Modeling opportunities for climate-smart approaches
anticipating extreme events and shocks




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THE UNIVERSITY OF CHICAGO

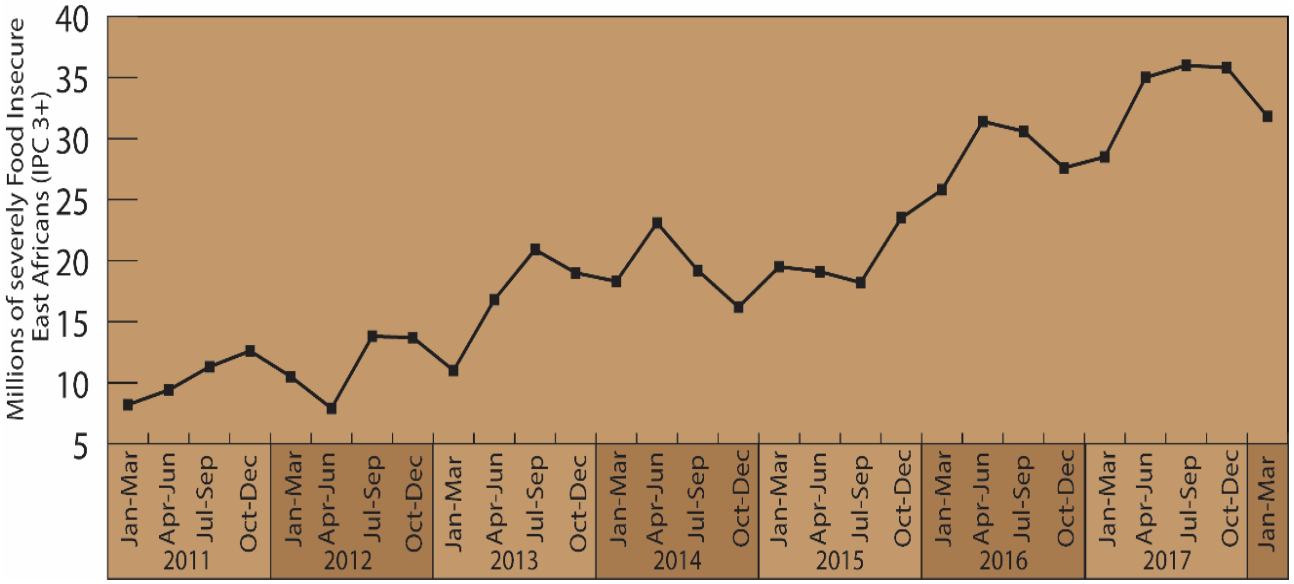
NASA

POTSDAM INSTITUTE FOR CLIMATE IMPACT RESEARCH
PIK

GACSA VISION: Working together to ensure that the world's agriculture can sustainably feed and nourish humanity and secure livelihoods in the face of a changing climate.

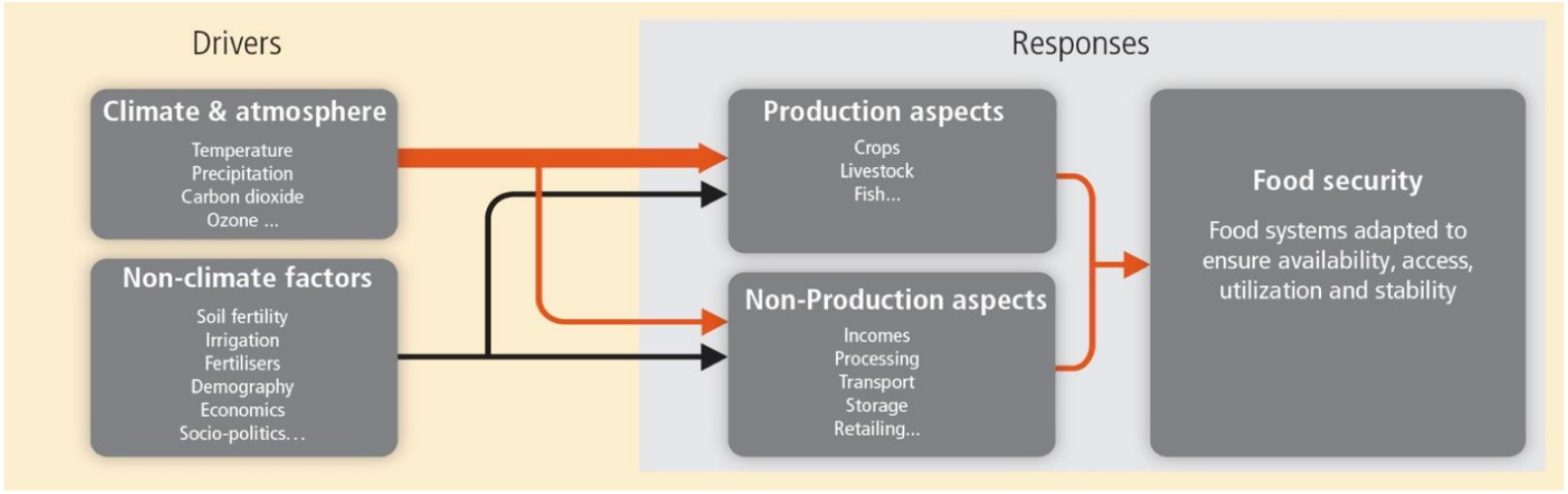
Food Insecurity is Increasing

Availability, Access, Utility, Stability



Millions of severely food insecure East Africans

Funk et al., 2019



Source: IPCC AR-5, WGII, Ch 7.

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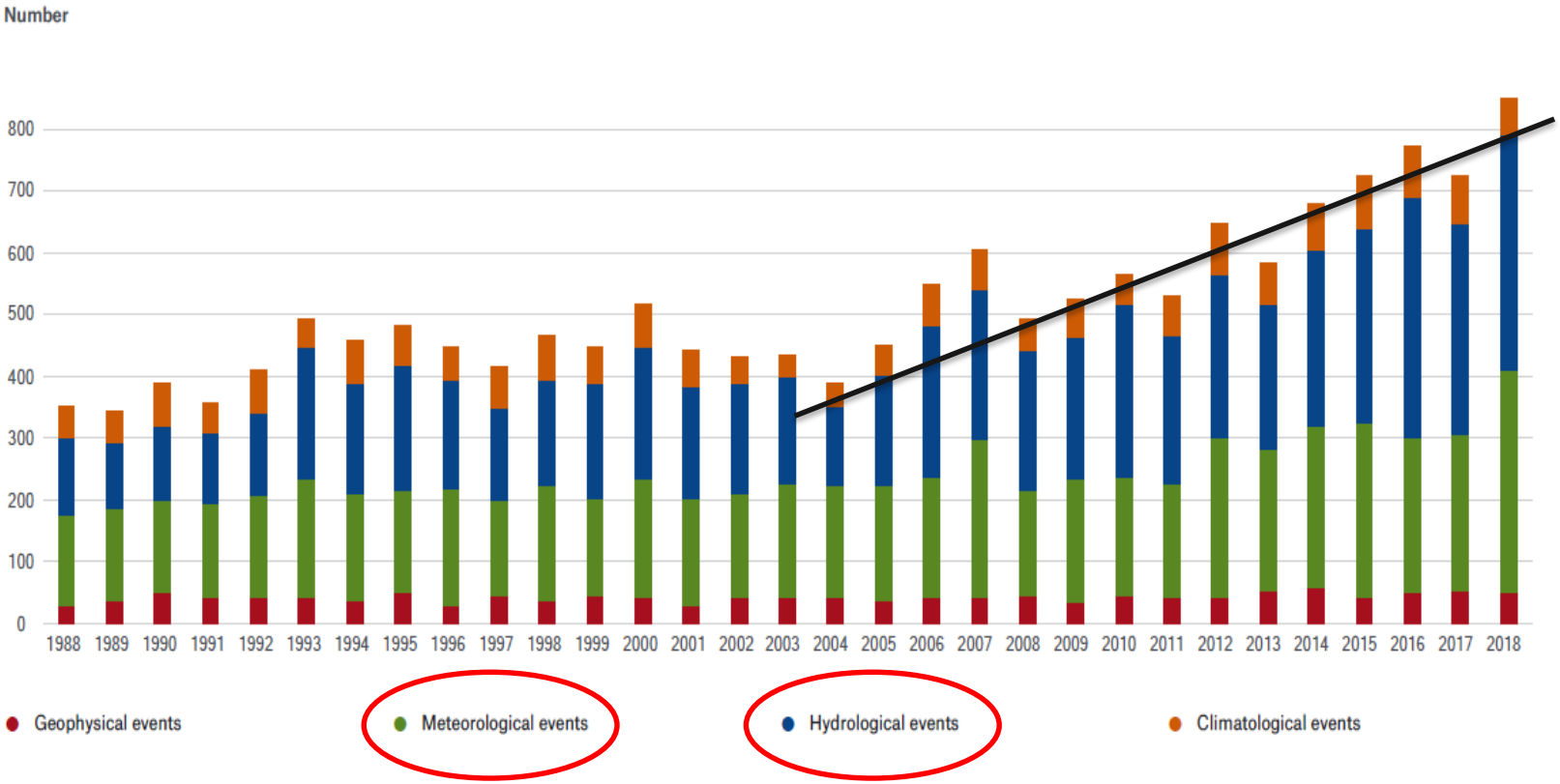
Increased Meteorological, Hydrological, and Climatological Loss Events

NatCatSERVICE

Munich RE

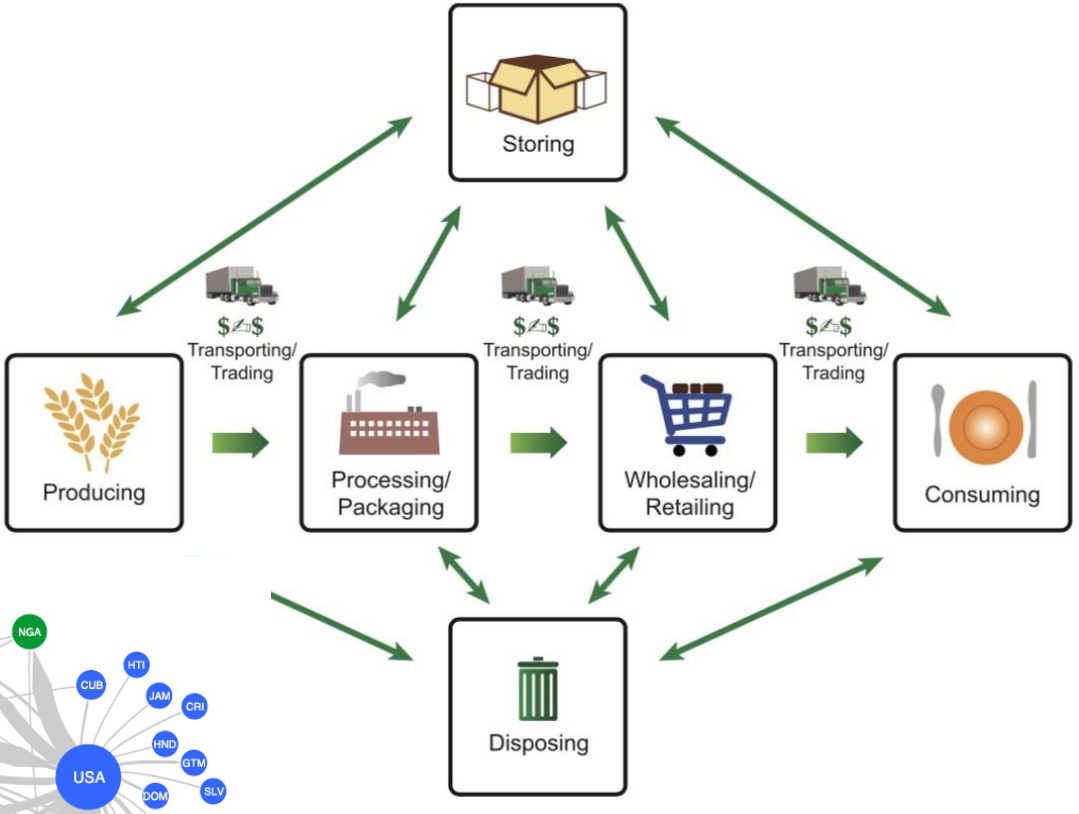
Number of events

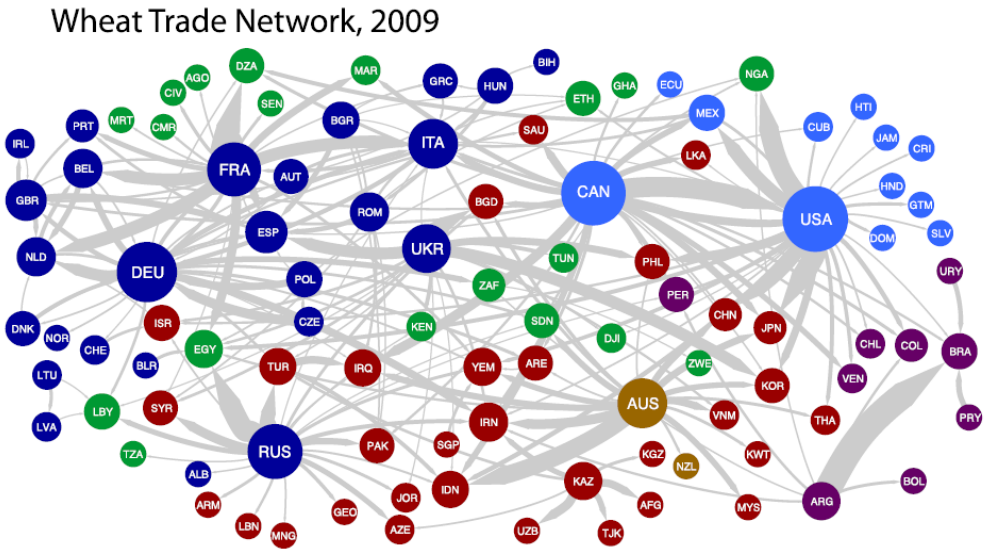
Relevant natural loss events worldwide 1988 - 2018



Staple crops need storage, transport, and processing to reach consumers

Large food system between producers and consumers





Trade dependencies buffer, but also trigger shocks to the system

Puma et al., 2015

Trend in world food prices

Figure 1.32. **Long-term price of maize in real terms**

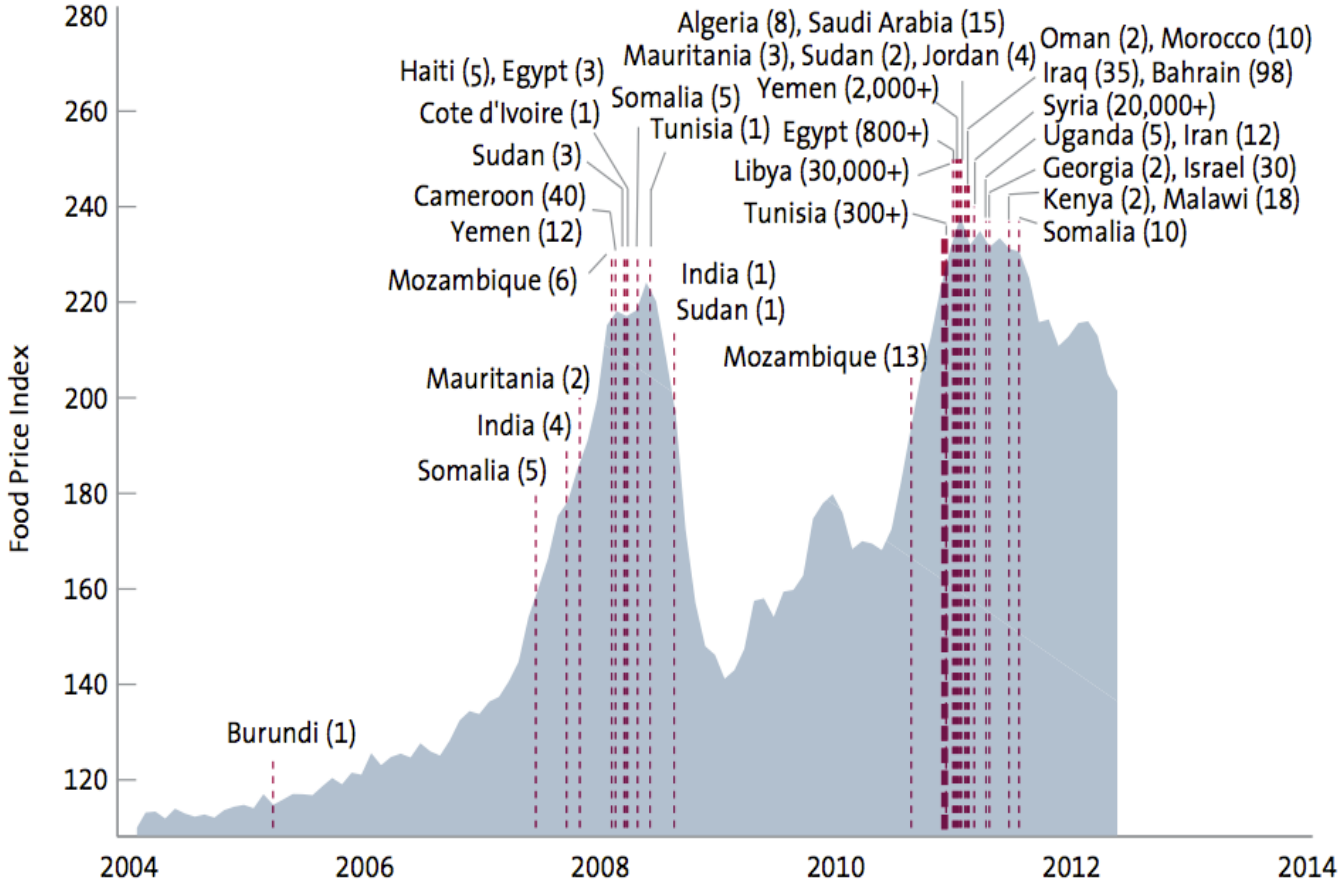
Note: Deviation refers to one standard deviation above and below the trend line.
Source: Monthly "Corn price received" from USDA Quickstats, deflated using monthly CPI data from *www.bls.gov/data*.
StatLink http://dx.doi.org/10.1787/888933521503

Spikes due to: climate in key production regions, energy price, declining food stocks, trade policy, expansion of biofuels

Consequences: increased number of malnourished, shift in diets, reduced spending on other essentials, social unrest, migration

Food price spikes can exacerbate instability

Assumption of perpetually declining food prices now called into question

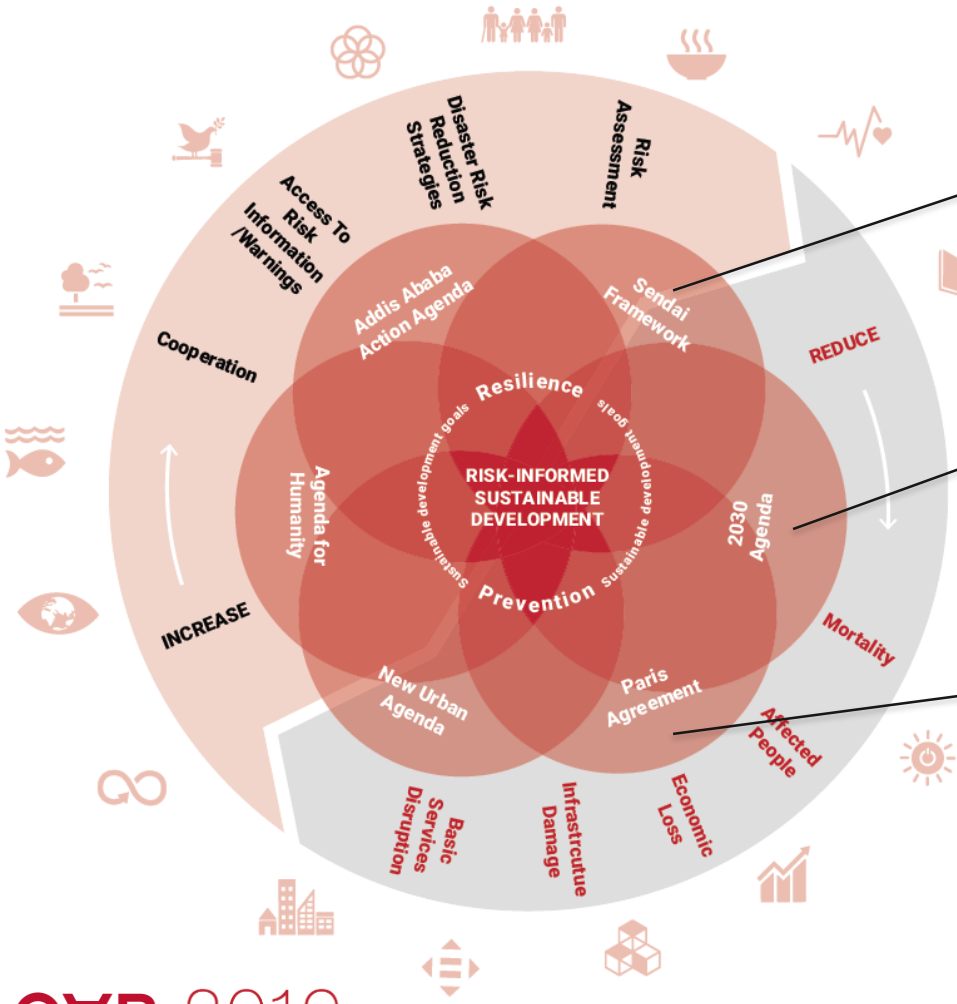


Red dashed lines correspond to the beginning dates of "food riots" and protests in North Africa and the Middle East between 2004 and 2011. The overall death toll is indicated in parentheses next to each country.

Source: Lagi, Bertand, Bar-Yam 2011.

Disasters undermine development

UN Office for Disaster Risk Reduction - Global Assessment Report



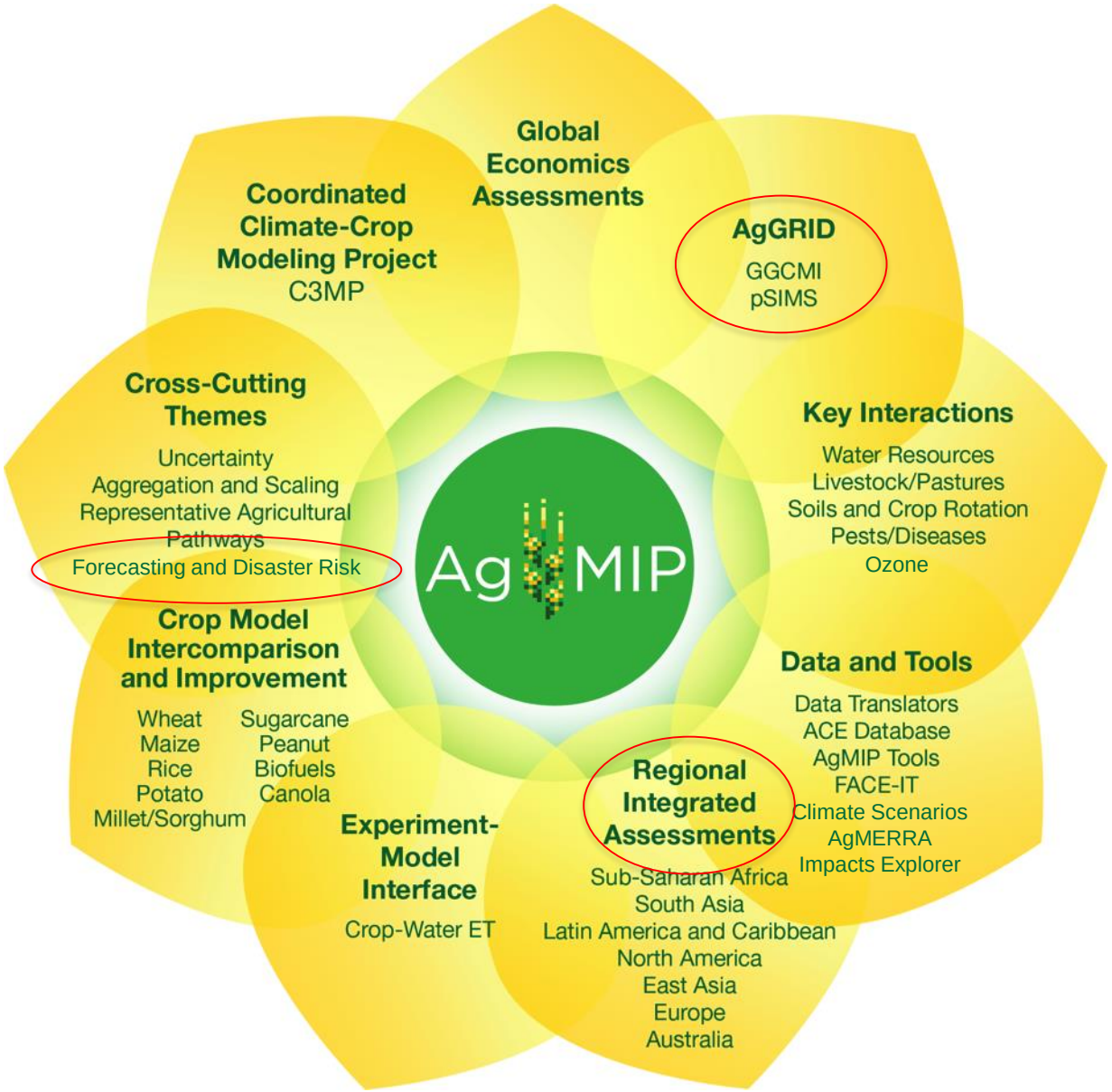
AgMIP interested in better connecting climate change and disaster community

GAR 2019

The Agricultural Model Intercomparison and Improvement Project (AgMIP)

AgMIP The Agricultural Model Intercomparison and Improvement Project

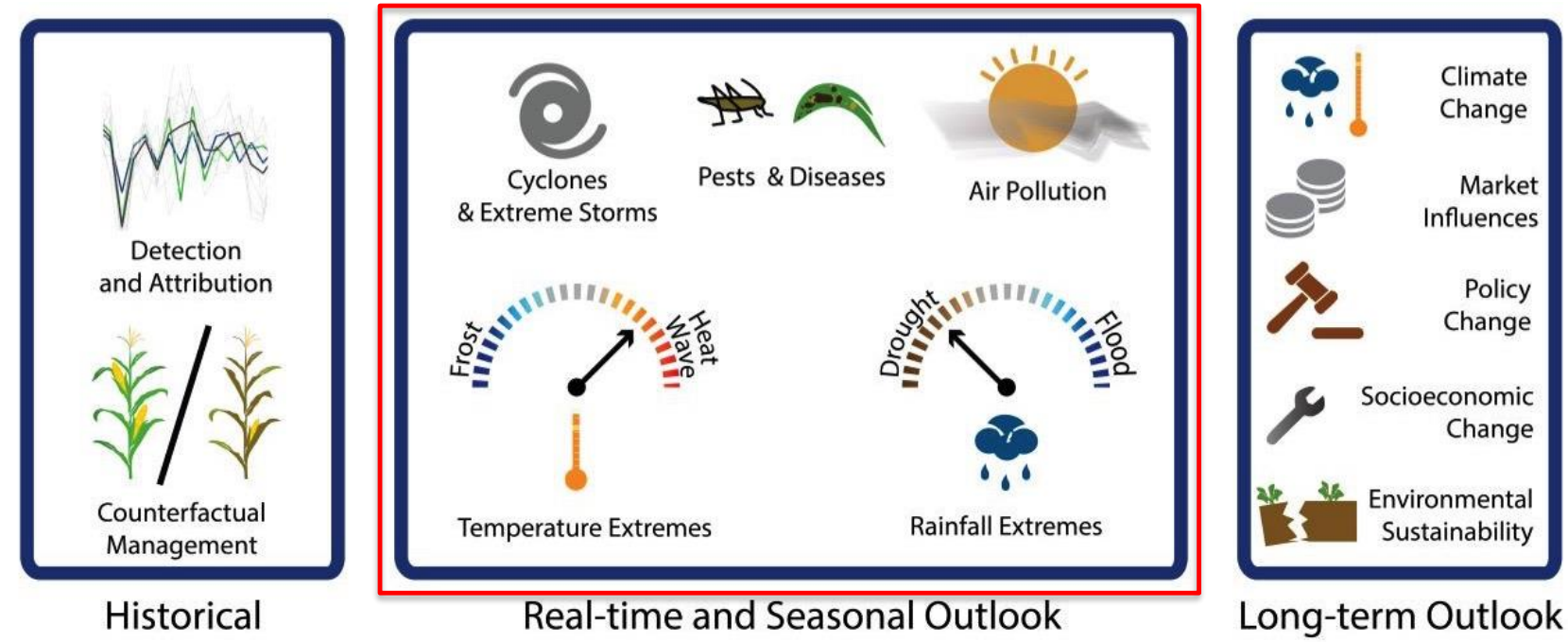
AgMIP's 30+ Initiatives

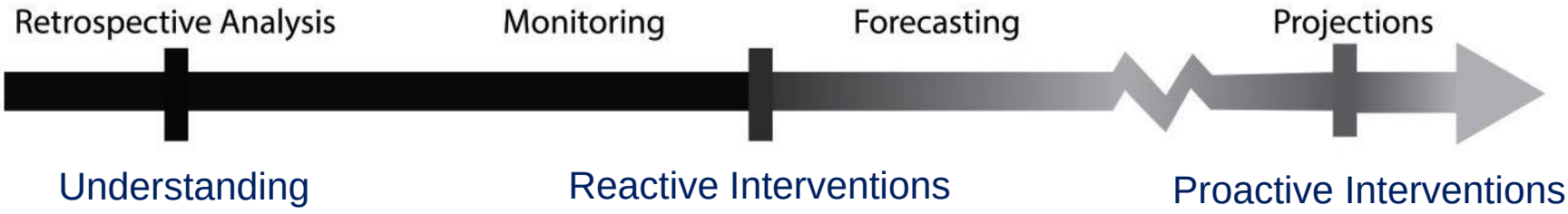


AgMIP is an international community of 1000+ **climate scientists**, **agronomists**, **economists**, and **IT experts** working to improve assessments of **current and future risks to food security** in order to **build a more productive, sustainable, and resilient future**

Adaptation-oriented Applications across Time Horizons

Needs to be understood to build more resilient systems





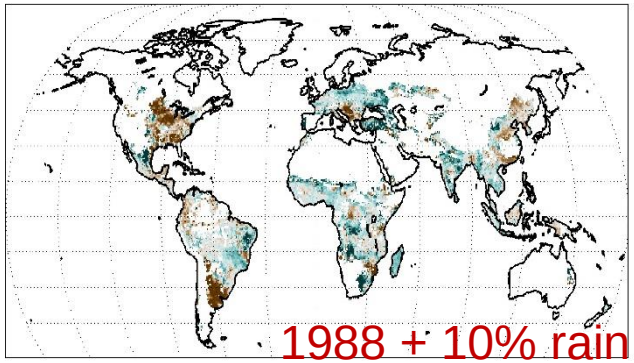
Ruane et al., in prep.

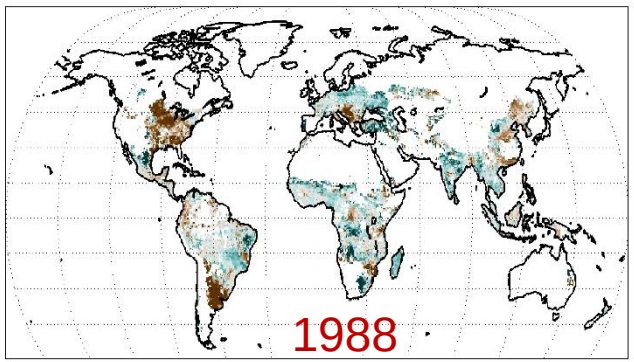
Shifting Risk with Climate Change
historic 1988 drought

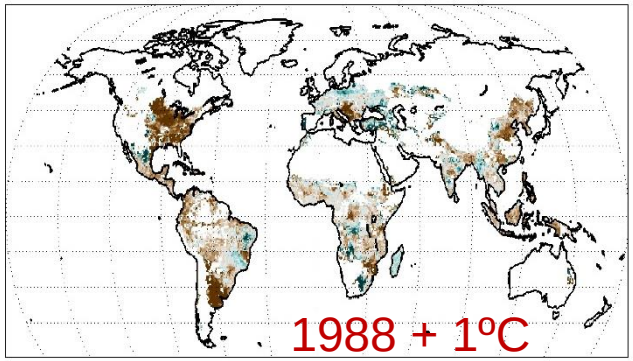
How would 1988 drought have been different if it were:

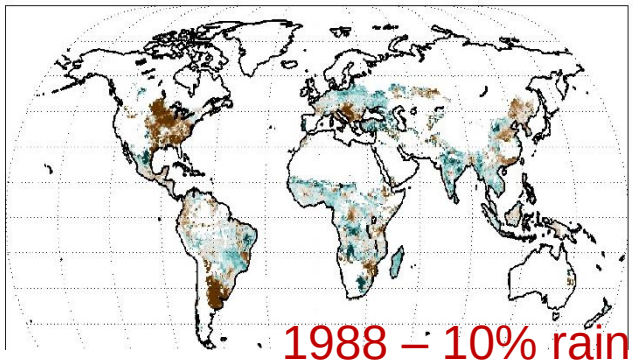
Wetter

Warmer





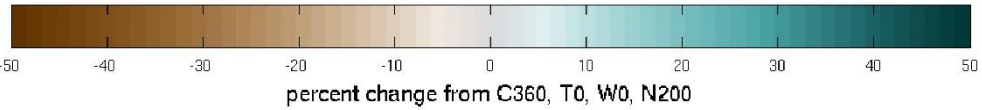




Simulated impacts on maize yield

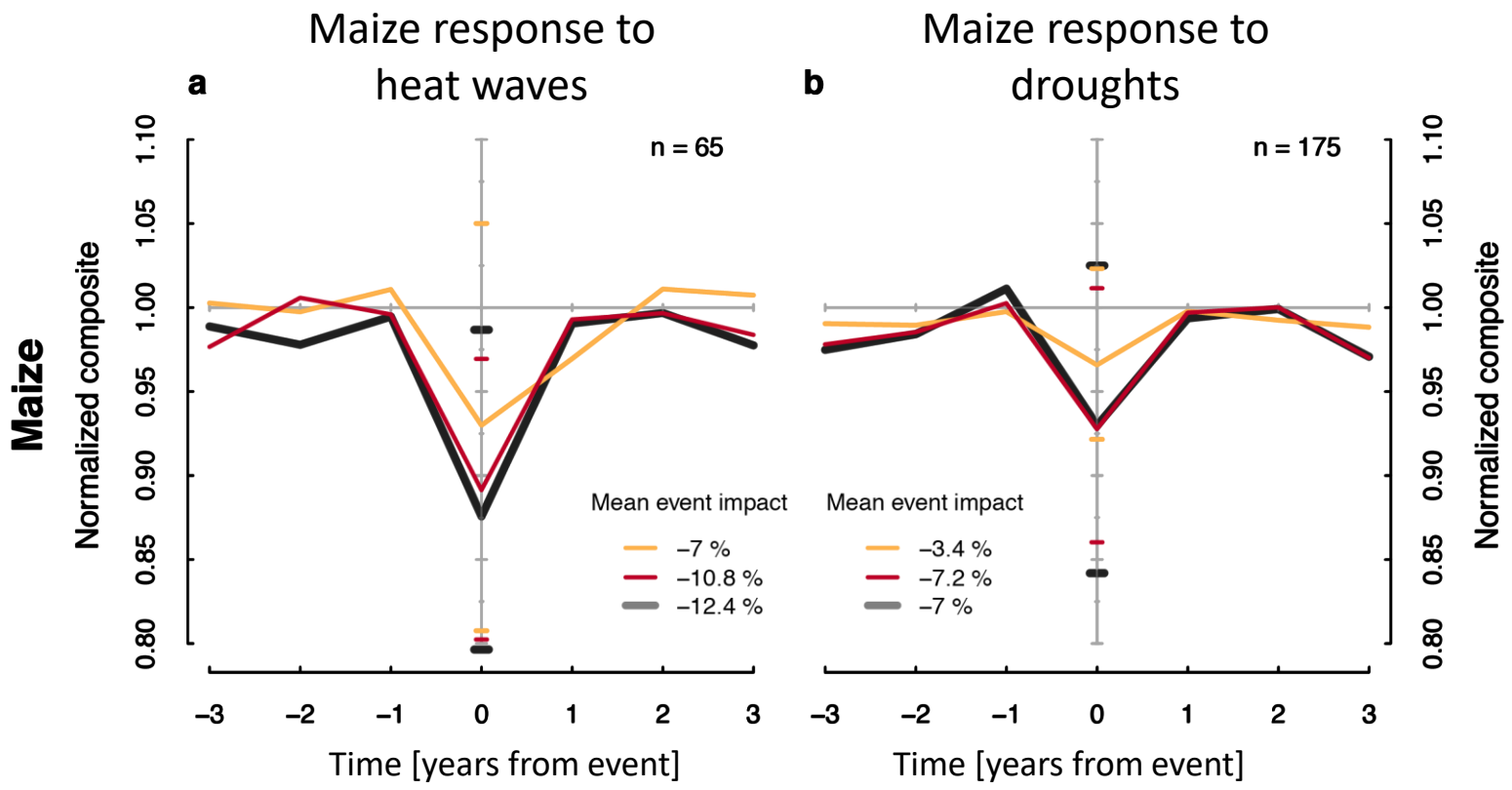
Multi-model response surfaces for systematic climate perturbations

Ruane et al., in preparation



Yield variability:
reproducing historical extremes

- All Extreme Weather Disaster records (EMDAT) 1961 – 2007 globally



Jägermeyr & Frieler (2018), *Science Adv.*

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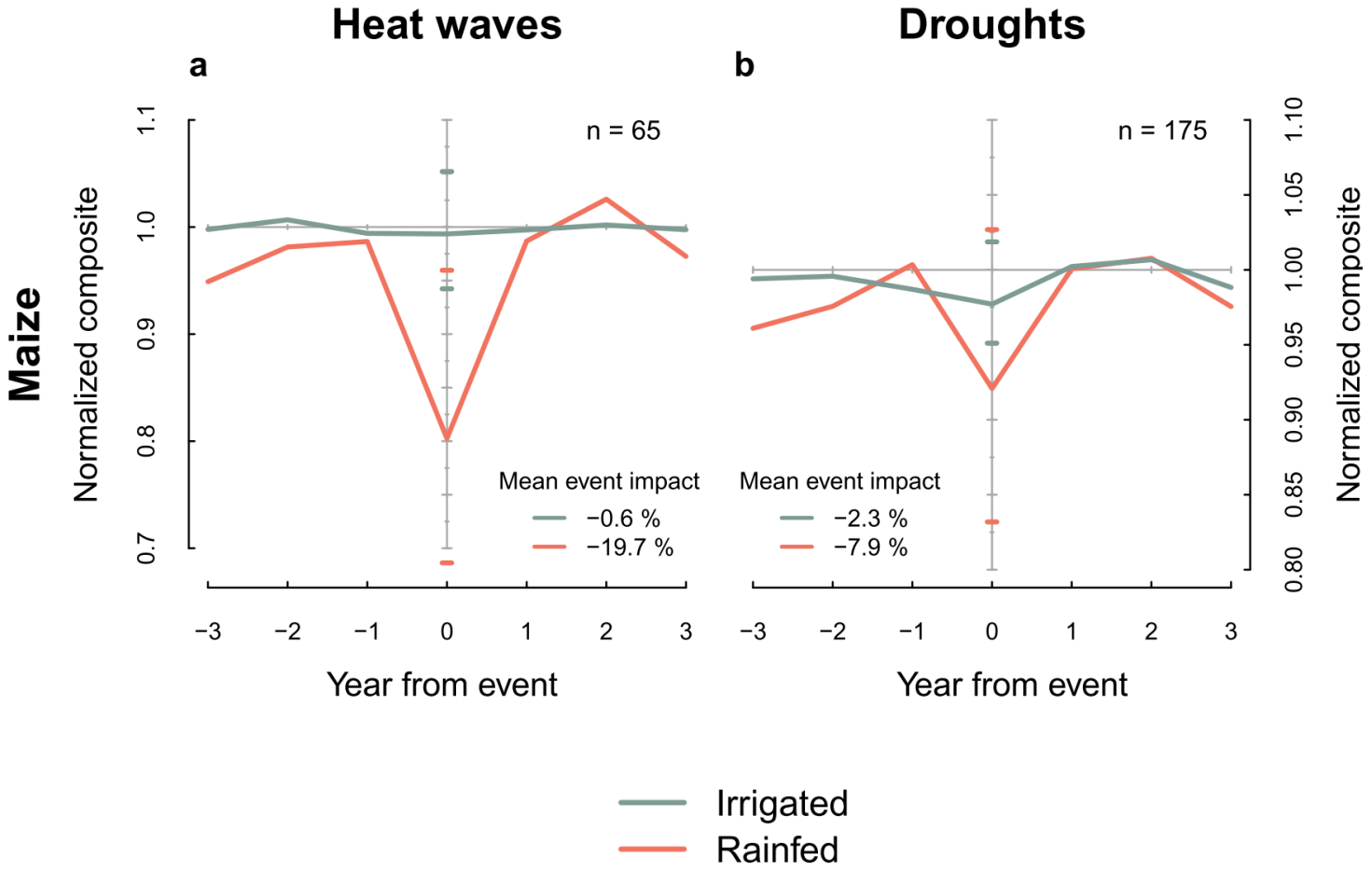
Irrigation buffers impacts from heat waves and droughts

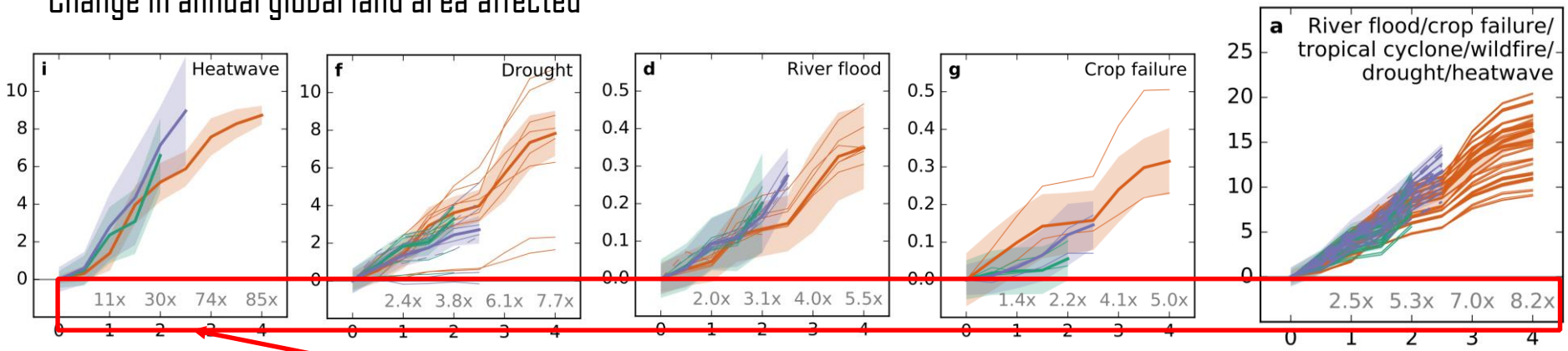


Jägermeyr & Frieler (2018), *Science Adv.*

Extreme event impacts on land area and people

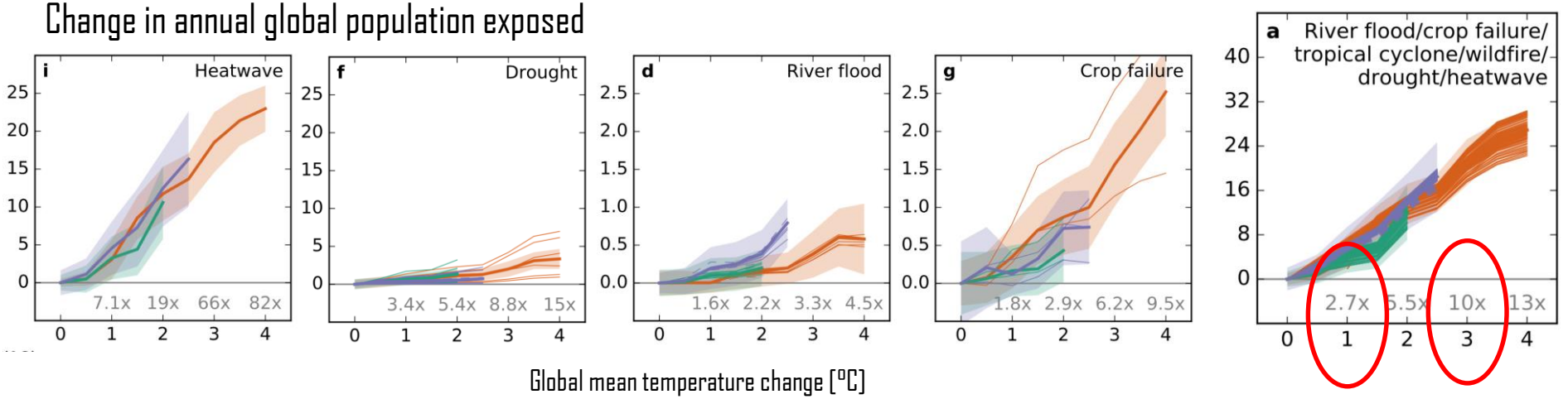
ISIMIP
Inter-Sectoral Impact Model Intercomparison Project

Change in annual global land area affected



Median change factor

Change in annual global population exposed



Climate model
- IPSL-CM5A-LR
- GFDL-ESM2M
- MIROC5

Lange, Frieler, et al. 2019, *in revision*

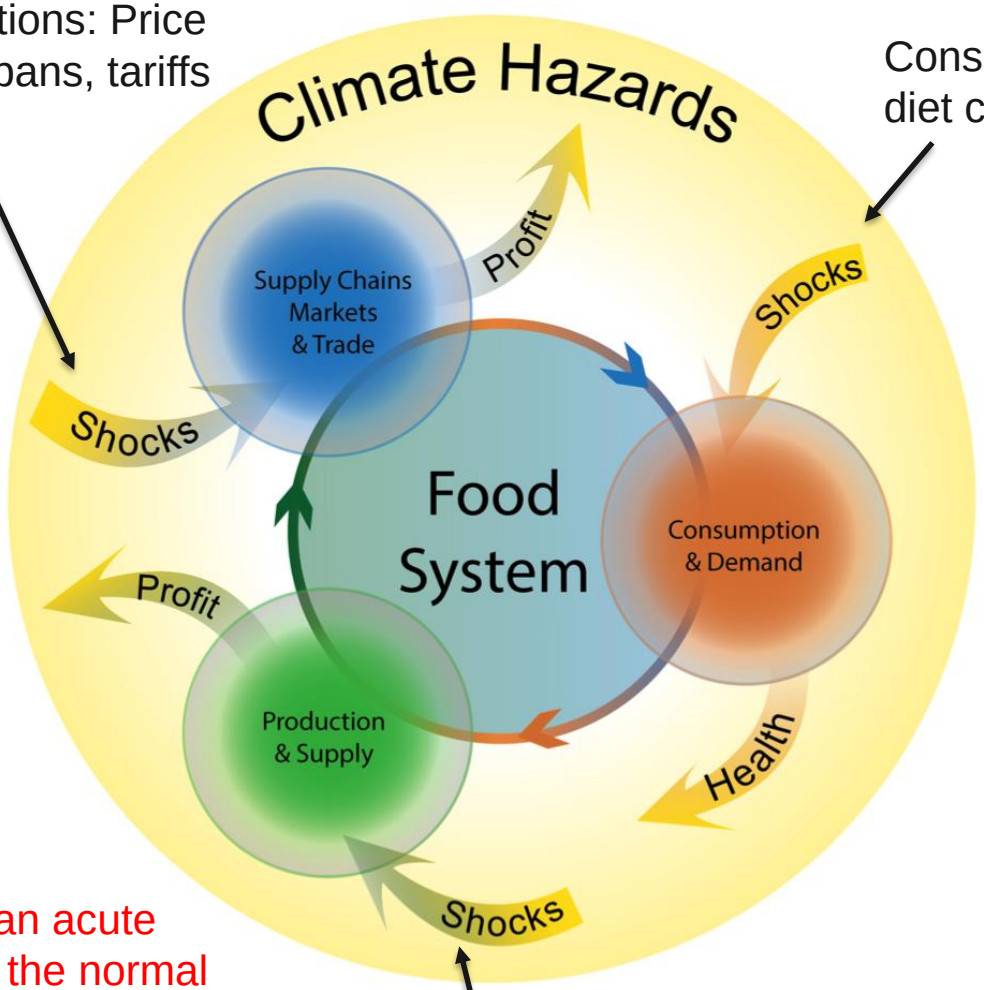
Aspen workshop: Understanding food system shocks

- High-level community to emphasize importance of shocks
- Integrating different fields: production, economy/markets, households, nutrition

All aspects of the food system can be affected by shocks

Market disruptions: Price spikes, trade bans, tariffs

Consumer preferences, diet changes



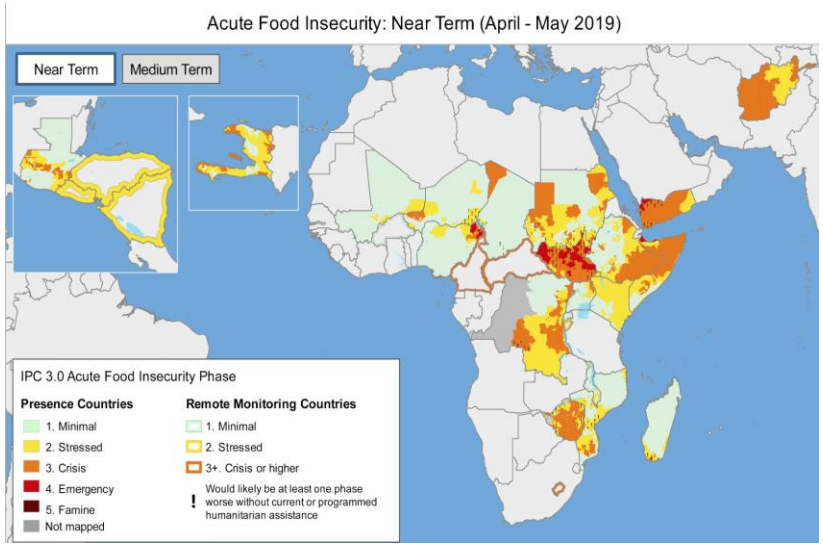
- motivation for building an ecosystem of food system models capable of capturing various types of stressors
- Linking and interaction of existing communities
- Making models useful for policy analysis and impact
- Understand what we can do and we can't

Food shock - an acute interruption of the normal food system, which can have complex and far-reaching societal impacts

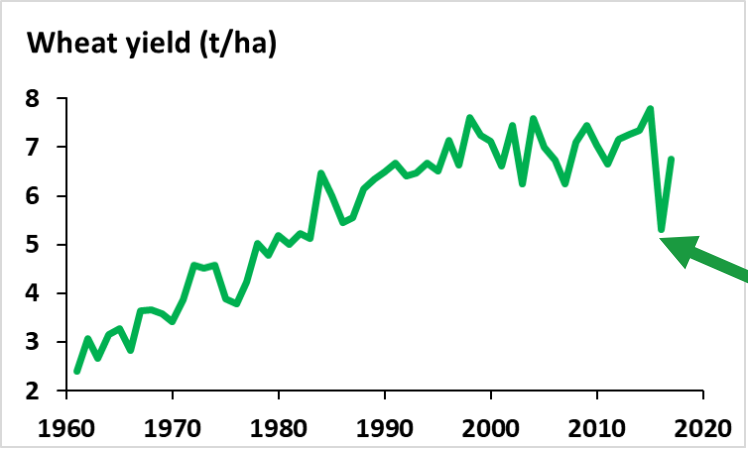
Environmental extremes: Droughts, floods, …

Yield shocks continue to surprise

Famine Early Warning System
http://fews.net/



France



Year 2016
(13 Mt or 32% drop)

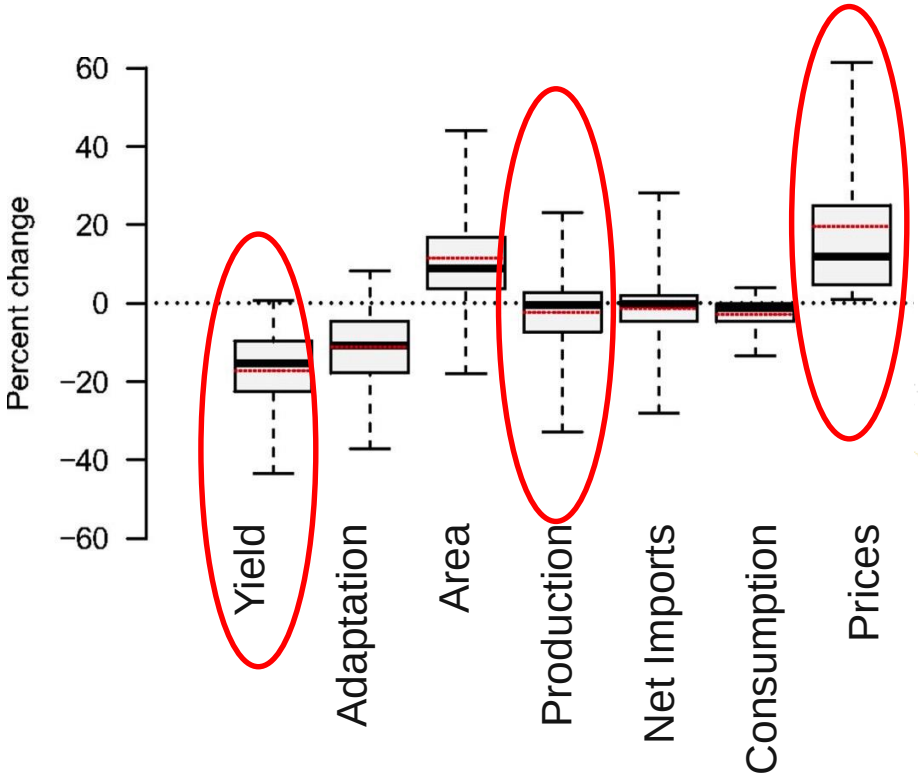
Ben-Ari et al. 2018 Nature Comms

- ***<u>Combination</u> of warmer early winter + intensive rainfall (during key crop stages)***
- ***caused increased disease pressure, water logging, nutrient leaching, lower solar radiation***
- ***Largest recent shock on productivity, but marginal effect on global markets***

→ ***Need to improve early warning and better understand price reactions***

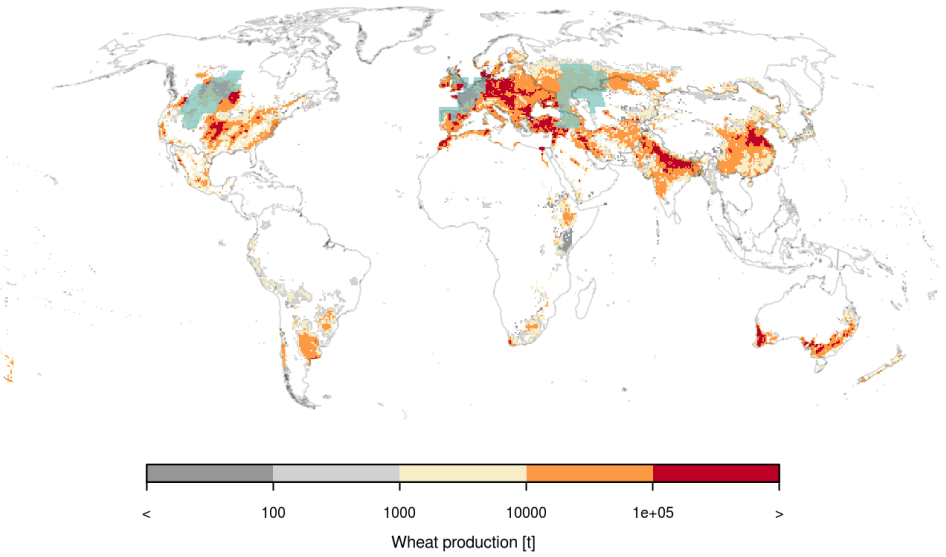
Anticipated vs. unanticipated shocks

Anticipated:
Climate Change (stress)



RCP8.5 2050s (no CO_2 effects)
Nelson et al., 2014

Unanticipated:
Multiple Breadbasket Failure (shock)

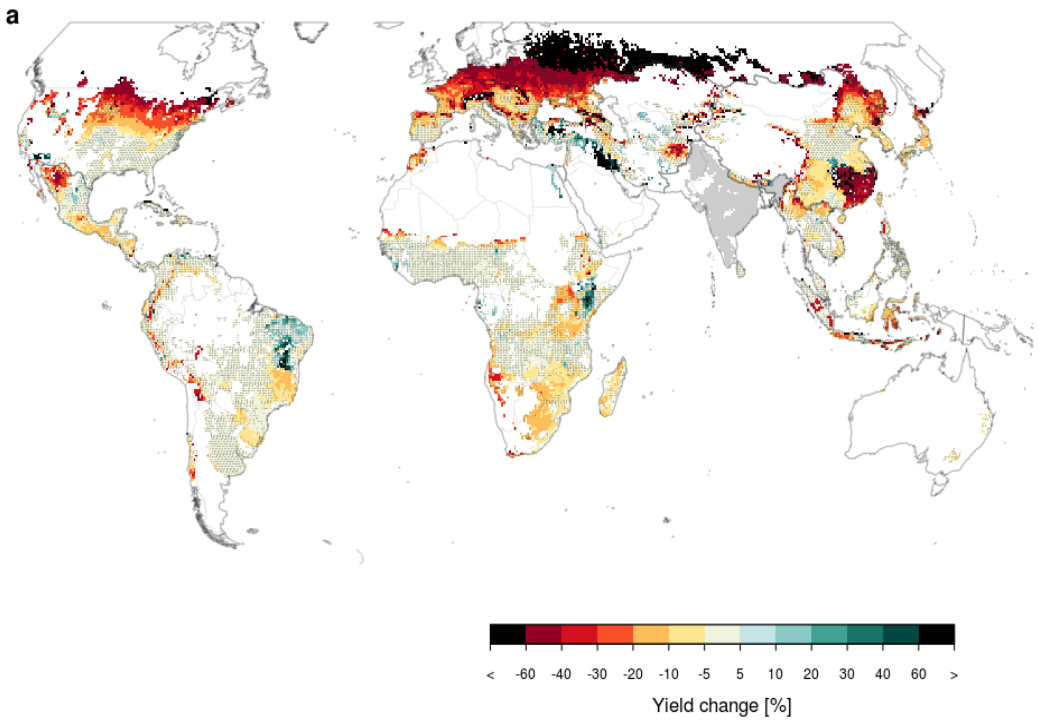


Kornhuber, Jägermeyr, in prep.

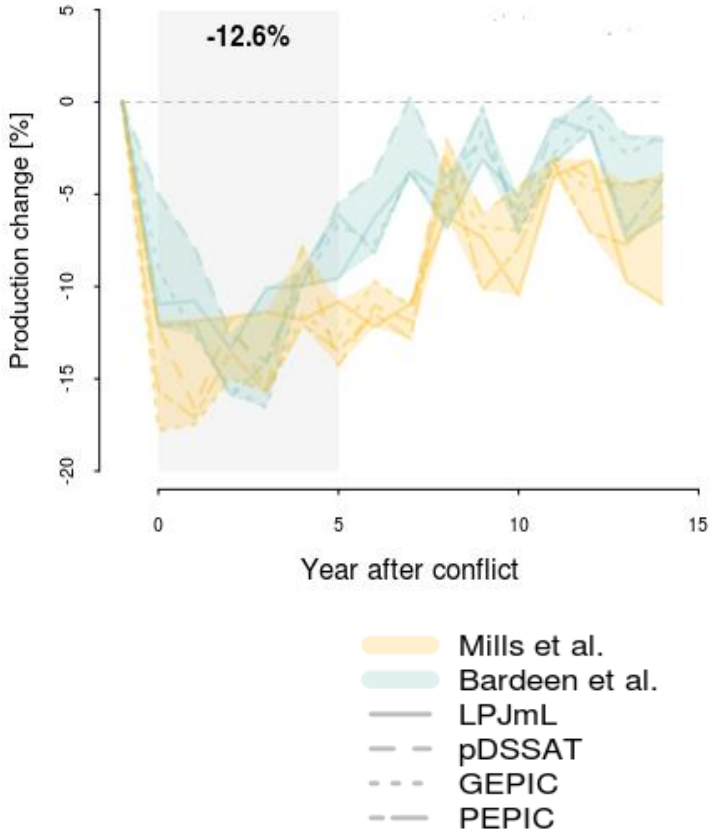
Food shock example: Nuclear Winter

Regional nuclear conflict between India and Pakistan has global implications for food security

5-year post conflict maize yield



b Global maize production



Jägermeyr et al., *in prep.*

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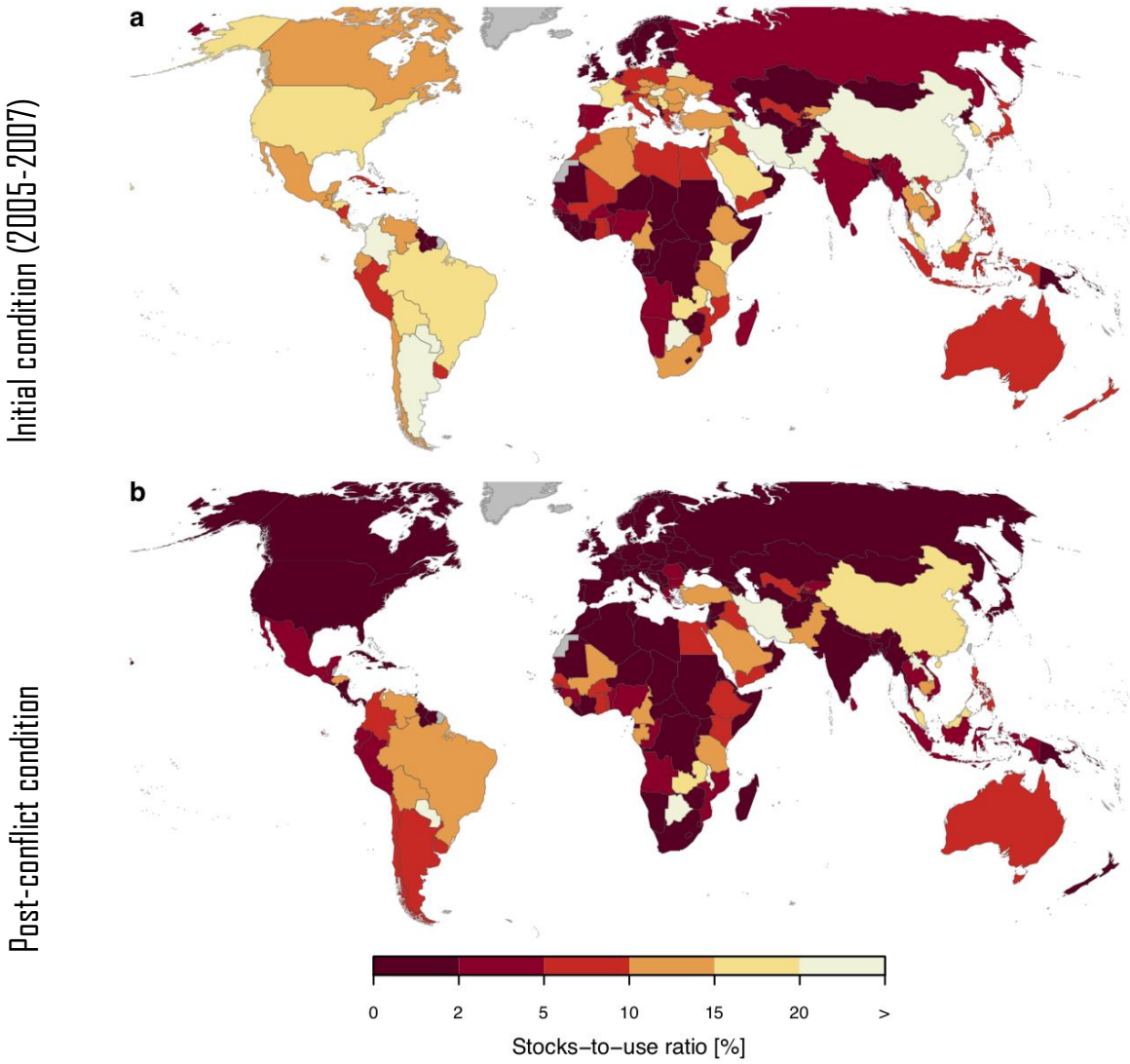
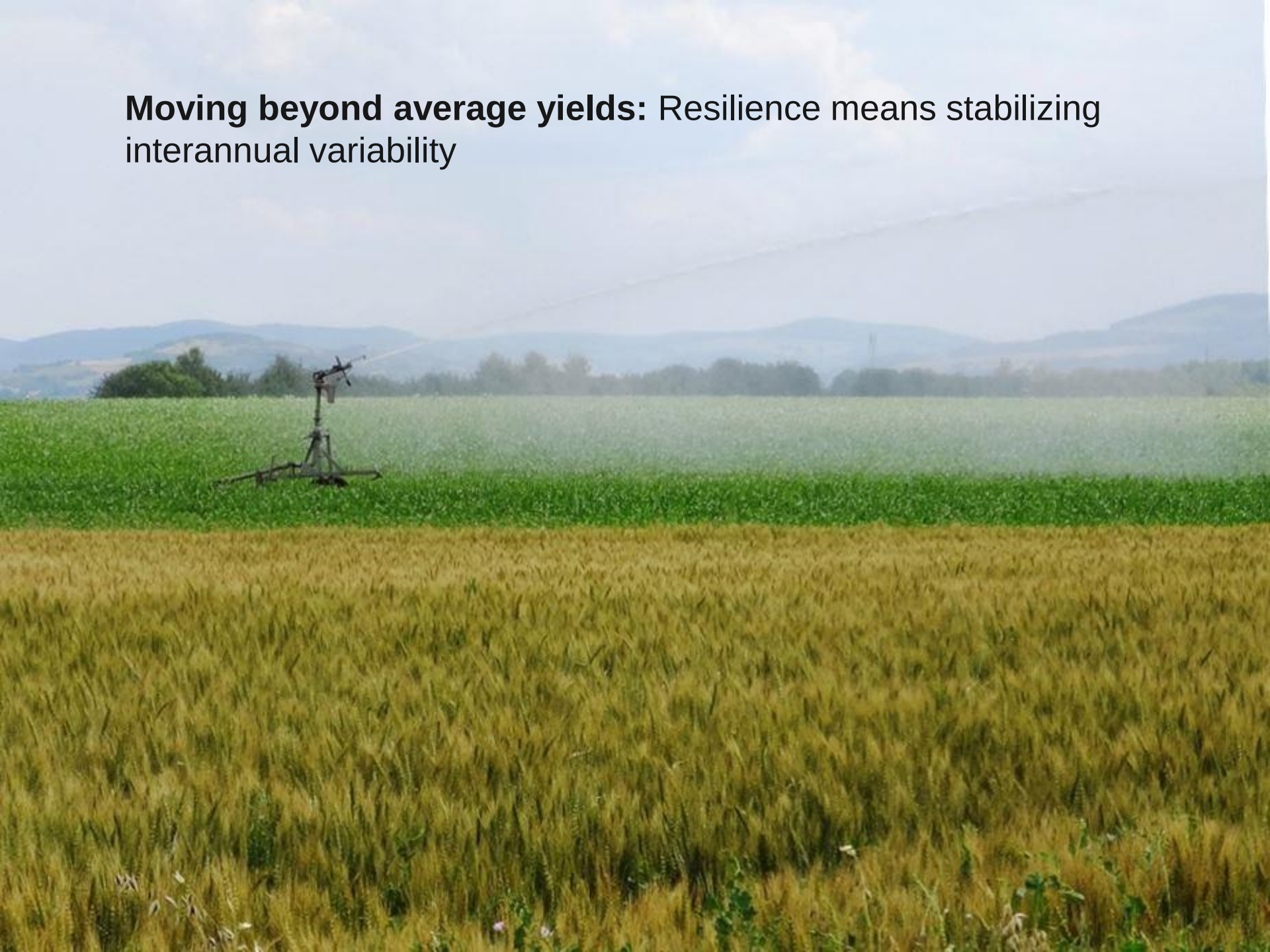
Trade dependencies propagate shock to Global South

Stock-to-use ratio (STU)



Jägermeyr et al., *in prep.*

Moving beyond average yields: Resilience means stabilizing interannual variability



Fertilizer increases yield fluctuations

- SDG 2: double ag yields
  - + Resilient
  - + Sustainable
- Higher inputs increase mean yield levels

- Irrigation stabilizes fluctuations
- Fertilizer inputs increases variability

→ Climate change impacts are smaller on underperforming systems

RESEARCH ARTICLE

Global patterns of crop yield stability under additional nutrient and water inputs

Müller et al. 2018, *Plos One*

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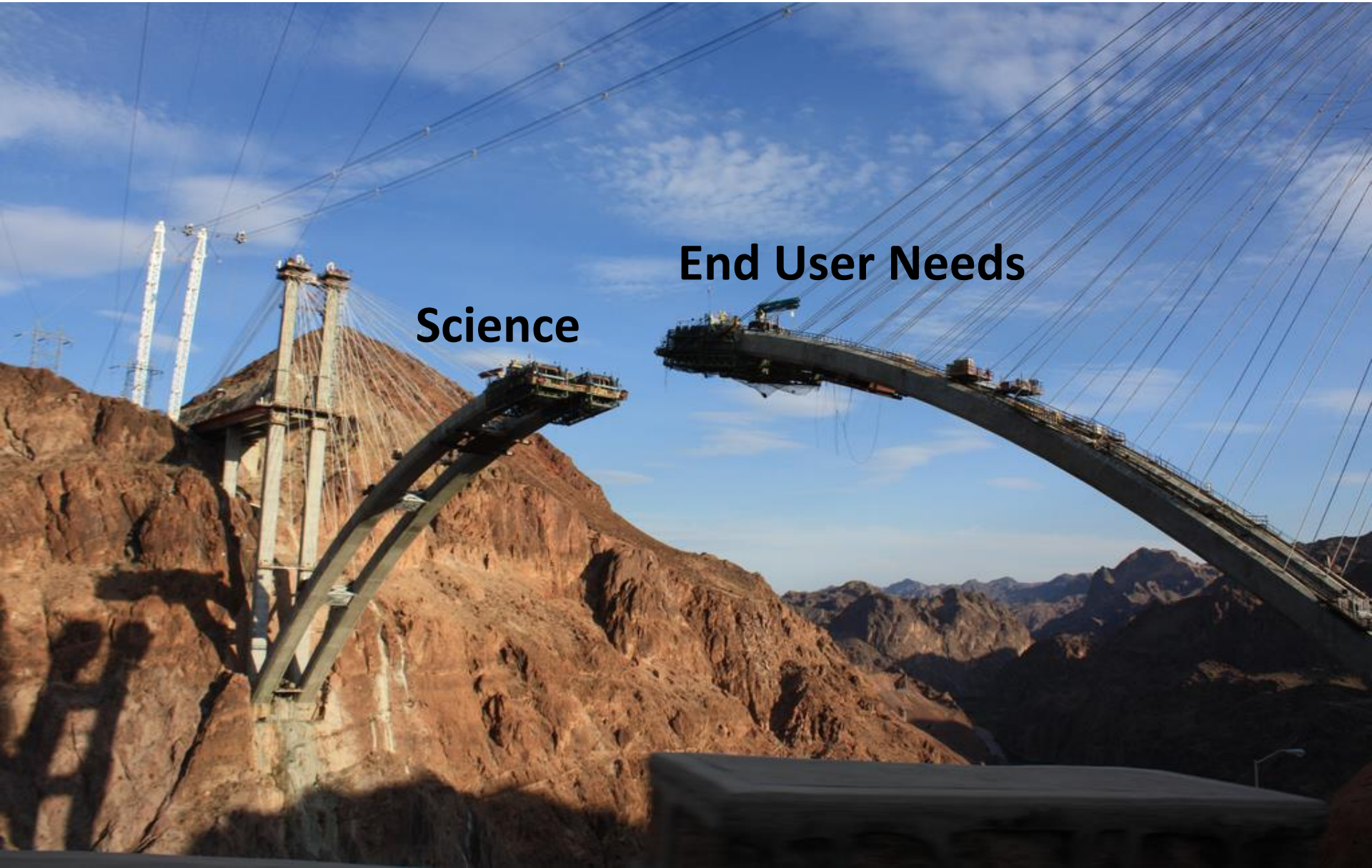
Role of AgMIP and Regional Integrated Assessment



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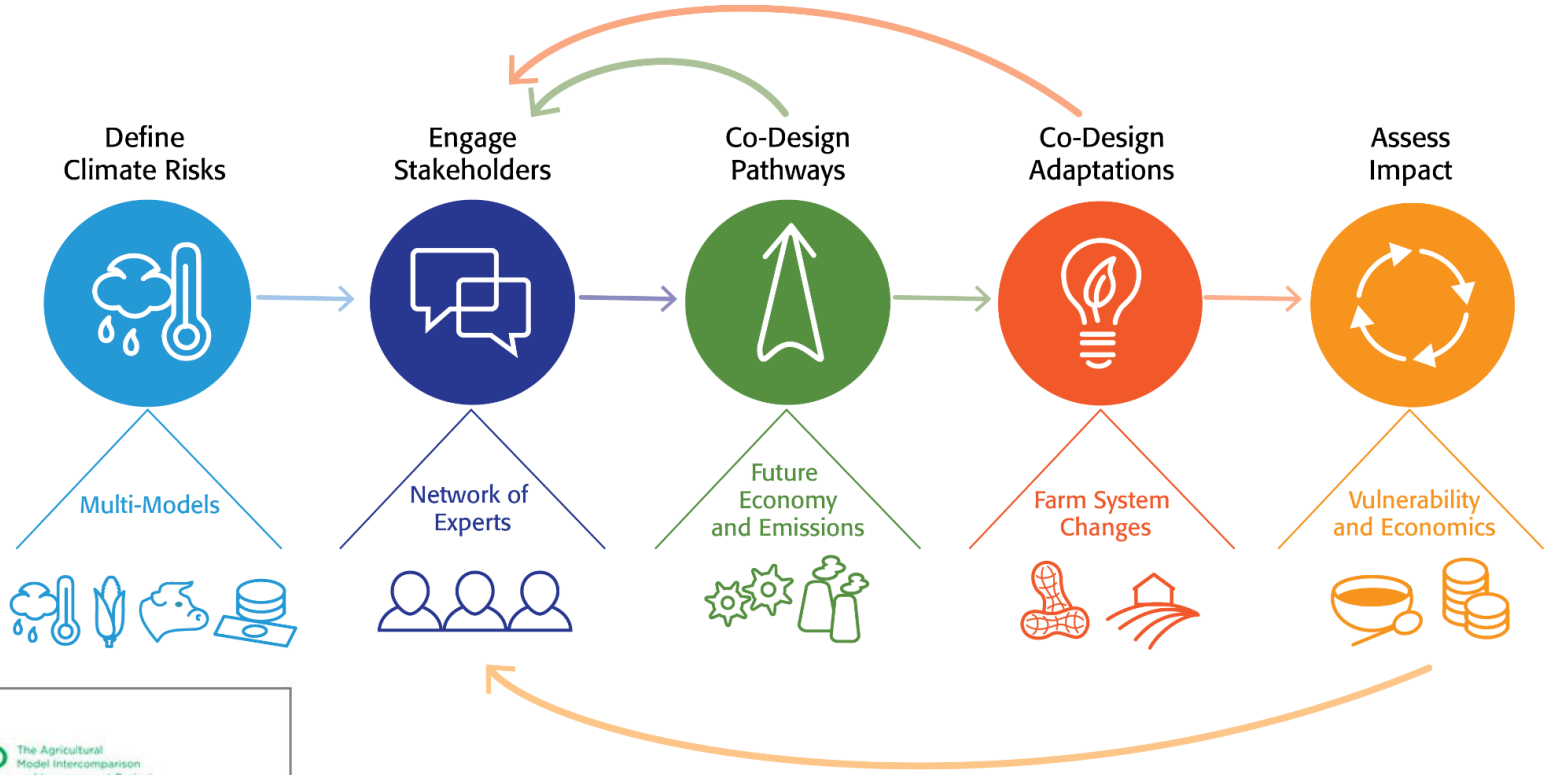
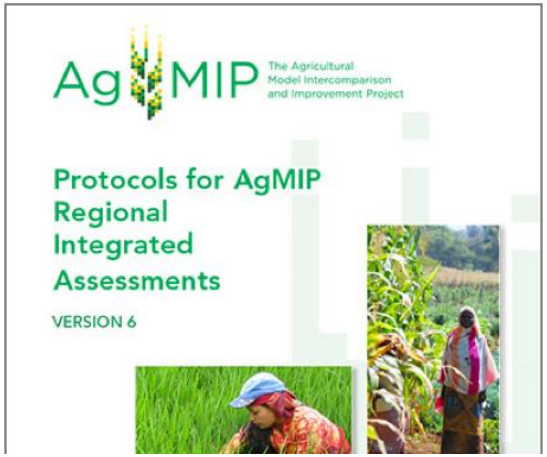
Engaging Stakeholders around Future Agricultural Systems

Regional Economic Assessment





AgMIP/DFID, 2018

UKaid from the British people | Department for International Development

Regional Integrated Assessment:
Results from Zimbabwe

Base

Current farm net returns for Zimbabwe farmers are low. To improve these levels, a three step approach is used.

Step 1

Promote and intensify drought-tolerant staple crops maize and sorghum

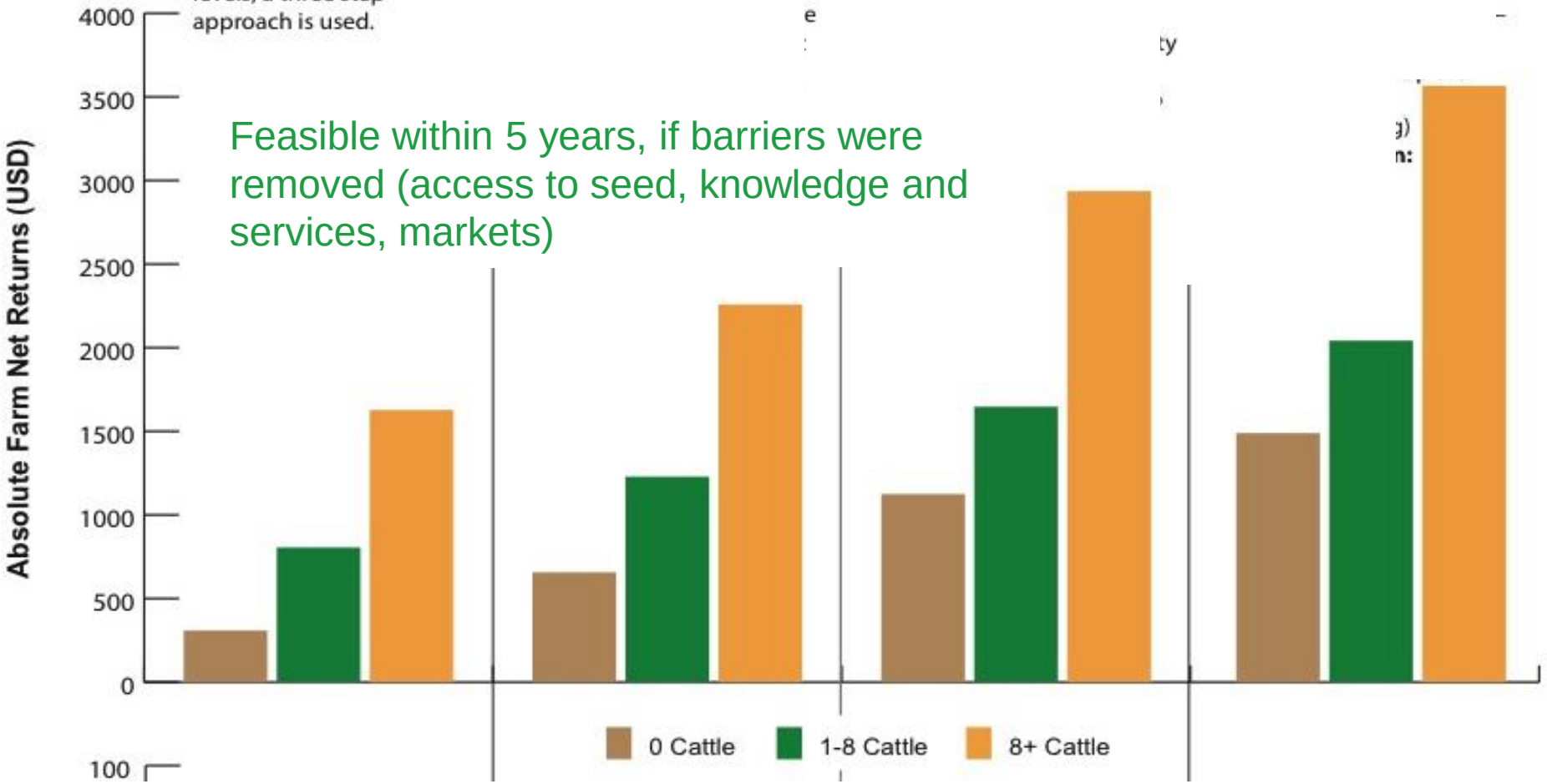
Step 2

With higher maize yields from Step 1, convert land from maize to legumes –

Step 3

With higher groundnut production from Step 2,

Feasible within 5 years, if barriers were removed (access to seed, knowledge and services, markets)



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Successful policy interventions in the Philippines

On-farm

- Drought-tolerant seed varieties
- Additional irrigation

Market

- Subsidize food imports during shock
- Remove trade bans and import quotas

Social

- Distribute stored grains
- Cash transfers for poor households

INTERNATIONAL FOOD POLICY RESEARCH INSTITUTE
IFPRI

Mark W. Rosegrant et al.

→ **Offset short-term losses and build long-term resilience**

The Road Ahead

Summary: Opportunities for enhanced resilience against unforeseen events

1. Incorporate resilience building in CSA approaches, especially in view of shocks

2. Work with Community and National Planners and other Stakeholders to identify and investigate priority vulnerabilities of agriculture and food systems.

3. Investigate future farming systems under changing climate and sociopolitical contexts for foresight into coming challenges and climate-smart solution spaces

4. Explore food shock decision contexts that would benefit from better scientific information and policy approaches.

5. Develop and improve operational forecasting and early-warnings systems

6. Test provisional plans with model-based assessments of anticipatory (resilience) and reactive (responsive) adaptations to food shocks.

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