Climate Change Impact on Key Crops in Africa

Alternative Scenarios Using Biophysical and Economic Models

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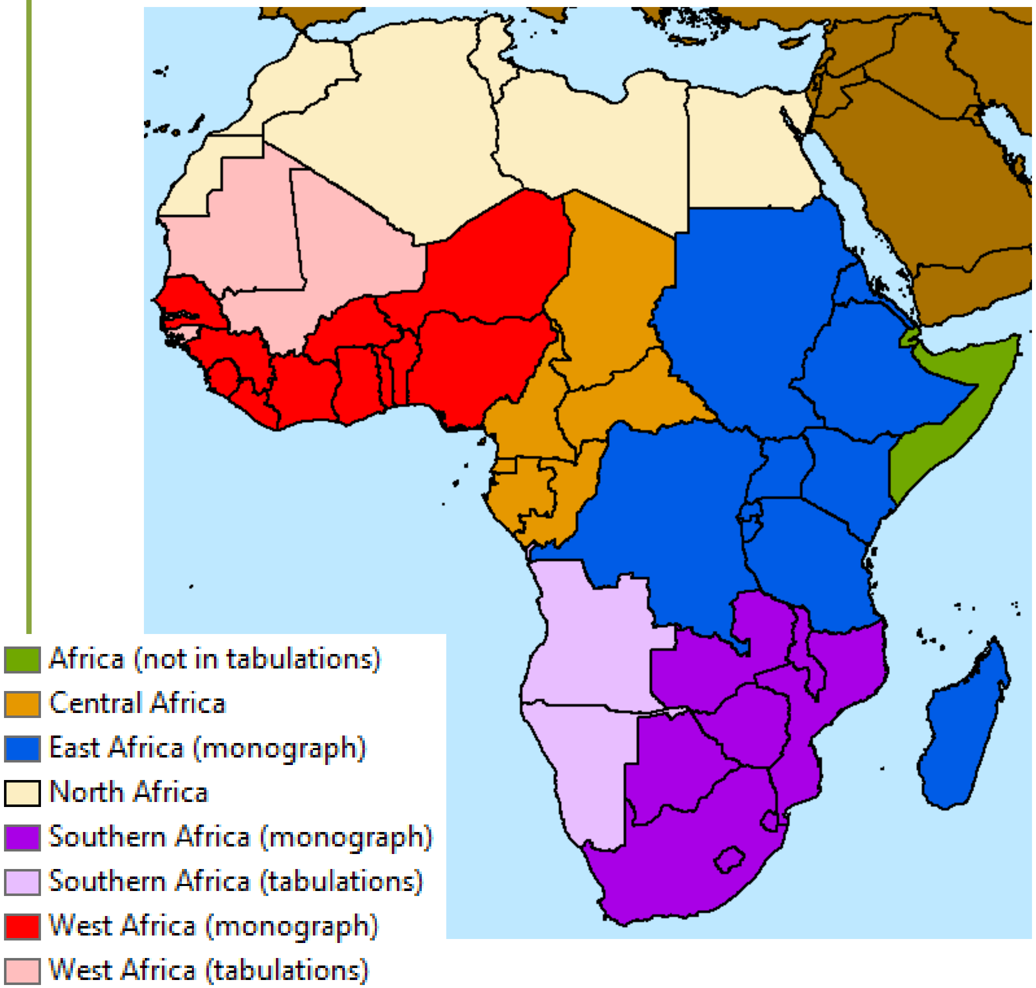
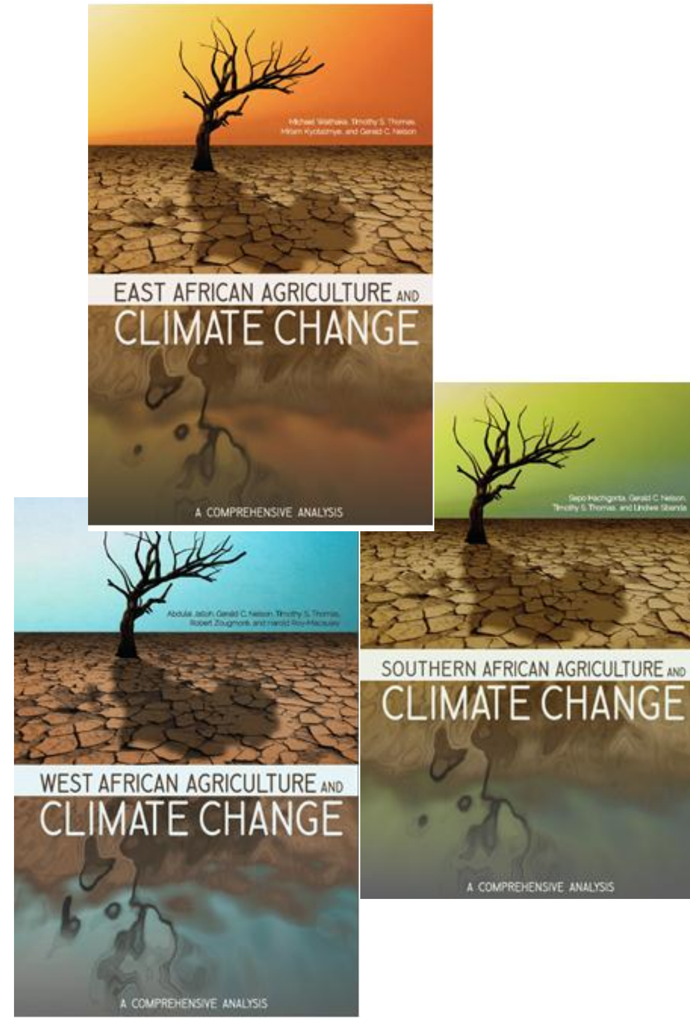
Outline

- Background and Overview
- Modeling Framework
- Climate Projections
- DSSAT Crop Model Results
- IMPACT Model Results
- Major Policy Conclusions

Background and Overview

Regions for Monographs and Analysis





Population

Name	Population			
	2008	2050		
		Low	Median	High
	WDI	IMPACT (UNPOP projections)		
West Africa	287,604	545,233	618,835	697,456
Ghana	23,351	39,660	45,213	51,163
Nigeria	151,319	254,129	289,083	326,395
Southern Africa	135,054	208,209	241,513	277,655
Mozambique	21,781	38,268	44,148	50,480
South Africa	48,687	47,536	56,802	67,051
East Africa	340,843	678,634	773,746	875,639
Congo, DR	64,205	130,013	147,512	166,249
Ethiopia	80,713	152,720	173,811	196,245

GDP per Capita

Name	Income Per Capita			
	2008	2050		
		Pessimistic	Baseline	Optimistic
	WDI	IMPACT		
West Africa	324	764	1,423	2,850
Niger	180	684	1,364	2,491
Nigeria	487	559	637	1,671
Southern Africa	1,957	2,708	5,814	11,355
Botswana	4,440	3,686	25,628	48,646
Malawi	165	656	744	2,488
South Africa	3,764	5,409	15,473	29,941
East Africa	121	564	1,162	1,780
Congo, DR	99	277	440	715
Kenya	464	543	2,255	3,286

Top 5 Crops per Region, Ranked by Hectares Harvested, average 2006-2008

East Africa			Southern Africa			West Africa	
Crop	Hectares		Crop	Hectares		Crop	Hectares
Sorghum	9,893,208		Maize	9,199,950		Millet	16,002,237
Maize	9,367,883		Cassava	2,015,384		Sorghum	14,288,715
Millet	3,622,654		Groundnuts	1,073,603		Cowpeas	10,297,759
Beans	3,512,688		Millet	988,690		Maize	7,747,435
Cassava	3,474,208		Sorghum	848,518		Rice	5,725,947

Modeling Framework

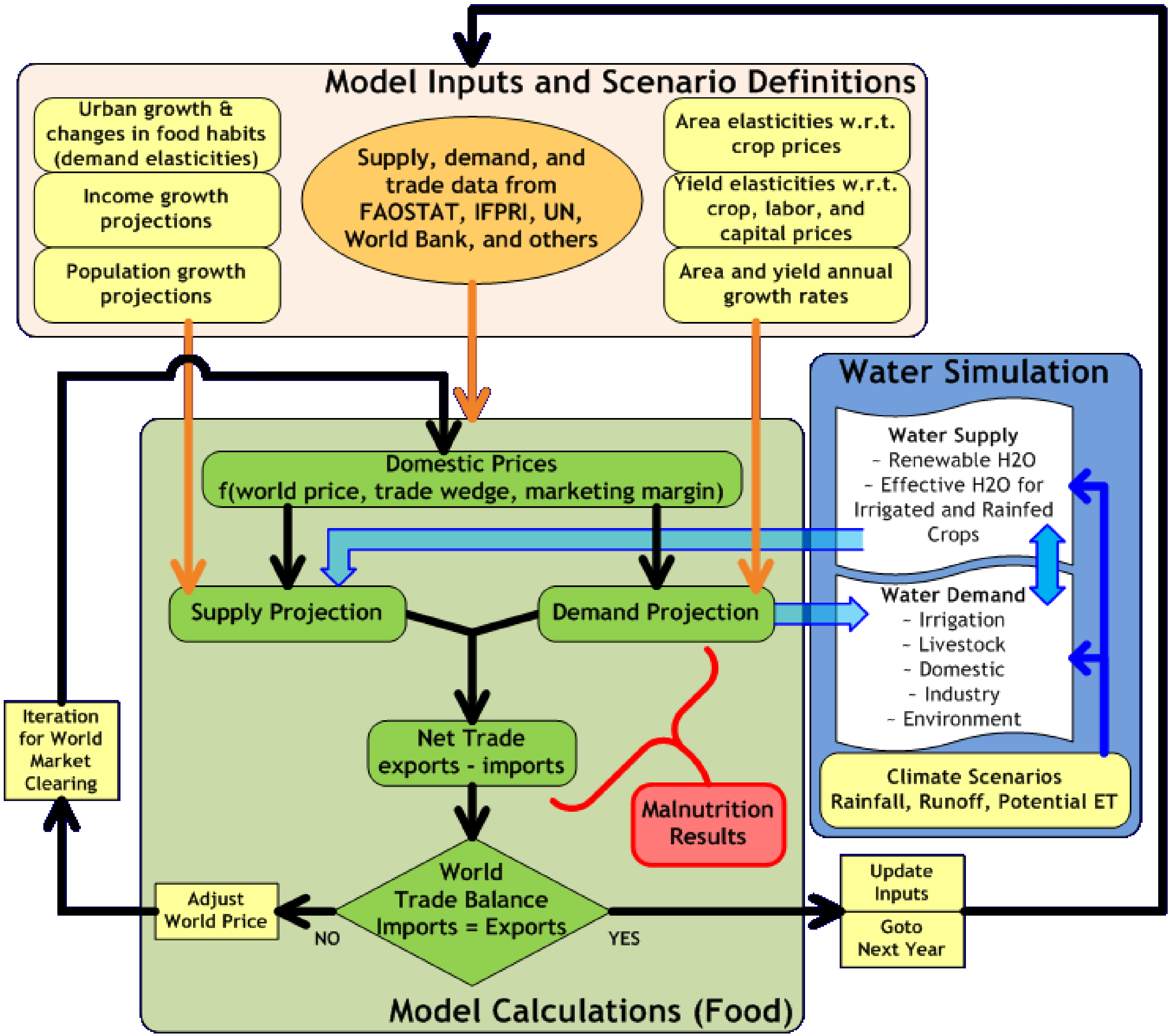
Climate Change Model Components

- GCM climate scenarios
  - Multiple GCM using IPCC SRES A1B scenario, downscaled temperature and rainfall
- SPAM
  - Spatial distribution of crops based on crop calendars, soil characteristics, climate of 20 most important crops
- DSSAT crop model
  - Biophysical crop response to temp and precipitation
- IMPACT
  - Global food supply demand model to 2050 with global hydrology and water simulation by river basin

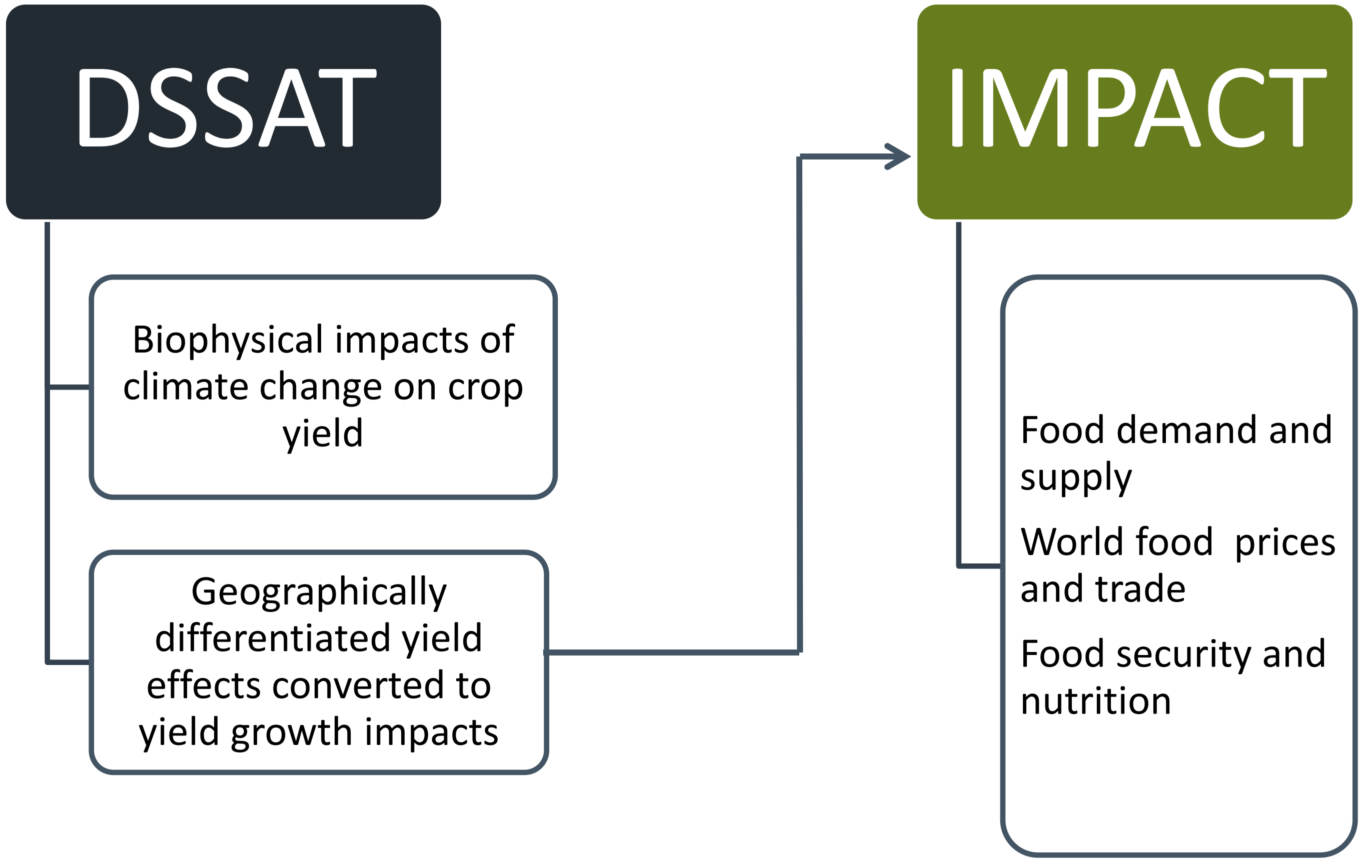
DSSAT Crop Models

- Simulate plant growth and crop yield by variety day-by-day, in response to
  - Temperature
  - Precipitation
  - Soil characteristics
  - Applied nitrogen
  - CO_2 fertilization
- DSSAT-based simulations at crop-specific locations (using local climate, soil and topographical attributes)
- 10 km by 10 km (East and Southern Africa) and 30 km by 30 km pixels (for West Africa)

Structure of IMPACT Model

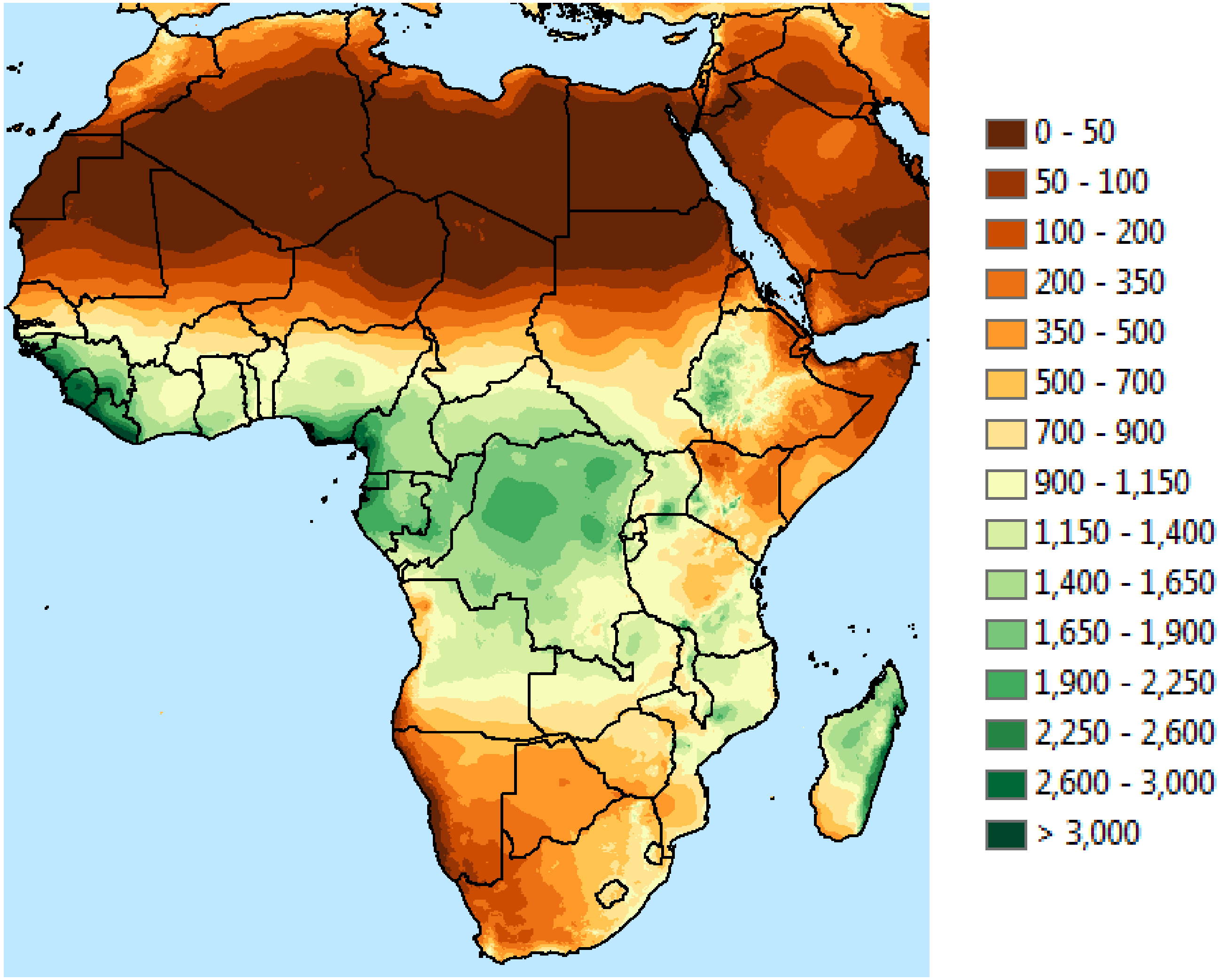


Linking DSSAT & IMPACT

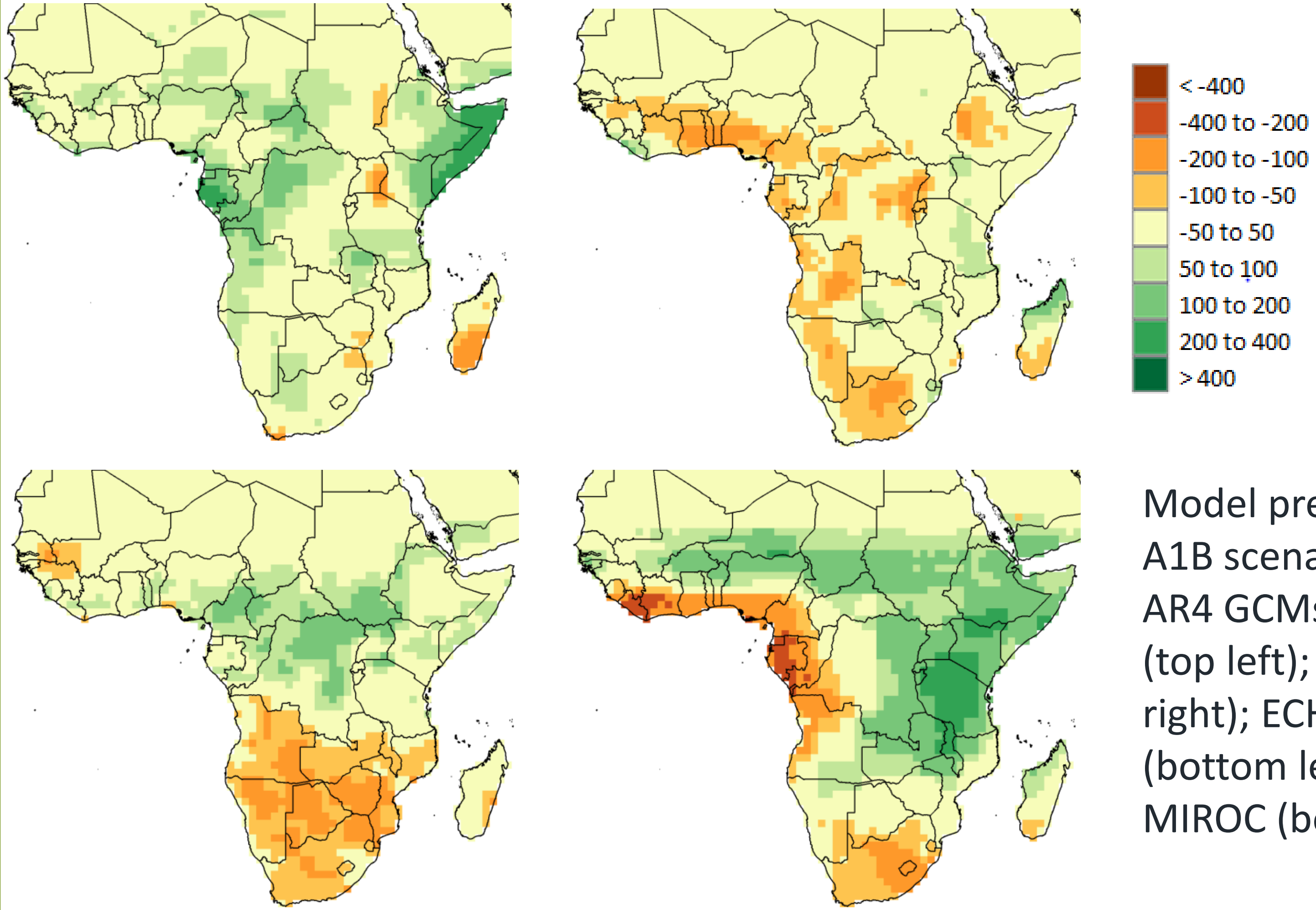


Climate Projections

Mean Annual Rainfall, 1950-2000

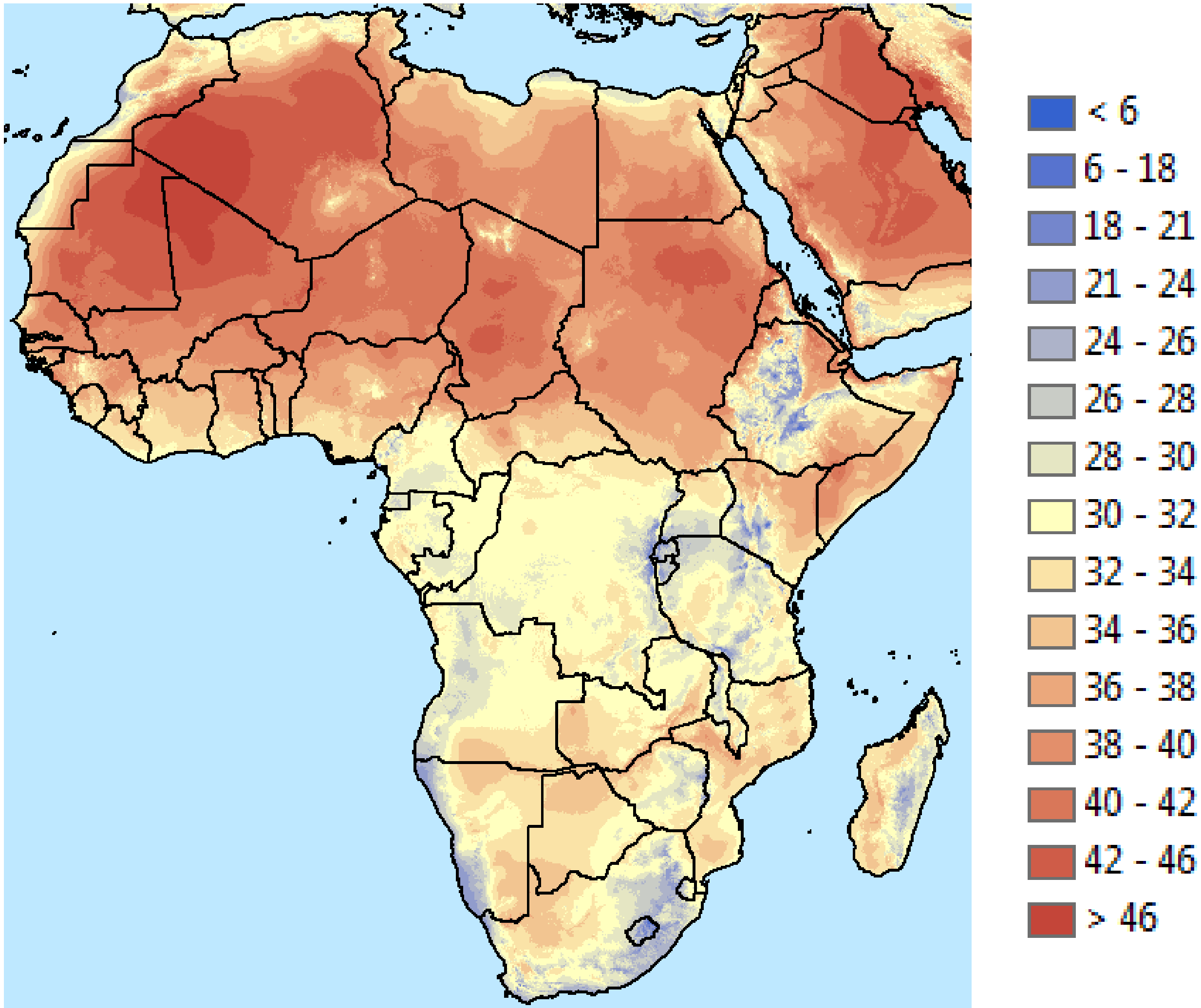


Change in Mean Annual Rainfall (mm), from 1950-2000 climate to climate of 2050

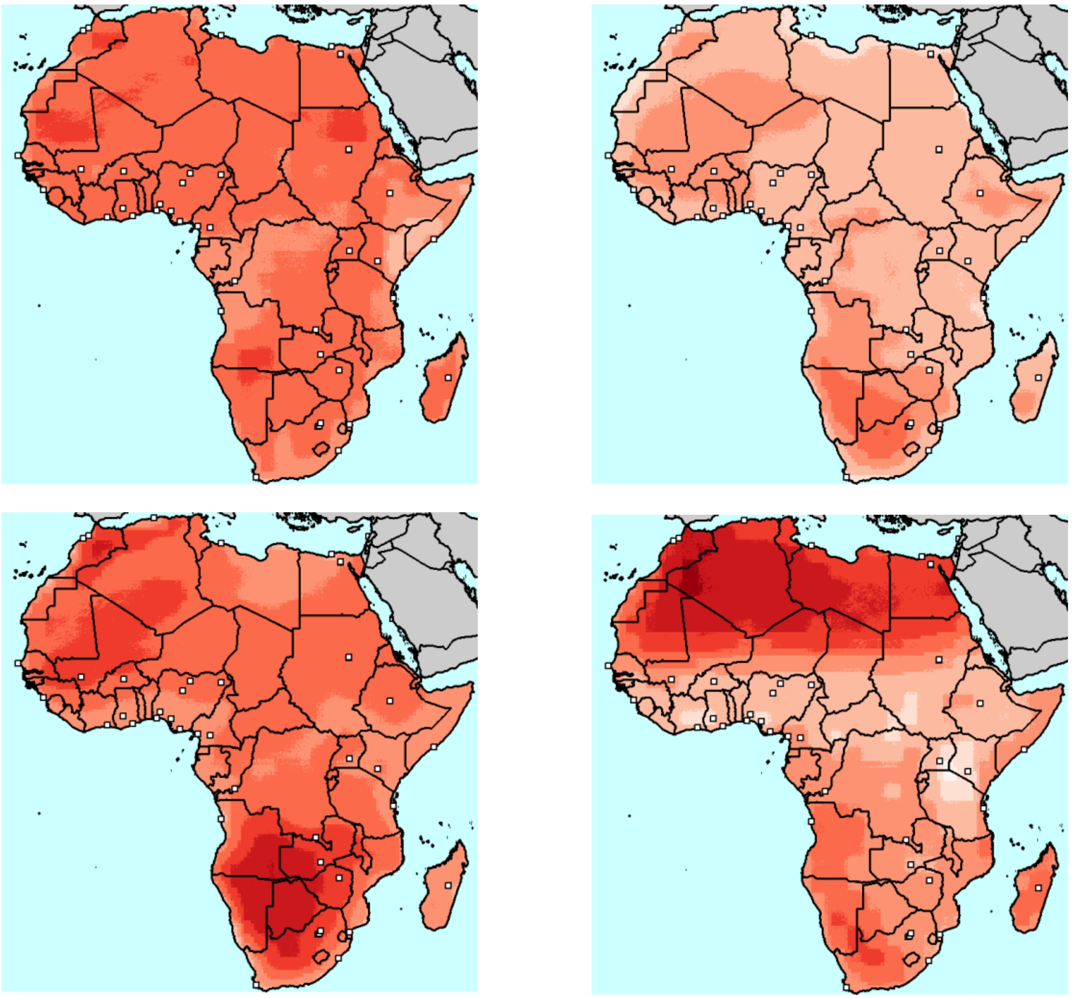


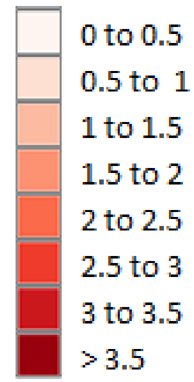
Model predictions for A1B scenario and 4 AR4 GCMs: CNRM (top left); CSIRO (top right); ECHAM (bottom left; and MIROC (bottom right).

Mean Daily Maximum Temperature for the Warmest Month, 1950-2000



Change in Mean Daily Maximum Temperature for the Warmest Month, 2000 to 2050

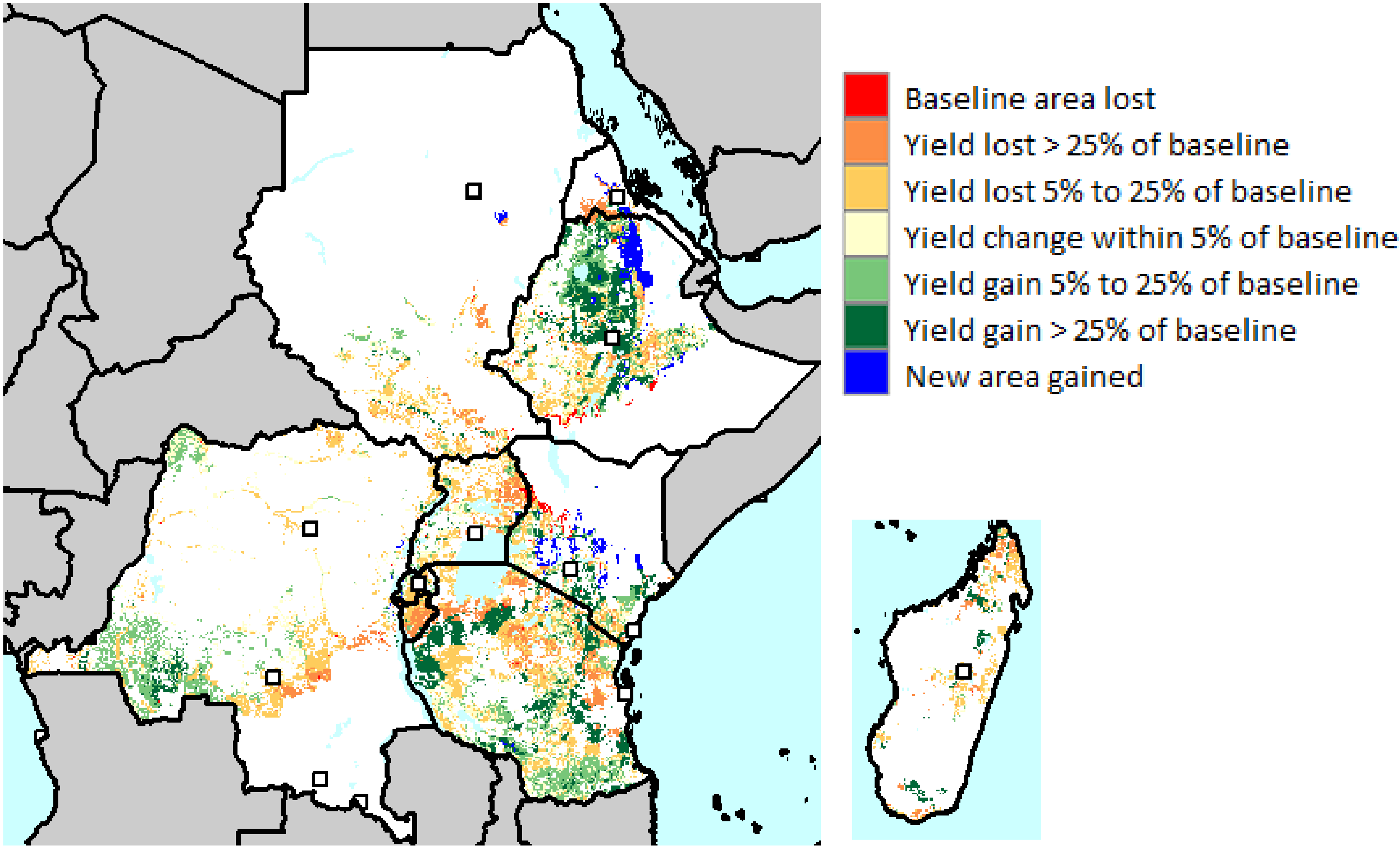




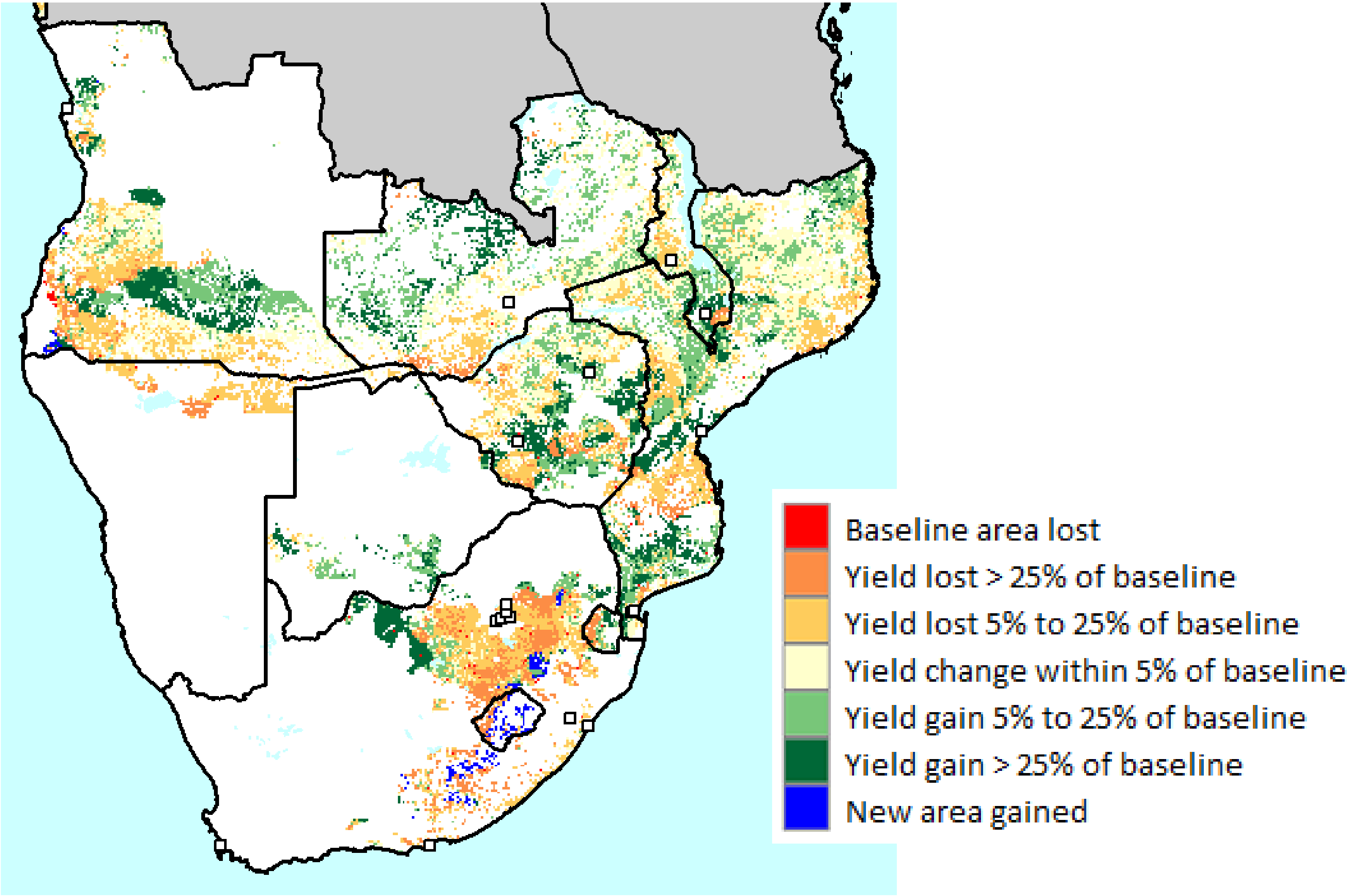
Model predictions for A1B scenario and 4 AR4 GCMs: CNRM (top left); CSIRO (top right); ECHAM (bottom left; and MIROC (bottom right).

DSSAT Crop Model Results

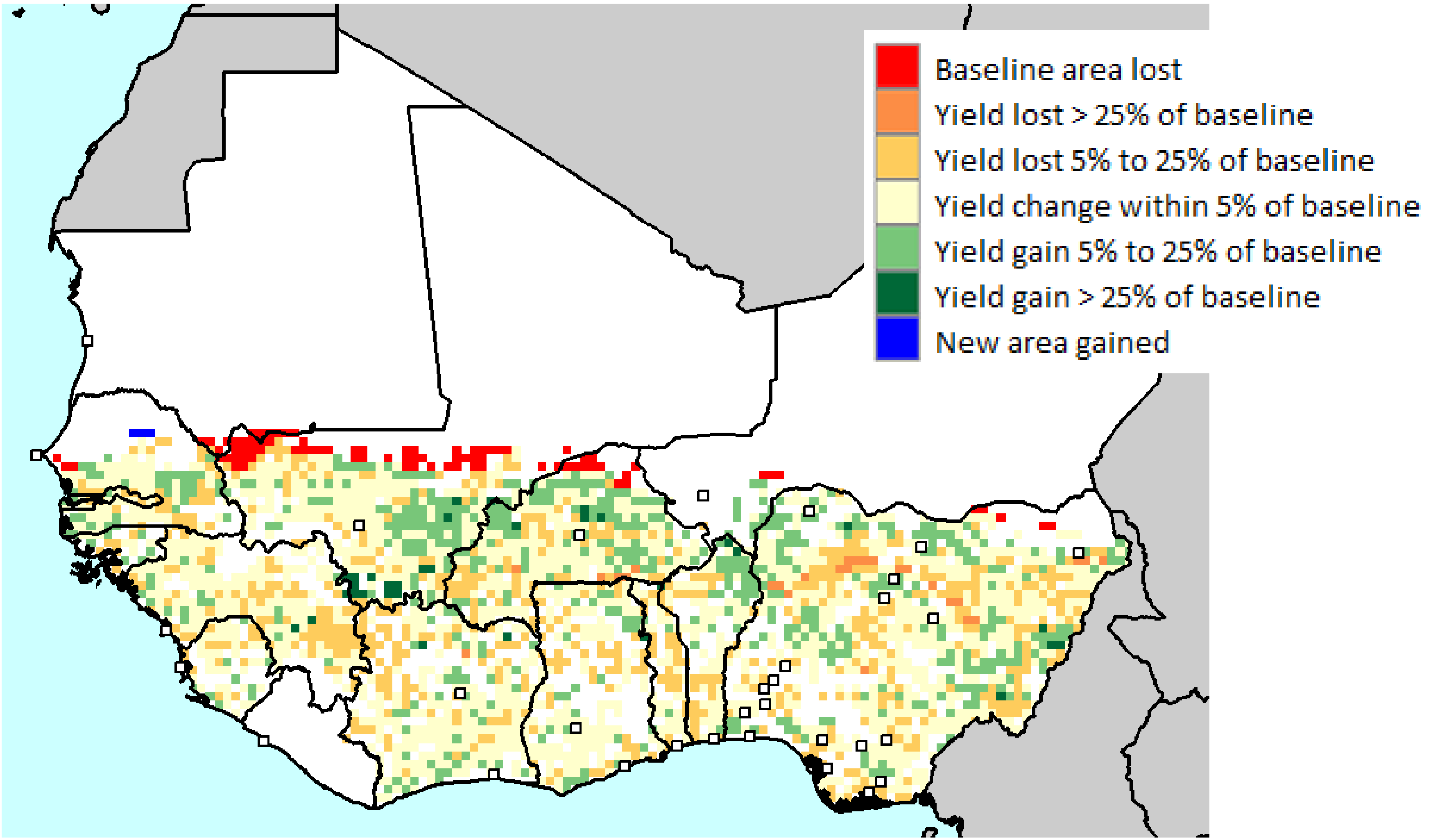
Change in Rainfed Maize Yield for East Africa, CNRM



Change in Rainfed Maize Yield for Southern Africa, CNRM



Change in Rainfed Maize Yield for West Africa, CNRM



Yield Differences for East Africa Between Climates of 2000 and 2050

Water	Crop	Yield differences, 2000-2050, %			
		CNRM	CSIRO	ECHAM	MIROC
Rainfed	Groundnuts	-8.3	1.9	2.4	11.6
Rainfed	Maize	1.5	2.5	-1.7	6.3
Irrigated	Rice	-19.7	-10.4	-17.3	-18.7
Rainfed	Rice	2.2	2.8	3.4	6.7
Rainfed	Sorghum	-15.5	-6.0	-7.4	-0.5
Rainfed	Soybeans	-21.4	-10.0	-15.9	-10.6
Irrigated	Wheat	1.7	-12.9	-16.1	-10.1
Rainfed	Wheat	-6.2	-5.4	-13.8	-7.9

Yield Differences for Southern Africa Between Climates of 2000 and 2050

Water	Crop	Yield differences, 2000-2050, %			
		CNRM	CSIRO	ECHAM	MIROC
Rainfed	Groundnuts	1.7	3.3	-5.7	2.1
Irrigated	Maize	-5.6	-3.1	-2.8	-4.0
Rainfed	Maize	-1.6	-2.8	-12.9	-4.0
Rainfed	Rice	-0.6	0.1	-0.4	-1.6
Rainfed	Sorghum	-5.8	-4.6	-10.4	-4.8
Rainfed	Soybeans	-15.4	-12.8	-24.7	-7.3
Irrigated	Wheat	-5.1	-5.1	-7.1	-3.8
Rainfed	Wheat	18.5	18.3	11.0	-6.1

Yield Differences for West Africa Between Climates of 2000 and 2050

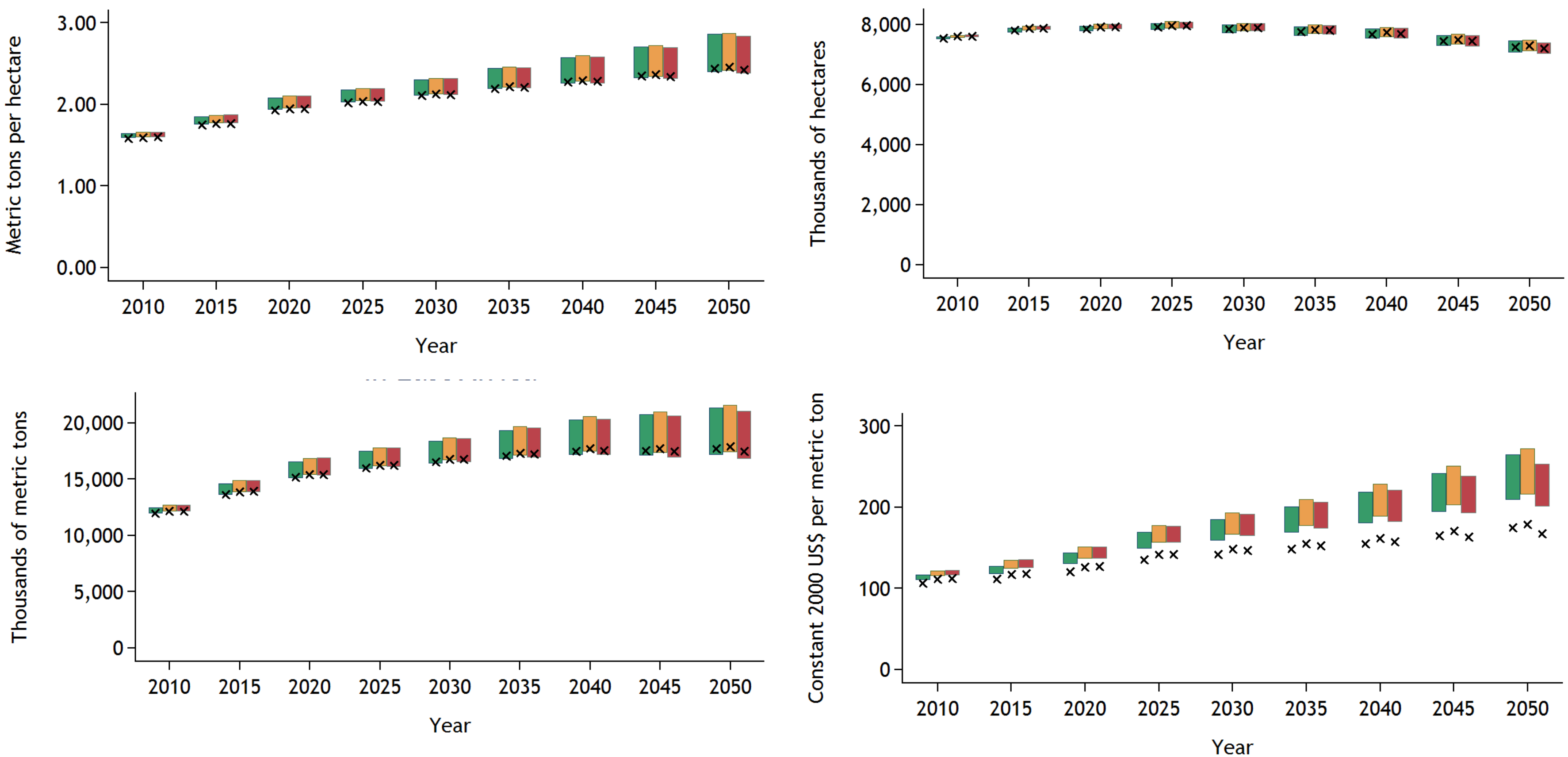
Water	Crop	Yield differences, 2000-2050, %			
		CNRM	CSIRO	ECHAM	MIROC
Rainfed	Groundnuts	-5.8	-7.7	-9.2	0.3
Rainfed	Maize	-2.3	-8.1	-6.0	-4.9
Irrigated	Rice	-19.9	-12.4	-20.0	-18.2
Rainfed	Rice	4.4	0.5	0.9	1.0
Rainfed	Sorghum	-15.9	-9.5	-14.8	-13.0
Rainfed	Soybeans	-1.5	-8.4	-1.6	-14.2
Irrigated	Wheat	-37.8	-10.9	-28.5	-14.3

IMPACT Model Results

IMPACT World Price Changes

Crop	% Change in Price, 2000 to 2050				
	MIROC		CSIRO		No climate change
	A1B	B1	A1B	B1	
Rice	83	87	85	82	54
Wheat	121	106	99	93	66
Maize	209	165	156	145	103
Sweet potatoes & yams	141	96	156	120	60
Cassava	78	50	64	42	18
Sugarcane	125	113	108	103	77
Sorghum	115	104	110	104	82
Millet	8	8	14	13	8
Groundnuts	35	33	37	33	13

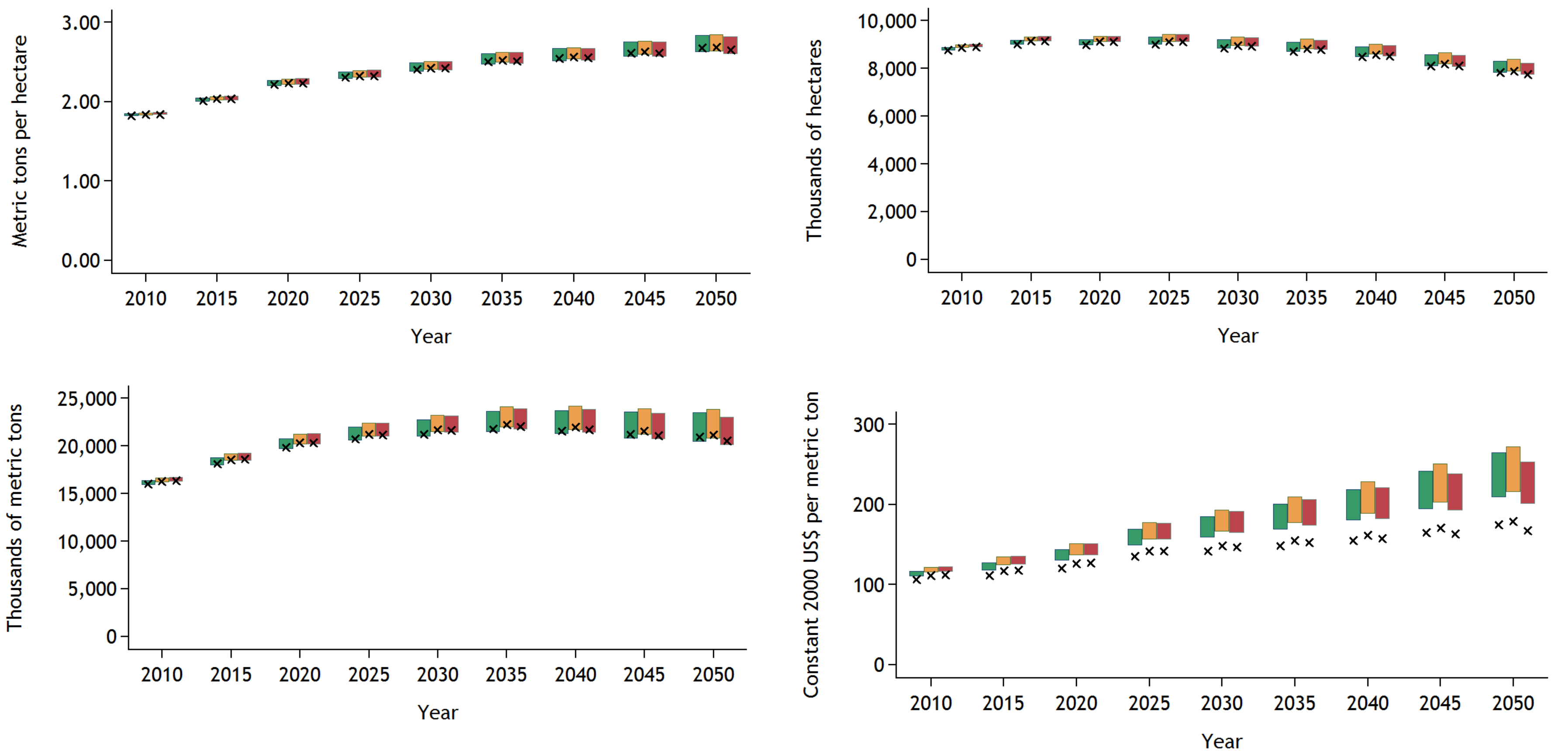
IMPACT Results for Maize for East Africa



Yield (top left); area (top right);
production (bottom left);
price (bottom right)

Pessimistic, with clim chg × Without clim chg
Baseline, with clim chg × Without clim chg
Optimistic, with clim chg × Without clim chg

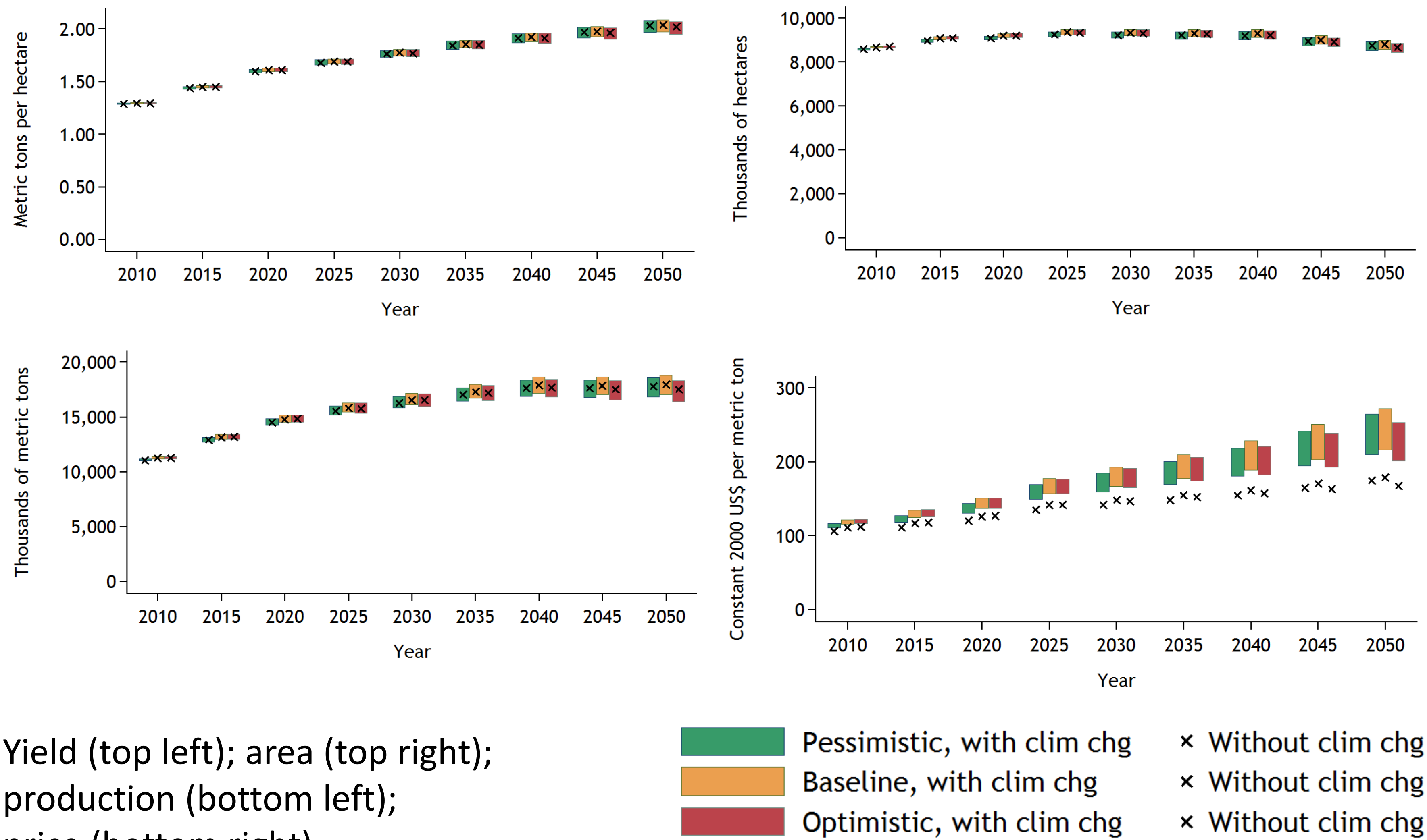
IMPACT Results for Maize for Southern Africa



Yield (top left); area (top right); production (bottom left); price (bottom right)

Pessimistic, with clim chg — × Without clim chg
Baseline, with clim chg — × Without clim chg
Optimistic, with clim chg — × Without clim chg

IMPACT Results for Maize for West Africa



Yield (top left); area (top right); production (bottom left); price (bottom right)

IMPACT Yield Changes, East Africa

Crop	% Change in Yield, 2010-2050, IMPACT Model				
	Baseline (Economic-Demographic) Scenario				
	No Climate Change	CSIRO A1B	MIROC A1B	CSIRO B1	MIROC B1
Cassava	54.7	46.1	51.4	53.0	47.7
Groundnuts	12.9	15.8	23.5	16.5	21.6
Maize	54.0	51.1	73.5	54.7	62.7
Millet	137.7	139.9	163.8	134.4	147.0
Rice	120.1	136.6	140.3	136.5	137.4
Sorghum	77.4	83.0	111.6	75.5	90.7
Sweet potatoes and yams	161.3	145.0	188.2	162.9	179.2
Wheat	128.6	119.1	127.2	123.3	118.9

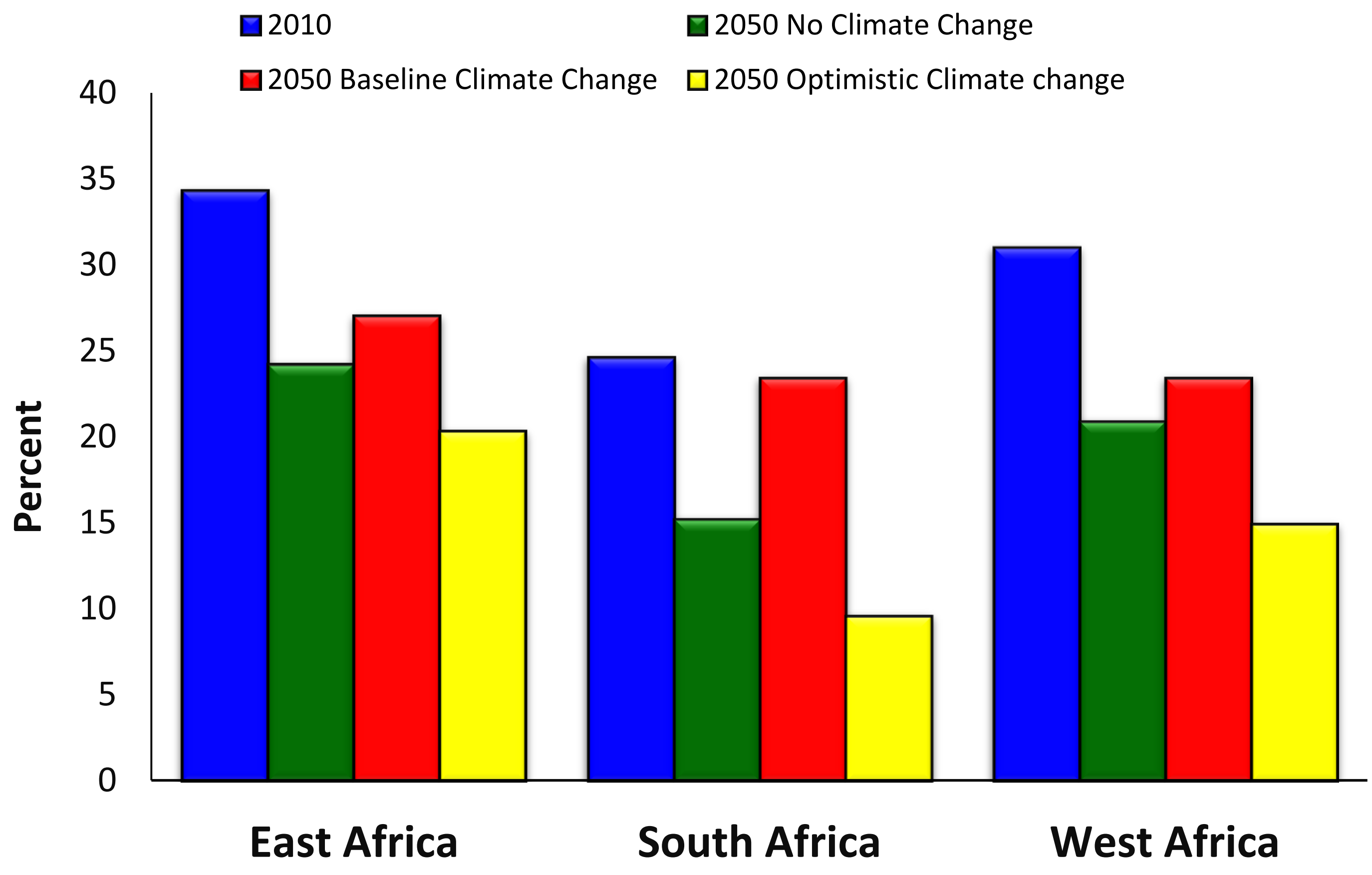
IMPACT Yield Changes, Southern Africa

Crop	% Change in Yield, 2010-2050, IMPACT Model				
	Baseline (Economic-Demographic) Scenario				
	No Climate Change	CSIRO A1B	MIROC A1B	CSIRO B1	MIROC B1
Cassava	26.9	27.9	42.0	29.0	39.5
Cotton	155.3	165.3	175.1	155.6	176.5
Groundnuts	47.2	51.6	51.6	50.6	55.4
Maize	46.3	48.6	53.3	44.2	52.5
Millet	243.4	243.1	255.6	247.5	248.5
Potatoes	49.4	53.1	53.4	53.7	52.4
Rice	119.8	109.7	115.2	114.1	102.6
Sorghum	107.0	108.7	109.9	107.8	108.7
Soybeans	61.6	48.9	58.1	47.7	64.3
Sugarcane	60.2	62.3	66.5	63.2	66.5

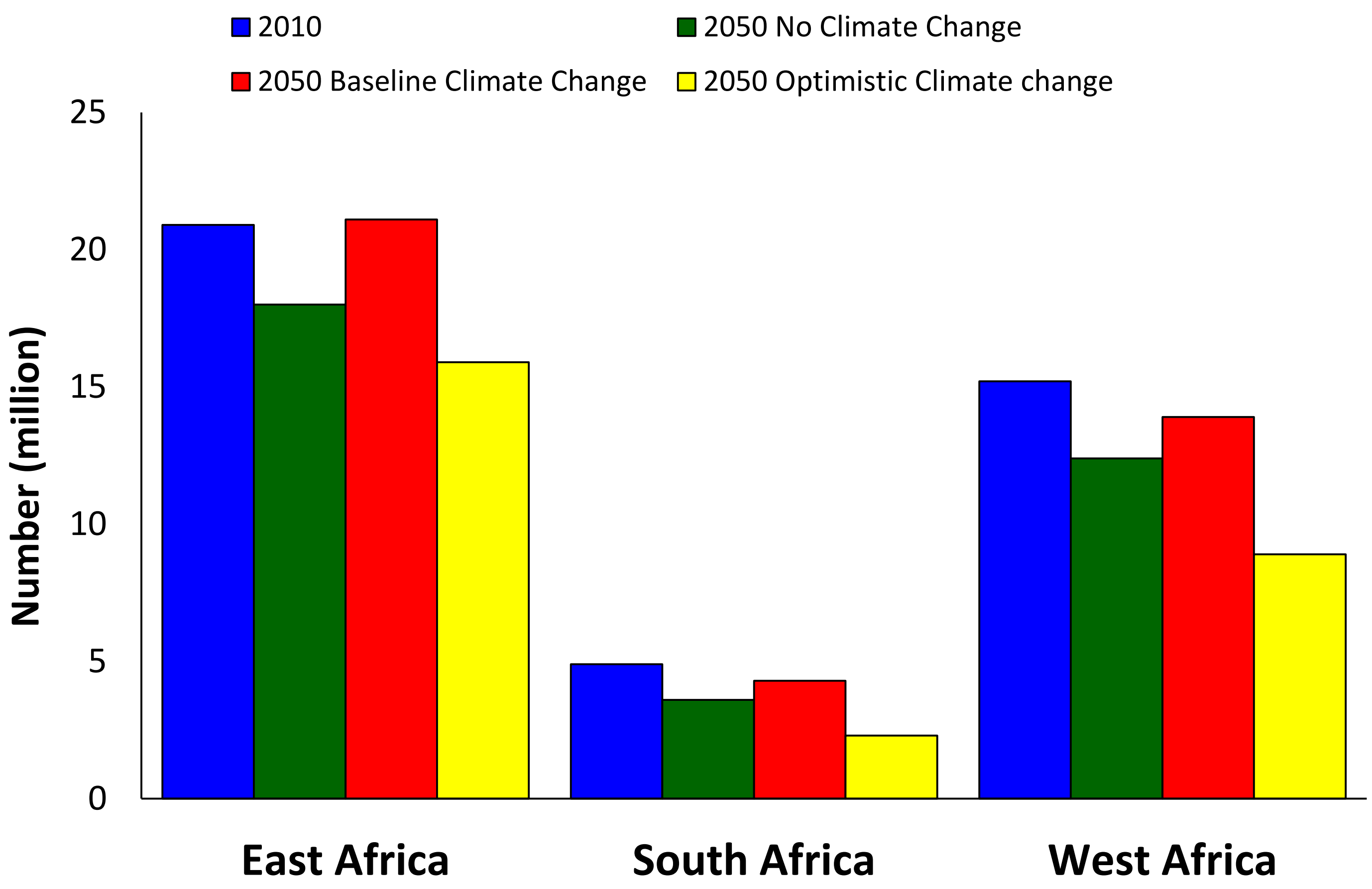
IMPACT Yield Changes, West Africa

Crop	% Change in Yield, 2010-2050, IMPACT Model				
	Baseline (Economic-Demographic) Scenario				
	No Climate Change	CSIRO A1B	MIROC A1B	CSIRO B1	MIROC B1
Cassava	49.5	35.5	37.2	55.5	62.5
Cotton	90.9	71.4	76.5	89.1	85.2
Groundnuts	42.0	35.4	43.9	41.1	47.3
Maize	57.4	53.0	59.8	55.9	58.7
Millet	147.2	151.9	176.2	147.5	156.2
Rice	89.3	87.5	89.1	89.1	89.7
Sorghum	94.1	95.5	106.3	95.2	99.4
Soybeans	81.5	80.0	77.7	84.6	78.5
Sweet potatoes and yams	73.5	48.1	49.1	72.3	84.0

Percent of Malnourished Children Under 5 (%), 2010 and 2050



Number of Malnourished Children Under 5 (millions), 2010 and 2050



Major Policy Conclusions

Conclusions

- Climate change will have negative impacts on food security in Africa
- There is significant variation in severity of impacts across countries and crops (and GCM models)
- In many countries, productivity losses will be experienced in some parts while productivity gains will be experienced in other parts, creating pressure for migration
  - laws in the areas of property rights and in protecting environmentally sensitive areas may need to be examined and improved

Conclusions

- World price increases due to climate change impacts in other regions will be a major determinant of impacts on food security in Africa
- Climate change is a threat multiplier: requires higher investment to reach development goals
- To a significant extent, good agricultural development policy is good adaptation policy
- Greater investment needed in climate-sensitive traits and protection against climate variability and extremes

Key Adaptation Policies and Investments

- Breed crops for biotic and abiotic stresses: agricultural productivity growth is key to future food security under climate change
- Enhance water control
- Implement knowledge, information and risk-sharing approaches to support flexible farmer adaptation
- Support open trading regimes to share climate risk
- Redesign Institutions and policies in agriculture to be more flexible and robust across a range of possible future climates, and diverse outcomes across ecozones

Adaptation through Agricultural Productivity Growth

- Increasing crop productivity: agricultural research, water management, and rural investment
  - Emphasis on crop and livestock breeding (including biotechnology) targeting abiotic and biotic stresses
  - Water harvesting, precision agriculture, minimum tillage, crop protection, integrated soil fertility management, integrated pest management, reduce post harvest losses
  - Rural infrastructure investment to improve access to markets, risk insurance, credit, inputs, mobile phone towers