Transitioning Cereal Systems to Adapt to Climate Change

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Global challenges and opportunities for adaptation of cereal systems in sub-Saharan Africa

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Global challenges and opportunities for adaptation of cereal systems in sub-Saharan Africa

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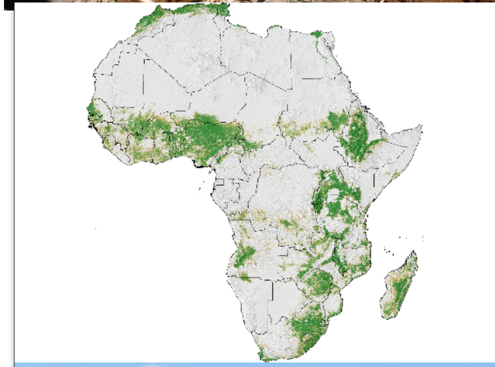
Content

- Context of farming in SSA
- Historical & future changes in climate; projected impacts on cereals in SSA
  - Maize
  - Wheat
  - Sorghum & Millet
- Opportunities to address challenges



Small-holder farming context in SSA

- About 80% all farms
- Employ 175m people
- 70% are women
- Small fields/parcels of land
- Often degraded & infertile
- No irrigation
- Poor access to credit & inputs
- Poor access & low participation in markets

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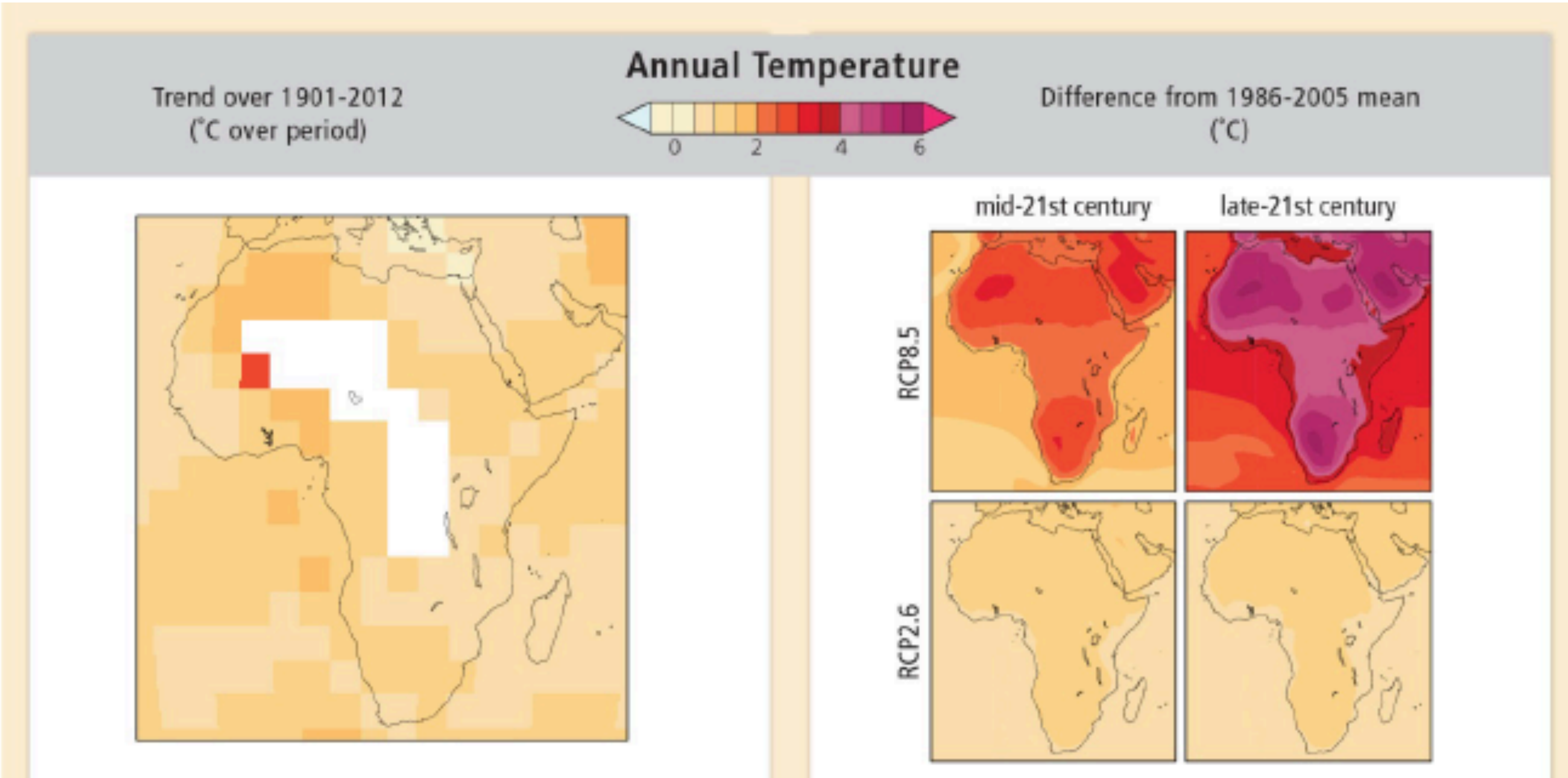
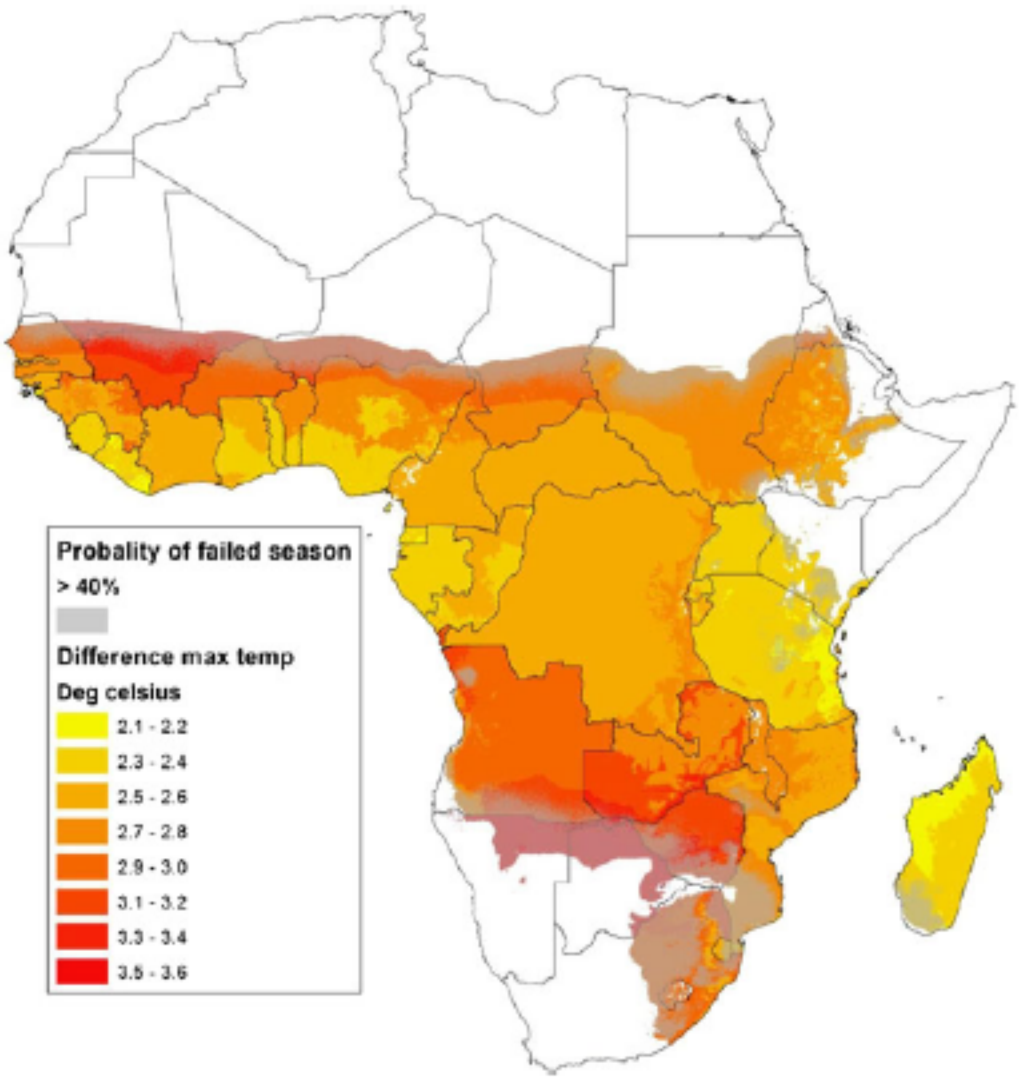
Historical & future changes in temperature



'*Very likely* that mean annual temperature has increased over the past century' IPCC Africa 2014

"Increases in mean annual temperature over all land areas are *very likely*..'

Change in maximum temperature in maize mega-environments



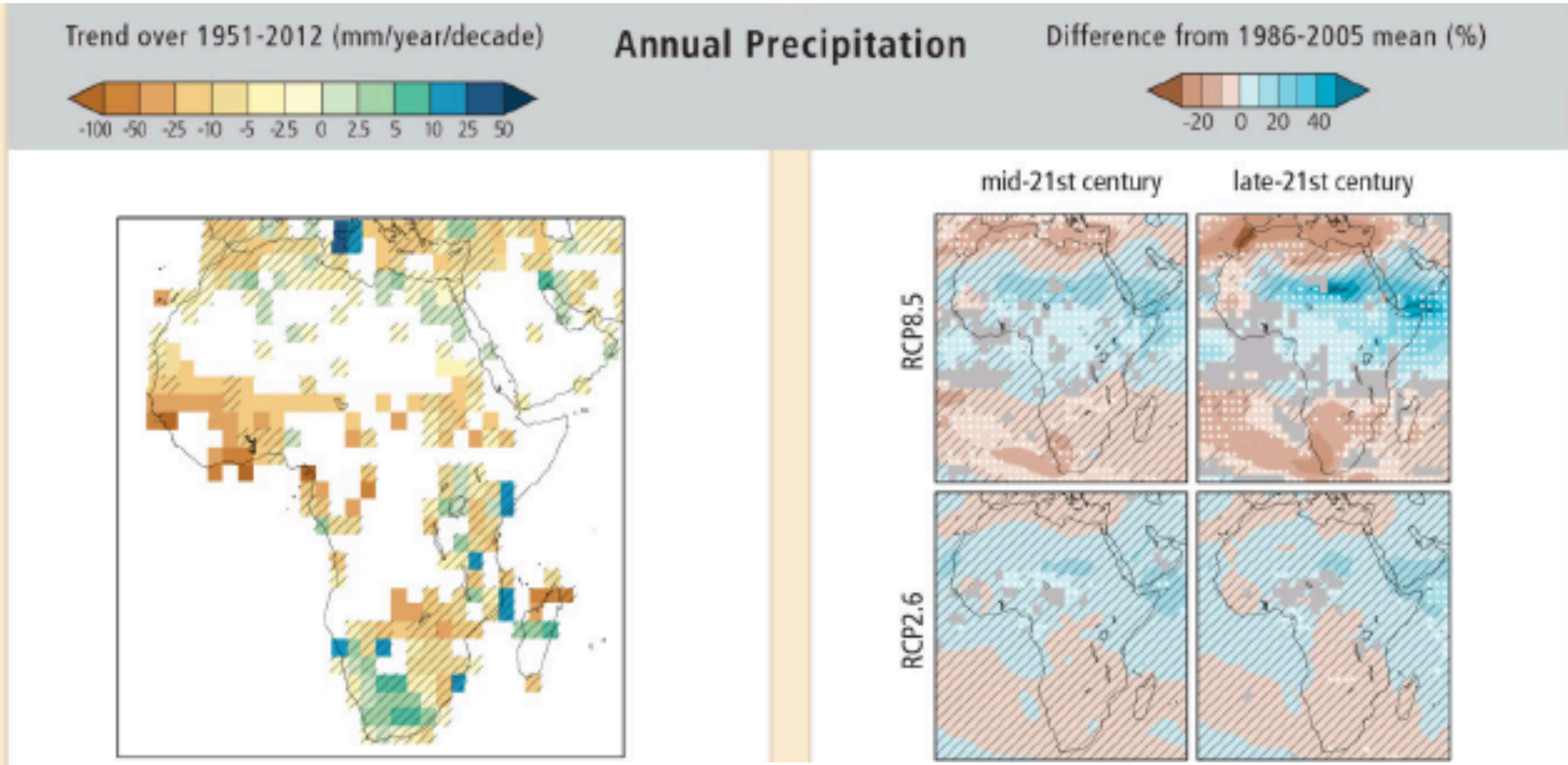
2050 relative to 1960-2000 baseline

19 GCMs

A2 scenario

Source: Cairns et al. 2013

Historical & future changes in precipitation



Areas where there are sufficient data include *very likely* decreases in annual precipitation over the past century over parts of the western and eastern Sahel region in northern Africa, along with *very likely* increases over parts of eastern and southern Africa. IPCC Africa 2014

Summary of meta-analyses of impact of climate change on African cereals

Crop	*n*	Mean change (%)
Africa	163	-7.7
Maize	10	-5.4
Wheat	20	-17.7
Sorghum	6	-14.6
Millet	13	-9.6
Rice	5	NS

Source: Knox et al. Environ Res Let 2012

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Maize

Annual production, harvested area in 2008-10, and gain per year in farm yield 1991-2010 in maize in SSA

Country/ Region	Production (Mt)	Area (Mha)	Yield (t/ha)	Gain per year in yield (kg/ha)	CV (%)	Nutrients applied (kg/ha/yr)
East	**21.9**	**14.3**	**1.5**	**13**	**10**	**10**
Tanzania	4.5	3.3	1.3	-5	48	5
Malawi	3.2	1.6	2.0	47	23	29
West	**14.7**	**8.3**	**1.8**	**33**	**13**	**3**
Nigeria	7.5	3.8	2.0	46	15	3
Central	**4.0**	**4.0**	**1.0**	**12**	**10**	**3**
RSA	12.5	2.7	4.7	142	23	116

Source: Fischer et al. 2014

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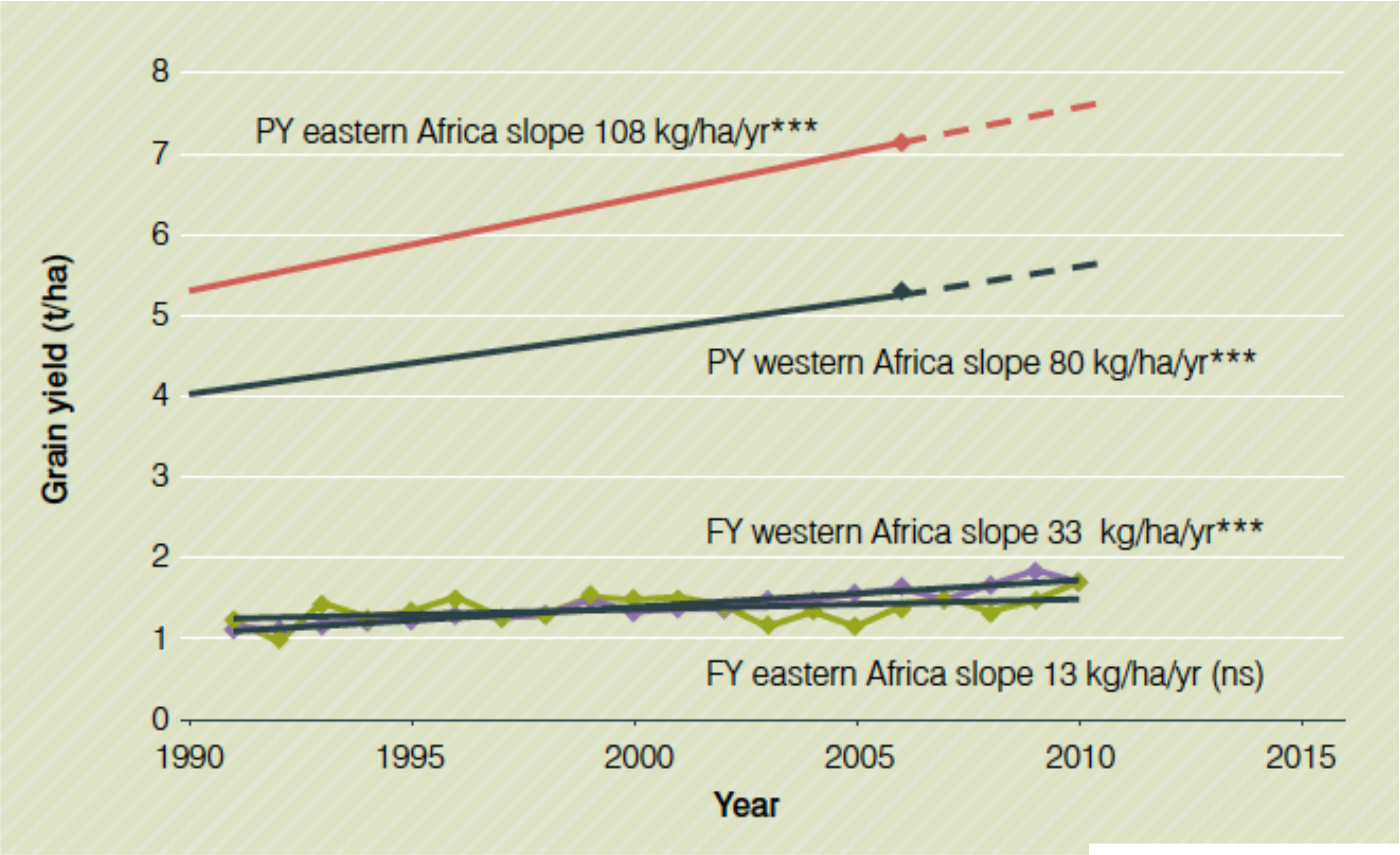
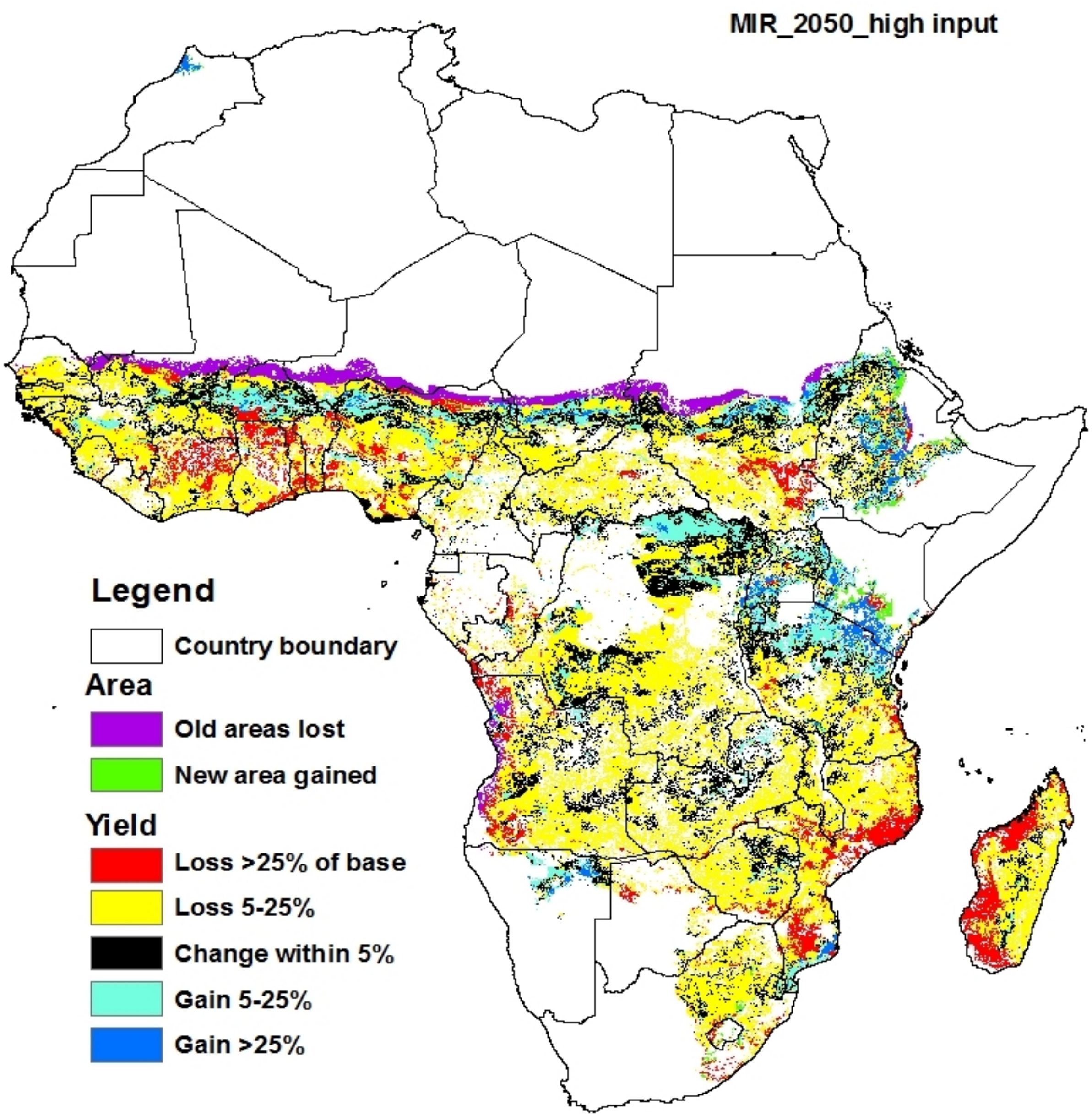
Farm yields (FY) are increasing slowly & the yield gap growing



PY=attainable yield

Source: Fischer et al. 2014

Changes in yield & area in SSA in 2050



CERES Maize

High N scenario

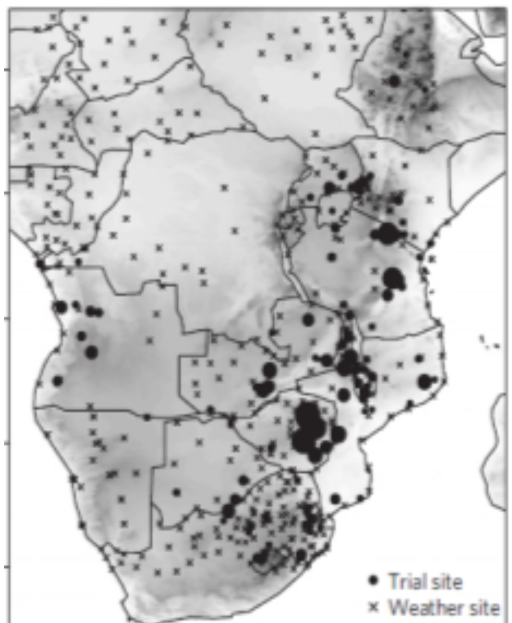
MIROC A1B (warmer, wetter)

Projection relative to baseline (2000)

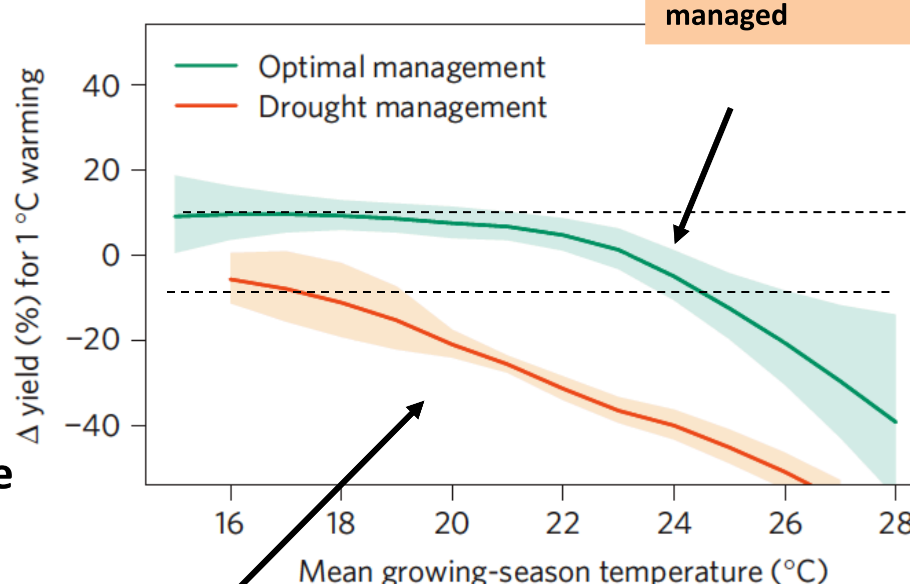
Source: Tesfaye et al. 2015

In some places good management will not be enough

Effect of +1ºC warming on maize yield in southern Africa



20,000+ maize trials in 123 research sites

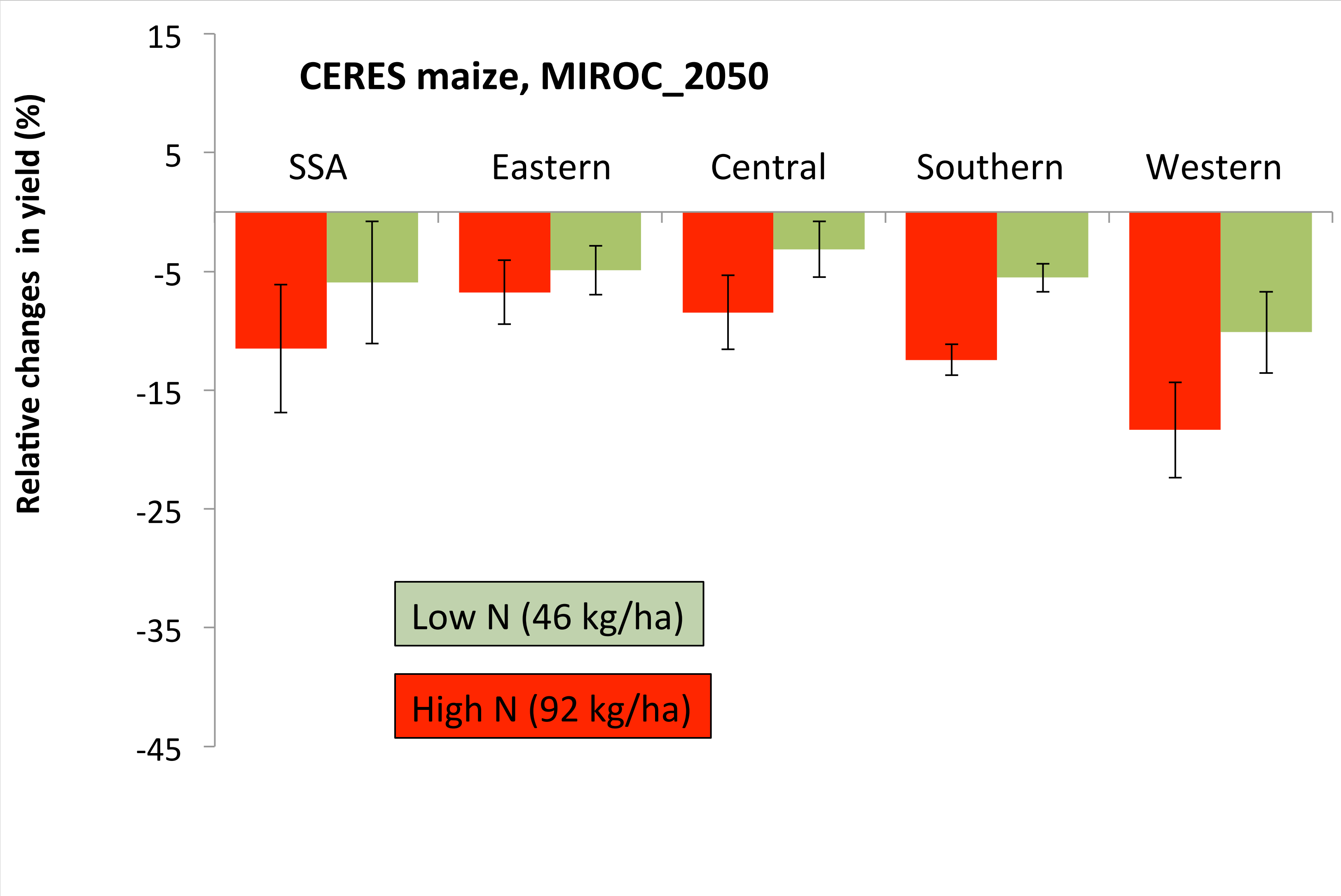


Sites with >23ºC would suffer even if optimally managed

More than 20% loss in sites with >20ºC, under drought

Source: Lobell et al. 2011

Regional changes in maize yield



Source: Tesfaye et al. 2015

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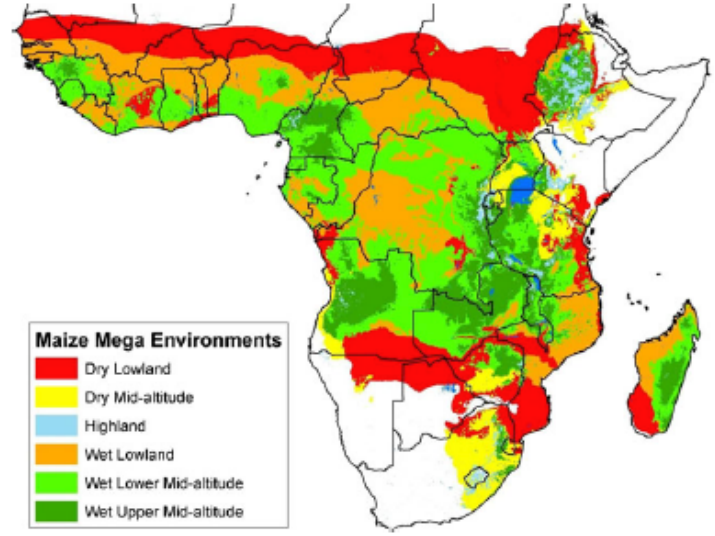
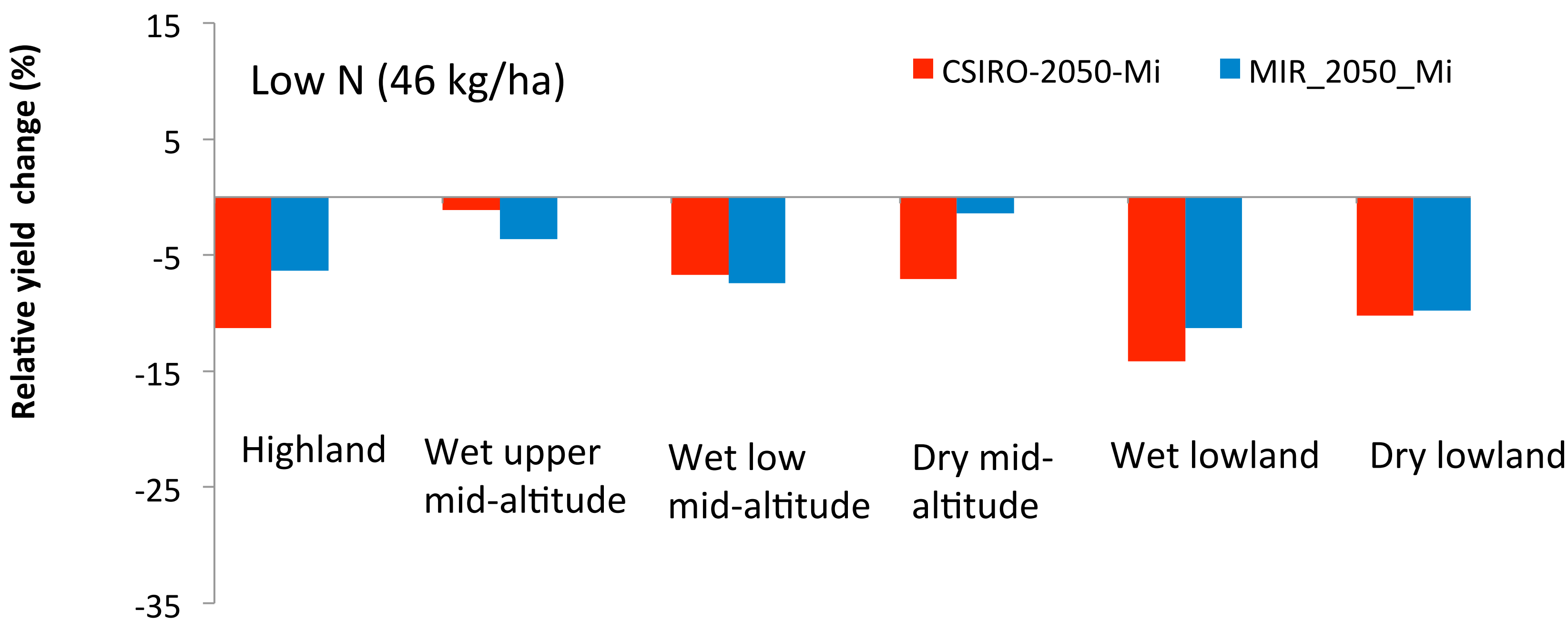
Changes in yield of maize in six mega-environments





Source: Tesfaye et al. 2015

Projected impact climate change on maize production, trade & consumption (all Mt)

	Δ Production	Δ Net exports	Δ Consumption
World	-139.9 (-3)	-98.2 (-36)	-139.9 (-10)
East Africa	5.6 (20)	15.0 (-53)	-9.4 (-17.7)
Central Africa	0.4 (5)	2.0 (-109)	-1.6 (-18)
Southern Africa	1.3 (13)	3.3 (-27)	-2.0 (-9)
West Africa	0.5 (0.5)	5.2 (-60)	-4.7 (-16)

(% in parentheses)

Gridded CERES outputs & IMPACT (partial equilibrium global economic model)

Source: Tesfaye et al. 2015

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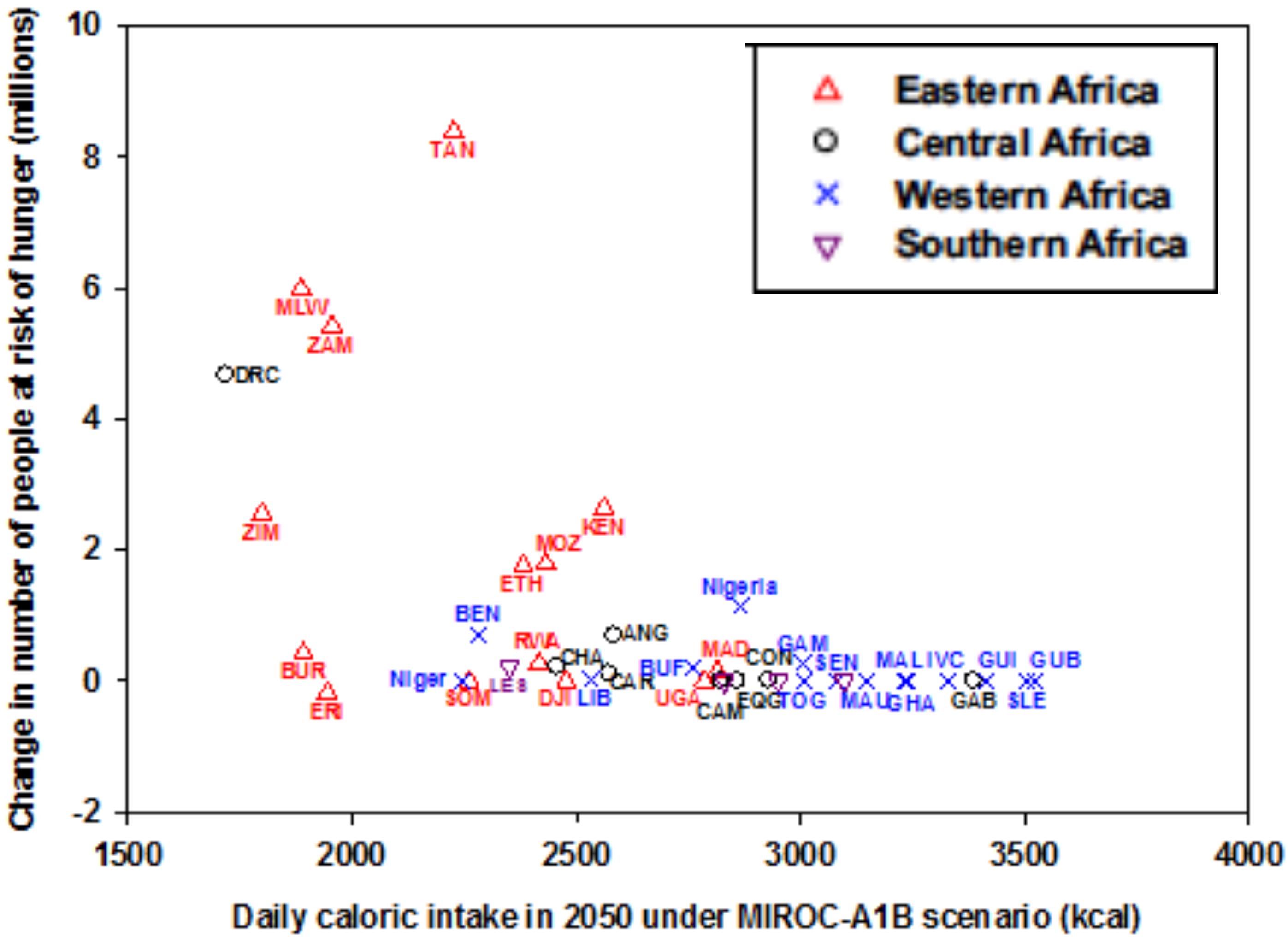
Daily calorific intake & changes in number of people at risk of hunger



And not forgetting less well analysed impacts…

Impact climate change on stem borer damage (% yield loss) in maize in Kenya

		C. partellus		*B. fusca*	
Ecology	**Altitude**	**Observed 2013**	**Predicted 2055**	**Observed 2013**	**Predicted 2055**
Highland tropical	>1600	0	8.3	10.7	14.9
Moist transition	1300-1600	11.1	12.4	14.6	15.8
Dry mid-altitude	1000-1300	11.1	17.9	5.5	12.3
Lowland tropical	<1000	22.7	28.1	0.5	9.5

Source: Mwalusepo et al. 2015

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Wheat

Simulated Change (%) in Average Wheat Yield

AE zone	Fertilizer (kg/ha)	Base yield (t/ha)	CSIRO A2	MIROC A2
Tropical Highlands	0	1304	12	2
	100	3068	6	5
Humid	0	1308	19	17
	100	2470	7	9
Sub-humid	0	851	10	9
	100	898	5	8

- Climate change will tend to have a positive impact on yield
- Response to CO_2 fertilization

Gbegbelegbe et al., 2011

Sorghum and Millet

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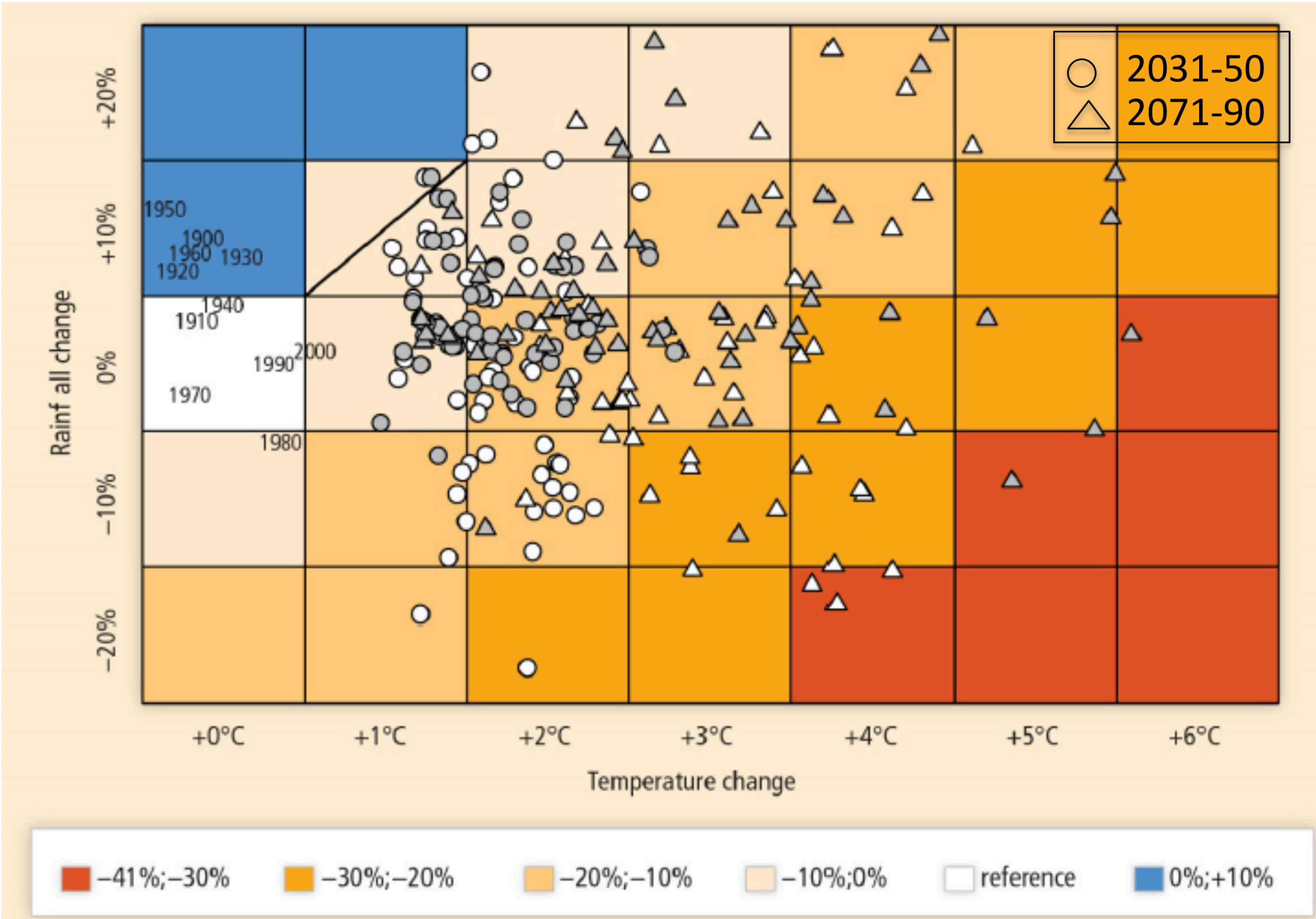
Changes in sorghum and millet production, harvested area and yield

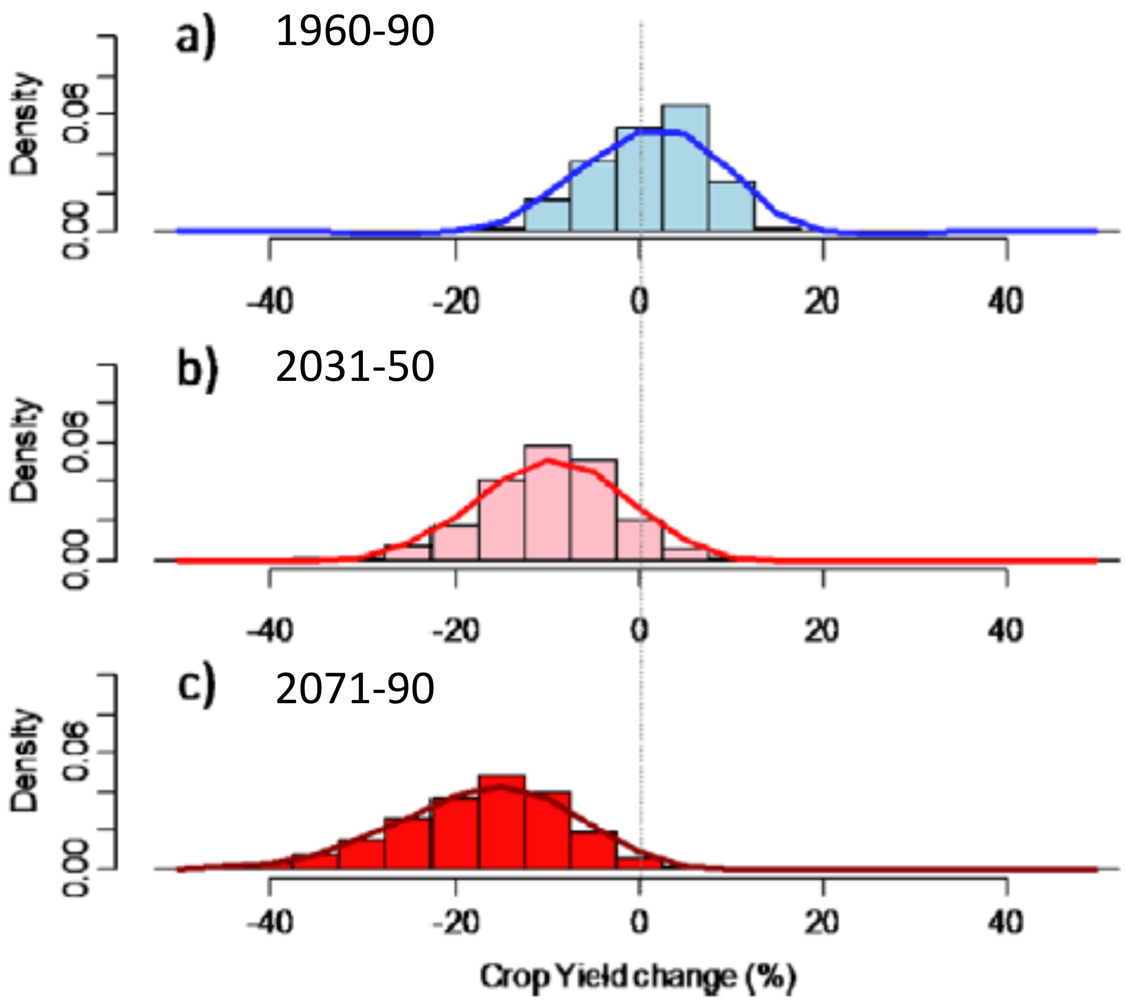
	Production (Mt)	Area (Mha)	Yield (t/ha)	Δ Area (pa)	Δ Yield (pa)
Sorghum					
Nigeria	7.2	5.8	1.26	0.8	1.0
Sudan	3.6	6.3	0.56	1.0	0.3
Ethiopia	2.7	1.6	1.69	3.6	1.4
Millet					
Nigeria	6.4	4.4	1.44	-0.6	2.4
Niger	3.3	6.8	0.49	1.7	1.5

Simulated millet yields with -20 to +20% rainfall & 0 to 6°C temperature change



Source: Sultan et al. Environ Res Let 2013

Millet yield change density curves



Simulations suggest:

- 10% reduction by 2031-50
- Increase in variability, especially by 2071-90

Source: Sultan et al. Environ Res Let 2013

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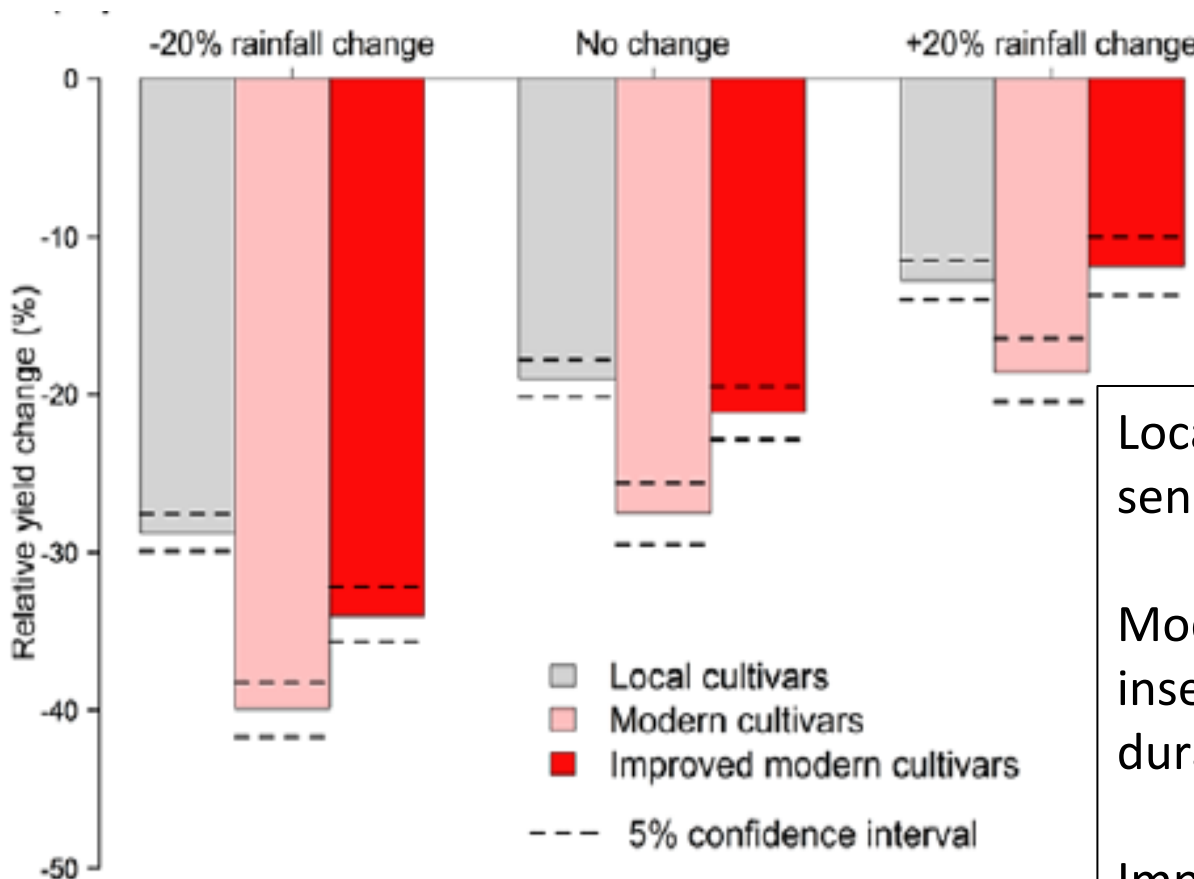
Simulated impact of +4° change in temperature on different types of variety



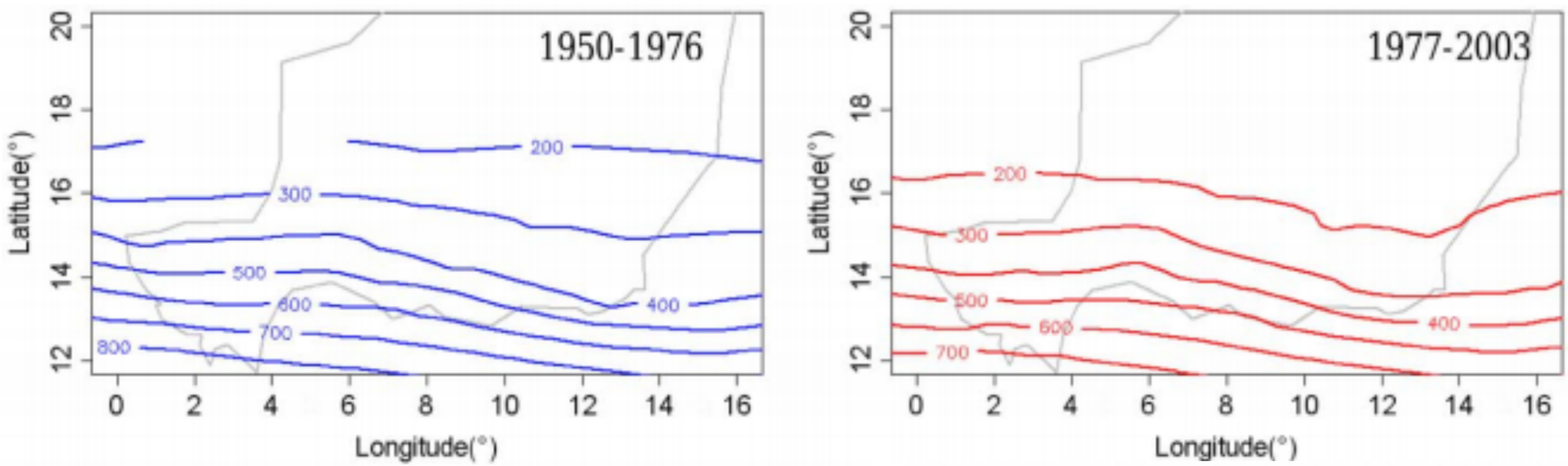
Local: photoperiod-sensitive, longer duration

Modern: photoperiod-insensitive, shorter-duration

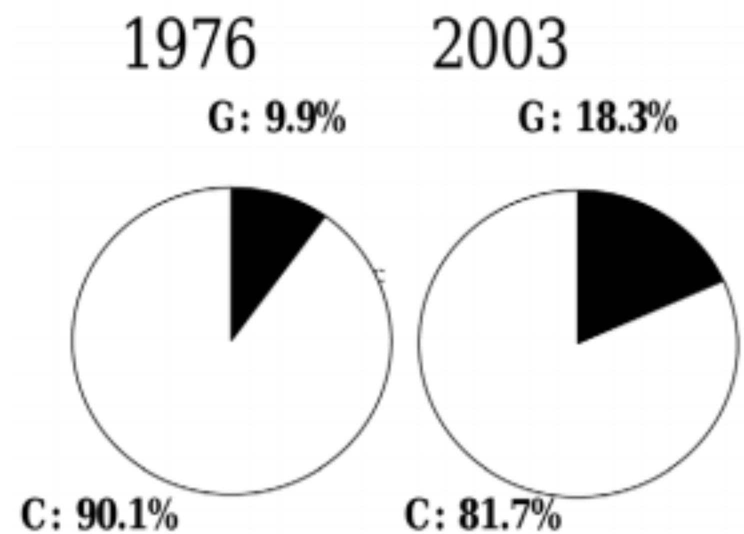
Improved: photoperiod-sensitive, high HI

Source: Sultan et al. Environ Res Let 2013

Crop adaptation in millet to a changing climate?



- Rainfall isohyets moved 100-150km further south in this period in Niger
- Allelic frequencies of the earliness allele at PHYC locus have increased



Source: Vigouroux et al., 2011


Addressing the issues

Breeding for climate change

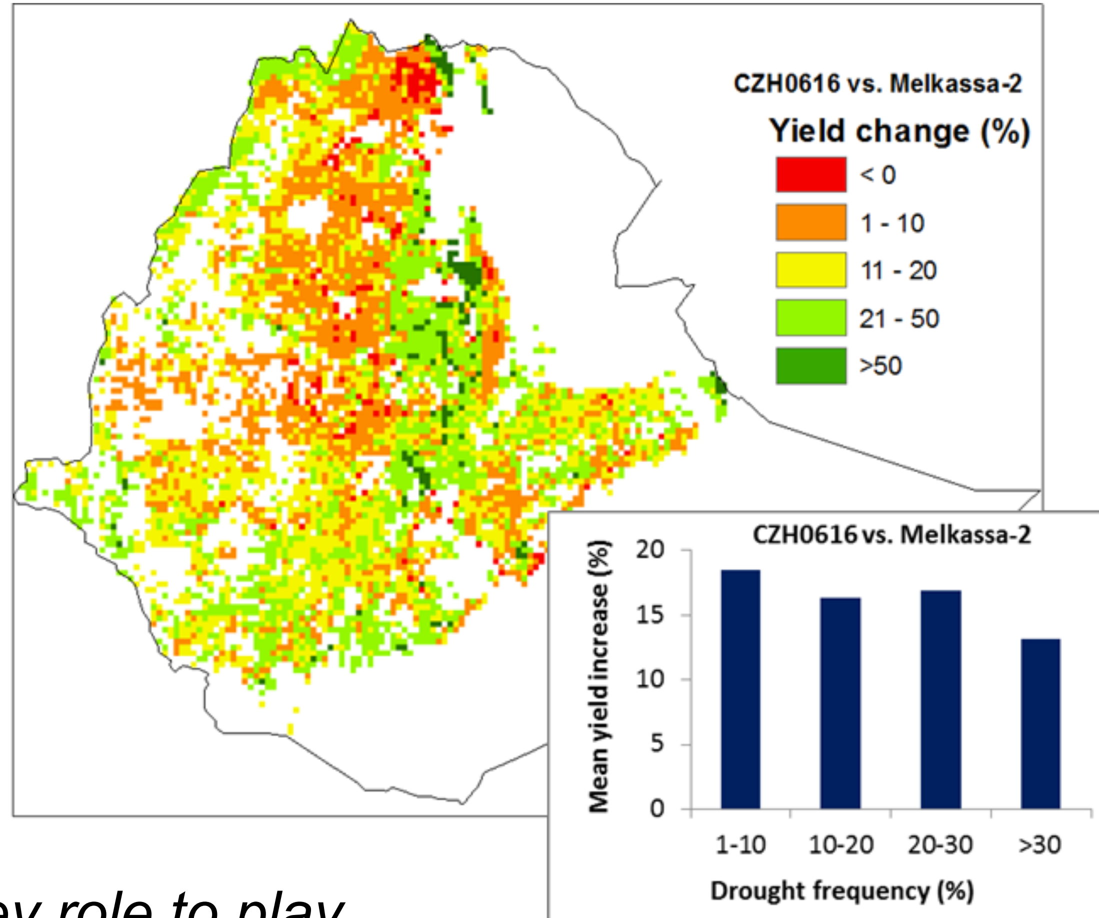
	Yield (t/ha)		Rank		
Entry	Drought	Heat	Drought	Heat	D+H
[SYN—USAB2/ SYN_ELIB2]-12-1-1-2	3.22	2.08	1	49	296
DTPWC9-F2-3-2-1	3.10	2.15	4	41	256
DTPYC9-F46-1-2-1-2	3.07	1.52	7	126	4
La Posta Seq C7-F64-1-6-2-1	2.90	1.48	9	126	7
Check	2.36	1.35	261	155	169

- Multi-site testing of 300 inbred x common tester, CML539
- Genetic correlations of drought, heat & D+H suggests traits are largely independent
- Best drought tolerant lines are from 70-90s
- Repeatability low

Source: Cairns et al Crop Sci 2013

Targeting of new maize varieties

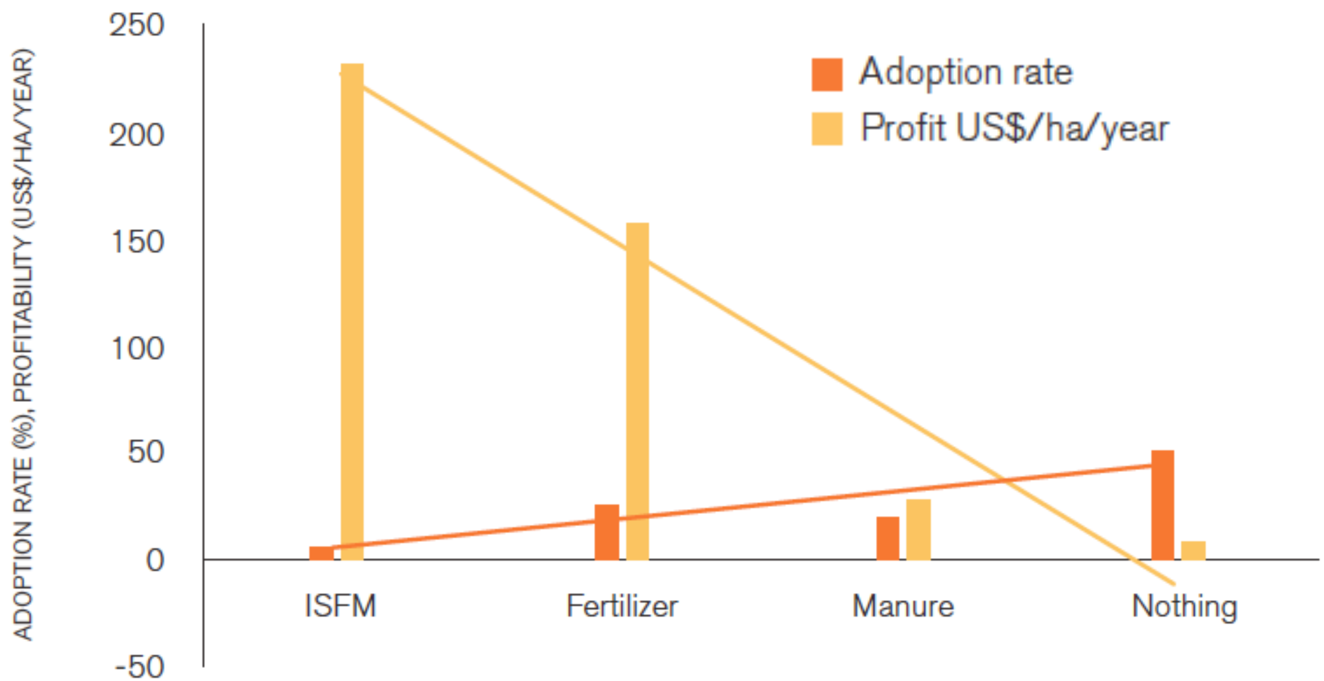
- New drought tolerant varieties performed better than check Melkassa2 in many areas
- Tolerant varieties, climate information & good agronomy increased income of farmers by up to 40%
- *Index insurance has a key role to play*



CCAFS. Courtesy K. Tesfaye

Many farmers need lower cost & less knowledge intensive solutions

An 'unholy cross': The inverse relationship between adoption rate and profitability



ISFM: integrated soil fertility mgt

Source: AGRA: The Africa Agriculture Status Report 2014

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Women are very vulnerable to climate change

Parameter (all %)	Ethiopia
Female share of population	50.2
Agricultural share of economically active women	73.5
Share of rural households that are female headed	20.1

- High dependence on natural resources
- Control less land
- Land tenure is less secure
- Land is poorer quality
- Less education
- Less likely to use inputs
- Less access to extension

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A two-pronged adaptation strategy:

1. Addressing rainfed farming to better cope with current 'season-to-season' and 'within-season' rainfall variability

2. Proactively adapt farming practices to future climate through:

- **incremental adaptation** (e.g., changing crop planting dates)
- **systems adaptation** (changing choices about crops or livestock)
- **transformational adaptation** (possibly seeking alternative livelihoods as agriculture becomes unfeasible)

Source: AGRA 2014

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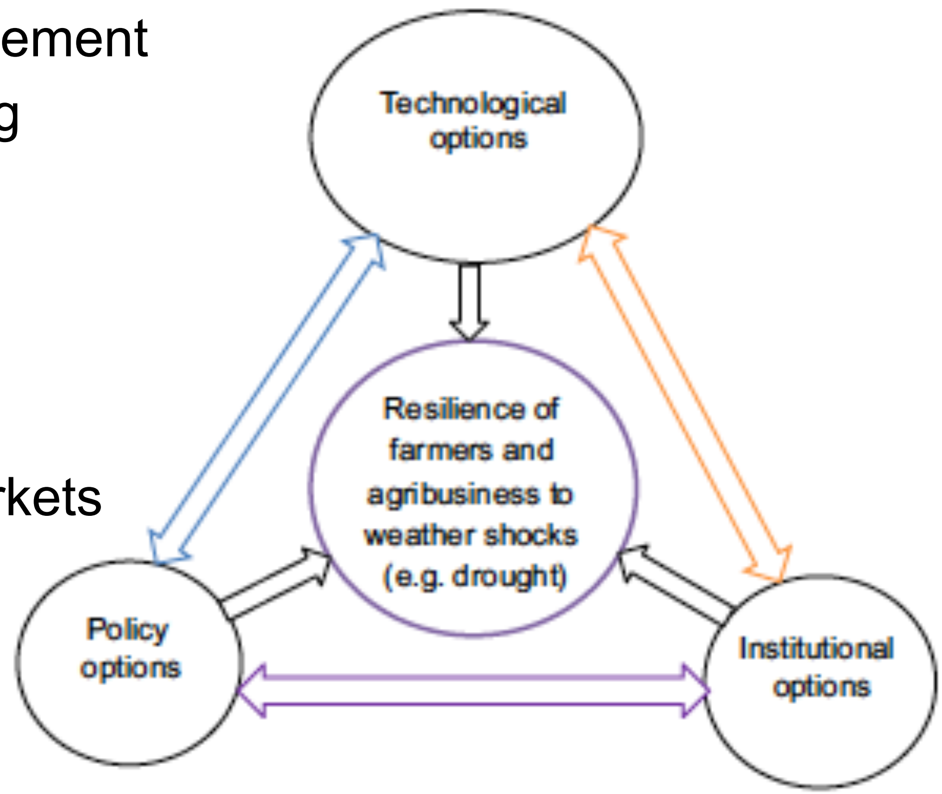
Integrated & ex-ante approaches to risk management are needed

- Drought & heat tolerant varieties
- Improved crop & water management
- Climate & seasonal forecasting
- Better access to information

- Livelihood diversification
- Index insurance
- More efficient input/output markets

- Price stabilization
- Strategic food reserves
- Social protection



Source: Shiferaw et al. Weather and Climate Extremes 2014

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Develop capacity & networks in SSA

- Influencing climate change policy & investment is needed across scales: international – regional - local
- There is huge gap between global (i.e. IPCC community) & regional to local capacity & policy needs
- Need to develop core expertise in SSA to fill this gap:
  - Local context & understanding
  - Climate change impacts (especially near-term)
  - Integrated assessment (to drive change)
  - How to influence policy (not just policy briefs)
- Train & empower more women

Thank you for your interest!

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REACCH
Regional Approaches to Climate Change – PACIFIC NORTHWEST AGRICULTURE

Thank you!

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Pacific Northwest Farmers Cooperative

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