Four degrees and beyond: What might this mean for agriculture in sub-Saharan Africa?

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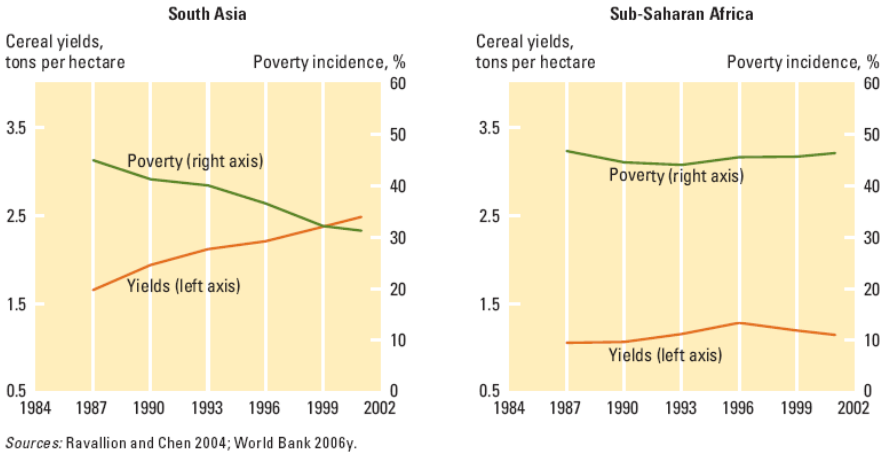
Outline

- The African agricultural development context
- Impacts of climate change on agriculture in SSA
  - What do we know?
  - Impacts of +5°C on growing seasons and crop yields
- What's the outlook, and what needs to be done?

The African context

- Population: 0.8 billion now to 1.8 billion in 2050
- Income per capita growing slowly in some places
- Population is urbanising: <30% in 1980 to >40% in 2009
- Food demand:
  - Livestock products up from 200 kcal per person per day (2000) to 400 kcal (2050)
  - Cereal demand will more than double

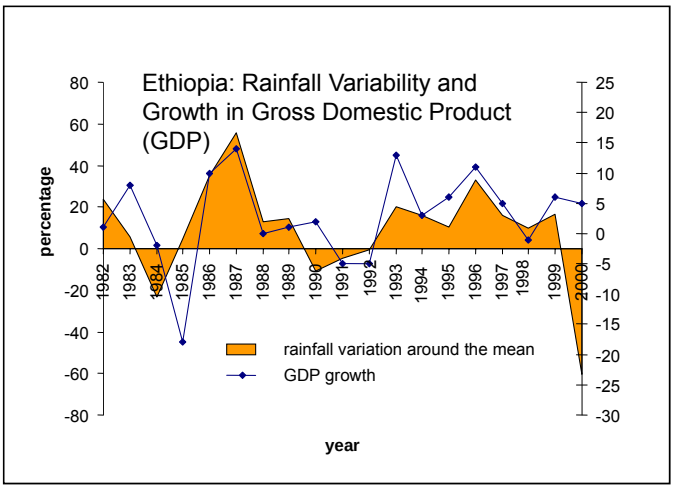
In South Asia, cereal yields are up and poverty down … … but not in Sub-Saharan Africa



Sources: Ravallion and Chen 2004; World Bank 2006y.

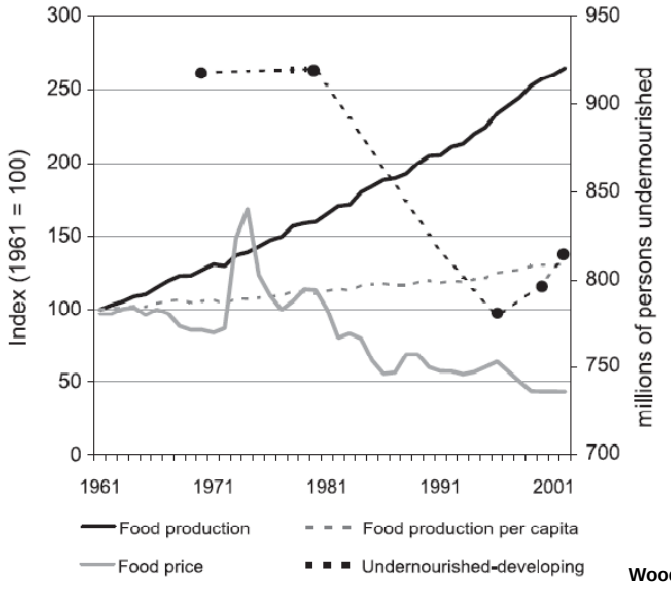
World Development Report 2008 (WB)

Why is climate change so important in SSA?



de Jong (2005), World Bank (2005)

Can it all be held together into the future?



Wood et al. (2005)

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Impacts of climate change on crops in SSA

- Several studies on yield impacts: ranges depend on the methods, models, emission scenarios, time horizon
- Major cereals: yields reduced overall by 10-30% to mid-century and beyond
- Considerable heterogeneity in response by crop, by location

Indicative production changes to the 2050s

DSSAT v4, mean of 2 GCMs and 2 emission scenarios

	National Production	By System		
		MRT	MRH	MRA
Maize:				
Burundi	+14%	+18%	-9%	
Tanzania	-8%	+9%	-6%	-11%
Phaseolus Beans:				
Uganda	-18%	+4%	-21%	-13%

MRT Mixed rainfed tropical highland
MRH Mixed rainfed humid-subhumid
MRA Mixed rainfed arid-semiarid

Thornton et al. (2009)

Impacts of climate change on livestock production systems

	Grazing systems	**Non-grazing systems**
Direct impacts	– Extreme weather events – Drought and floods – Productivity losses (physiological stress) due to temperature increase – Water availability	– Water availability – Extreme weather events
Indirect impacts	Agro-ecological changes: – fodder quality & quality – host-pathogen interactions – disease epidemics	– Increased resource price, e.g. feed and energy – Disease epidemics – Increased cost of animal housing, e.g. cooling systems

Gerber (2009)

Impacts on systems and livelihoods

Considerable uncertainty, much still to be quantified:

- Interactions between crops, livestock, other livelihood activities
  - Shifts in cropping, in livestock species
  - Livelihood transitions
  - Household-level risk
  - …
- Interactions with health, water, energy, …
  - Human health and labour issues (droughts, floods)
  - Access to food, to markets
  - …

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GCM data used

IPCC Fourth Assessment models and data:

- 14 GCMs
- 3 emissions scenarios (SRES B1, A1B, A2)
- Monthly data for the 2090s: rainfall, tmax, tmin
- Scaled to +5°C

http://www.geog.ox.ac.uk/~clivar/ClimateAtlas/4deg.html

Thanks to Mark New and Gil Lizcano

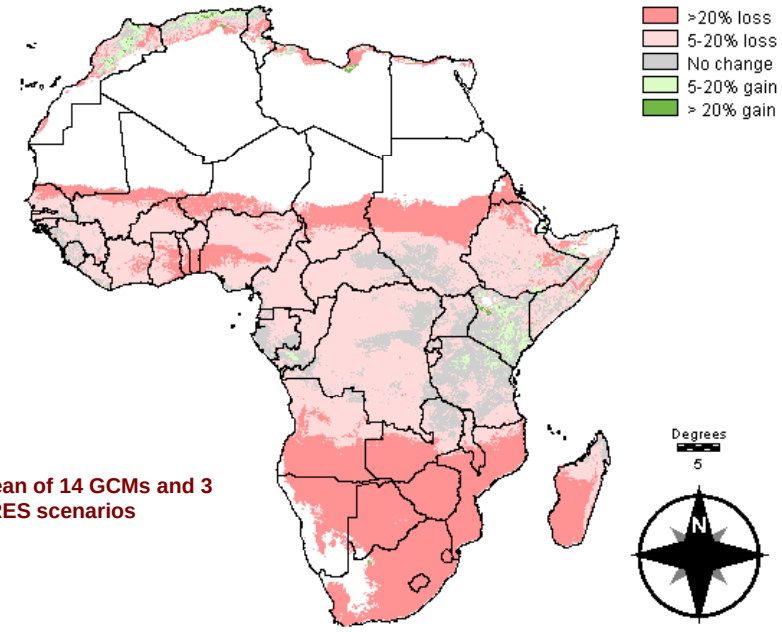
Analysis

• Generated characteristic daily weather data using MarkSim as a GCM downscaler (difference interpolation + stochastic downscaling + weather typing)

• Estimated growing days and growing seasons using daily weather data and a simple water balance model

• Estimated number of failed seasons over 100 years (no season at all, fewer than 50 growing days in a season, more than 30% stress days within a season that has started)

Changes in length of growing period from 2000s to 2090s

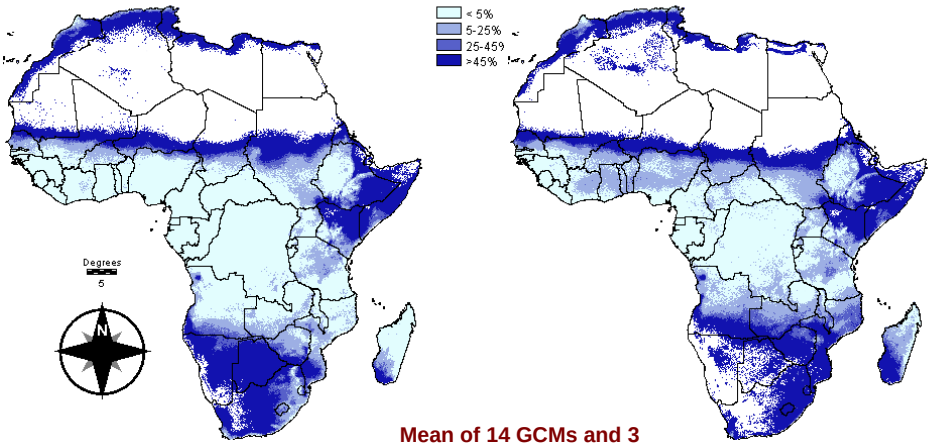


Mean of 14 GCMs and 3 SRES scenarios

Probability of failed seasons

2000s

2090s



Mean of 14 GCMs and 3 SRES scenarios

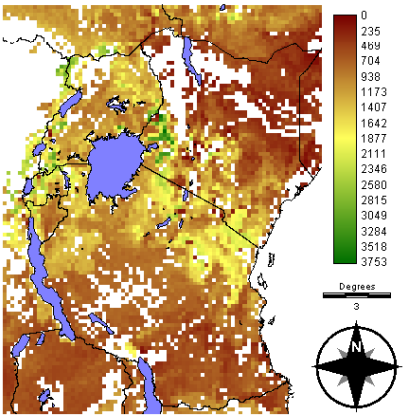
Crop modelling

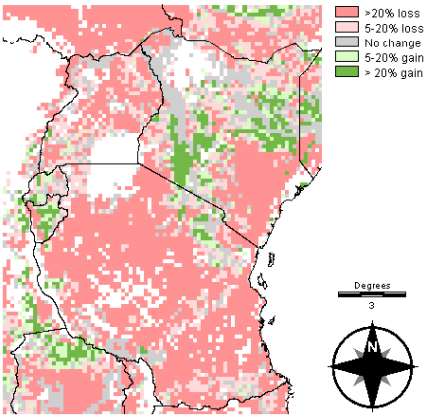
For the area from latitudes 12°S - 6°N and longitudes 28°E - 42°E

- We looked at
  - Maize
  - *Phaseolus* bean
  - *Brachiaria decumbens*
- Used the crop models in the DSSAT v4 (ICASA, 2007)
- Used a 10-arc-minute pixel triage based on cropland and pastureland as defined by Ramankutty et al. (2006)

Simulated current maize yield and % change to the 2090s

Mean of 18 GCMs and 3 SRES scenarios





Simulated yields (pixel-weighted averages of 30 independent replications) for E Africa for three crops grown on cropland and pastureland

Crop	Yield (kg per ha)		% Yield Change
	2000s	2090s +5°C	
Maize	954	706	-26
Beans	656	305	-54
B. decumbens	1386	1368	-1

Work in progress:
- Impacts for all SSA may be considerably worse (few other areas where LGP ↑)
- Look at variation between GCMs, scenarios, systems

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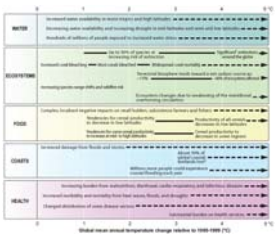
What will a +5°C agriculture look like in SSA?

- Much less food for people overall
- In many places, much higher probabilities of crop failures
- Massive increases in intensive cropping in the highlands ("sustainable intensification")
- Huge expansion of the marginal areas (highly uncertain cropping)
- Radical livelihood transitions (croppers to livestock keepers, abandonment of agriculture, …)

and what about

- Water, human health, crop/livestock disease, weeds & pests, other ecosystem and coastal impacts, …



The prognosis for a +5°C SSA

- Appalling – rainfed agriculture in many places would cease to viable
- Croppers and livestock keepers have been highly adaptable to short- and long-term variations in climate
- But the changes in a plus five-degree world would be way beyond experience
- Number of people at risk from hunger has never been higher: 300 million in 1990, 700 million in 2007, and >1 billion in 2010 (FAO)

What needs to be done?

• Many uncertainties: tipping points, thresholds, limits to adaptation, systems' impacts

• Evidence gaps: e.g., interactions between CO_2, ozone, biotic and abiotic stresses, on crops, rangeland, livestock

• Need comprehensive tools for the analysis of tradeoffs and for negotiations: economic growth vs food security vs equity vs environmental sustainability

What needs to be done?

• Build on adaptability of African croppers and livestock keepers: many options could help farmers adapt

• Need substantial investments in technological R&D, institution building, and infrastructural development

• Do we really have the right development paradigm for Africa, one that builds on local, indigenous skills, knowledge, culture?

• But a +5°C world? We had better avoid it at all costs

Photo: An Notenbaert

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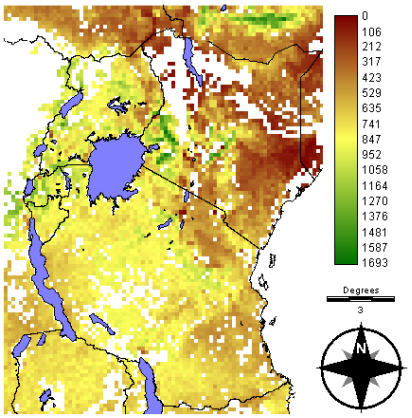
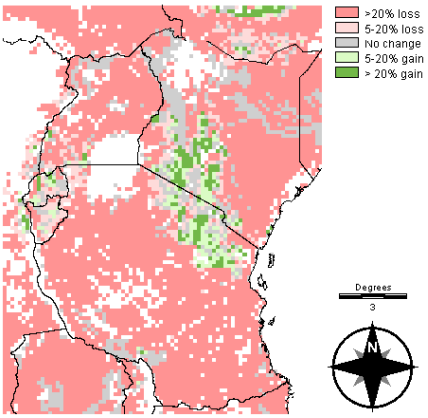
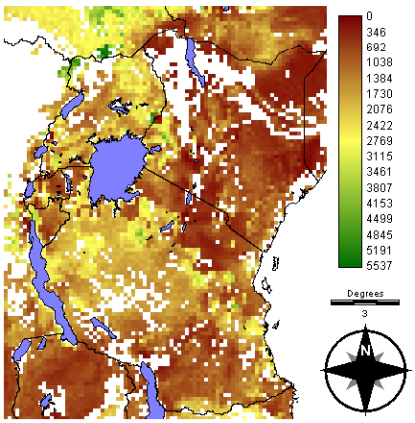
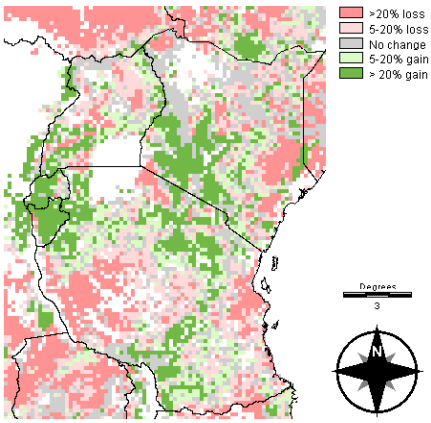
Simulated current bean yield and % change to the 2090s
Mean of 18 GCMs and 3 SRES scenarios

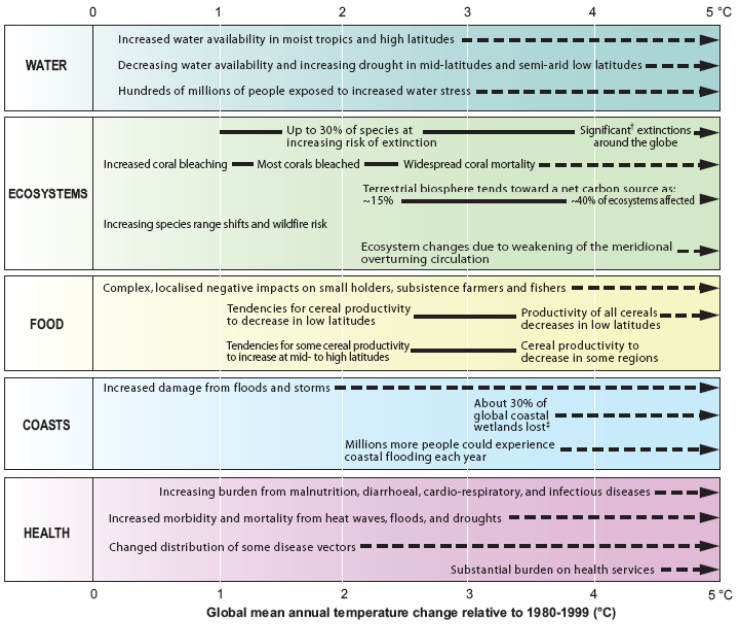




Simulated current *B decumbens* yield and % change to the 2090s
Mean of 18 GCMs and 3 SRES scenarios







Demand for maize grain for human consumption in 2000 and 2050 in E Africa

		2000		2050	
	Maize consumption (kg per person)[a]	Population (million)[b]	Demand for maize (t*1000)	Population (million)[b]	Demand for maize (t*1000)
Burundi	24	6.67	160	28.31	679
Kenya	88	31.25	2,750	84.76	7,459
Rwanda	9	8.18	73	22.63	204
Tanzania	73	33.85	2,471	85.08	6,211
Uganda	31	24.69	765	92.93	2,881
Total		104.64	6,220	313.71	17,434

a Data for 2003 from FAOSTAT (2008).
b Data from UNPD (2008).