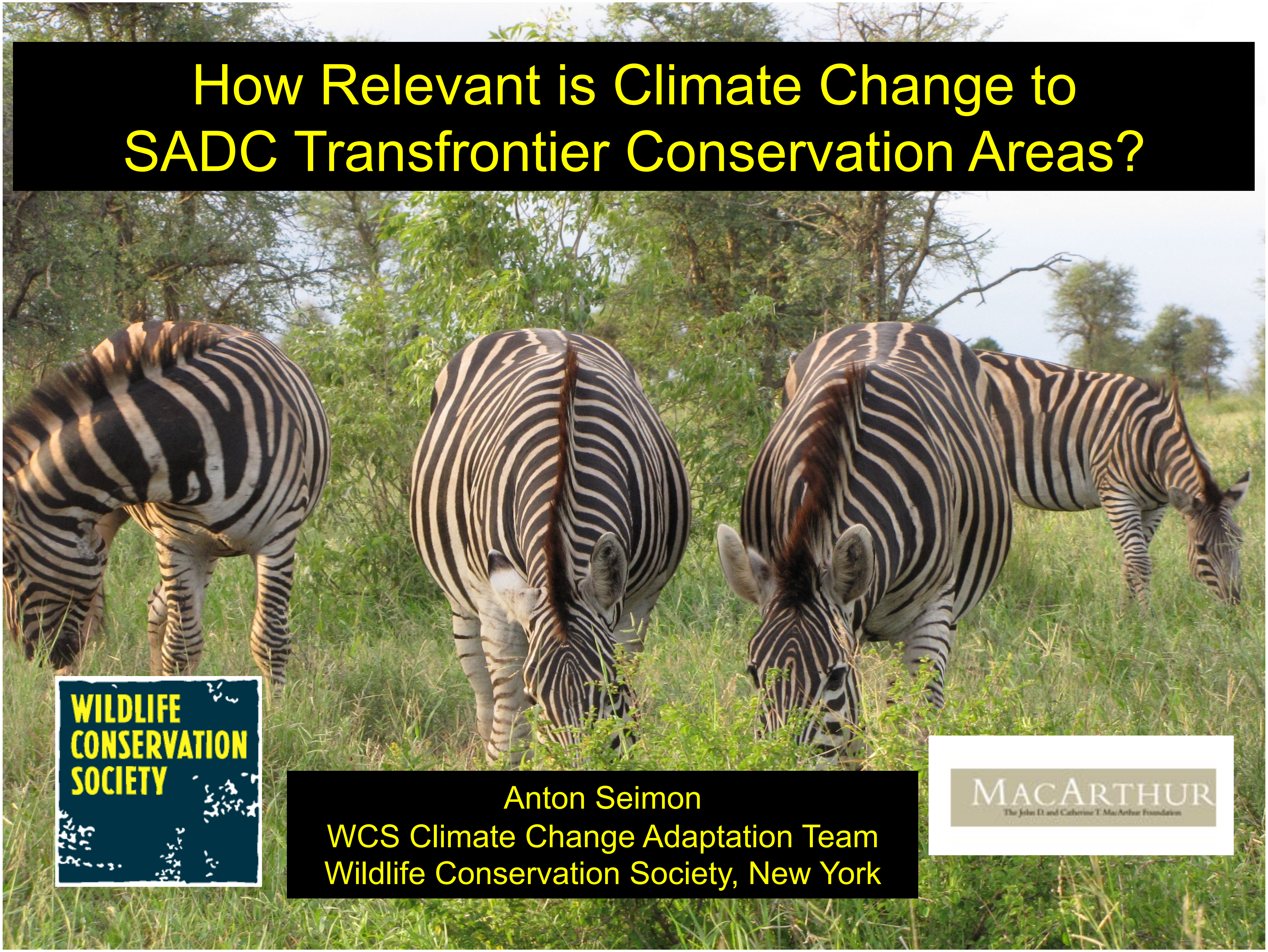
How Relevant is Climate Change to SADC Transfrontier Conservation Areas?



WILDLIFE CONSERVATION SOCIETY

Anton Seimon
WCS Climate Change Adaptation Team
Wildlife Conservation Society, New York

MACARTHUR
The John D. and Catherine T. MacArthur Foundation

General Principles of Climate Change Adaptation for Conservation

From "Adaptation 2009" discussion paper by Glick, Staudt, Stein

1. Reduce non-climate stressors

2. Manage for ecological function and protection of biological diversity

3. Establish buffer zones and connectivity

4. Implement "proactive" management strategies

5. Increase monitoring and facilitate management under uncertainty

Requires baseline measurements and understanding of relationship between climatology and ecology.

CLIMATE CHANGE AND INFECTIOUS DISEASES

Climate change and population health in Africa: where are the scientists?

Peter Byass*

Umeå Centre for Global Health Research, Department of Public Health and Clinical Medicine, Umeå University, Umeå, Sweden

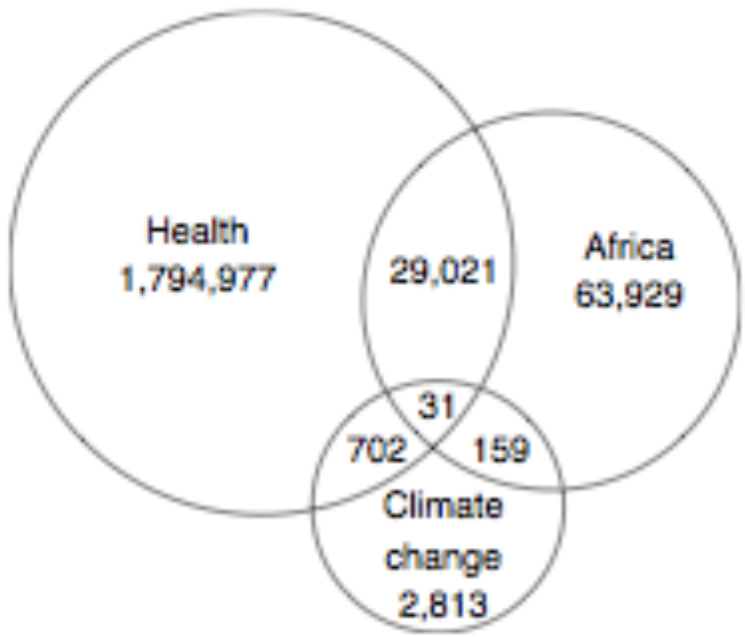


Fig. 1. Results of a PubMed search for 'health', 'Africa' and 'climate change' (26 June 2009) showing the intersections between the three terms (total citations 1,891,632).

Byass, Global Health Action 2009

Omumbo *et al. Malaria Journal* 2011, **10**:12
http://www.malariajournal.com/content/10/1/12

MALARIA JOURNAL

RESEARCH **Open Access**

Raised temperatures over the Kericho tea estates: revisiting the climate in the East African highlands malaria debate

Judith A Omumbo[1], Bradfield Lyon[1], Samuel M Waweru[2], Stephen J Connor[1], Madeleine C Thomson[1*]

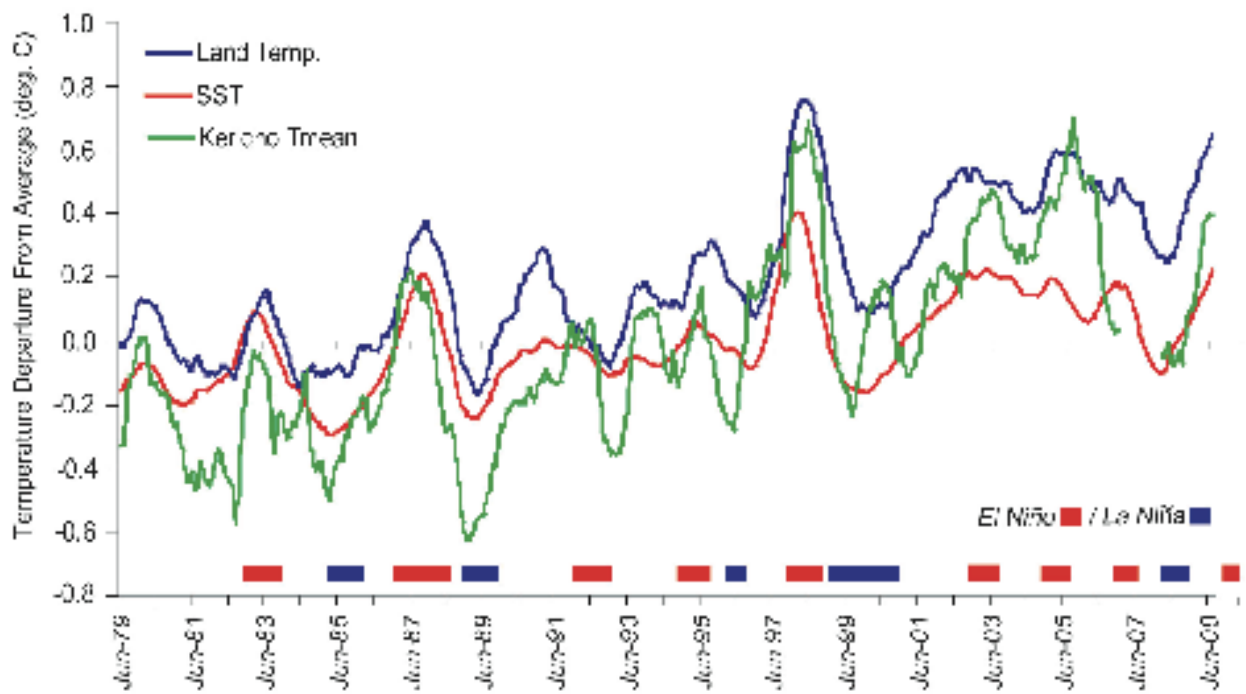


Figure 4 Time series of monthly departures from 1980-2009 mean values (deg. C) with an 11-month moving average applied for Kericho Tmean (green line), global tropical SST (25S-25N) (red line) and tropical land area mean temperature (blue line). Color bars at the bottom of the figure show the occurrence of El Niño and La Niña events (based on the definition in use at the US Climate Prediction Center). See Table 2 for temporal correlations between these variables.

Omumbo *et al. Malaria Journal* 2011, **10**:12
http://www.malariajournal.com/content/10/1/12

MALARIA JOURNAL

RESEARCH **Open Access**

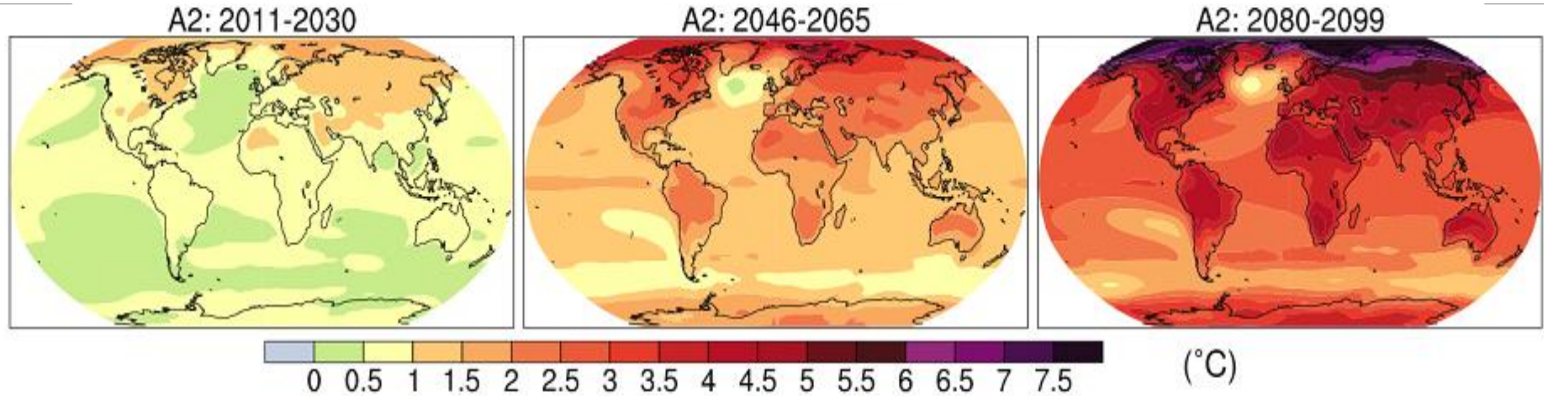
Raised temperatures over the Kericho tea estates: revisiting the climate in the East African highlands malaria debate

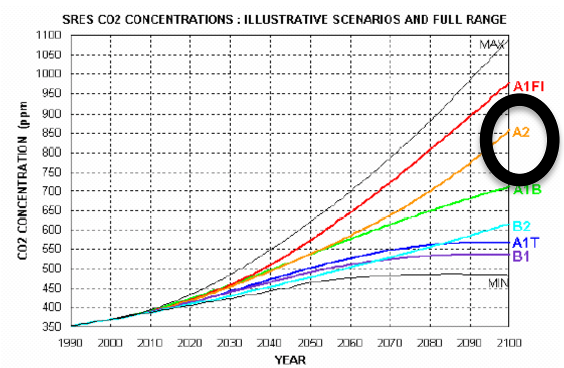
Judith A Omumbo[1], Bradfield Lyon[1], Samuel M Waweru[2], Stephen J Connor[1], Madeleine C Thomson[1*]

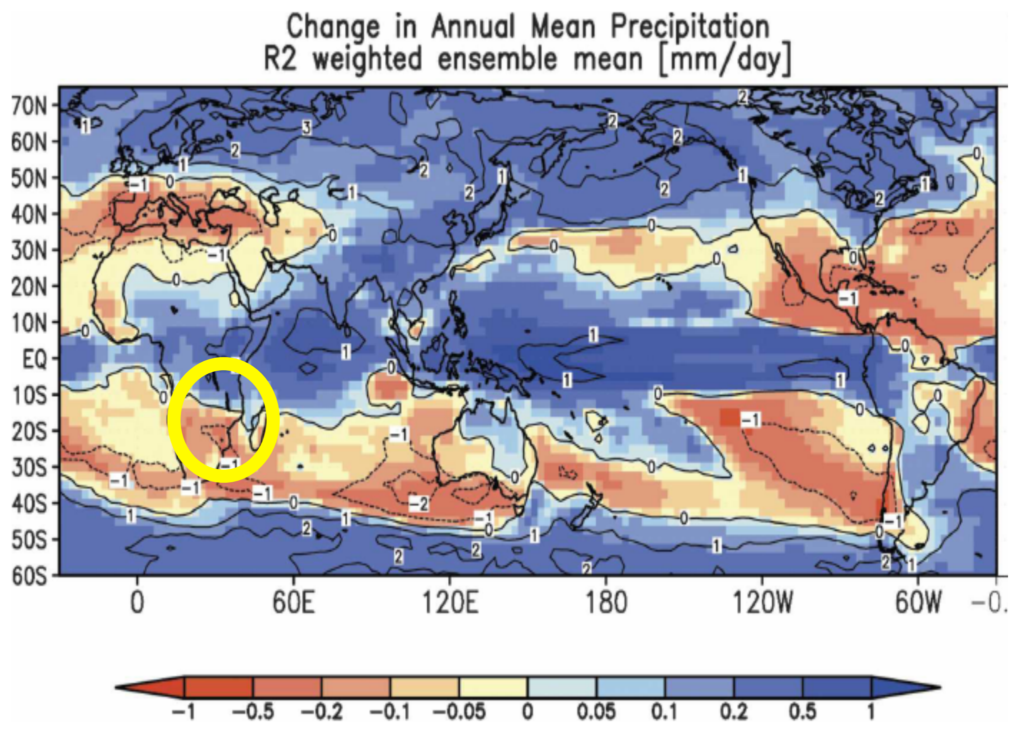
“The significance of the warming trend observed in this study (> 0.2°C per decade) to changes in malaria transmission potential has yet to be assessed but indications from other studies suggest that in this region, even a modest change in temperature can have a significant effect on transmission.“

“The missing links in addressing knowledge gaps of the role of local climate processes in disease transmission are high quality data coupled with the skilled interpretation of epidemiologists working in collaboration with climate scientists.”

IPCC A2 scenario





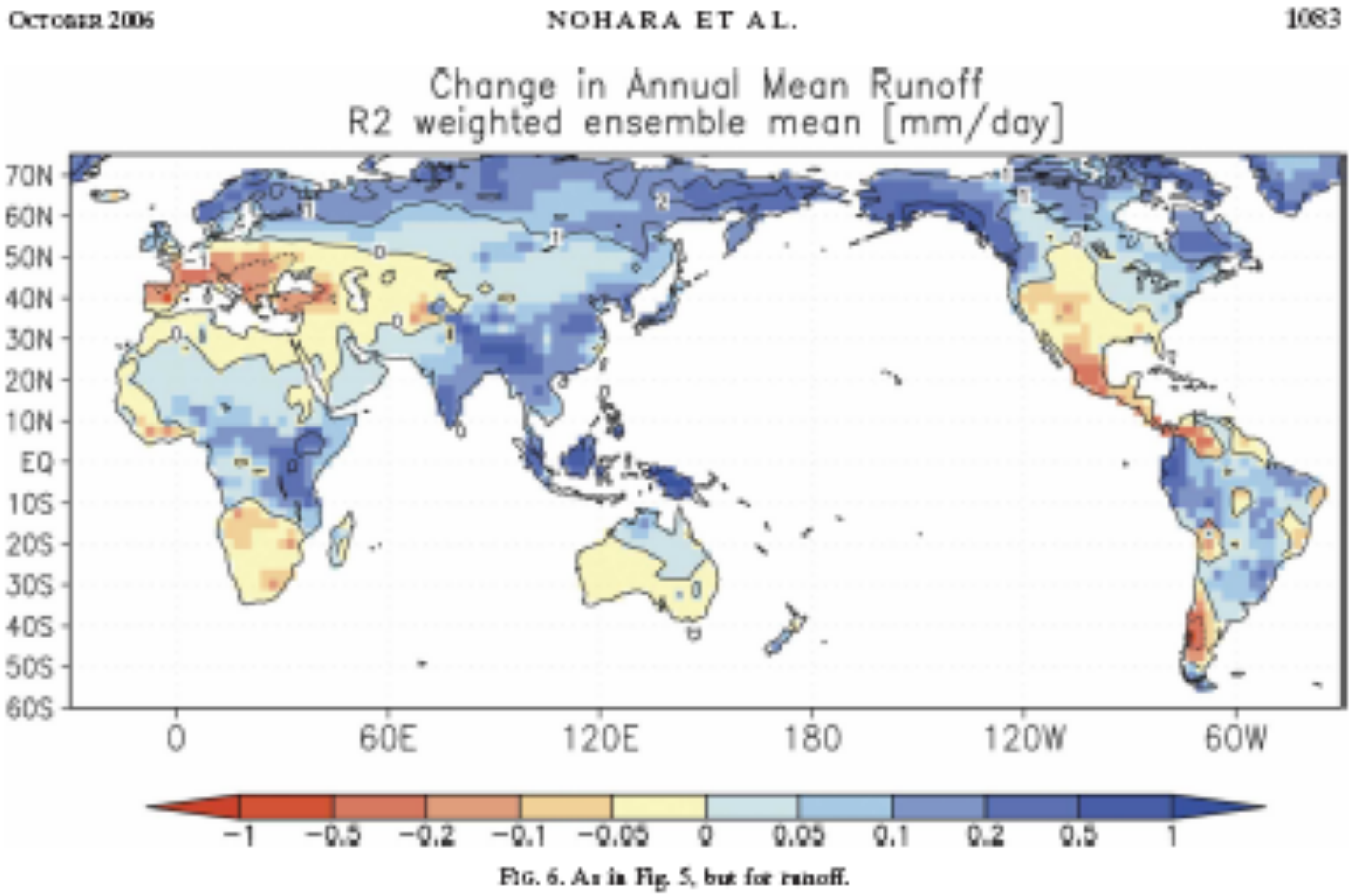


IPCC multi-model projections for end of 21st century compared to present

Nohara et al.,*Journal of Hydrometeorology,* 2006

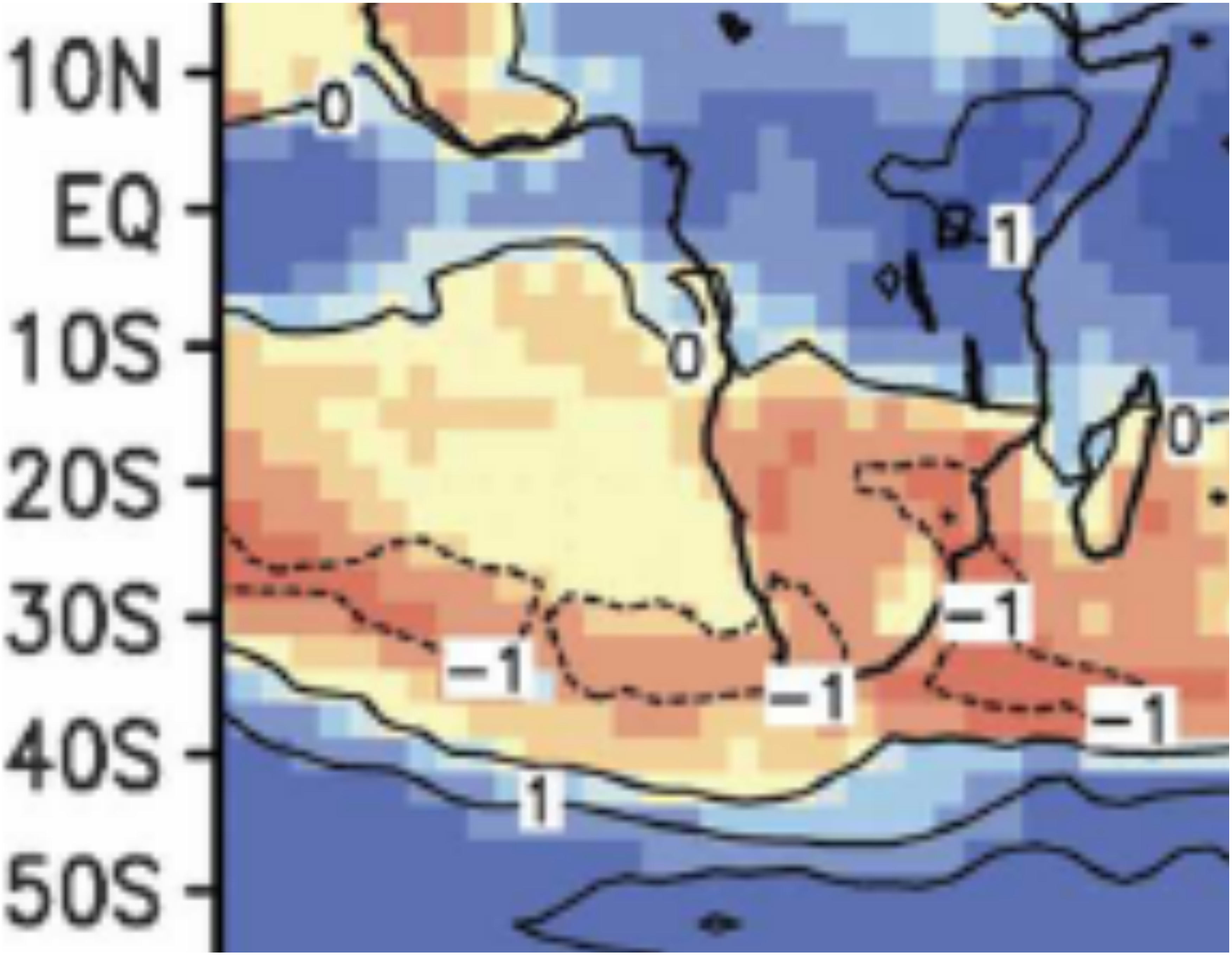
River discharge changes in 2100

derived product combining modeled precipitation and evaporation



Impact of Climate Change on River Discharge Projected by Multimodel Ensemble

Nohara et al.,*Journal of Hydrometeorology,* 2006



10N
EQ
10S
20S
30S
40S
50S
0
0
0
1
-1
-1
-1
-1
-1
1

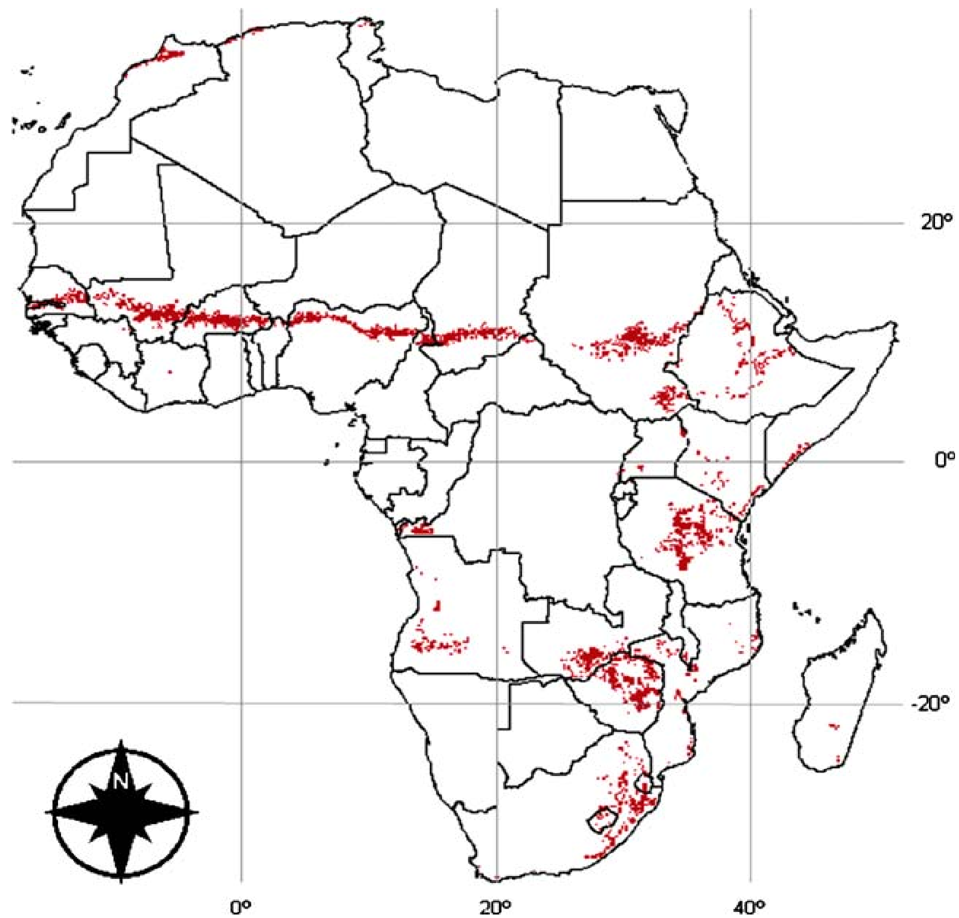


Fig. 3 – Transition zones in the mixed rainfed arid–semiarid system, in which the Reliable Crop Growing Days (RCGD) falls below 90 between 2000 and 2050, as projected using the HadCM32 model and the A1FI scenario.

Peter G. Jones and Philip K. Thornton, 2009: Croppers to livestock keepers: livelihood transitions to 2050 in Africa due to climate change, Environmental science & policy 12 (2009) 427–437

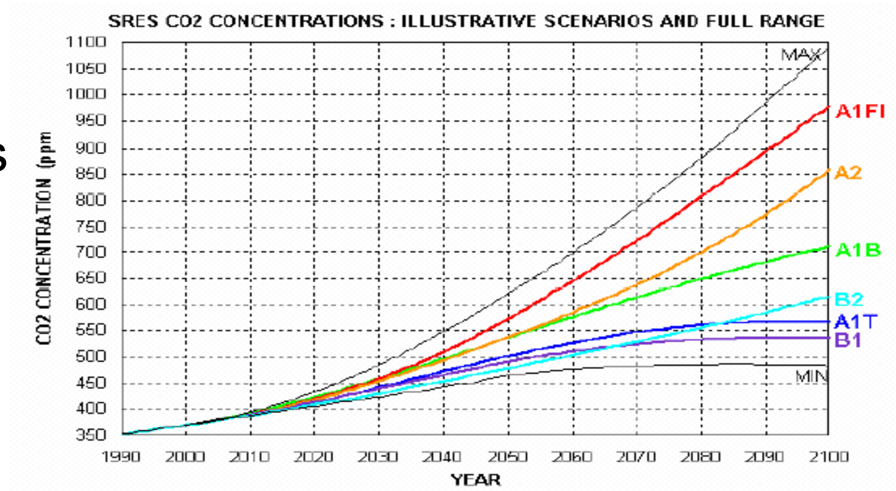
Agriculture and food systems in sub-Saharan Africa in a four-plus degree world

P K Thornton, P G Jones, P J Ericksen, A J Challinor

Phil. Trans. R. Soc. A, 2011

IPCC Fourth Assessment models and data:

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



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

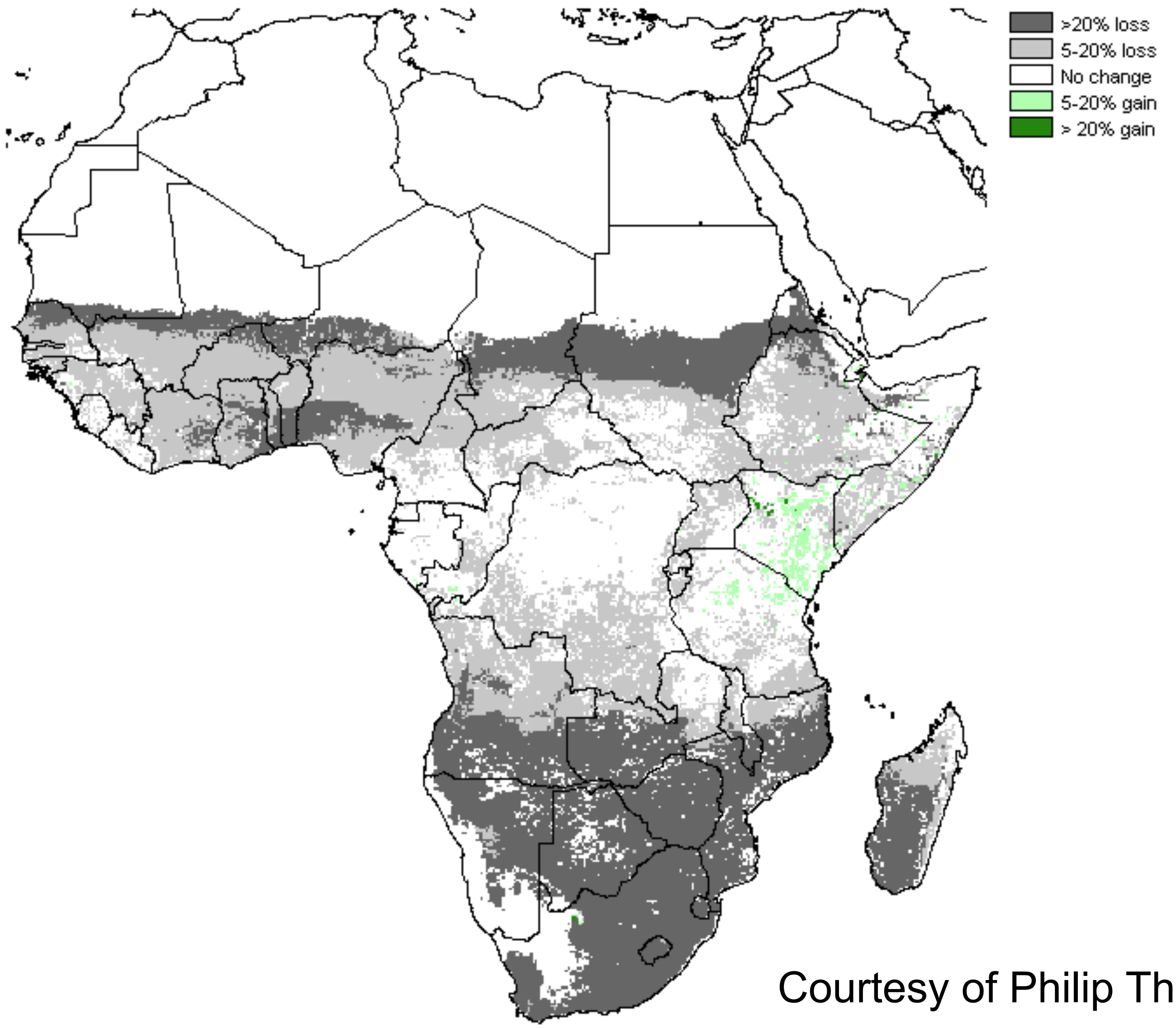
• Estimated number of failed seasons over 100 years (defined as no season at all or fewer than 50 growing days in a season or more than 30% stress days within a season that has started)

• Crop modeling study looked at:
  - Maize (a C_4 crop)
  - *Phaseolus* bean (a C_3 crop)
  - *Brachiaria decumbens* (an indicator pasture species)

Philip Thornton (ILRI) 2011

Ensemble mean of Length of Growing Period change estimates to the 2090s

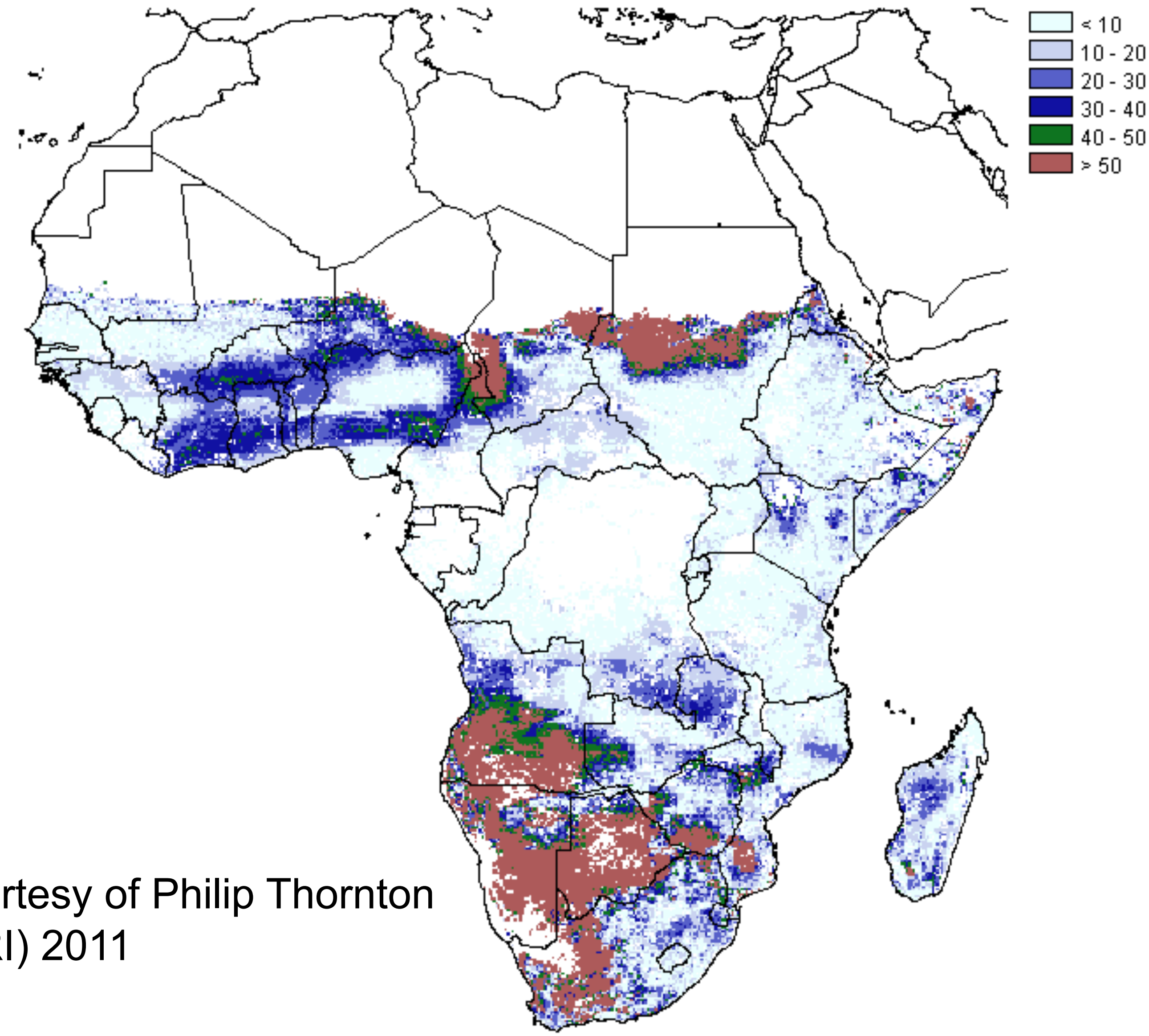
Substantial losses away from equator, some small gains in parts of E Africa



Courtesy of Philip Thornton (ILRI) 2011

Ensemble CV (%) of LGP change estimates to the 2090s

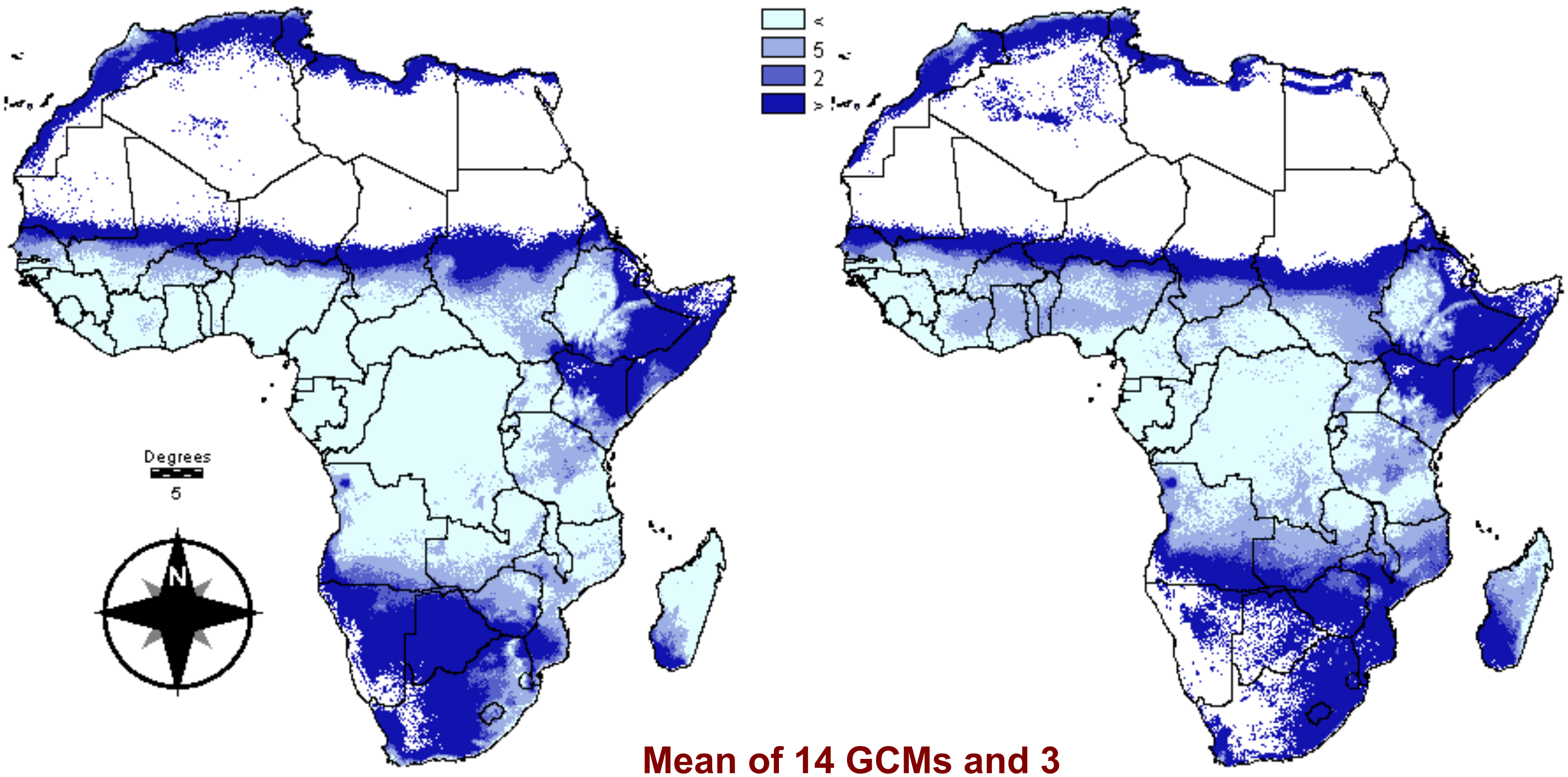
Three zones – background small variation (<20), then higher in cropland (dark blue), then green and brown in arid-semiarid rangelands



Courtesy of Philip Thornton (ILRI) 2011

Probability of failed seasons

2000s **2090s**



Mean of 14 GCMs and 3 SRES scenarios

Courtesy of Philip Thornton (ILRI) 2011

Simulated yields (30 reps) in SSA under current conditions and in the 2090s

	2000s Yield kg/ha	2090s +5°C Yield kg/ha †	Mean % change in production †	CV of change in production % ‡
Maize				
Central	744	612	-13	23
East	954	689	-19	7
Southern	748	612	-16	22
West	764	536	-23	23
Mean	806	612	-24	19
Beans				
Central	666	175	-69	58
East	685	263	-47	6
Southern	716	220	-68	48
West	487	63	-87	47
Mean	639	182	-71	34
B. decumbens				
Central	1493	1311	-4	3
East	1745	1570	+9	7
Southern	1384	1344	+11	18
West	1498	1437	-6	27
Mean	1525	1422	-7	15

Thornton, Jones, Ericksen, Challinor (2010)

Simulated yields (30 reps) in SSA under current conditions and in the 2090s

	2000s Yield kg/ha	2090s +5°C Yield kg/ha †	Mean % change in production †	CV of change in production % ‡
Maize				
Central	744	612	-13	23
East	954	689	-19	7
Southern	748	612	-16	22
West	[illegible]	[illegible]	[illegible]	23
Mean	[illegible]	[illegible]	[illegible]	19
Beans				
Central	[illegible]	[illegible]	[illegible]	58
East	[illegible]	[illegible]	[illegible]	6
Southern	[illegible]	[illegible]	[illegible]	48
West	[illegible]	[illegible]	[illegible]	47
Mean	639	182	-71	34
B. decumbens				
Central	1493	1311	-4	3
East	1745	1570	+9	7
Southern	1384	1344	+11	18
West	1498	1437	-6	27
Mean	1525	1422	-7	15

High CVs of yield changes: results depend on choice of GCM & emissions scenario

Thornton, Jones, Ericksen, Challinor (2010)

What will a +5°C agriculture look like in Sub-Saharan Africa?

Losses in length of growing season translate directly into crop yield decreases:

- Much less food for people overall
- In many places, much higher probabilities of crop failures
- Massive increases in intensive cropping in the highlands will be needed
- Huge expansion of the marginal areas (highly uncertain cropping)
- Radical livelihood transitions (croppers to livestock keepers, abandonment of agriculture…)
- Rainfed agriculture in many places (including south of the Zambezi) would cease to viable
- …and what about water, human health, crop/livestock disease, weeds & pests, other ecosystem impacts…?

Courtesy of Philip Thornton (ILRI) 2011

The prognosis for a +5°C Sub-Saharan Africa

- Appalling – rainfed agriculture in many places (including south of the Zambezi) 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

Courtesy of Philip Thornton (ILRI) 2011

Climate change and adaptive management for conservation

Climate model output = means of temperature, wind circulation and precipitation, etc.

What information do we need?
- precipitation amount – *how much will it rain?*
- extreme events – *floods, droughts, thermal extremes*
- seasonality – *when will it rain?*
- evaporation – *water loss from soils, vegetation, water bodies*
- river flows – *how will they change?*
- biomes – *change in extent and species composition*
- fire and pests – *how will disturbance regimes change?*
- human/wildlife health – *disease type, transmission and characteristics*

Challenge is to utilize climate model output create more meaningful products to inform conservation needs

Lund-Potsdam-Jena Vegetation Model simulations

- Driven by climate and soils inputs, LPJ simulates:
  - Daily: carbon and water fluxes
  - Annually: vegetation dynamics and competition amongst 10 Plant Functional Types (PFTs)
- Average grid-cell basis with a 1-year time-step
- Spin-up period of 1000 years to develop equilibrium vegetation and soil structure at start of simulation

Source: Dr. Ruth Doherty, University of Edinburgh, Kampala workshop 2008

LPJ Outputs

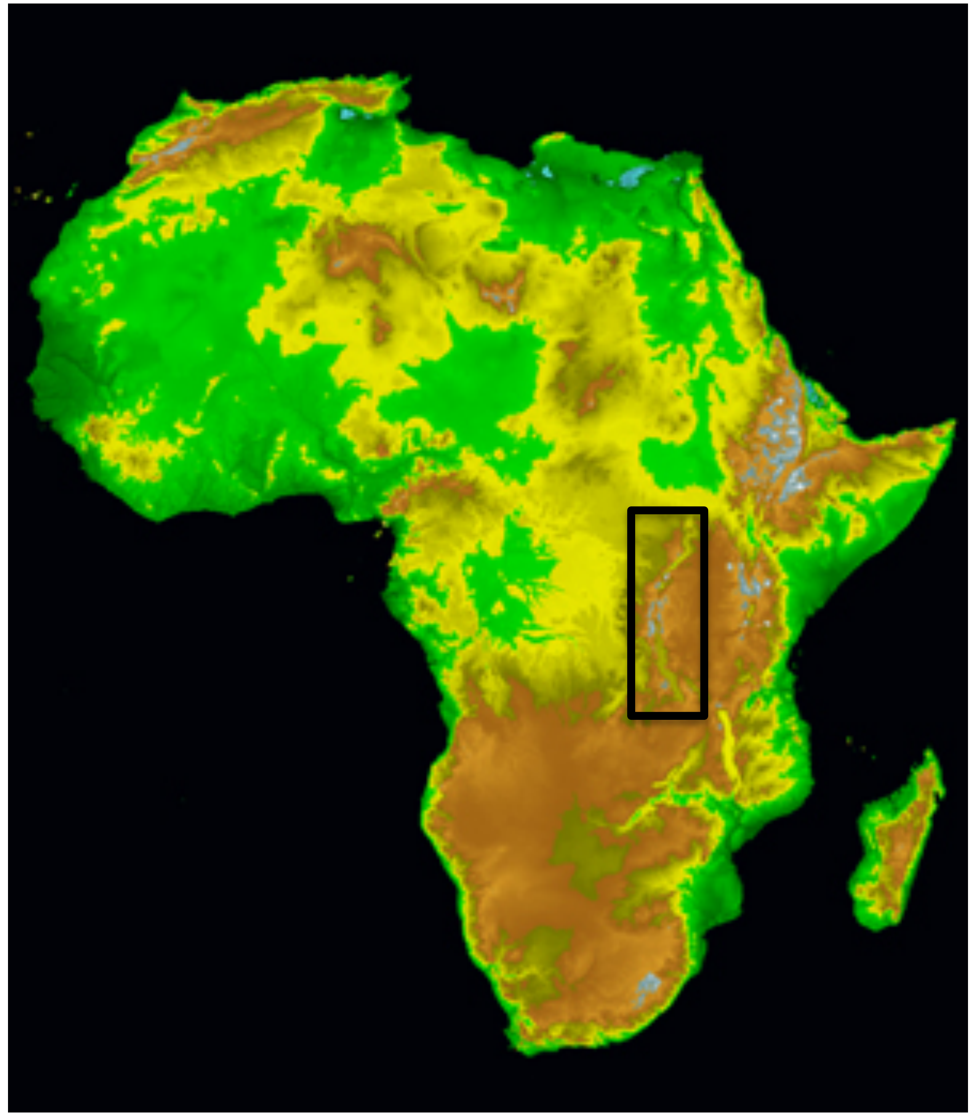
For each grid cell LPJ produces annual values for:

- Net Primary Production
- Net Ecosystem Production
- Plant Functional Type
- Heterotrophic respiration
- Vegetation carbon
- Soil carbon
- Fire carbon
- Run-off
- Evapotranspiration

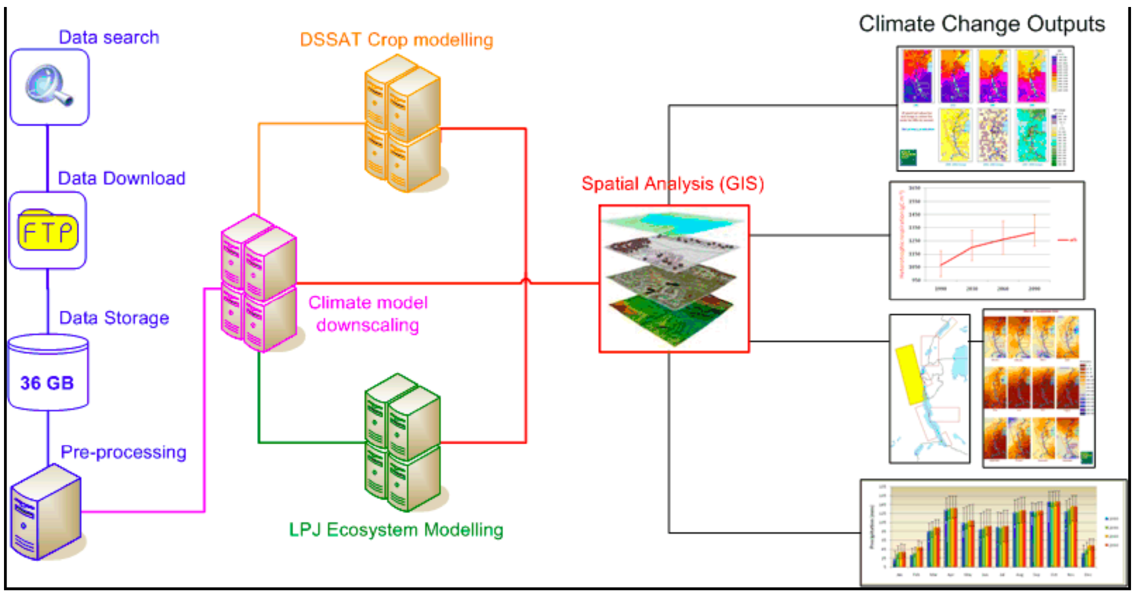
Albertine Rift Climate Assessment

Project methodology

1. Climatological assessment
2. Modeling
3. Monitoring for climate change
4. Stakeholder consultation and outreach
5. Implement adaptation activities
6. Repeat process every 5-10 years



Procedure used to generate ecologically meaningful products specific to the Albertine Rift from raw, low resolution climate model output



Picton Phillips and Seimon (2010)

OUTPUT PARAMETERS

1. Climatological variables
- Monthly mean temperature (°C)
- Monthly mean precipitation amount (mm)
- Monthly mean cloud cover (% sky coverage)

2. Carbon Fluxes
- Net Primary Production (NPP)
- Land-Atmosphere flux
- Carbon Loss from Fire
- Heterotrophic respiration (Rh)

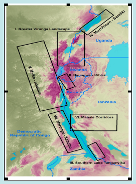
3. Carbon Pools
- Vegetation Carbon
- Soil Carbon
- Litter Carbon
- Annual Total Carbon

4. Hydrological Variables
- Total Runoff (mm)
- Actual Evapotranspiration (mm)

5. Vegetation and agriculture
- Annual Phaseolus Bean Yield (kg ha^{-2})
- Annual *Brachiaria decumbens* Yield (kg ha^{-2})
- Annual Maize Yield (kg ha^{-2})
- Fractional Cover of Plant Functional Type (%0

Feb 2011 - Rwanda workshop to interpret modeling results from Albertine Rift Climate Assessment

Albertine Rift Modeling Results to the year 2100 – outputs at regional scale



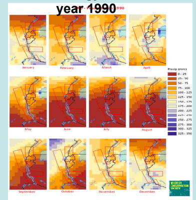
WCS Albertine Rift Climate Assessment modeling domain showing primary conservation landscapes

Domain-averaged statistics for temperature (deg. C), precipitation (mm per annum) and cloud cover (percent) for the 1900 baseline year and 20-year mean values centered on the years 2030, 2060 and 2090. The Maximum and Minimum values represent model gridpoint extrema across the project domain, where … gridpoints.

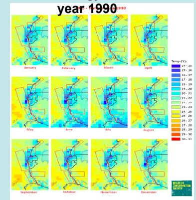
		1990	2030	2060	2090	
Mean annual temperature¥	Max	26.0	27.0	28.1	29.7	°C
	Mean	**22.7**	**23.6**	**24.7**	**26.3**	
	Min	15.0	16.0	17.1	18.7	
Mean annual precipitation¥	Max	1887	1900	1968	2098	mm
	Mean	**1199**	**1233**	**1287**	**1406**	
	Min	821	875	938	1057	
Mean annual cloud cover¥	Max	82.6	82.4	81.7	81.9	%
	Mean	**67.2**	**67.4**	**66.9**	**67.1**	
	Min	42.4	43.2	43.2	43.4	
Annual runoff¥	Max	723	760	871	986	mm
	Mean	**264**	**286**	**327**	**433**	
	Min	43	20	50	127	
Annual net primary productivity¥	Max	1520	1639	1748	1847	gC m⁻²
	Mean	**1060**	**1150**	**1242**	**1331**	
	Min	724	796	868	956	
Annual heterotrophic respiration¥	Max	1278	1474	1631	1681	gC m⁻²
	Mean	**916**	**1007**	**1105**	**1203**	
	Min	582	673	770	865	
Annual total carbon¥	Max	59.3	57.6	56.7	56.1	kg C m⁻²
	Mean	**33.0**	**33.1**	**32.9**	**32.8**	
	Min	19.0	19.6	20.2	20.4	
Bean Yield§	Max	1497	1443	1387	1332	kg ha⁻¹
	Mean	**799**	**754**	**721**	**627**	
	Min	1	11	73	67	
Maize Yield§	Max	3531	3539	3402	3111	kg ha⁻¹
	Mean	**1102**	**1103**	**1098**	**1025**	
	Min	32	46	46	44	
Brachiaria Yield§	Max	4147	4328	4577	4957	kg ha⁻¹
	Mean	**1663**	**1730**	**1884**	**1943**	
	Min	2	4	6	15	

¥Baseline reference year = 1990, §Baseline reference year = 2000

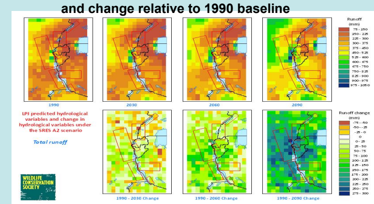
Monthly temperature climatology for the year 1990



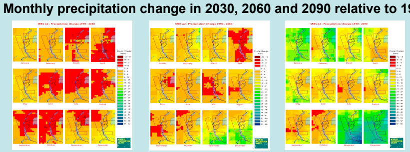
Monthly precipitation climatology for the year 1990



Hydrological runoff by year and change relative to 1990 baseline

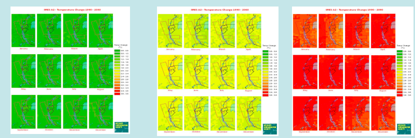


Monthly precipitation change in 2030, 2060 and 2090 relative to 1990



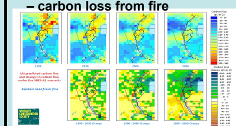
Downscaled climate model predictions of monthly precipitation amount change relative to 1990 baseline means over the Albertine Rift project domain for 2030 (left) 2060 (center) and 2090 (right)

Monthly temperature change in 2030, 2060 and 2090 relative to 1990



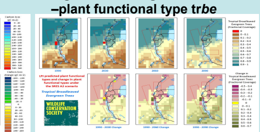
Downscaled climate model predictions of monthly mean temperature changes relative to the year 1990 over the Albertine Rift project domain for the years 2030 (left) 2060 (center) and 2090 (right)

Biomass burning indicator – carbon loss from fire



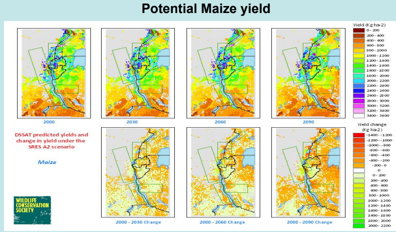
Predicted carbon loss from fire and change relative to 1990 historical baseline from LPJ model simulations for 2030, 2060 and 2090 under the A2 emissions scenario

Vegetation change indicator –plant functional type *trbe*

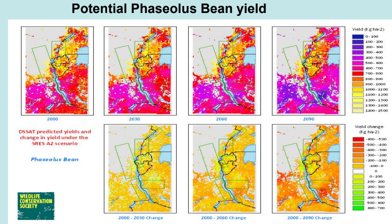


Fractional coverage and change relative to 1990 historical baseline of Tropical Broadleaved Evergreen Trees (Plant Functional Type trbe) from LPJ model simulations in 2030, 2060 and 2090 under the A2 emissions scenario

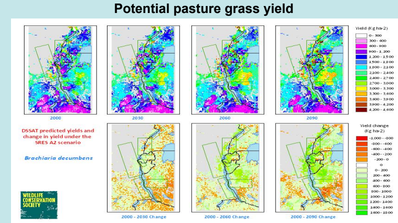
Potential Maize yield



Potential Phaseolus Bean yield



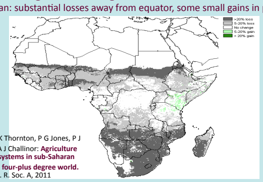
Potential pasture grass yield



Agricultural under intense warming scenarios (+5 degrees) – new results from Thornton, Jones, Ericksen, Challinor (2010)

Length of Growing Period change to the 2090s

Ensemble mean: substantial losses away from equator, some small gains in parts of E Africa



Source: P K Thornton, P G Jones, P J Ericksen, A J Challinor: Agriculture and food systems in sub-Saharan Africa in a four-plus degree world. Phil. Trans. R. Soc. A, 2011

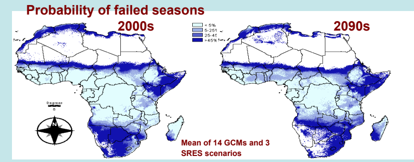
Agricultural under intense warming scenarios (+5 degrees) – new results from Thornton, Jones, Ericksen, Challinor (2010)

Simulated yields (30 reps) in Sub-Saharan Africa under current conditions and in the 2090s

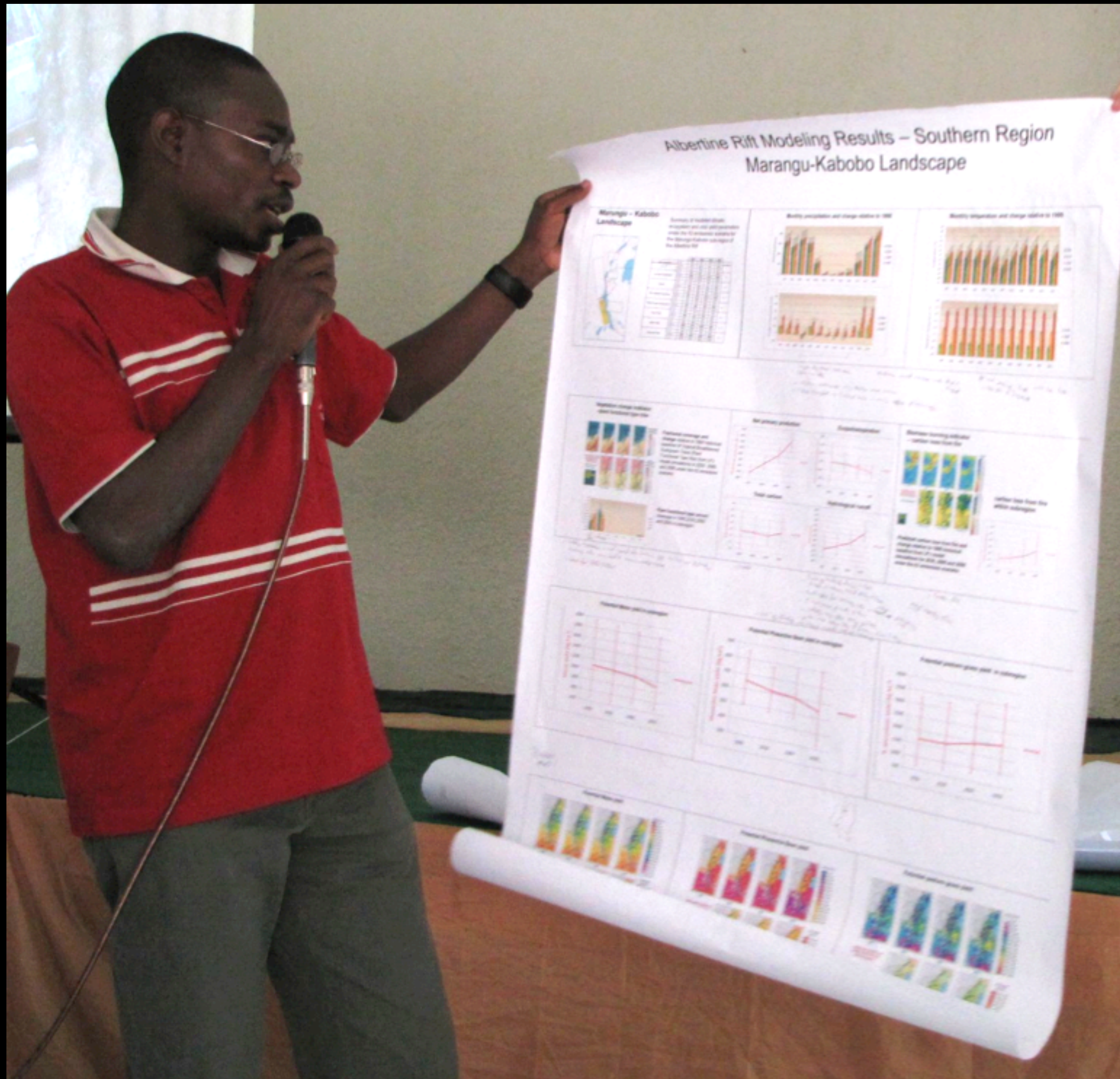
	2000s Yield kg/ha	2090s +5°C Yield kg/ha †	Mean % change in production †	CV of change in production
Maize				
Central	744	612	-13	23
East	954	689	-19	7
Southern	748	612	-16	22
West	764	536	-23	23
Mean	806	612	-24	19
Beans				
Central	666	175	-69	58
East	685	263	-47	6
Southern	716	220	-68	48
West	487	63	-87	47
Mean	639	182	-71	34
B. decumbens				
Central	1493	1311	-4	3
East	1745	1570	+9	7
Southern	1384	1344	+11	18
West	1498	1437	-6	27
Mean	1525	1422	-7	15

Agricultural under intense warming scenarios (+5 degrees) – new results from Thornton, Jones, Ericksen, Challinor (2010)

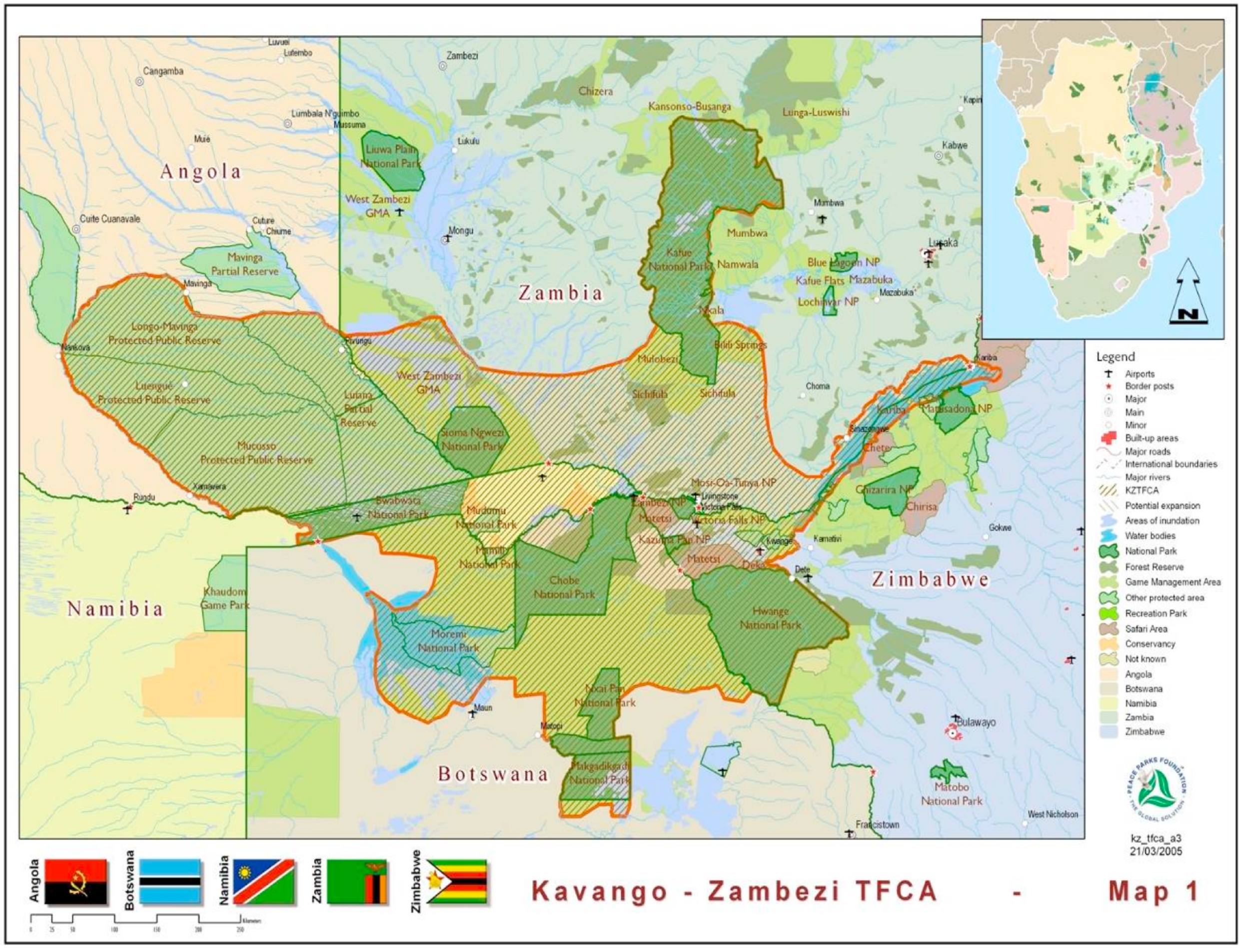
Probability of failed seasons



Source: P K Thornton, P G Jones, P J Ericksen, A J Challinor: Agriculture and food systems in sub-Saharan Africa in a four-plus degree world. Phil. Trans. R. Soc. A, 2011


Albertine Rift Modeling Results – Southern Region
Marangu-Kabobo Landscape

Kavango-Zambezi TFCA: literature review of climate change



The provisional extent of the KAZA (David Cumming - Courtesy of TCC (2007)/PPF)

KAZA: Findings from literature review

Climate change identified as threat to future sustainability of KAZA, but infusion of this knowledge into conservation planning remains little developed.

Low uncertainty: strong consensus among climate and hydrological models. → Opportunity for "bold" proactive actions

Research attention high for the Okavango, much lower elsewhere in KAZA, and absent in headwaters region of southeastern Angola

While biogeographical changes receive considerable research, little work on how altered ecological future might rearrange the political, social and economic geography among and within KAZA member states.

Conditions will increasingly stress human livelihoods based around cultivation, and may increase pastoralism as alternative.

KAZA: Findings from literature review

Regional rainfall decline evident over past several decades.

Vegetation and wildlife habitat changes are consistent with drying trend: shift from savannah grasses to woody scrub vegetation being observed in SE Okavango wetlands.

Net effects of hydrological drying and thermal increase will be a strong response by vegetation, with compositional shifts to be expected throughout the region causing migration of biomes and ecotones.

Strong climatic changes will inevitably result in marked epidemiological changes relative to present.

Review encountered very little in the way of studies specifically examining non-human disease in contexts of climate change within the KAZA region.

KAZA: Findings from literature review

Conservation planning is shaped on perceptions of landscape and ecology developed under a wetter and cooler climatic regime than the future

- Failure to fully incorporate climate change into planning has the potential to render current planning inappropriate or obsolete within several decades.

Project opportunity: linked climate, hydrology and vegetation modeling to inform planning scenarios on epidemiology, cultivation, pastoralism, wildlife management, tourism, etc.

- Could be performed using the next generation of global climate model output currently being generated for the IPCC 5th Assessment Report.

Acknowledgements

Philip Thornton – ILRI
Steve Osofsky & Mark Atkinson – WCS
USAID and AHEAD
John D. and Catherine T. MacArthur Foundation