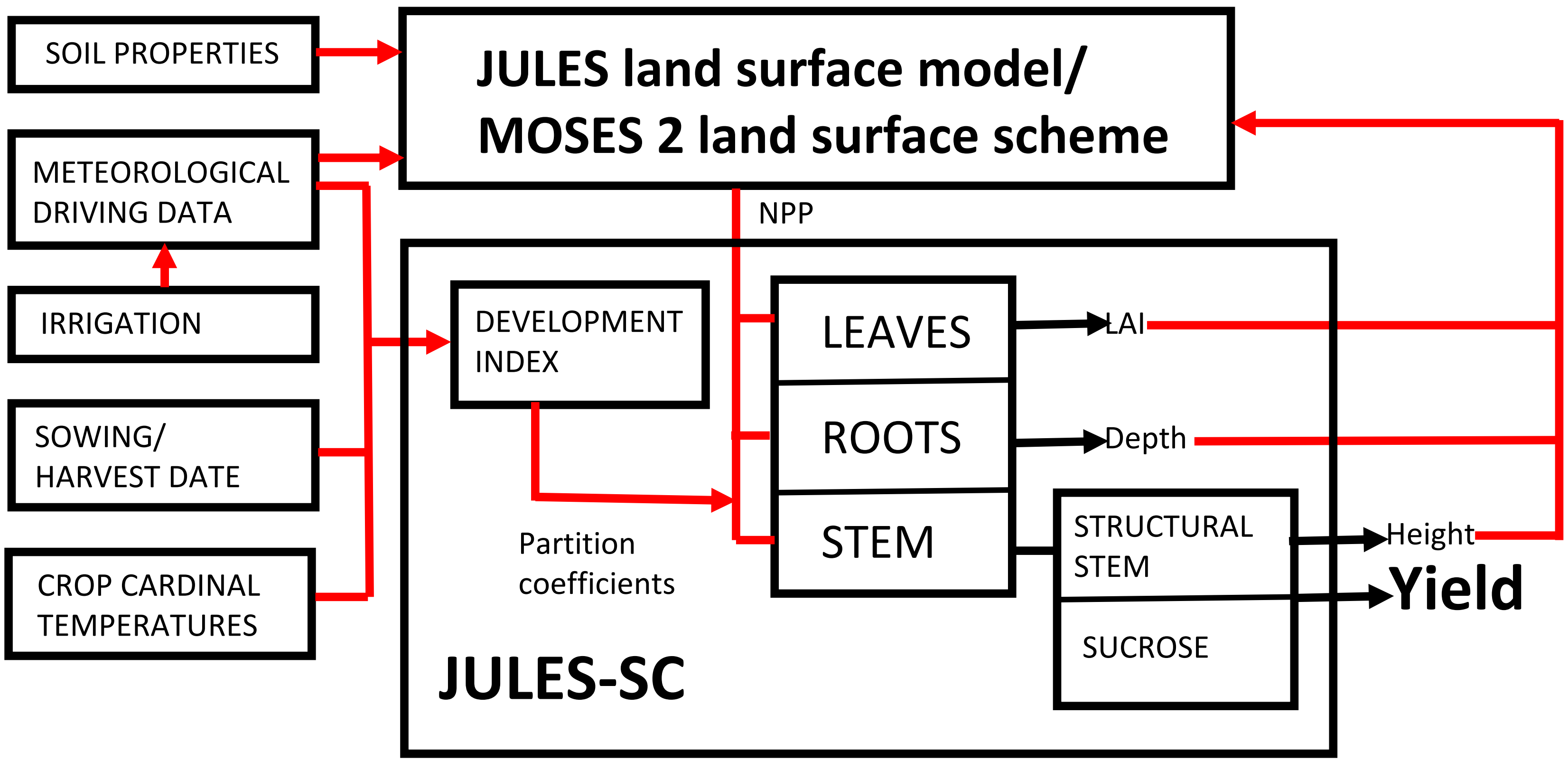
ICWALPA modelling framework



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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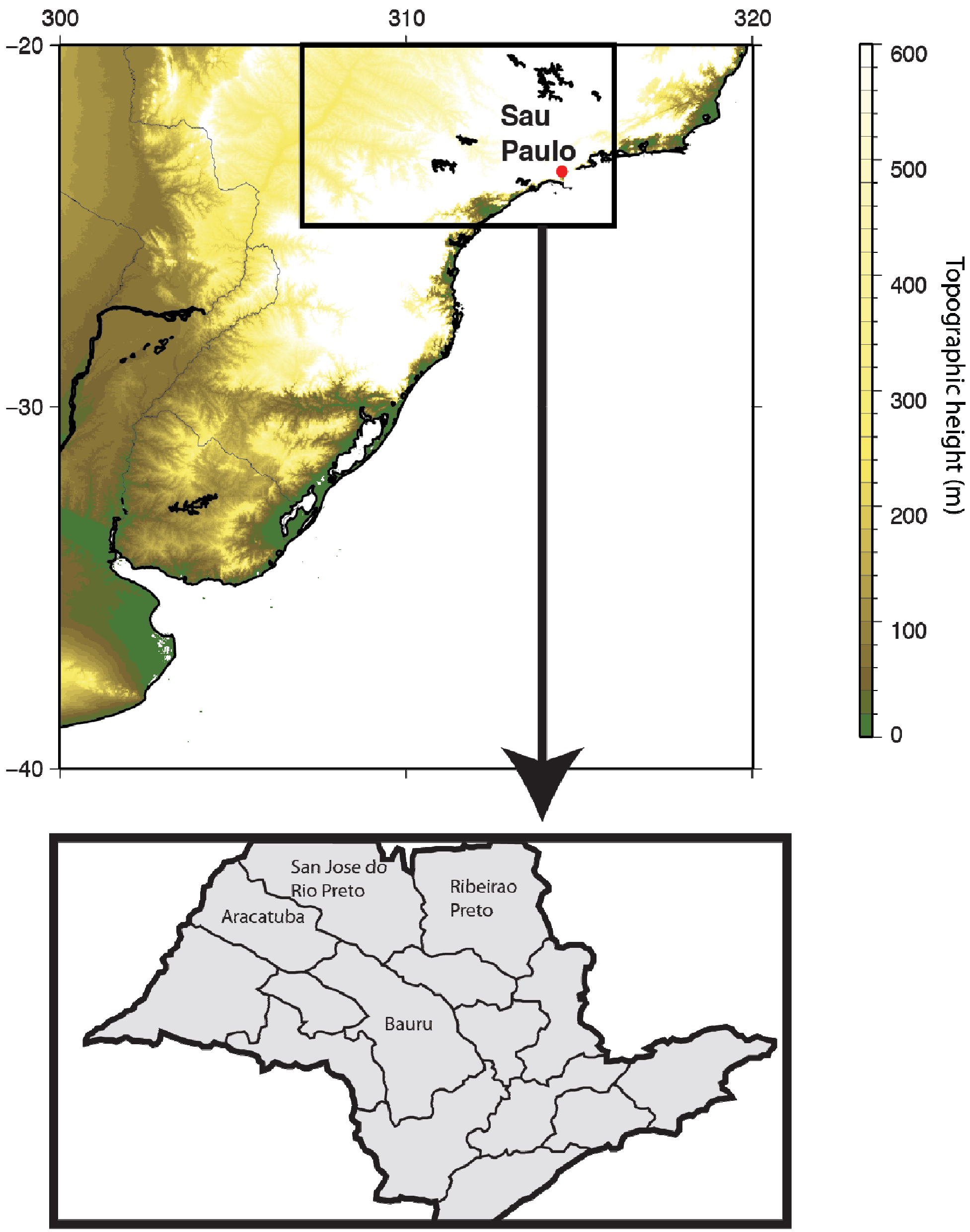
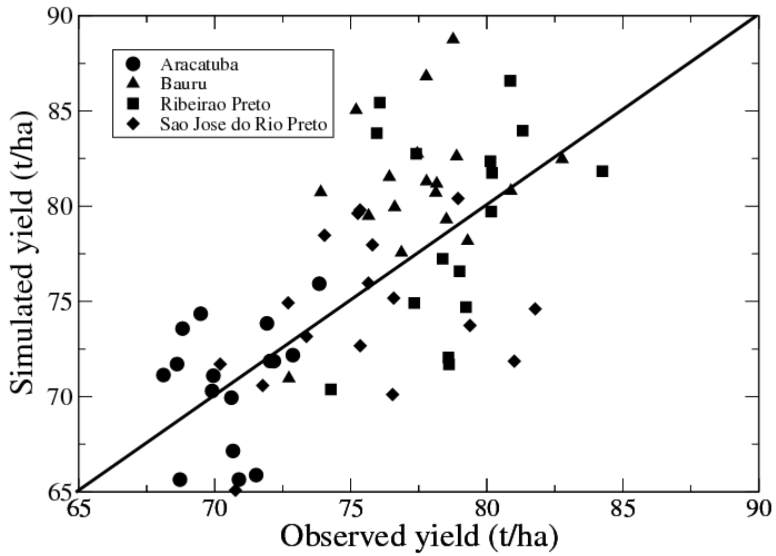
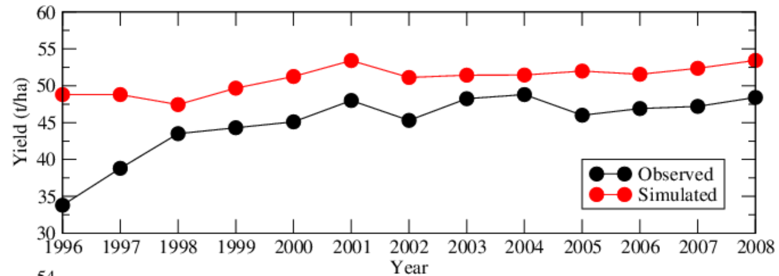
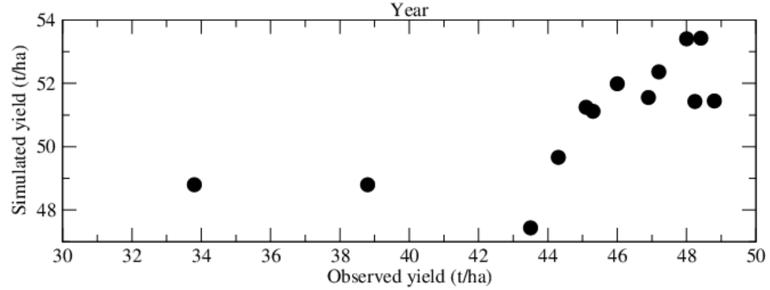
Cultivation of sugarcane

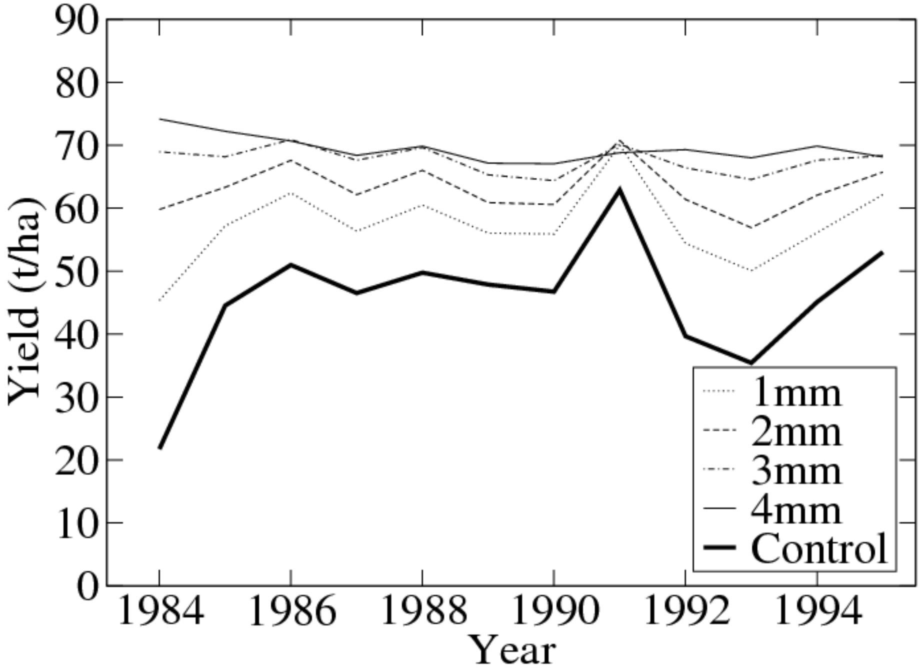




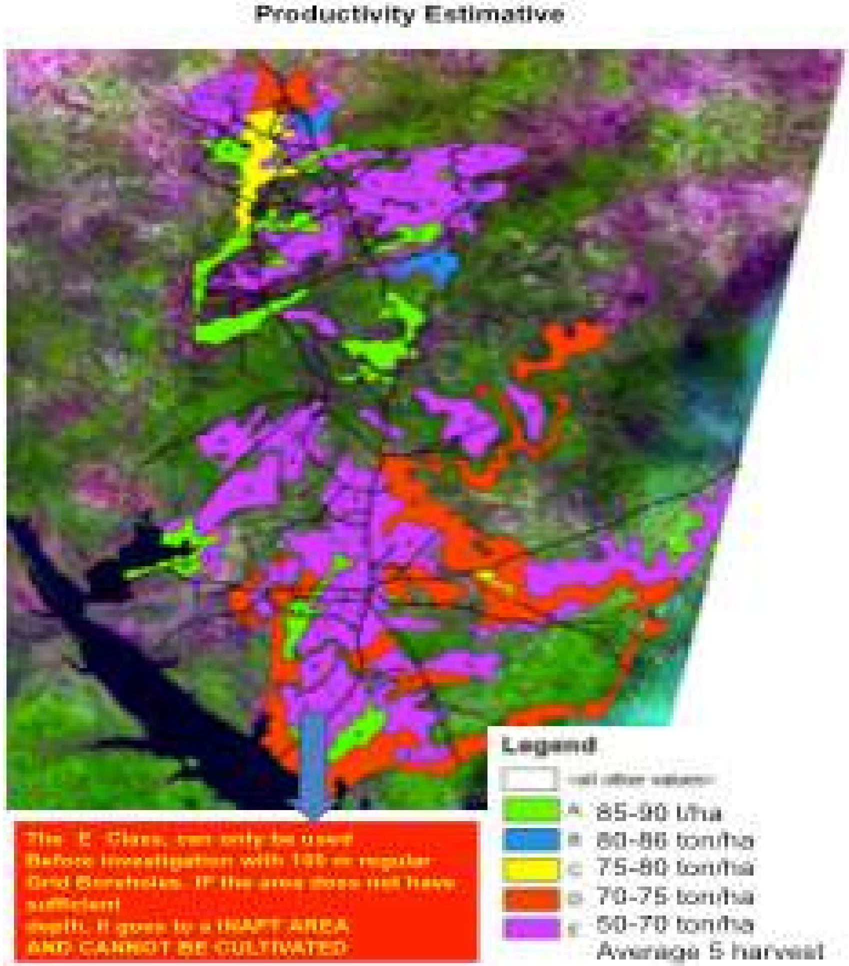




Application of model to Ghana

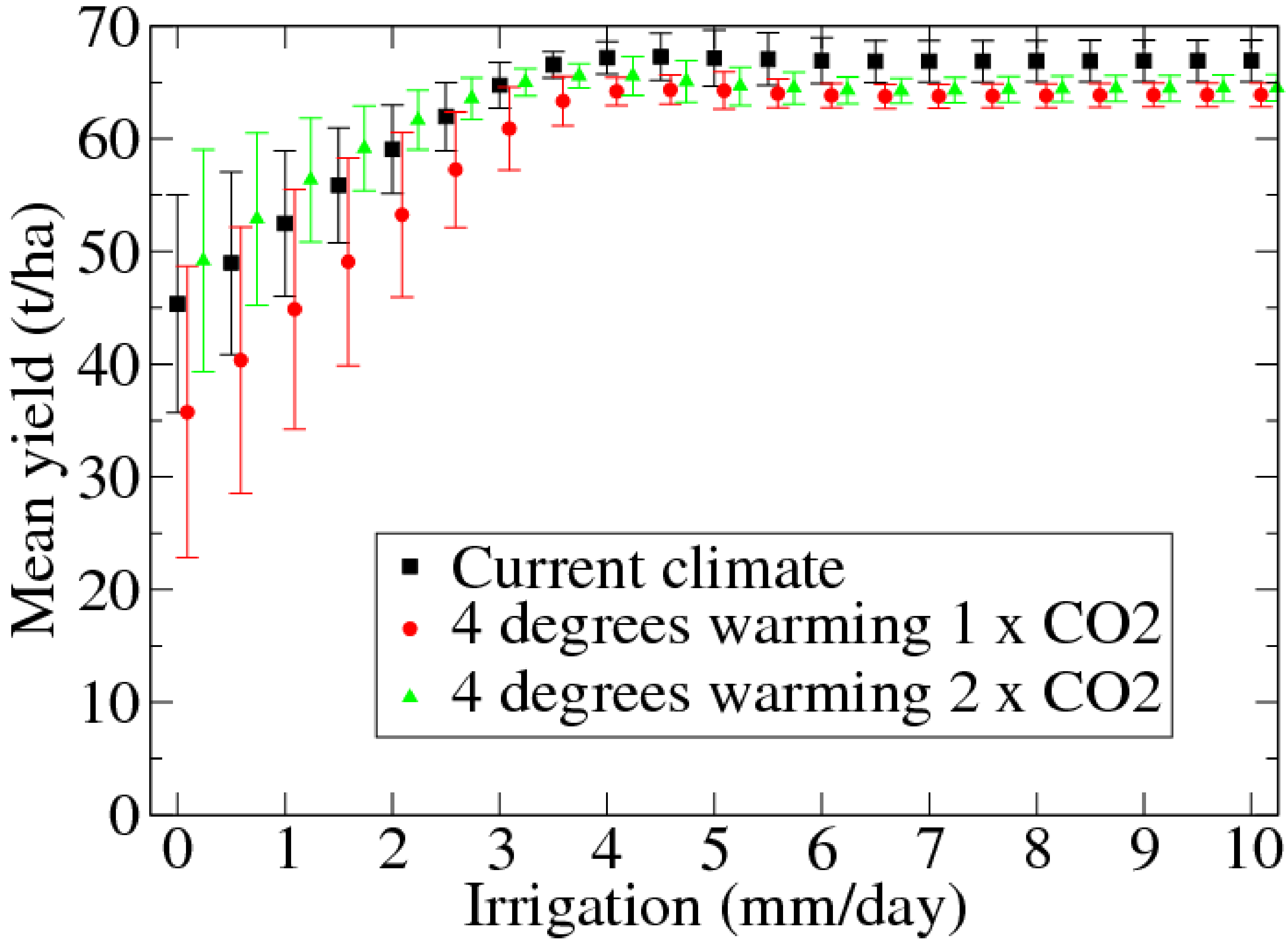


As expected, irrigation increases yield and reduces interannual variability.



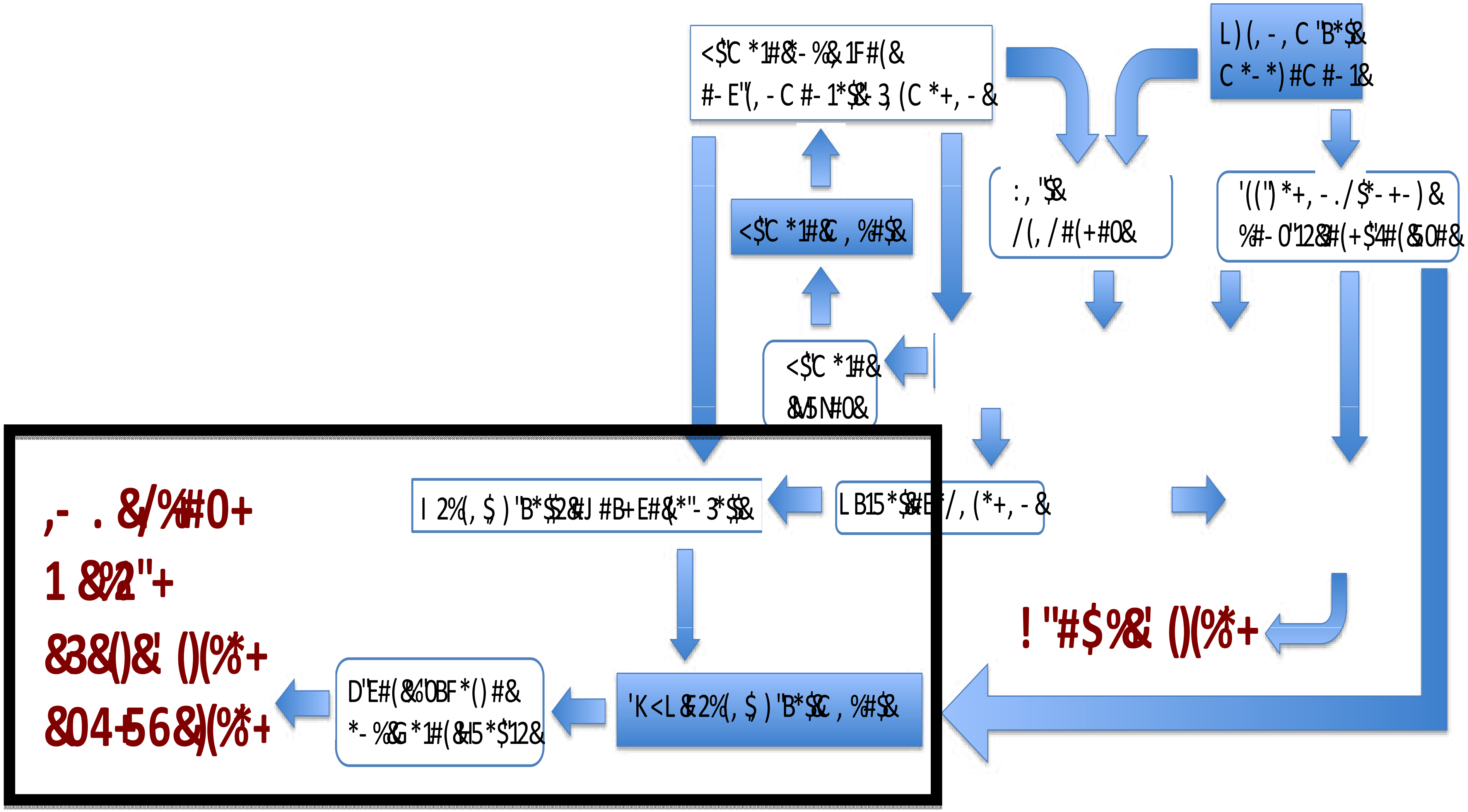
Expected yields under irrigation (courtesy of Northern Sugar Resources)

Idealized climate change scenario

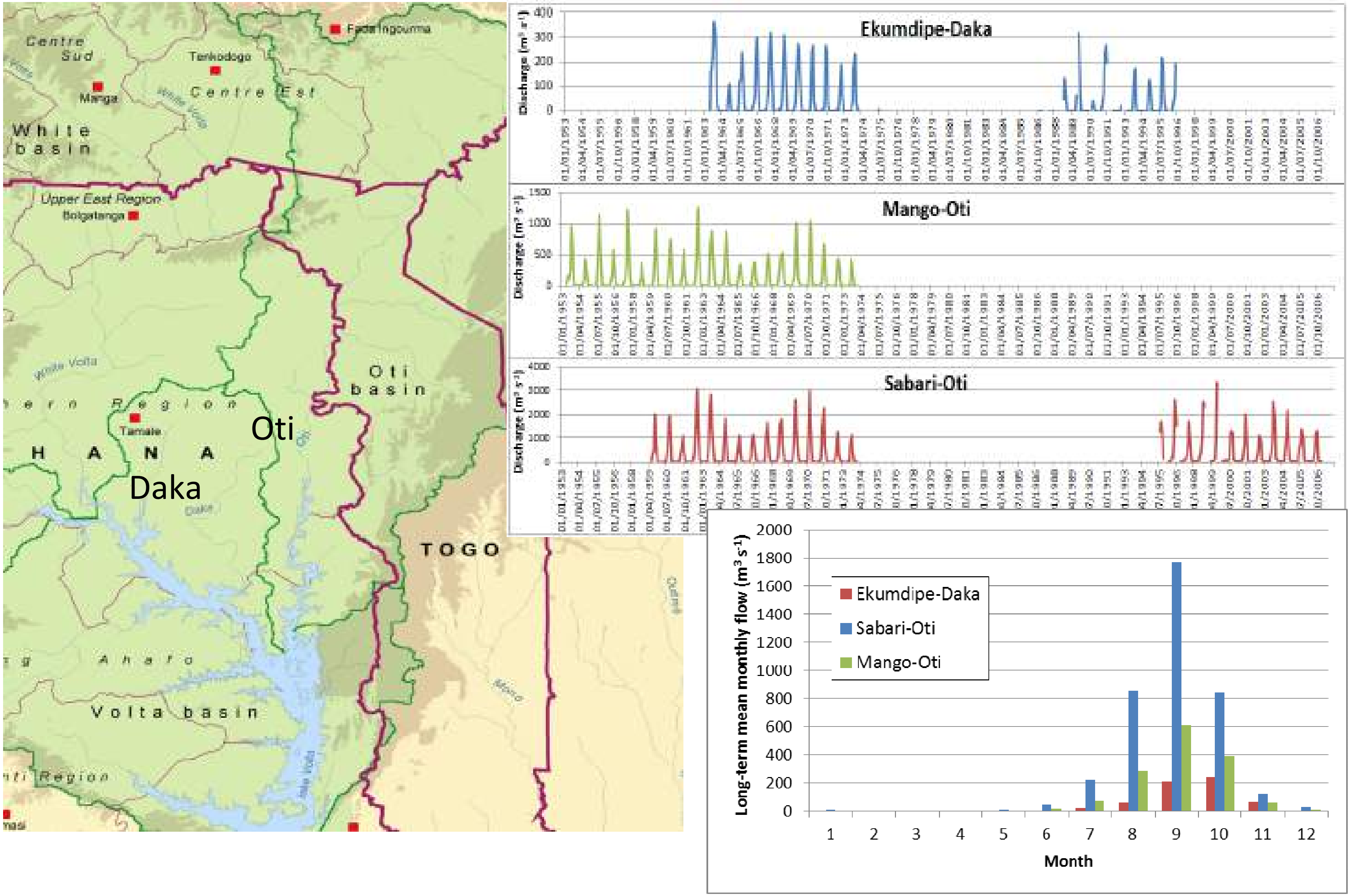


Idealised climate scenario: 4^0 increase in temperature uniformly imposed; consistent change in humidity (based on statistical model of observed temperature/humidity relationships and theoretical constraints); local water balance maintained

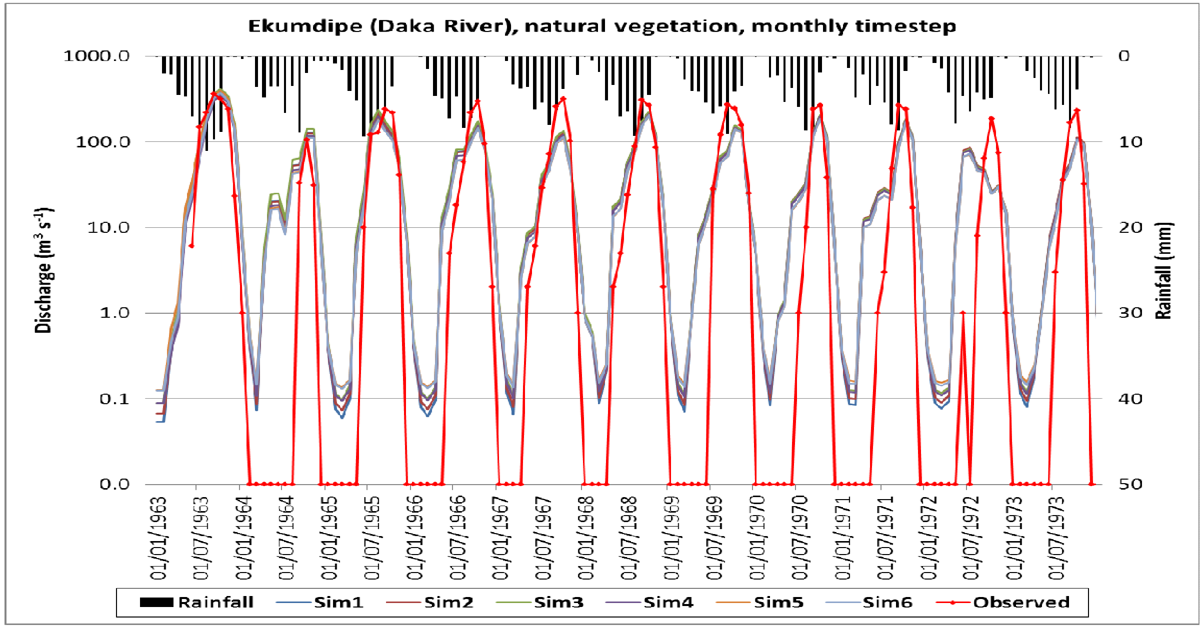
ICWALPA modelling framework

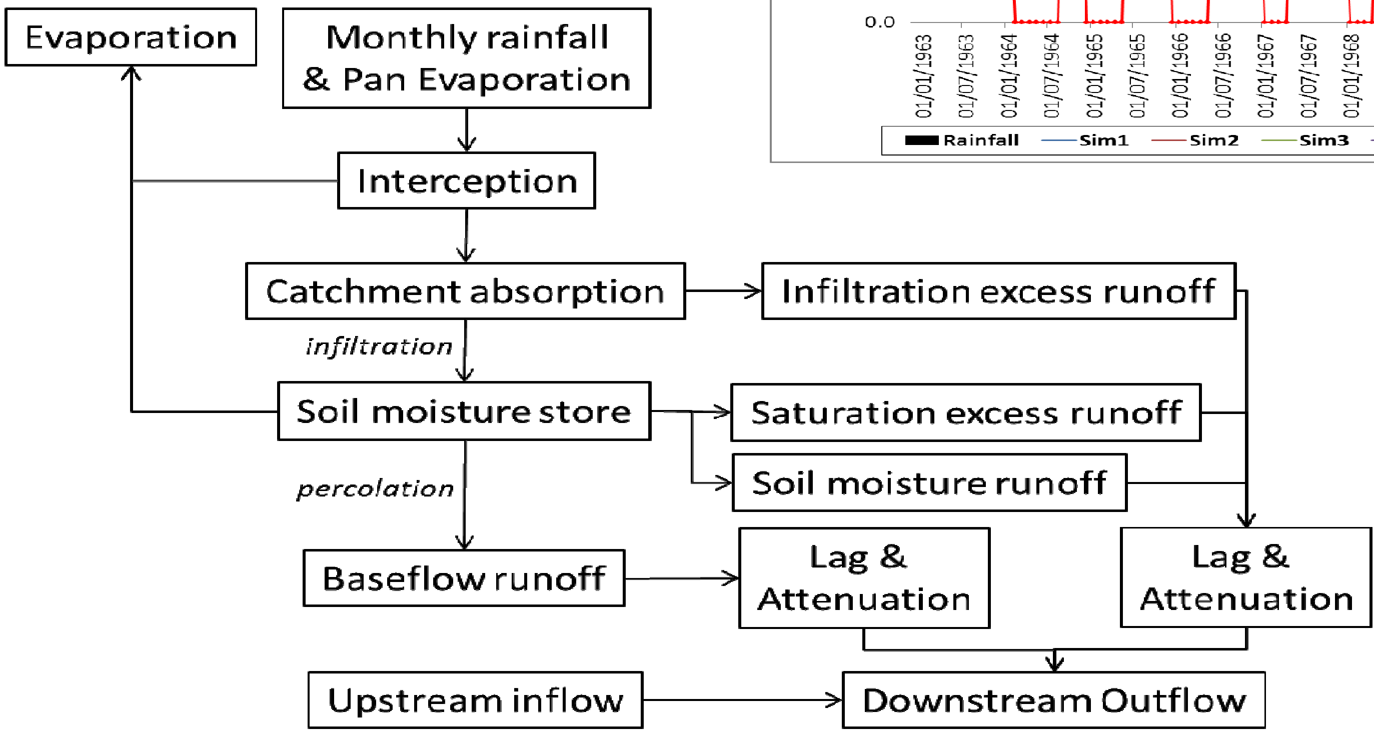


Hydrological setting

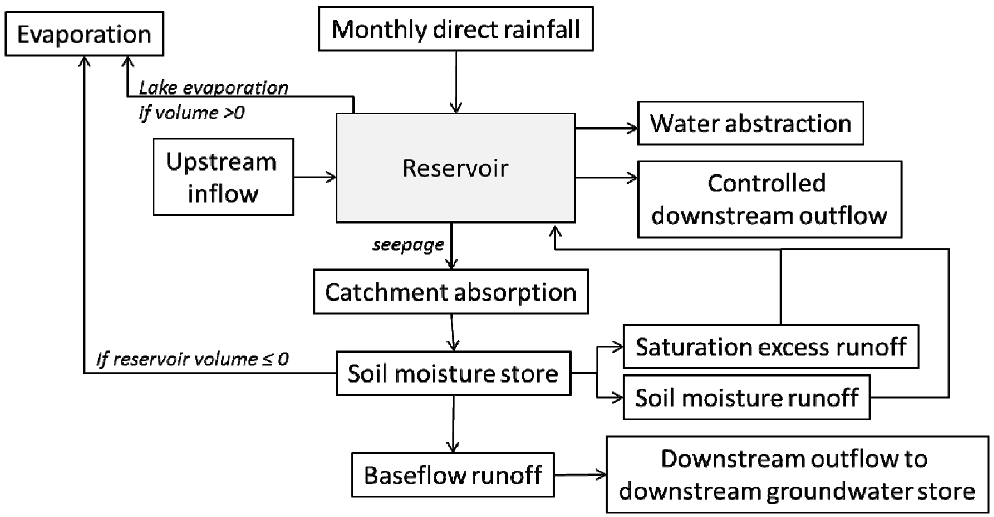


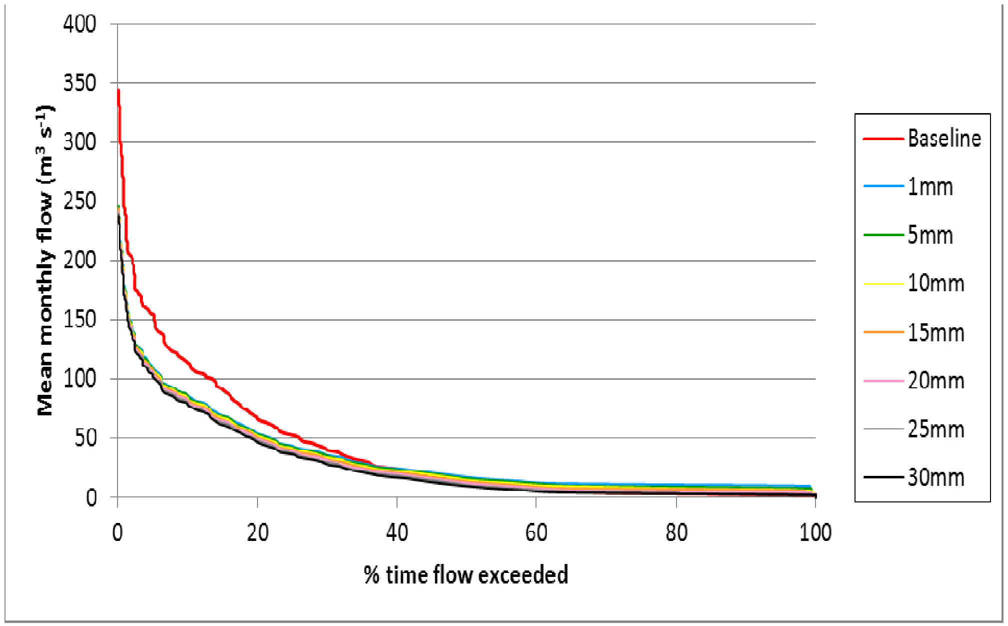
Pitman hydrological model





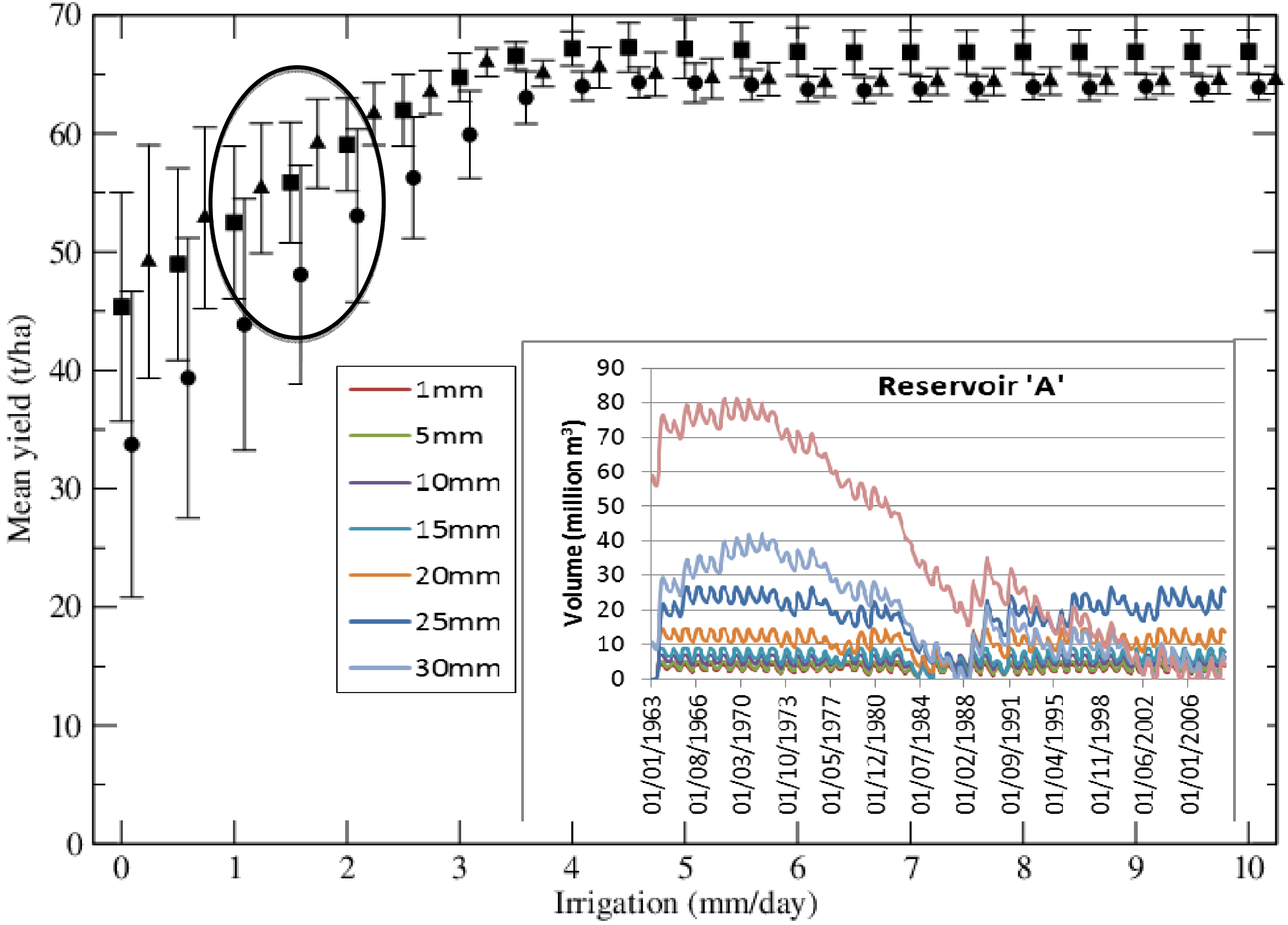
Damming the River Daka





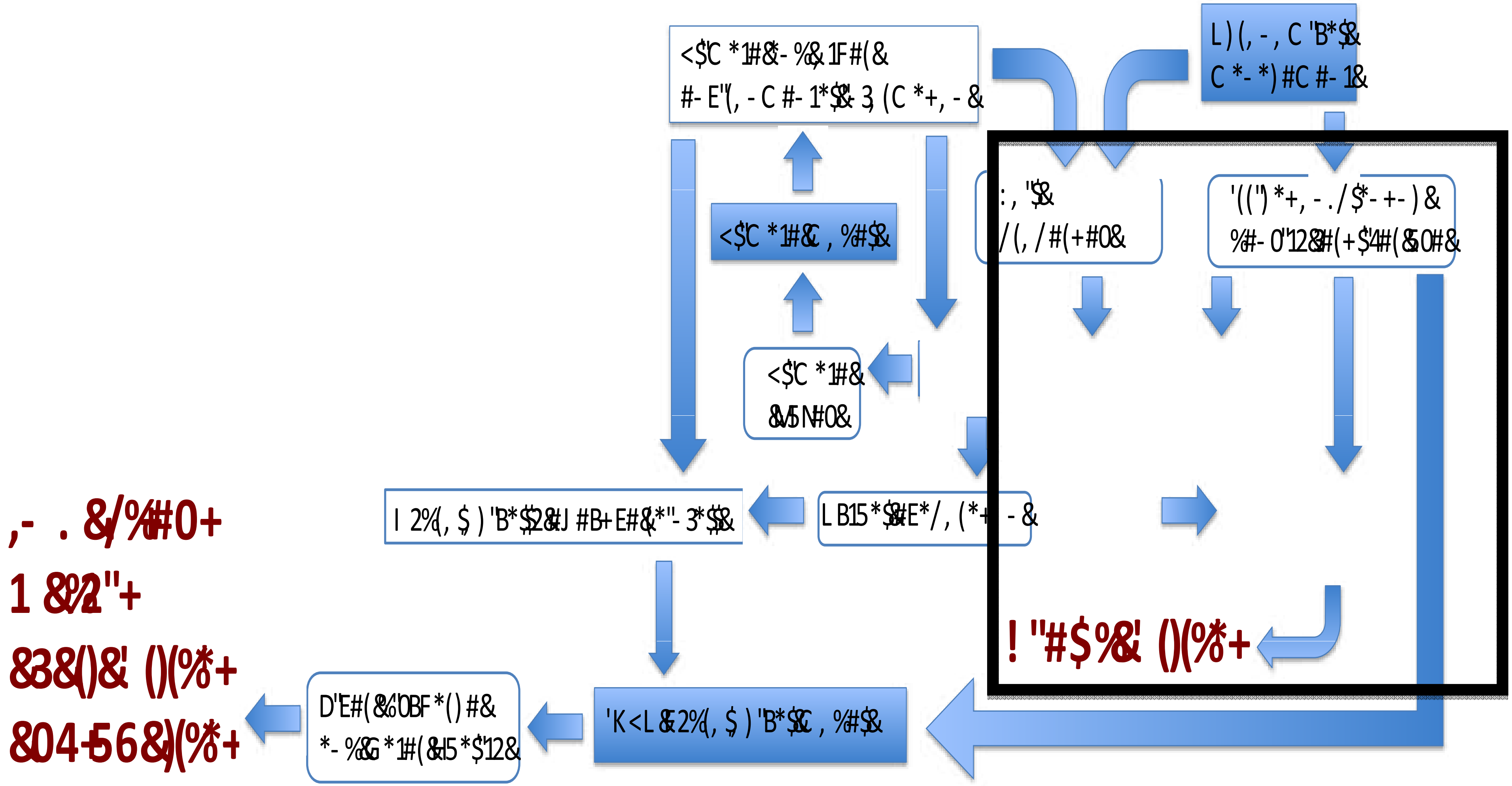
PITMAN was used to simulate damming of the River Daka. Two models were developed – with seepage (left) and without seepage (right)

Location of dams and subcatchments shown bottom right.

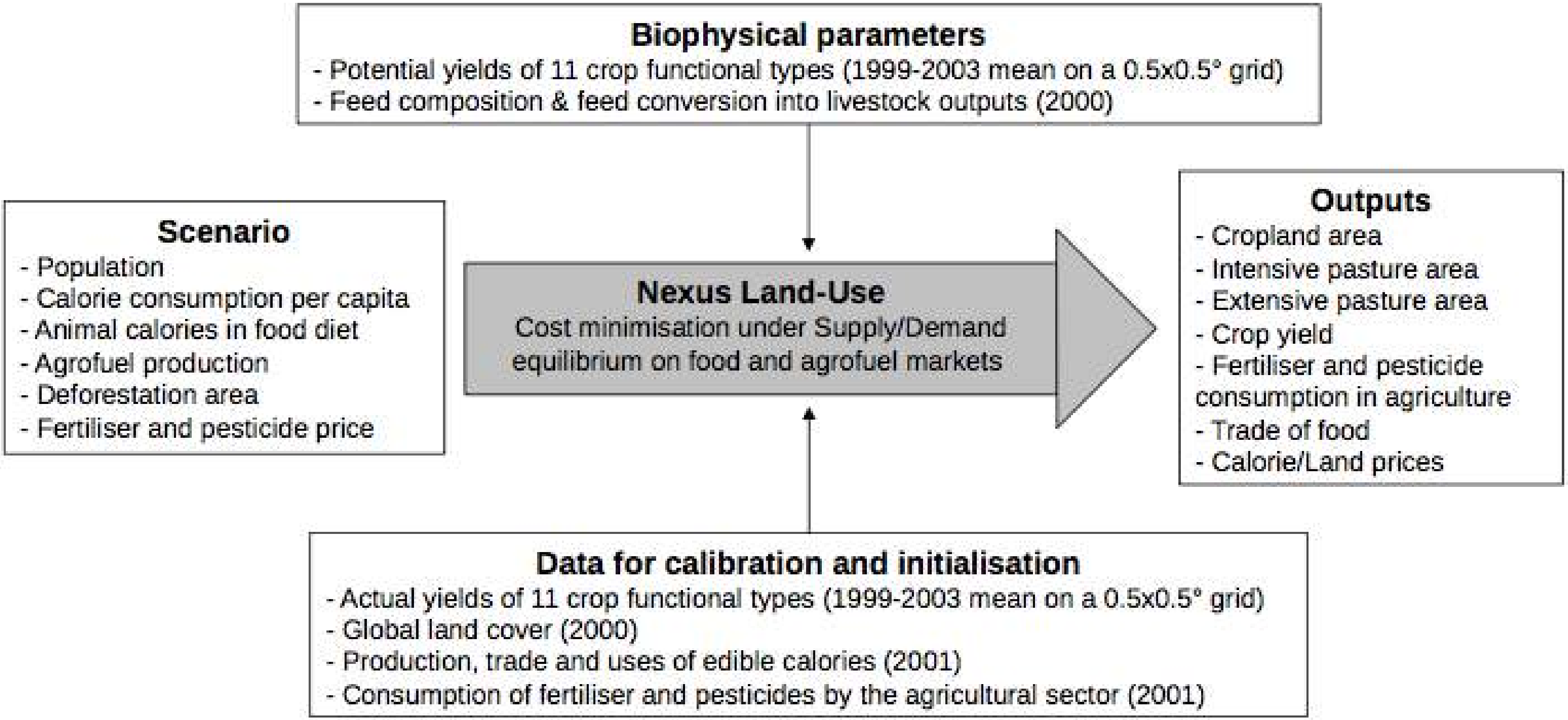


Mean yield (t/ha)
Irrigation (mm/day)
0
10
20
30
40
50
60
70
0
1
2
3
4
5
6
7
8
9
10
1mm
5mm
10mm
15mm
20mm
25mm
30mm
Reservoir 'A'
Volume (million m3)
90
80
70
60
50
40
30
20
10
0
01/01/1963
01/08/1966
01/03/1970
01/10/1973
01/05/1977
01/12/1980
01/07/1984
01/02/1988
01/09/1991
01/04/1995
01/11/1998
01/06/2002
01/01/2006

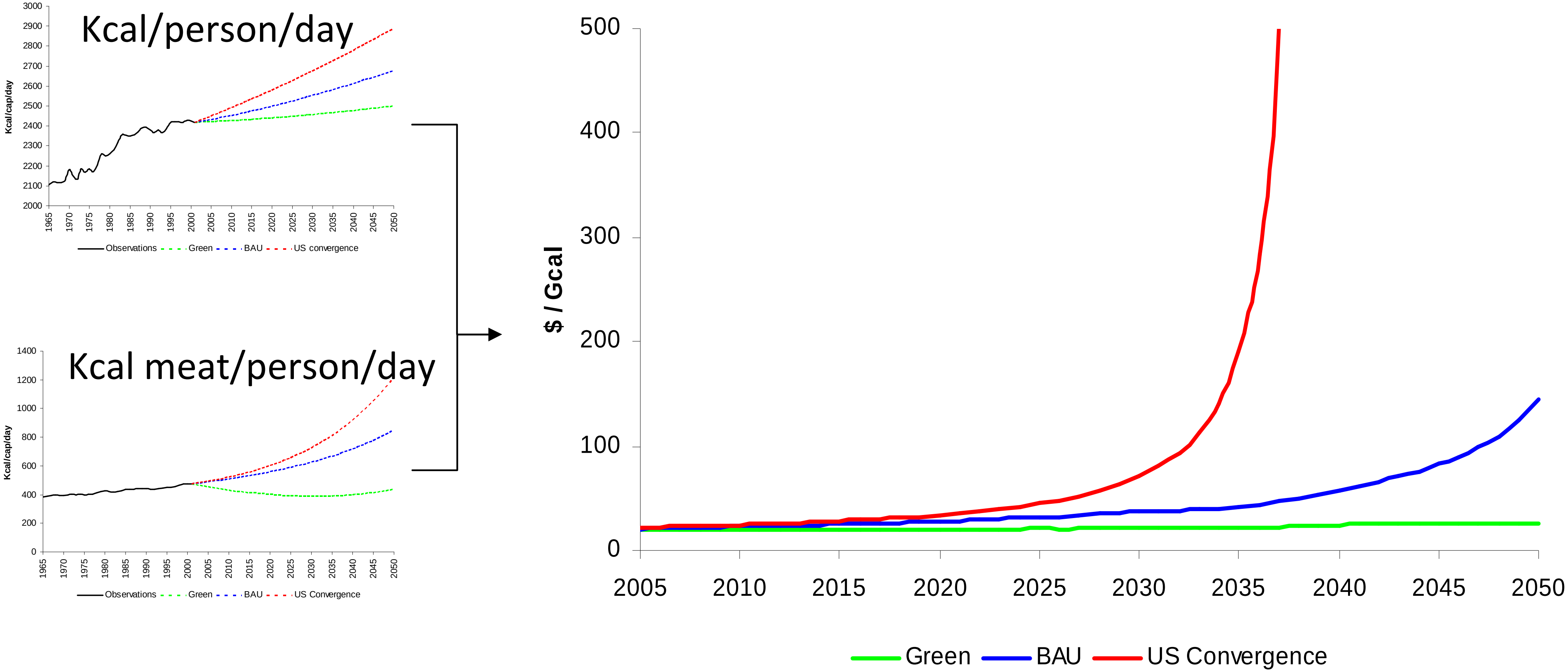
ICWALPA modelling framework



The Nexus Land-Use: a model articulating biophysical potentials and economic dynamic



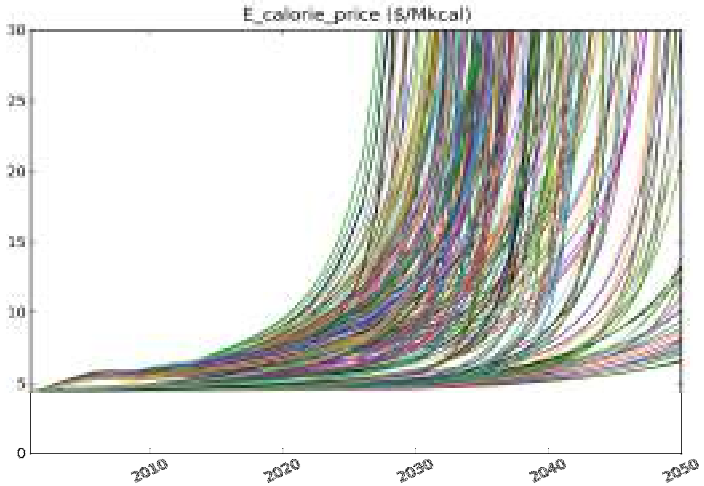
Calorie price evolution in the three food scenarios



The impact of bioenergy production on agricultural price

Yearly evolution of the world calorie price

	Référence	(1)	(1) + (2)
Green	1.1%	1.8%	1.4%
BAU	4.6%	12.4%	5.4%
US convergence	-	-	-



(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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