INSTITUTE FOR SUSTAINABLE RESOURCES

UCL

Land degradation and food security: impacts and adaptation options

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2020 GTAP conference

17th June 2020

Introduction

Land degradation:

- Affects more than a quarter of the global land area
- Reduces the quality of the soil, which declines crop yields, production volumes and farming incomes
- Together with climate change, it is expected to increase the risk of food security in many regions of the world

Water erosion and nutrient uptake by crops:

- Water erosion degrades the soil structure and washes away the topsoil, which reduces the availability of nutrients to crops
- An excessive uptake of soil nutrients through crops without a sufficient replenishment of soil nutrients through natural and artificial fertilizer causes soil nutrient depletion

Research gap:

- Many studies estimate the magnitude of land degradation processes, such as the amount of global soil loss due to water erosion, but not much attention has been given to the impact of land degradation processes on global crop yields

EPIC-IIASA crop model

Environmental Policy-Integrated Climate model

Global Input Data:

- Daily weather
- Soil properties, topography
- Nitrogen and phosphorus fertilizer
- Area of rainfed and irrigated crops
- Crop calendar
- Field management scenarios

Global Resolution:

- 5’ to 30’ (~10 – 50 km at equator)

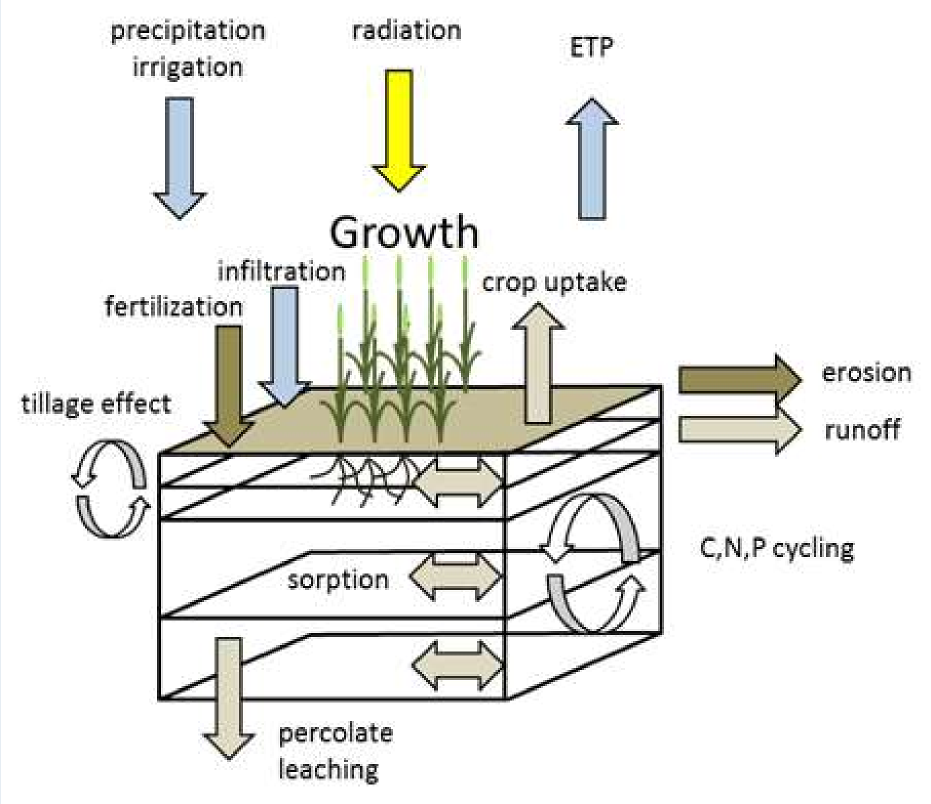
Erosion Model:

- Modified Universal Soil Loss Equation (MUSS)
- 6 other equations available

Validation Data:

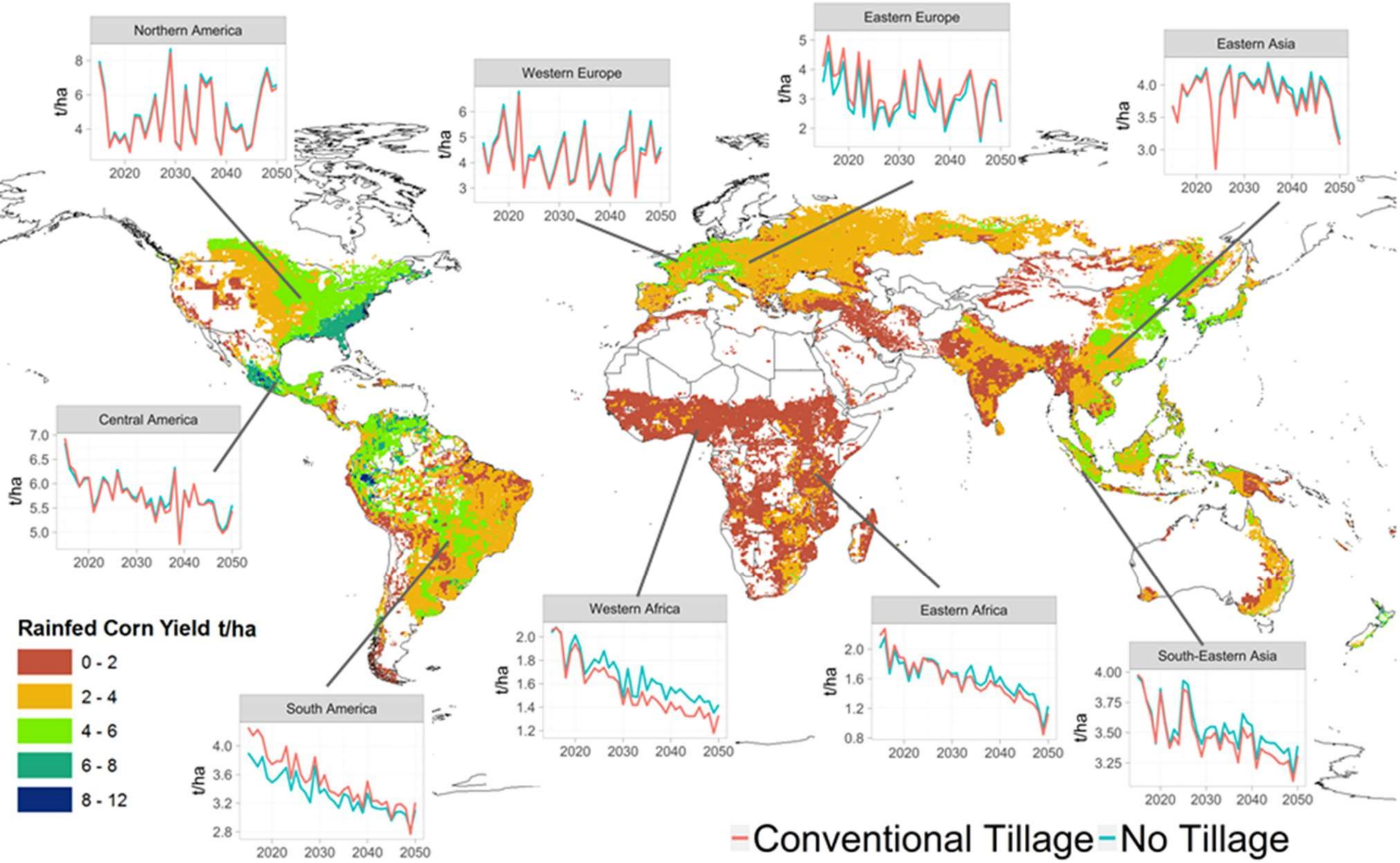
- Reported erosion rates (n=563, 46 countries)

Environmental Policy-Integrated Climate Model (EPIC)

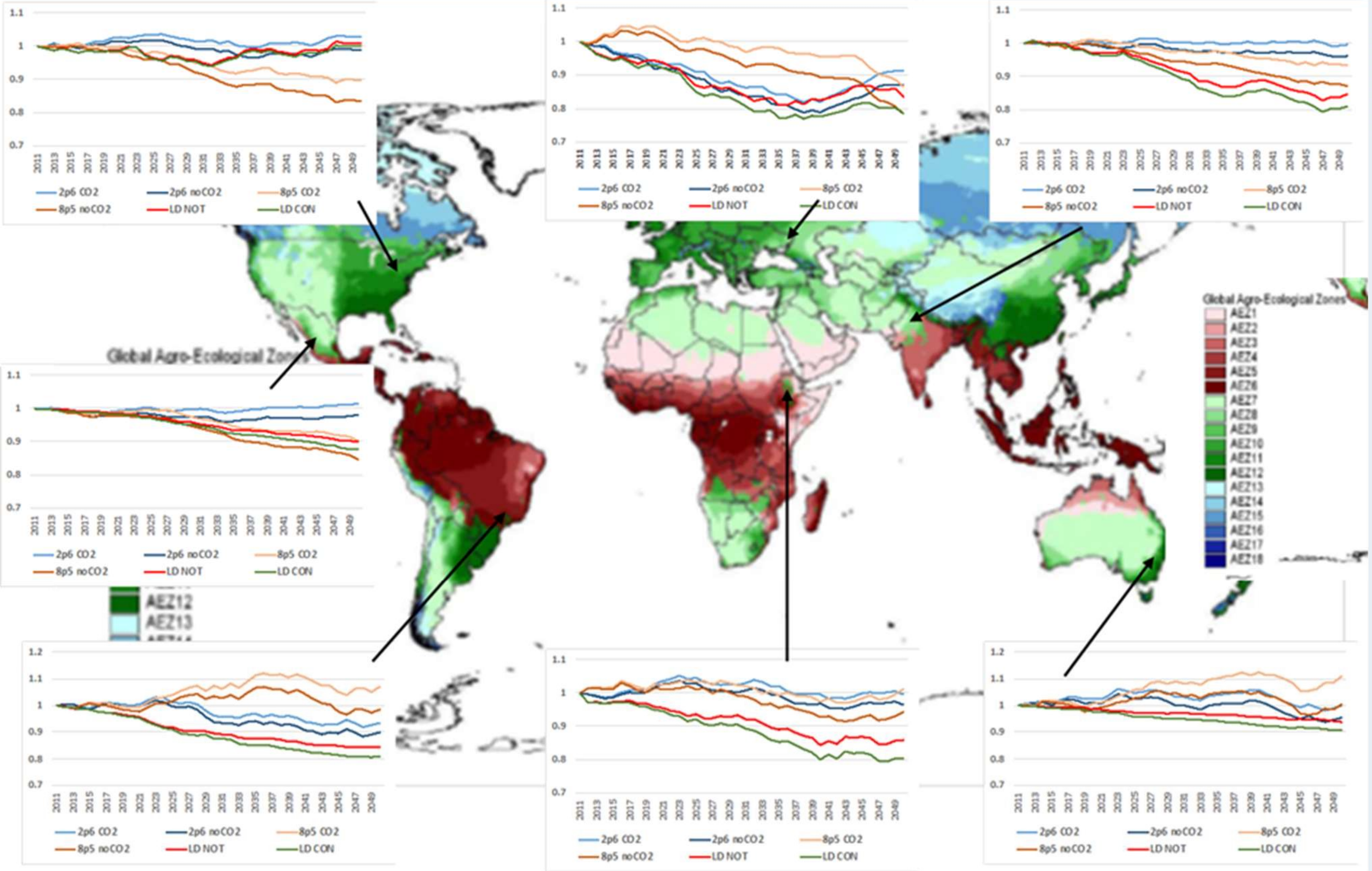


basic components of EPIC model to simulate the growth and development of crops (Source: Sharpley & Williams 1990).

EPIC-IIASA output data: Maize yields under land degradation



ENGAGE-land input data: Maize yields under land degradation and climate change



Maize yield changes due to climate change and land degradation for selected AEZs

ENGAGE-Land model

UCL - Environmental Global Applied General Equilibrium (ENGAGE) model

- Multi-region, multi-sector dynamic CGE model of the world economy
- Based on the GTAP-9a database, which represent the global economy in 2011
- Recursive dynamic model (2011-2050)
- Models 18 regions, 24 sectors (8 crops) and 21 factors of production
- Incorporates 18 agro-ecological zones (AEZ)
- Distinguishes between rainfed and irrigated crops
- Includes first generation biofuels

18 Regions		24 Sectors	
WEU	Western Europe	pdr	Paddy rice
EEU	Eastern Europe	wht	Wheat
USA	USA	gro	Cereal grains
CAN	Canada	v_f	Vegetables fruit
ANZ	Australia New Zealand	osd	Oil seeds
JPN	Japan	c_b	Sugar cane/beet
RUS	Russia	pfb	Plant-based fibers
FSU	Rest of Former Soviet Union and rest of Europe	ocr	Other crops
BRA	Brazil	olvs	Outdoor livestock
PAC	Paraguay Argentina Uruguay	ilvs	Indoor livestock
LAM	Rest of Latin America	frs	Forestry
CHN	China	fod	Rest of food
IND	India	vol	Vegetable oils
MAI	Indonesia Malaysia	sgr	Sugar
SEA	South East Asia	fri	Forest related industry
MEA	Middle East North Africa	pcm	Processed animal products
AFR	Sub Saharan Africa	coa	Coal
ROW	Rest of the World	oil	Oil
		gas	Gas
		p_c	Petroleum coal products
		ely	Electricity
		crp	Chemical rubber plastic prods
		ets	Paper, minerals and metals
		oth	Other goods and services

Scenarios

Baseline simulation

- No climate change, BAU policies
- SSP2 population growth, SSP2 economic growth
- Exogenous increase in total factor productivity and area according to the FAO long-term baseline outlook: ”World agriculture: towards 2030/2050” (Alexandratos and Bruinsma 2012)

4 Climate change scenarios applied to all crops

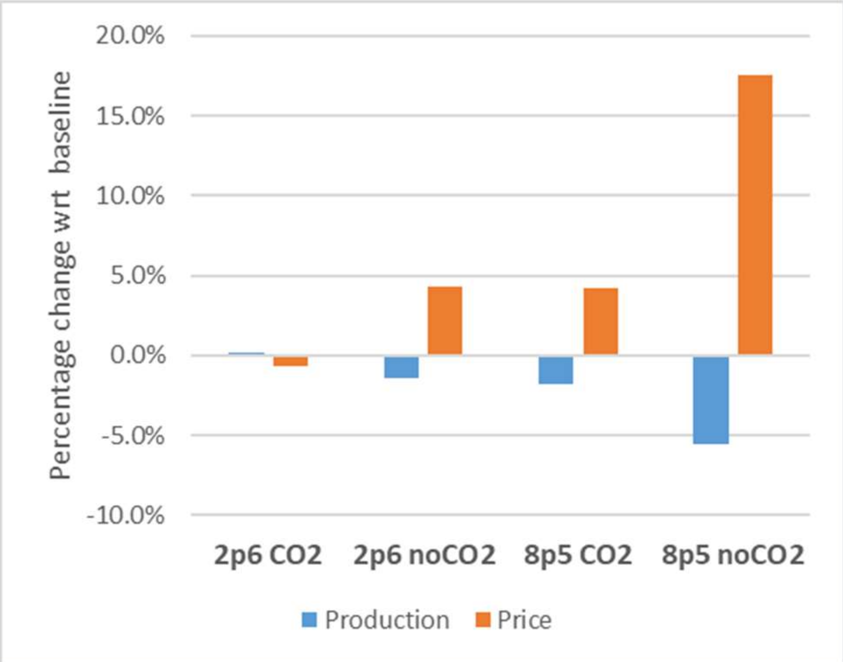
- RCP 2p6 with / without CO_2 fertilization (2p6 CO2 and 2p6 noCO2)
- RCP 8p5 with / without CO_2 fertilization (8p5 CO2 and 8p5 noCO2)

2 Land degradation scenarios applied only to maize (based on the RCP 2.6 climate forcing)

- Conventional tillage scenario (LD con)
- No-tillage scenario (LD not)

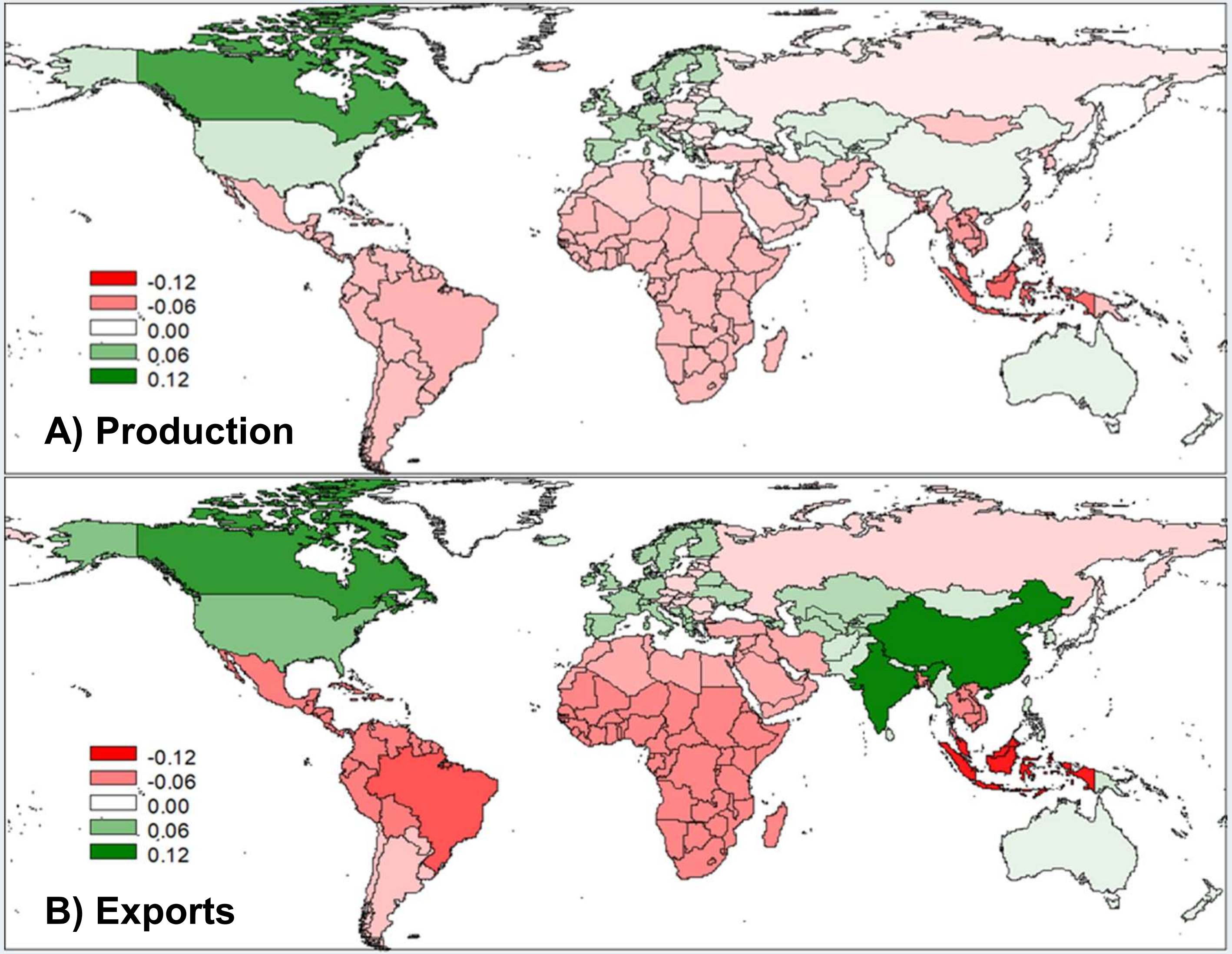
Climate change impacts: production and prices

Changes in global average price and production for five main crops in 2050



Changes in global average price and production in 2050

Climate change impacts: production and exports



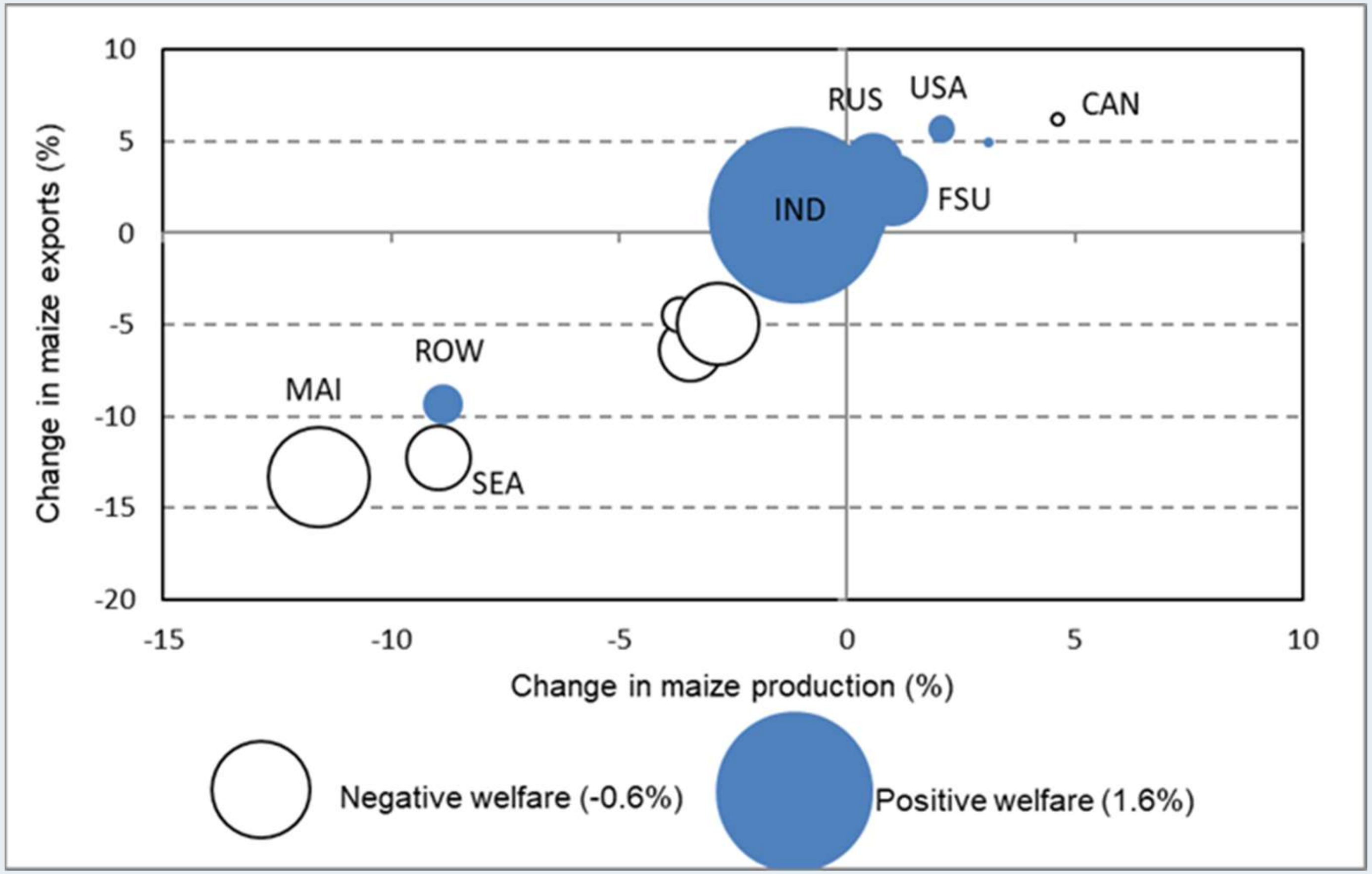
Changes in average production (A) and exports (B) for five main crops in 2050

RCP 2.6 no CO_2 scenario

(percentage change wrt baseline)

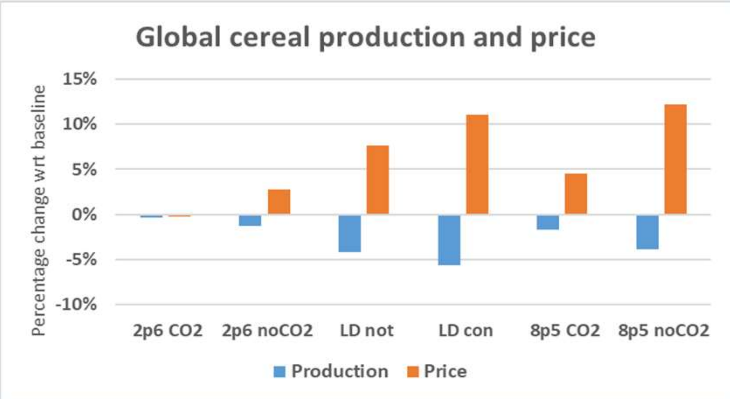
Climate change impacts: Production, export and welfare

Changes in regional maize production and exports in 2050. RCP 2.6 no CO_2 scenario

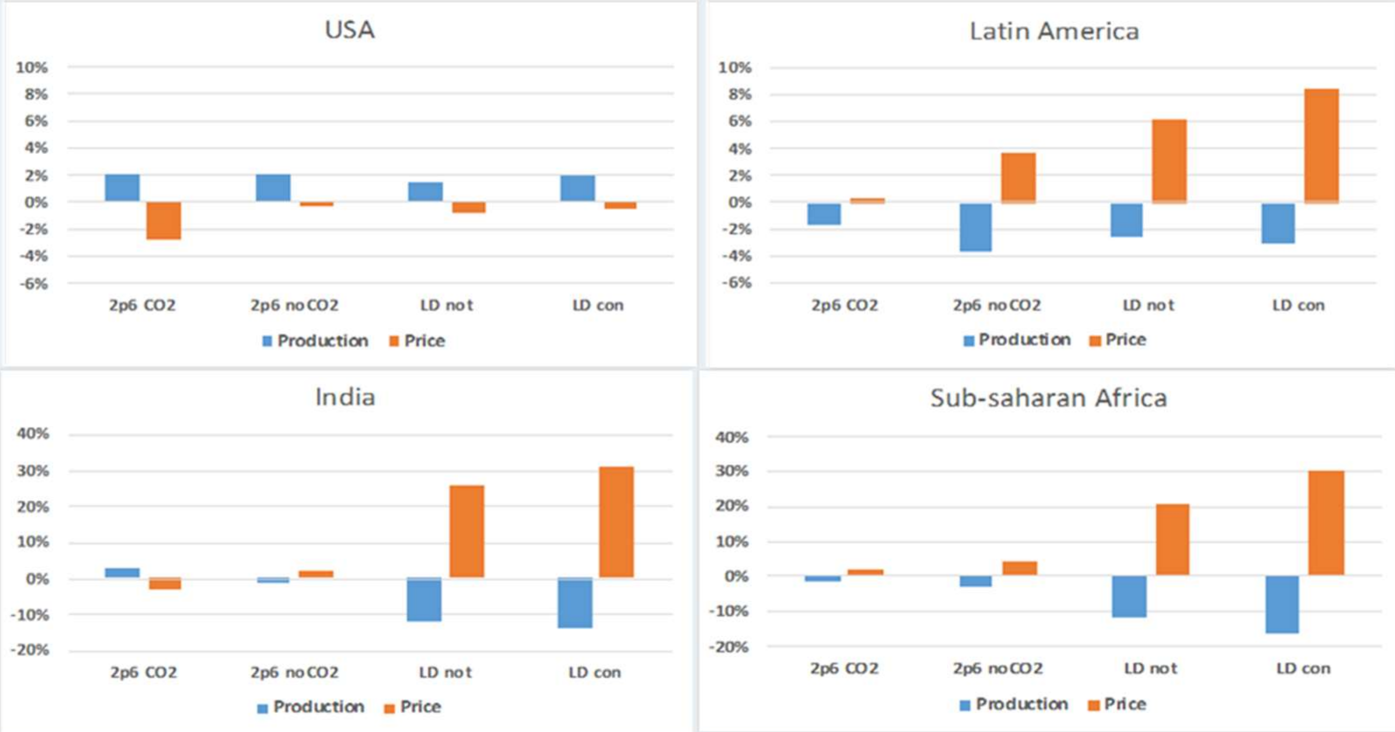


Land degradation impacts: production and prices

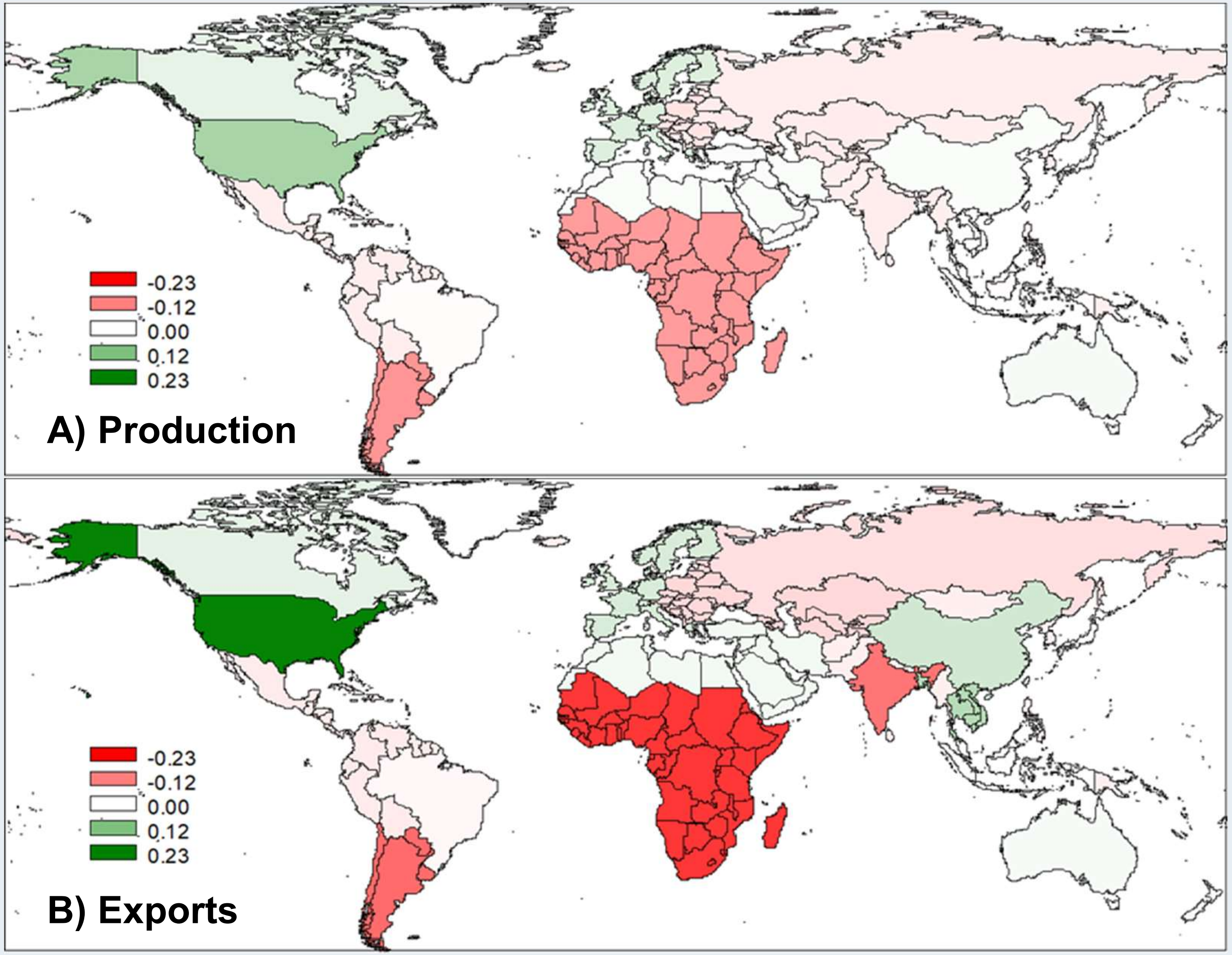
Changes in global maize production and average price in 2050



Changes in maize production and prices in 2050



Land degradation impacts: production and exports



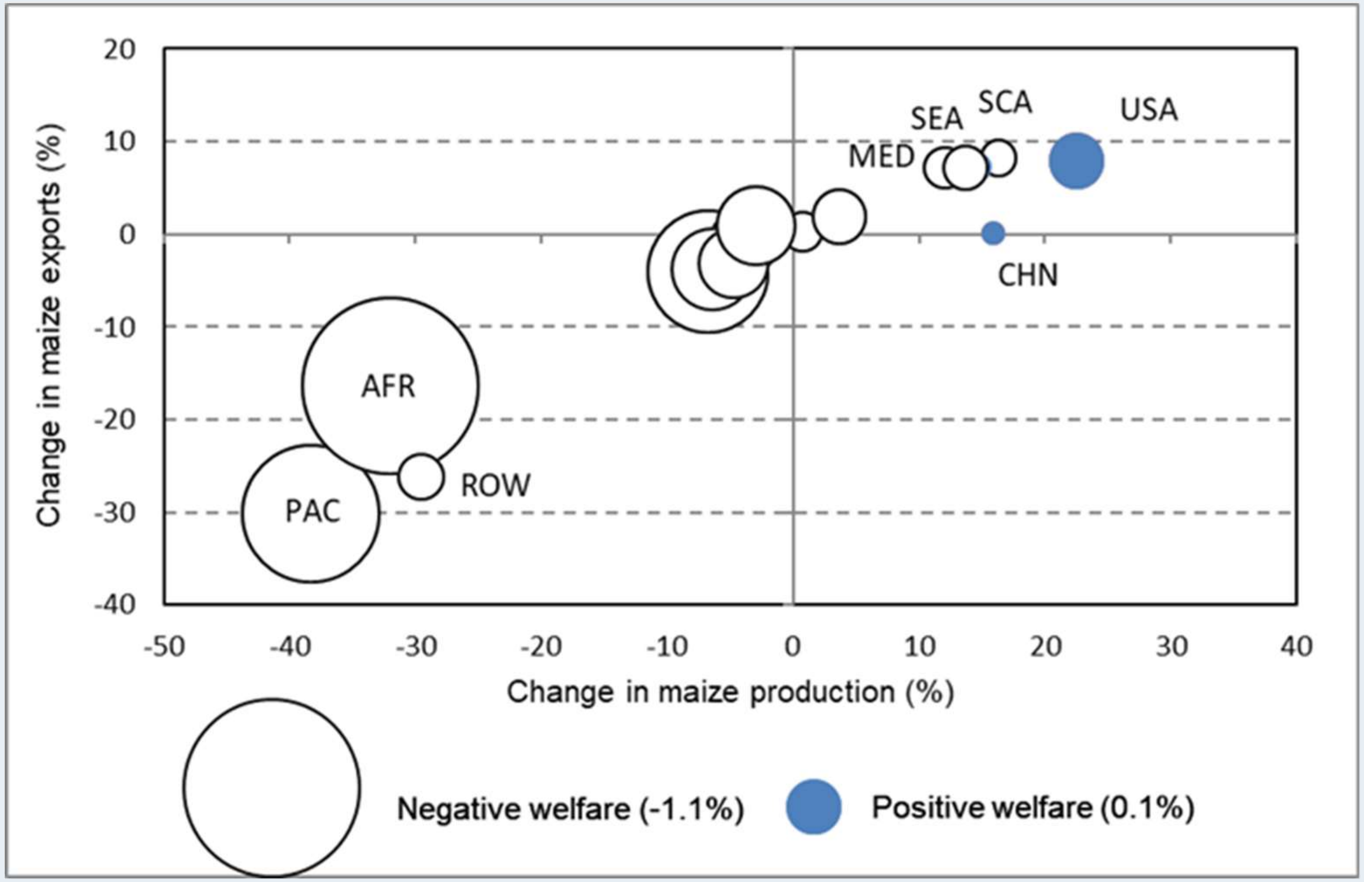
Changes in average production (A) and exports (B) for five main crops in 2050

Conventional tillage scenario

(percentage change wrt baseline)

Land degradation impacts: production, exports and welfare

Changes in regional maize production and exports in 2050. Conventional tillage scenario



Conclusions

- Both **climate change impacts** on crop production and **climate-induced changes in competitiveness** are crucial factors to determine the overall economic gains and losses

- **International trade** is a key mechanism of adaptation

- **Land degradation** might amplified significantly the impacts of climate change. It is important to include other crops in the economic analysis of land degradation (e.g. wheat, potatoes, sugar cane)

- As fertilizers, **soil management practices** play a key role on reducing the impacts of land degradation

- **Large nutrient mining** in developing countries will compromising the long-term sustainability of agricultural systems.

Thank you!

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