Climate change in sub-Saharan Africa: theoretical challenges, practical solutions and the adaptation towards unknown unknowns

African-Bavarian Alliance for Applied Life Sciences, October 2022

University of Applied Sciences Weihenstephan-Triesdorf

Prof. Dr. Bernhard Schauberger

Who am I?

Professor for Agricultural Systems and Climate Change at the University of Applied Sciences Weihenstephan-Triesdorf

Scientist at the Potsdam-Institute for Climate Impacts Research (PIK)

My research areas are risks in agriculture, short-term yield forecasts, the impacts of extreme events on crop yields and, recently, the attribution of crop losses to climate change.

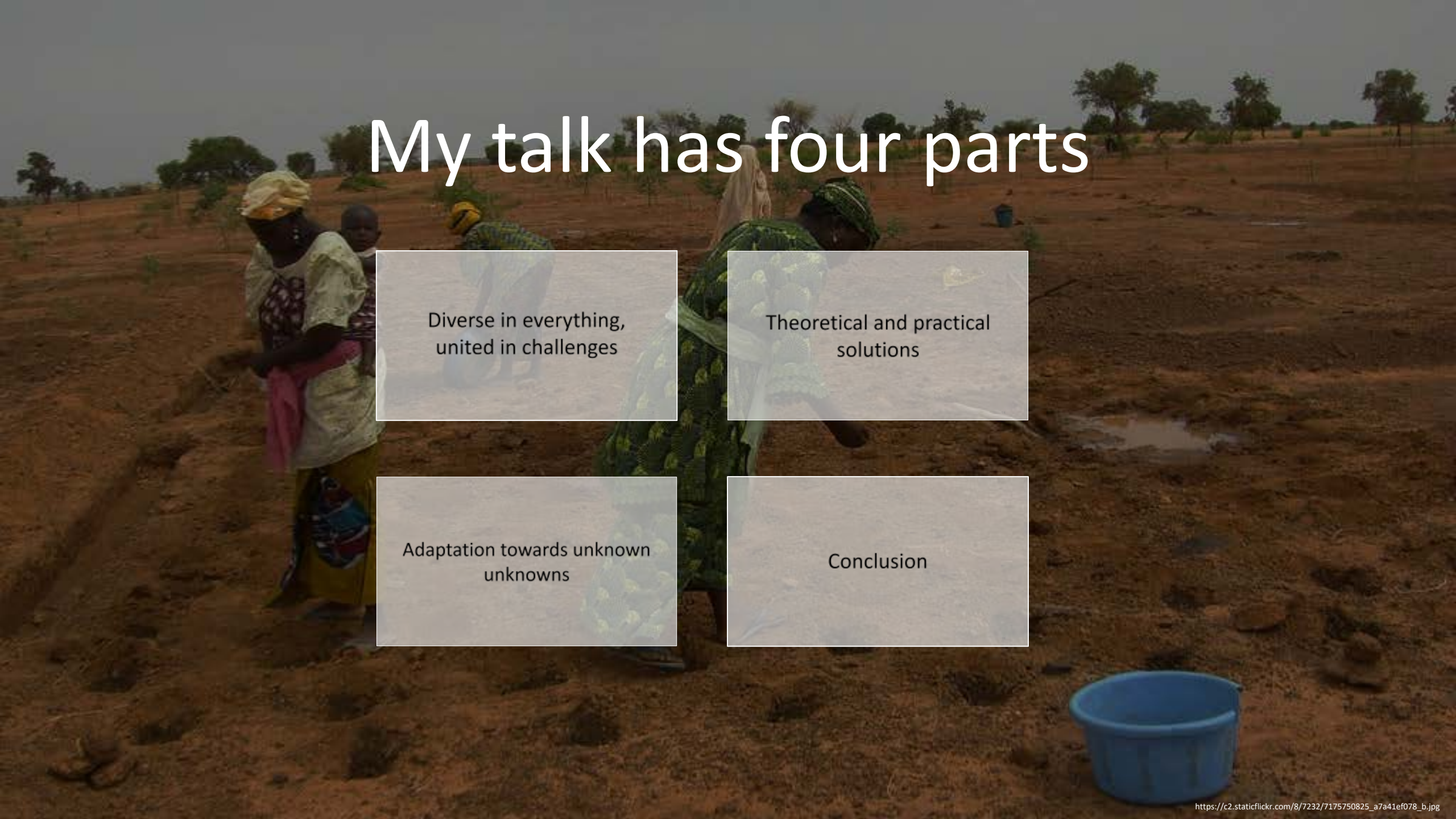
My talk has four parts

Diverse in everything, united in challenges

Theoretical and practical solutions

Adaptation towards unknown unknowns

Conclusion

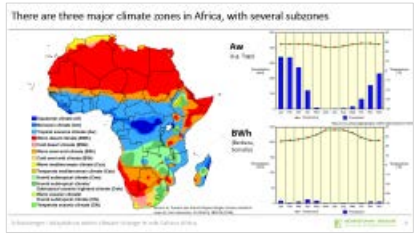


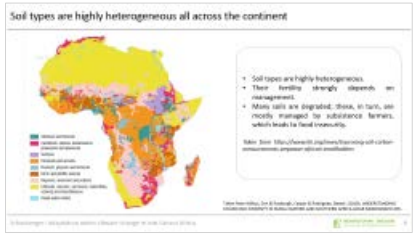
https://c2.staticflickr.com/8/7232/7175750825_a7a41ef078_b.jpg

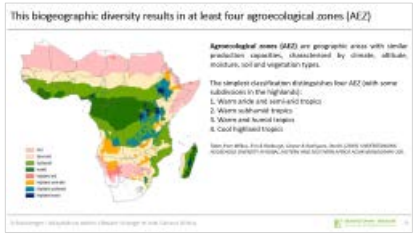
Diverse in everything, united in challenges

Africa is an extremely diverse continent

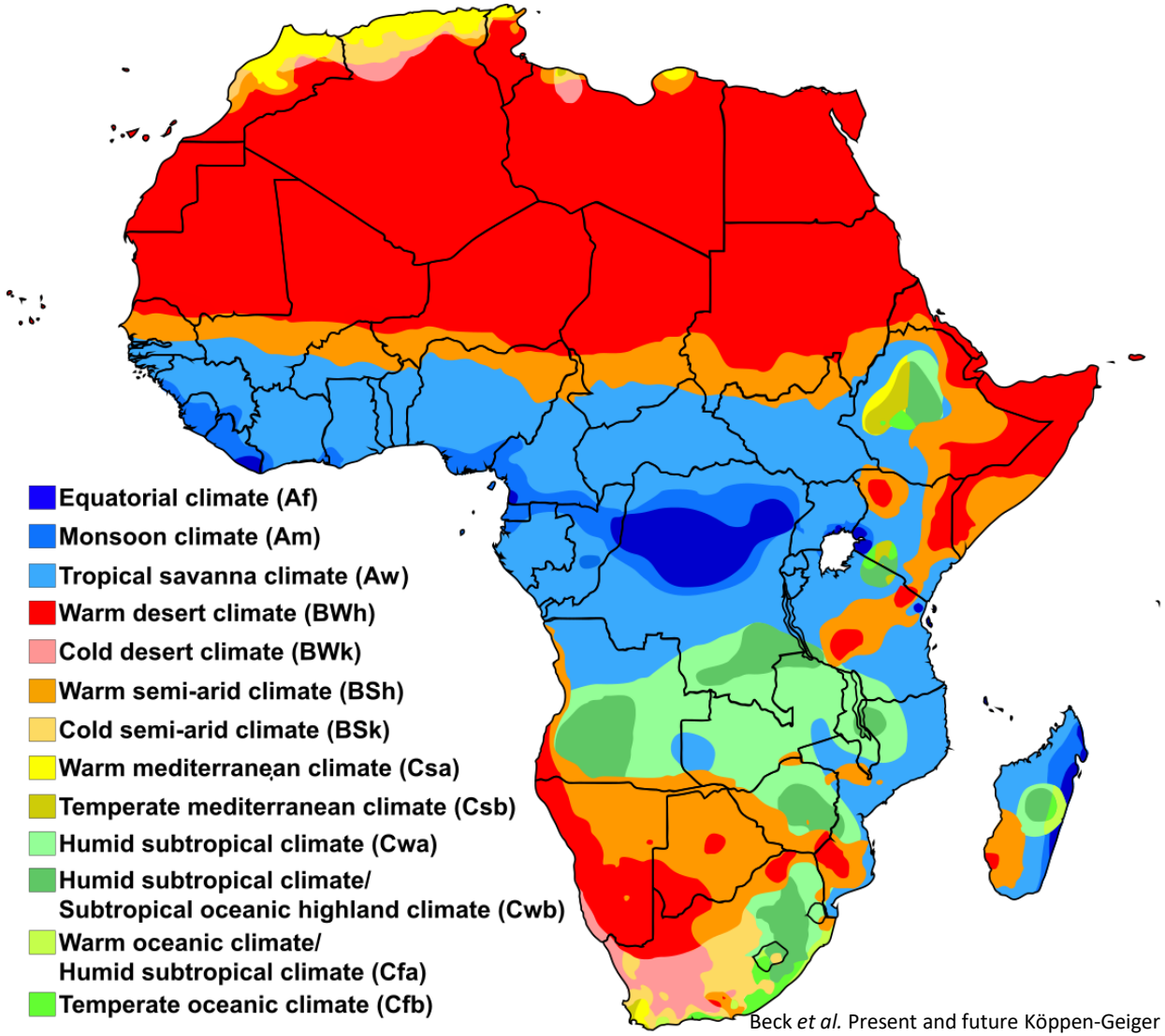
There is a plethora of differences: diversity in soil types, climate zones, farming systems, crops and many other aspects of the food system.





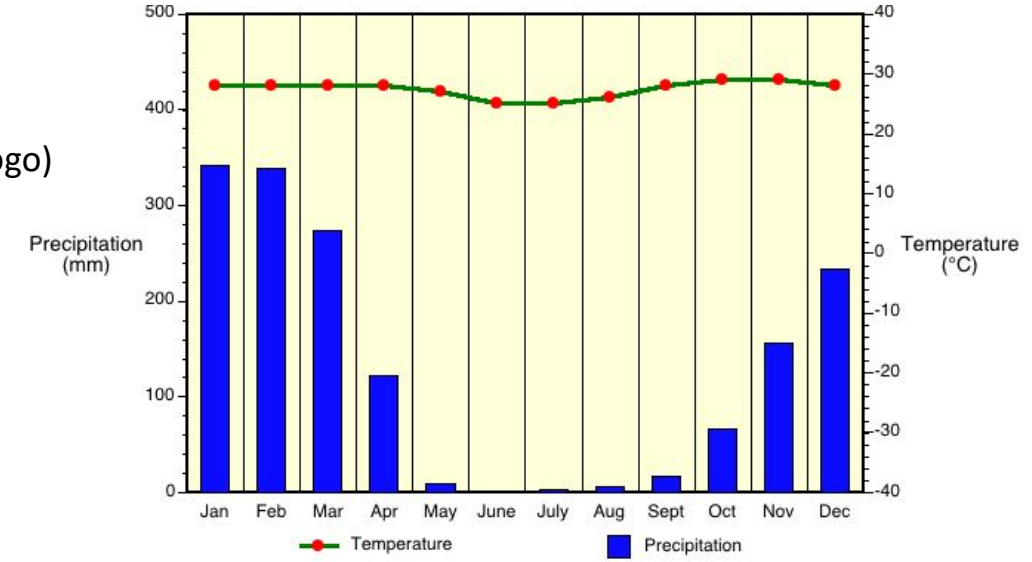


There are three major climate zones in Africa, with several subzones



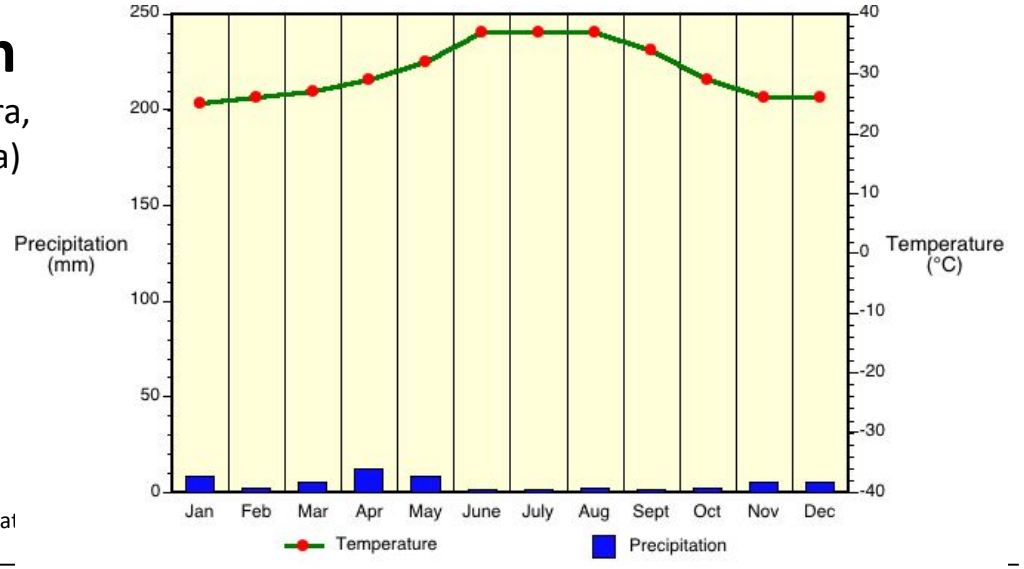
Beck *et al.* Present and future Köppen-Geiger climate classificat
maps at 1-km resolution. *Sci Data* **5,** 180214 (2018).

Aw
(e.g. Togo)

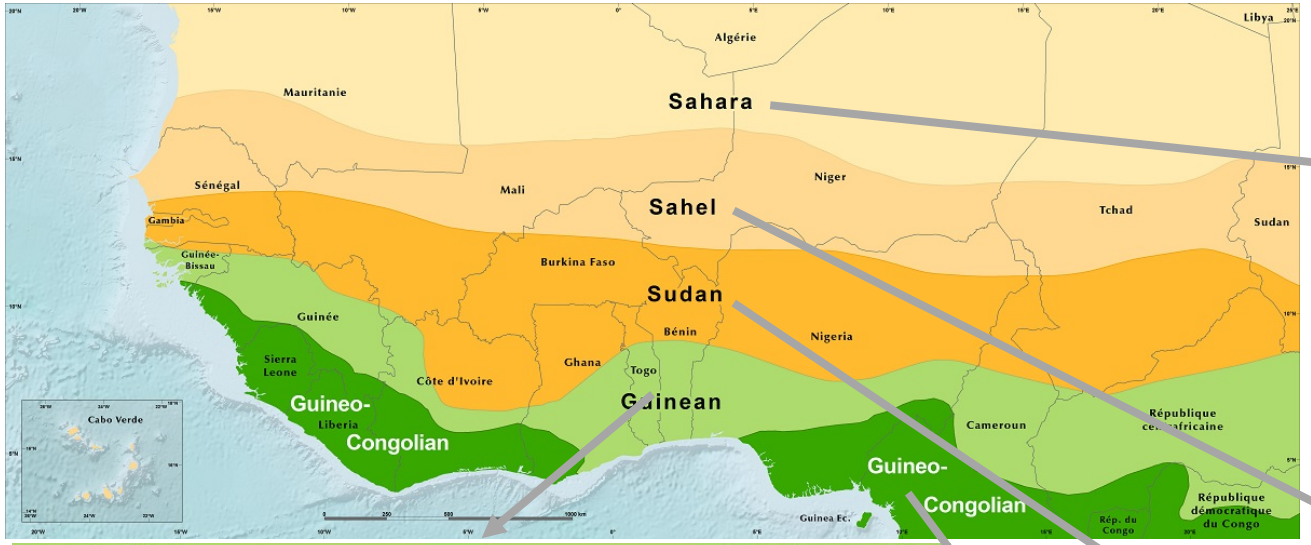


http://www.physicalgeography.net/fundamentals/7v.html

BWh
(Berbera, Somalia)

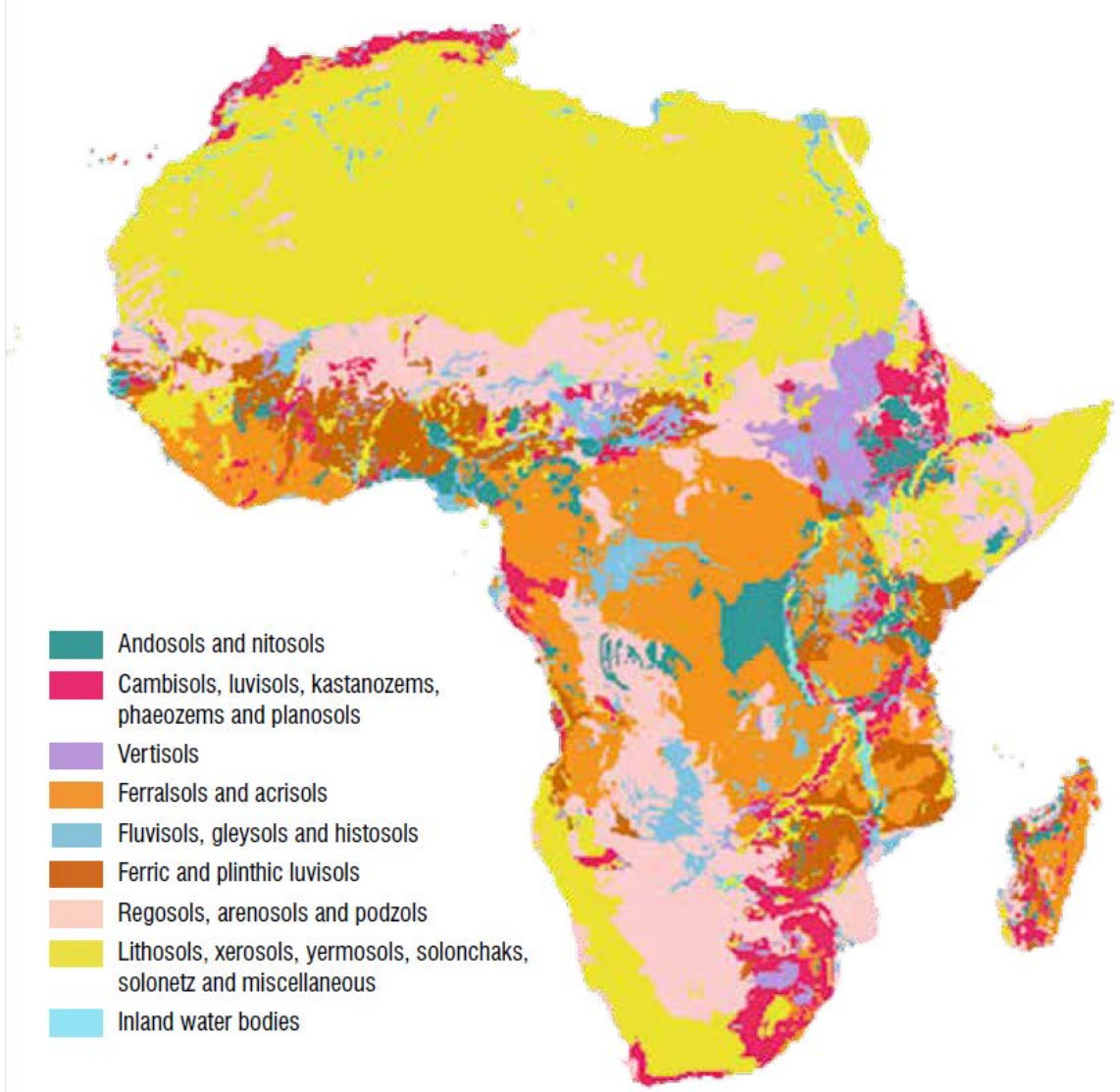


Along the different climates, there are diverse vegetation zones (*exemplified with West Africa*)



https://eros.usgs.gov/westafrica/node/147
http://www.mapsnworld.com/africa/natural-vegetationl-map-africa.jpg

Soil types are highly heterogeneous all across the continent

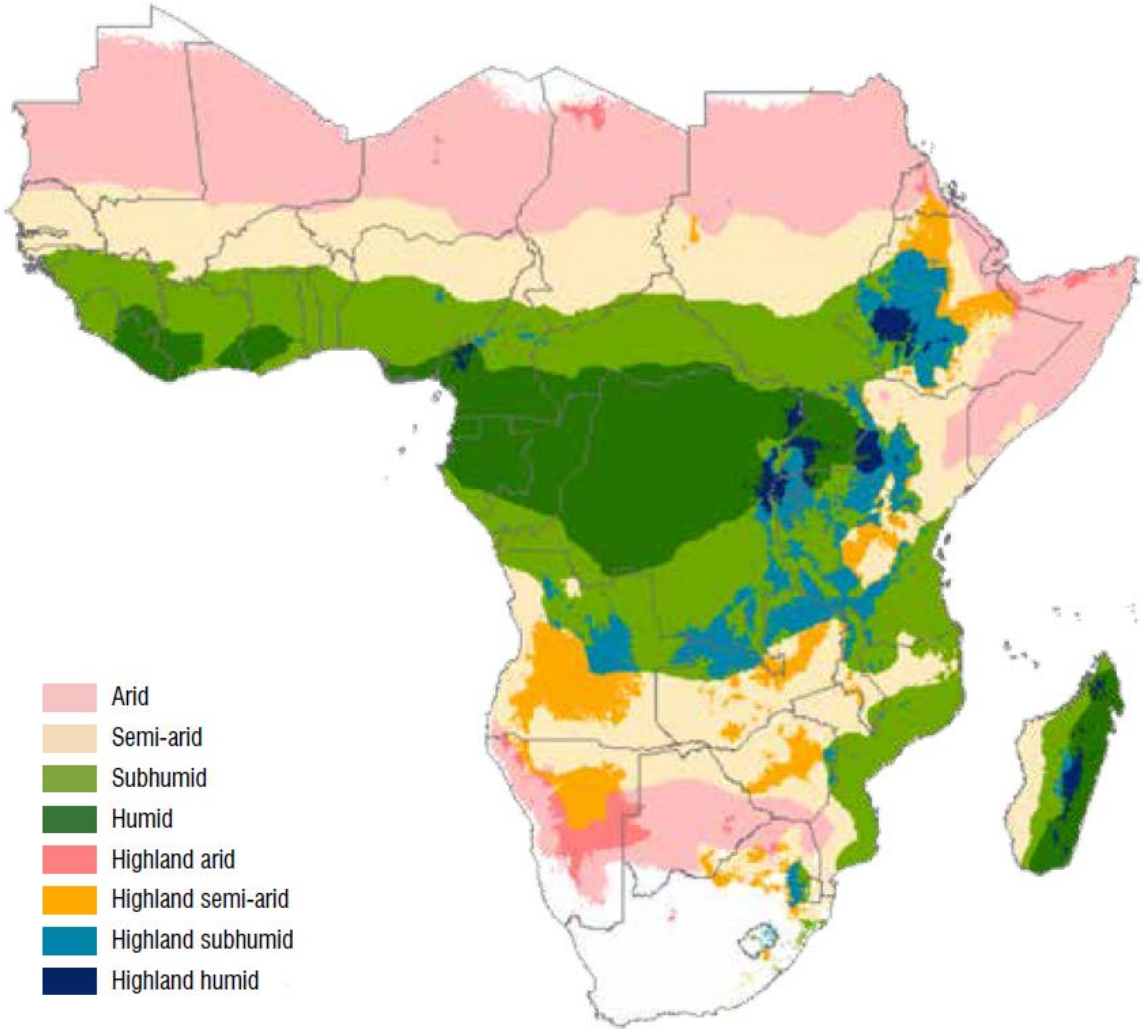


- Soil types are highly heterogeneous.
- Their fertility strongly depends on management.
- Many soils are degraded; these, in turn, are mostly managed by subsistence farmers, which leads to food insecurity.

Taken from https://www.ilri.org/news/improving-soil-carbon-measurements-empower-african-smallholders

Taken from Wilkus, Erin & Roxburgh, Caspar & Rodriguez, Daniel. (2019). UNDERSTANDING HOUSEHOLD DIVERSITY IN RURAL EASTERN AND SOUTHERN AFRICA ACIAR MONOGRAPH 205.

This biogeographic diversity results in at least four agroecological zones (AEZ)



Agroecological zones (AEZ) are geographic areas with similar production capacities, characterised by climate, altitude, moisture, soil and vegetation types.

The simplest classification distinguishes four AEZ (with some subdivsions in the highlands):

1. Warm aride and semi-arid tropics
2. Warm subhumid tropics
3. Warm and humid tropics
4. Cool highland tropics

Taken from Wilkus, Erin & Roxburgh, Caspar & Rodriguez, Daniel. (2019). UNDERSTANDING HOUSEHOLD DIVERSITY IN RURAL EASTERN AND SOUTHERN AFRICA ACIAR MONOGRAPH 205.

Within these zones, agriculture creates a huge variety of products

Maize

Pearl millet

Sorghum

Cassava

Ground nuts

Beans

Cattle

Tobacco

Cocoa

Cotton

Fonio

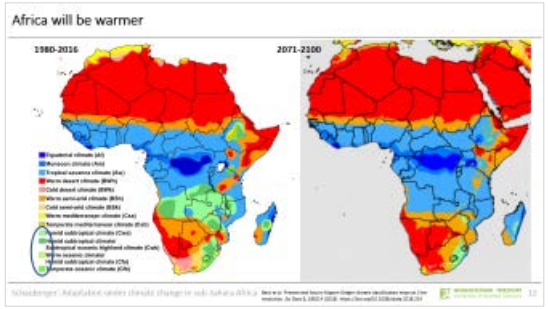
Poultry

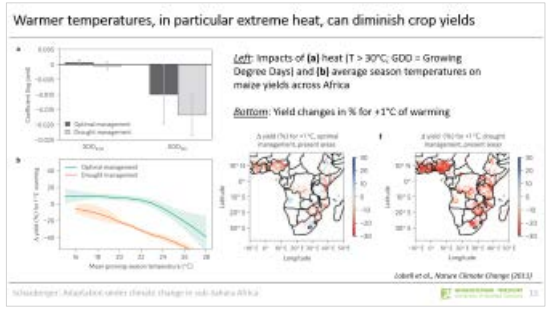
Oil palms

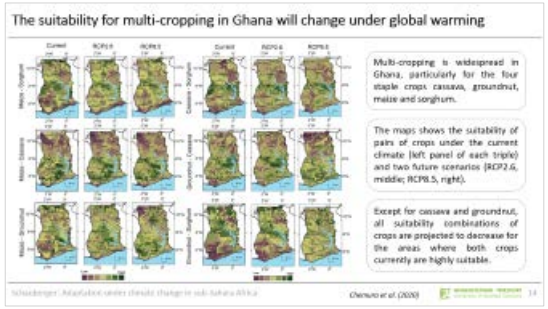
Rice

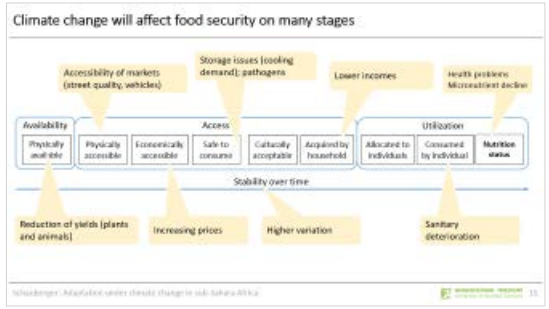
Climate change alters the scene profoundly – and requires bespoke adaptation

Under climate change, all from above will change: climate and weather, vegetation, agro-ecological zones, soil attributes and, consequently, also crop yields.

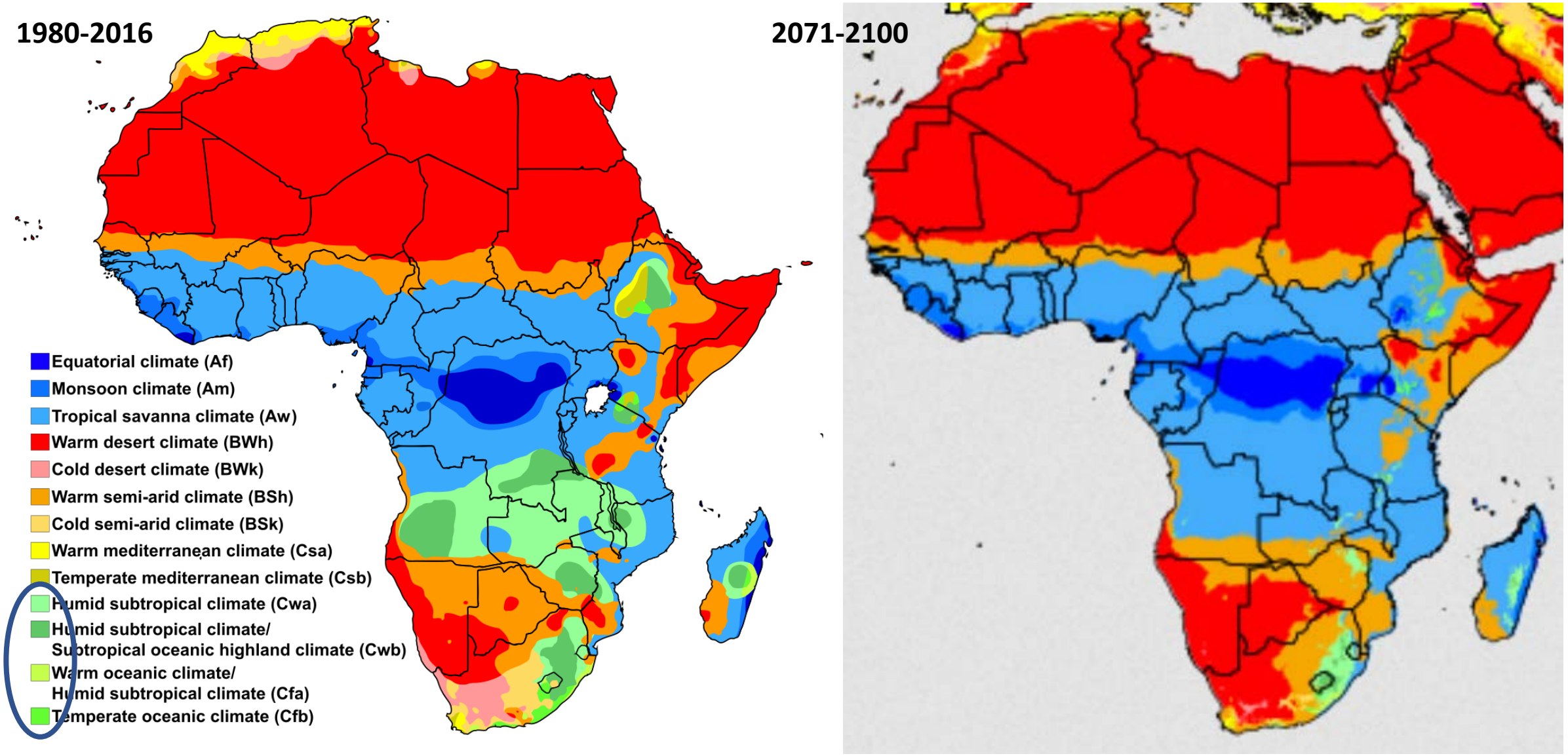






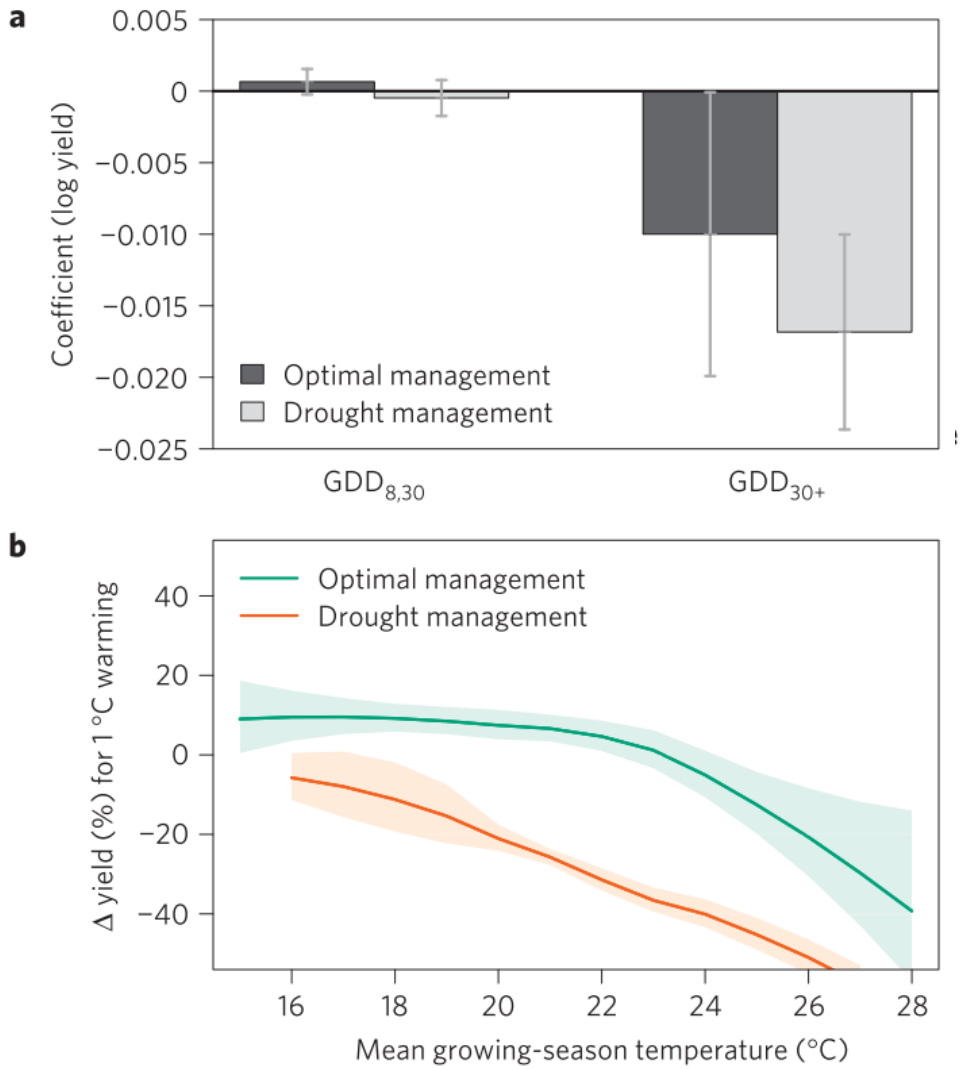


Africa will be warmer



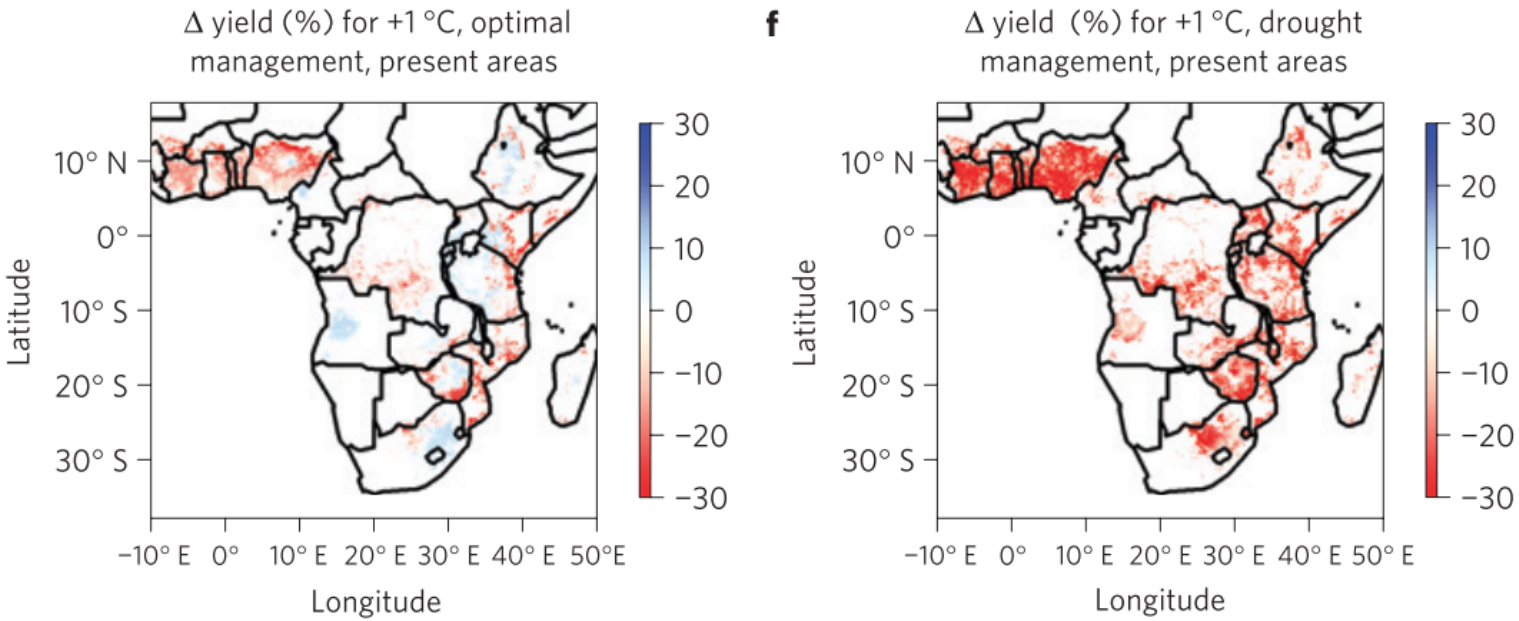
Beck *et al.* Present and future Köppen-Geiger climate classification maps at 1-km resolution. *Sci Data* **5,** 180214 (2018). https://doi.org/10.1038/sdata.2018.214

Warmer temperatures, in particular extreme heat, can diminish crop yields



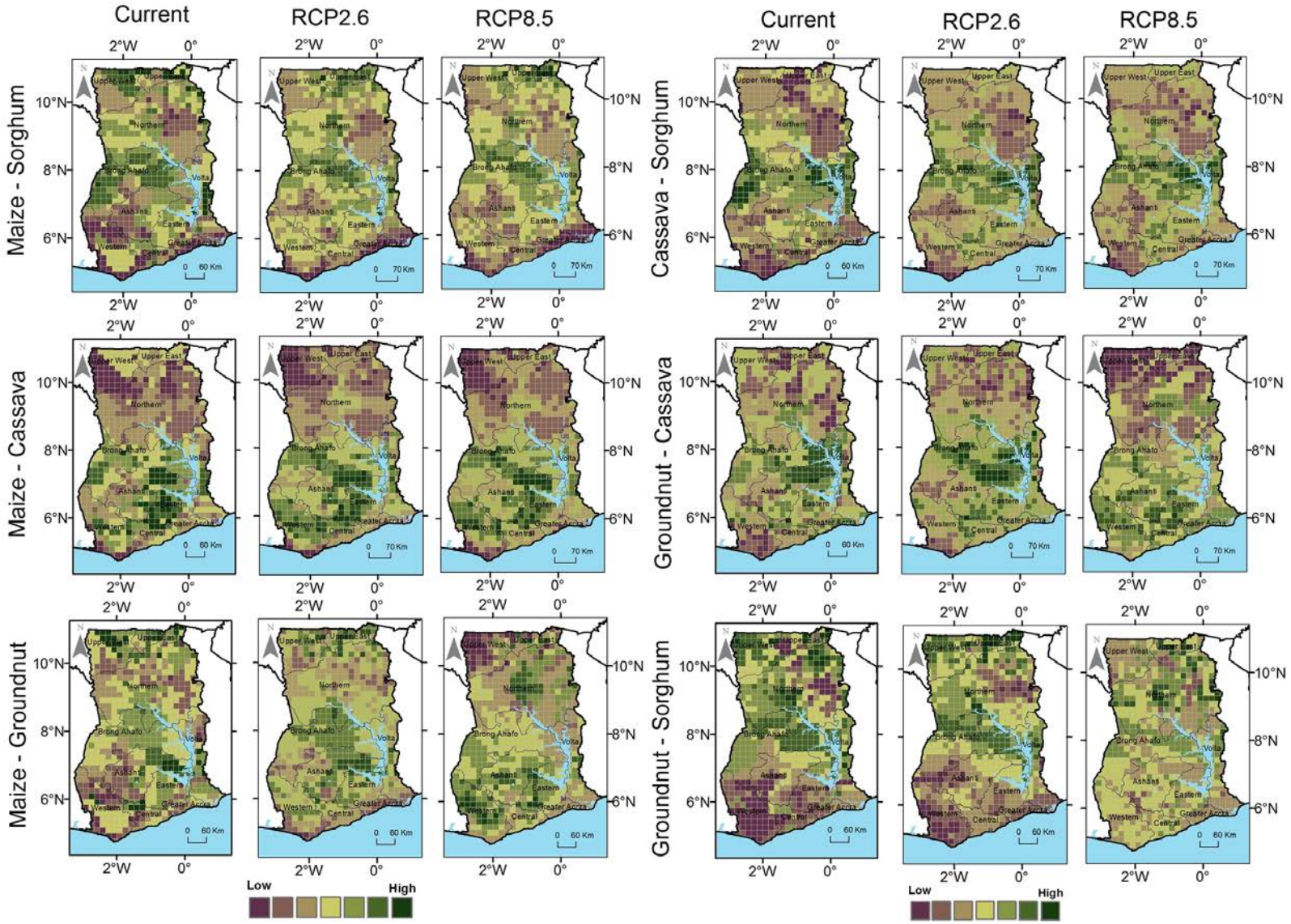
Left: Impacts of **(a)** heat (T > 30°C; GDD = Growing Degree Days) and **(b)** average season temperatures on maize yields across Africa

Bottom: Yield changes in % for +1°C of warming



Lobell et al., Nature Climate Change (2011)

The suitability for multi-cropping in Ghana will change under global warming



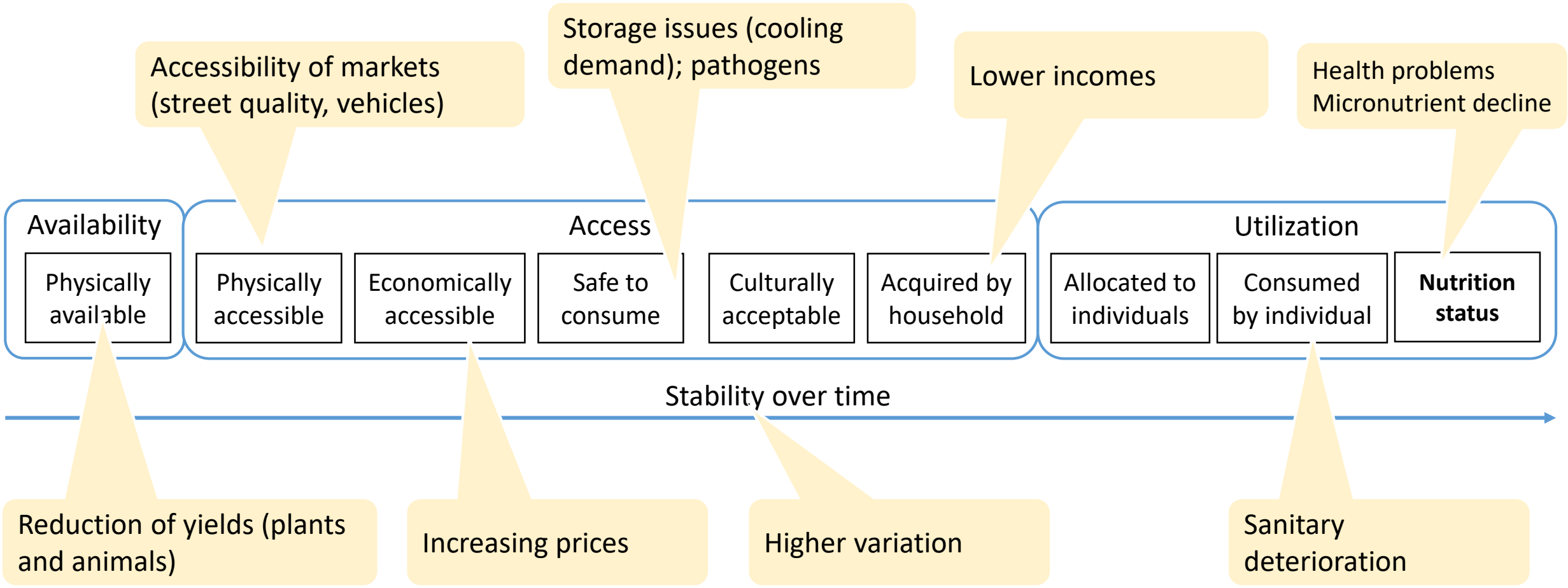
Multi-cropping is widespread in Ghana, particularly for the four staple crops cassava, groundnut, maize and sorghum.

The maps shows the suitability of pairs of crops under the current climate (left panel of each triple) and two future scenarios (RCP2.6, middle; RCP8.5, right).

Except for cassava and groundnut, all suitability combinations of crops are projected to decrease for the areas where both crops currently are highly suitable.

Chemura et al. (2020)

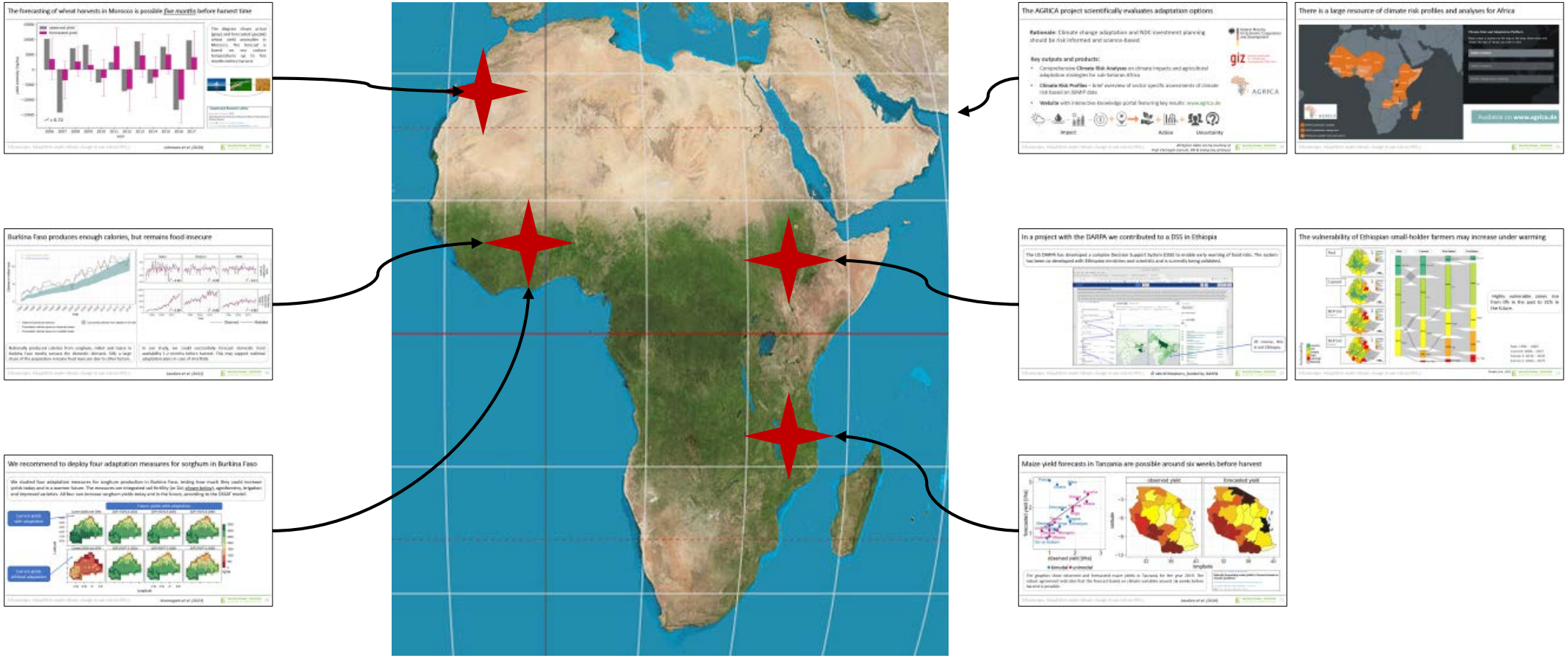
Climate change will affect food security on many stages



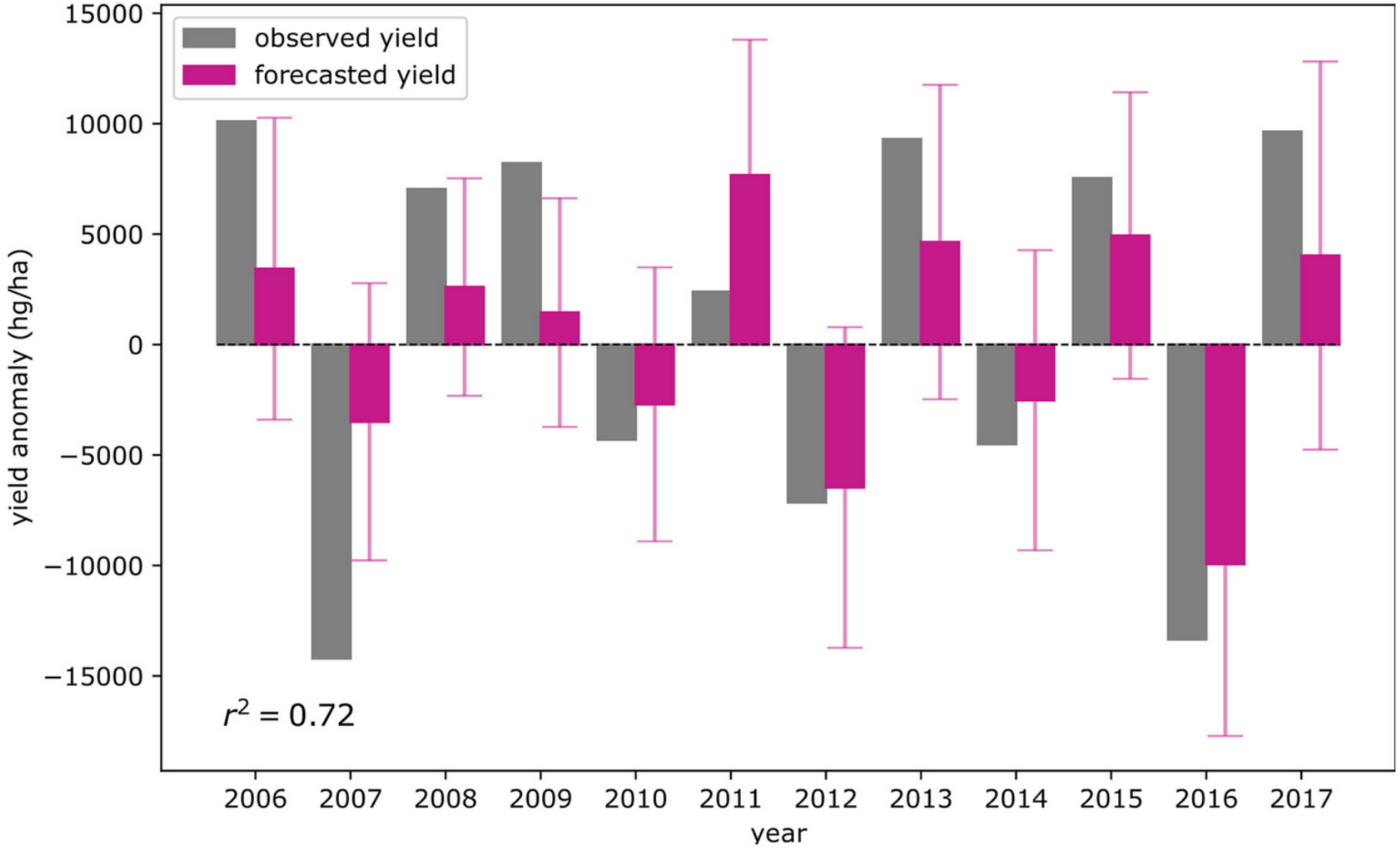
Theoretical and practical solutions

Adaptation must be adapted towards region, crop, risks and farming system

The following examples show different approaches aiming to strengthen farming systems or their administration.



The forecasting of wheat harvests in Morocco is possible *five months* before harvest time



The diagram shows actual (*grey*) and forecasted (*purple*) wheat yield anomalies in Morocco. The forecast is based on sea surface temperatures up to five months before harvest.

Geophysical Research Letters

Research Letter | Open Access

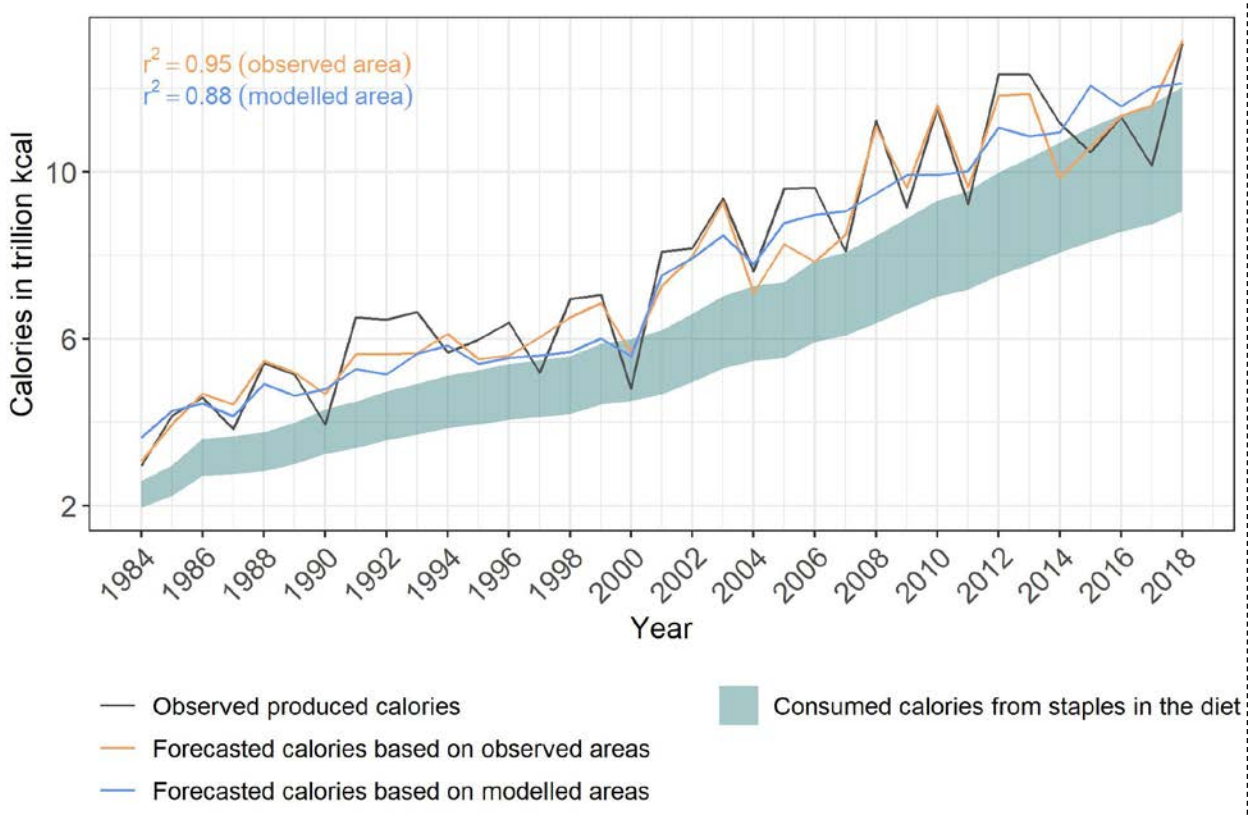
Potential for Early Forecast of Moroccan Wheat Yields Based on Climatic Drivers

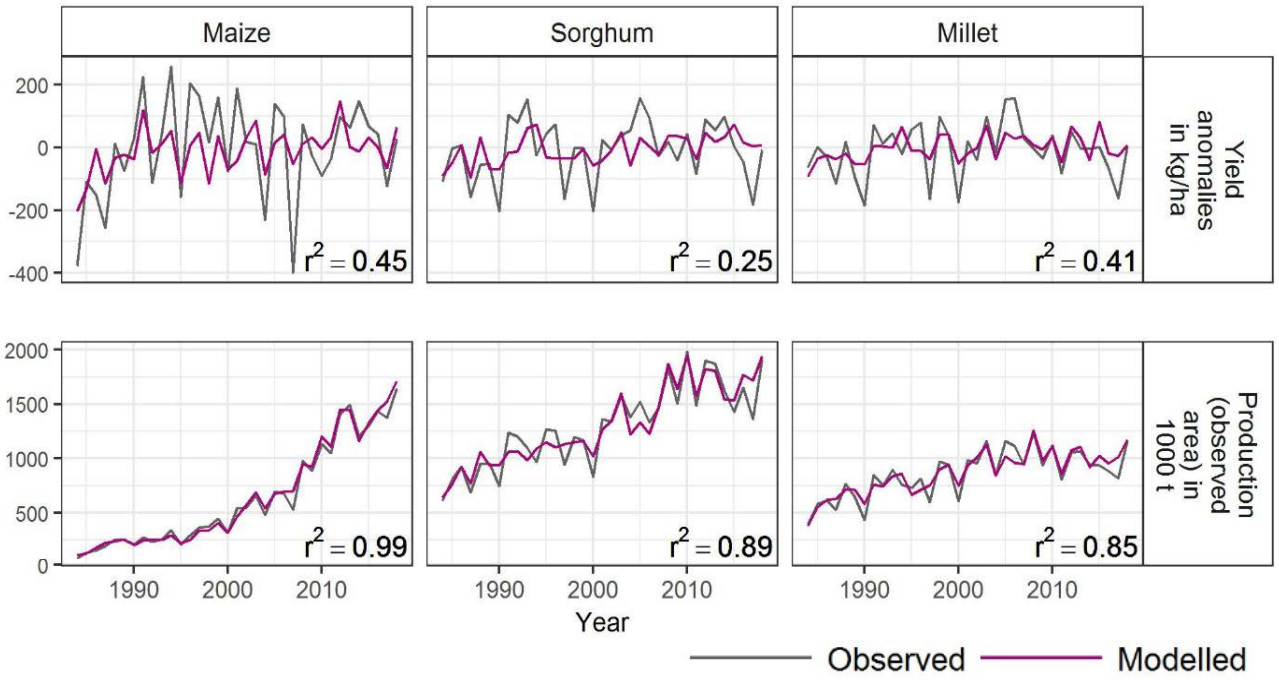
J. Lehmann, M. Kretschmer, B. Schauberger, F. Wechsung.

First published: 16 May 2020 | https://doi.org/10.1029/2020GL087516 | Citations: 5

Lehmann et al. (2020)

Burkina Faso produces enough calories, but remains food insecure





Nationally produced calories from sorghum, millet and maize in Burkina Faso mostly surpass the domestic demand. Still, a large share of the population remains food insecure due to other factors.

In our study, we could successfully forecast domestic food availability 1-2 months before harvest. This may support national adaptation plans in case of shortfalls.

Laudien et al. (2022)

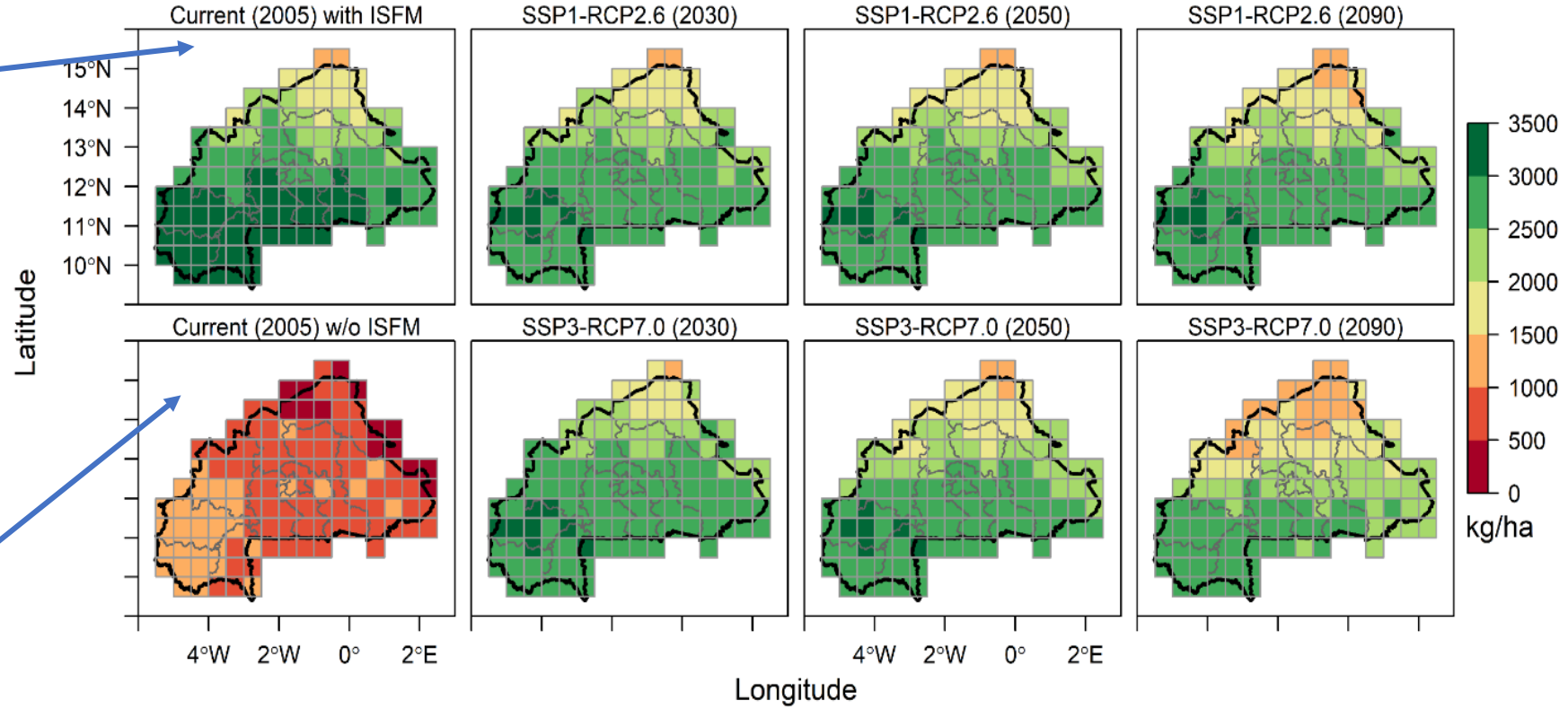
We recommend to deploy four adaptation measures for sorghum in Burkina Faso

We studied four adaptation measures for sorghum production in Burkina Faso, testing how much they could increase yields today and in a warmer future. The measures are integrated soil fertility (or Zaï; *shown below*), agroforestry, irrigation and improved varieties. All four can increase sorghum yields today and in the future, according to the DSSAT model.

Future yields with adaptation

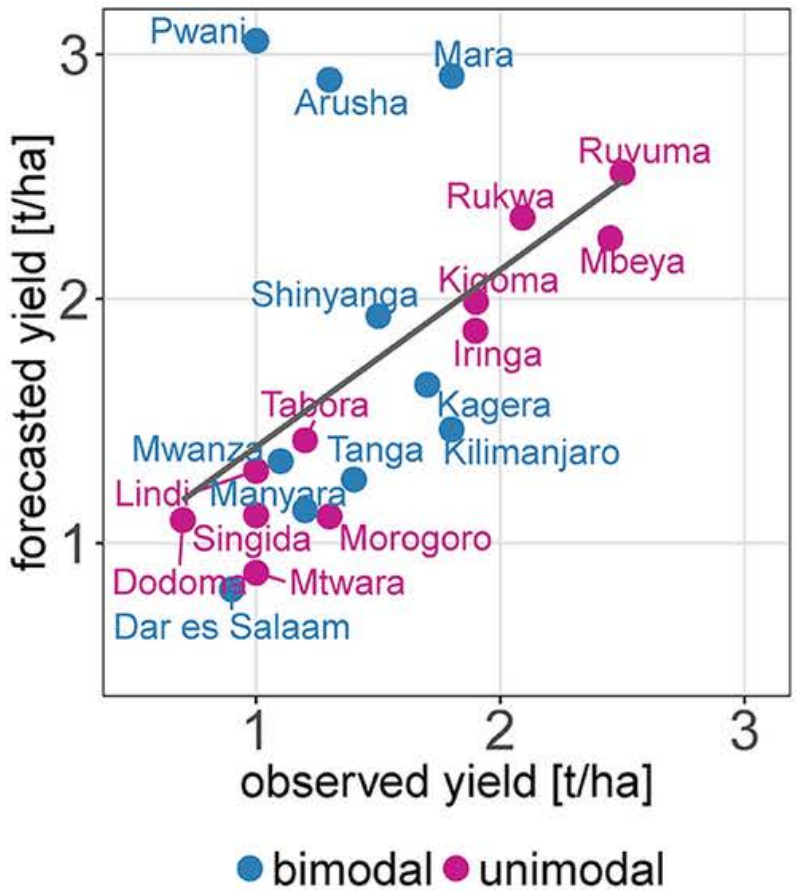
Current yields with adaptation

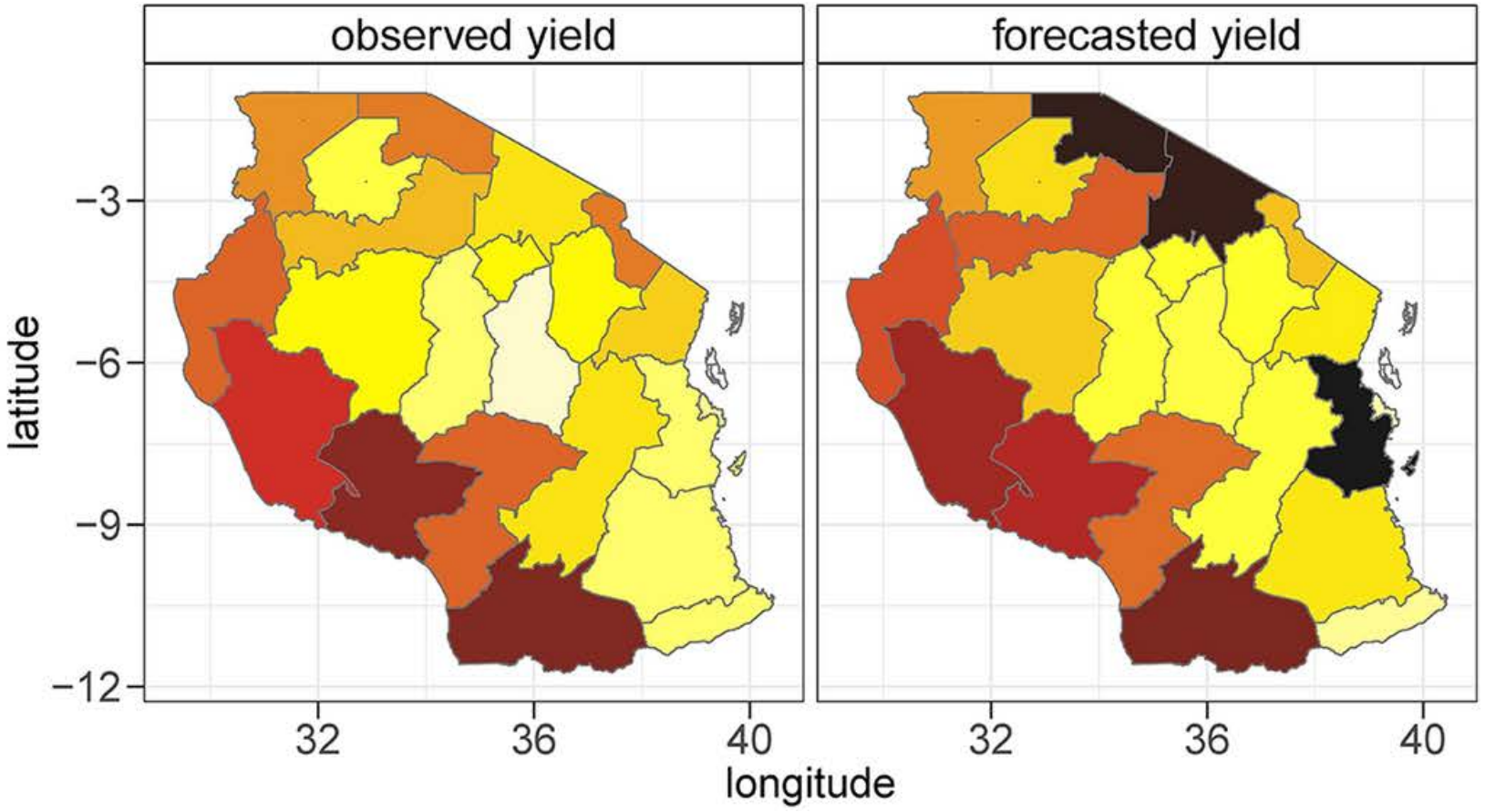
Current yields without adaptation



Arumugam et al. (2023)

Maize yield forecasts in Tanzania are possible around six weeks before harvest





The graphics show observed and forecasted maize yields in Tanzania for the year 2019. The robust agreement indicates that the forecast based on climate variables around six weeks before harvest is possible.


Article | Open Access | Published: 12 November 2020

Robustly forecasting maize yields in Tanzania based on climatic predictors

Rahel Laudien, Bernhard Schauberger, David Makowski & Christoph Gornott

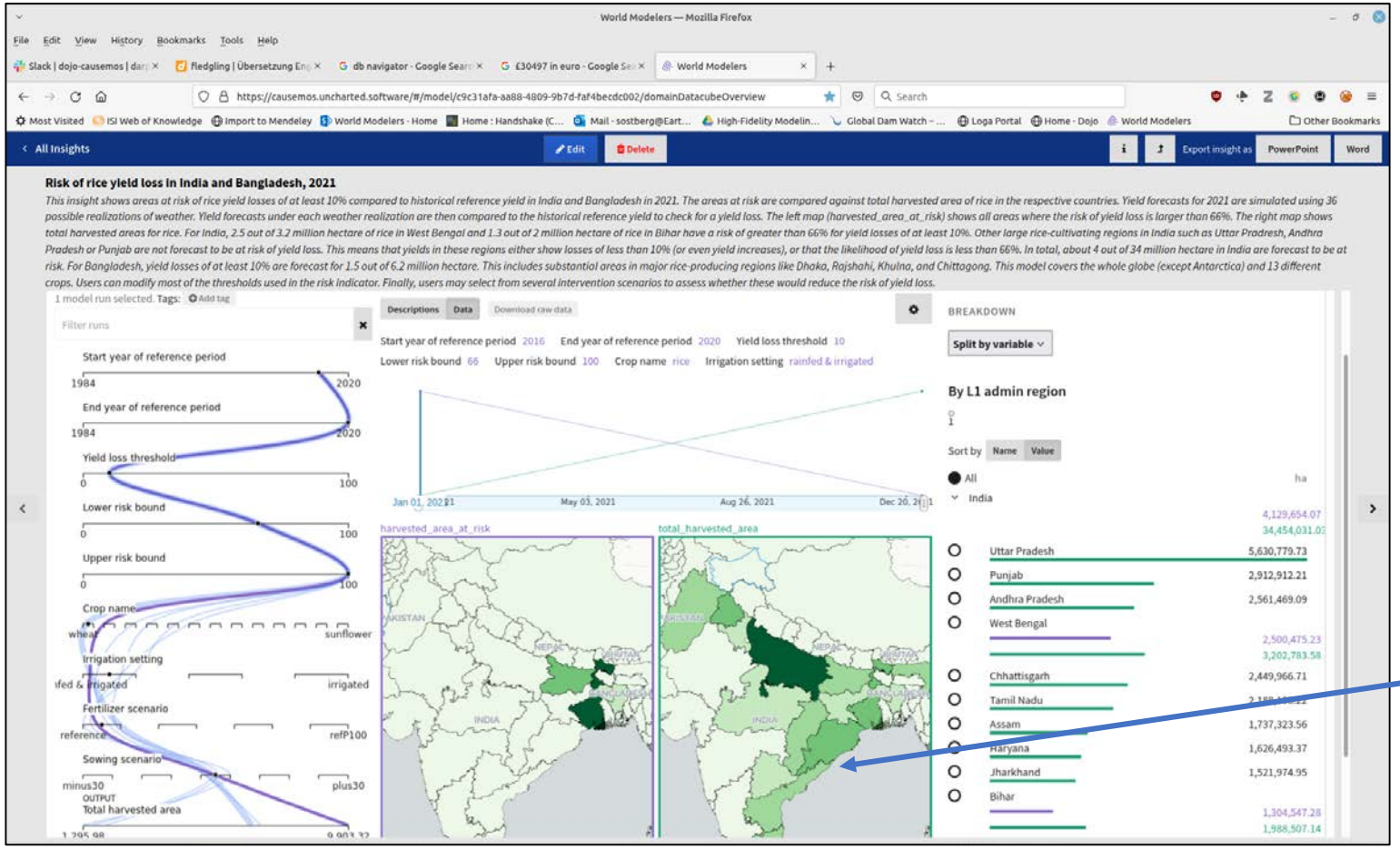
Scientific Reports **10**, Article number: 19650 (2020) | Cite this article

1406 Accesses | **2** Citations | **16** Altmetric | Metrics

Laudien et al. (2020)

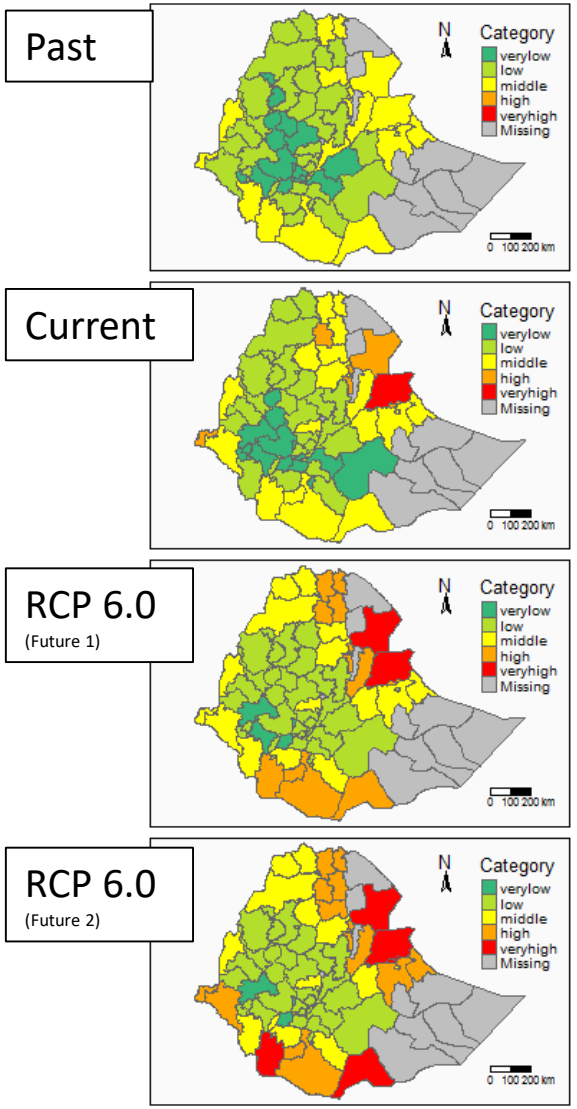
In a project with the DARPA we contributed to a DSS in Ethiopia

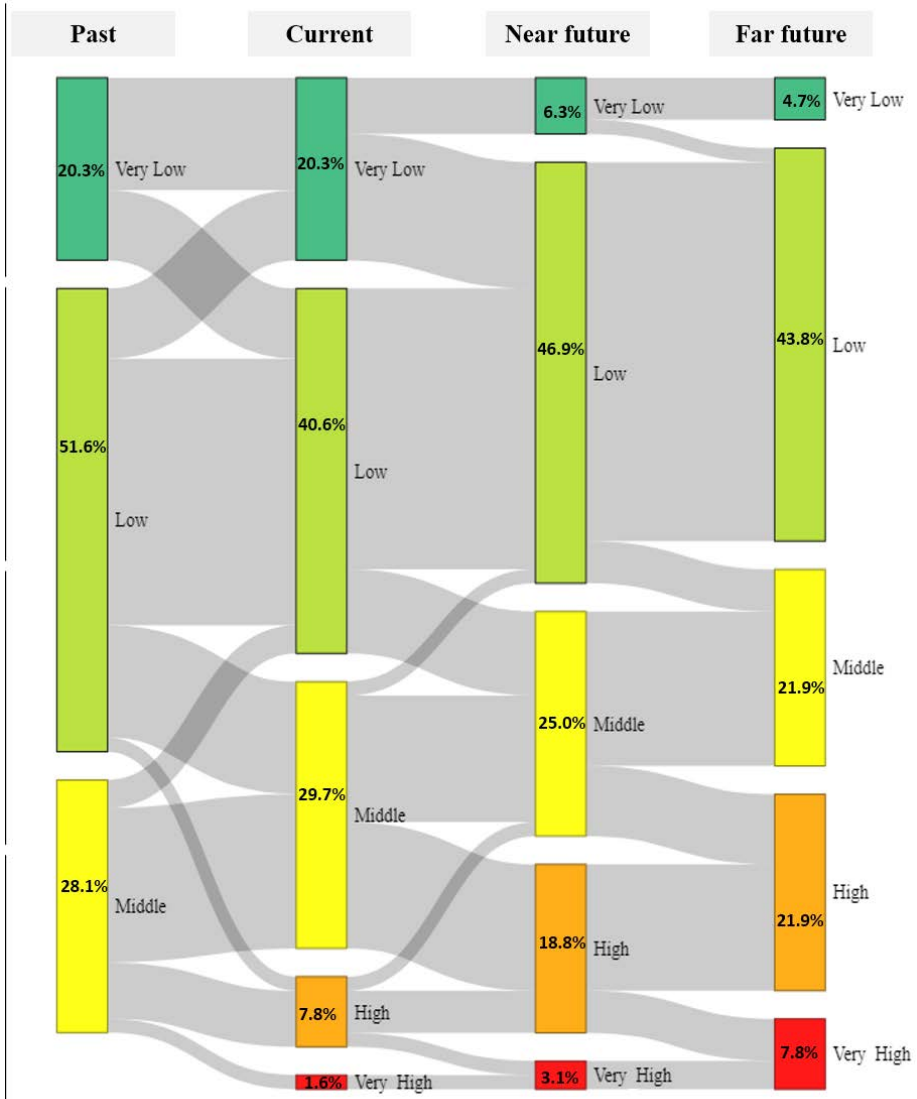
The US DARPA has developed a complex Decision Support System (DSS) to enable early warning of food risks. The system has been co-developed with Ethiopian ministries and scientists and is currently being validated.



Of course, this is not Ethiopia.

The vulnerability of Ethiopian small-holder farmers may increase under warming





Highly vulnerable zones rise from 0% in the past to 31% in the future.

Past: 1996 – 2005
Current: 2006 – 2015
Future 1: 2036 – 2045
Future 2: 2066 – 2075

Shukla et al., 2021

The AGRICA project scientifically evaluates adaptation options

Rationale: Climate change adaptation and NDC investment planning should be risk informed and science-based

Federal Ministry for Economic Cooperation and Development

giz Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

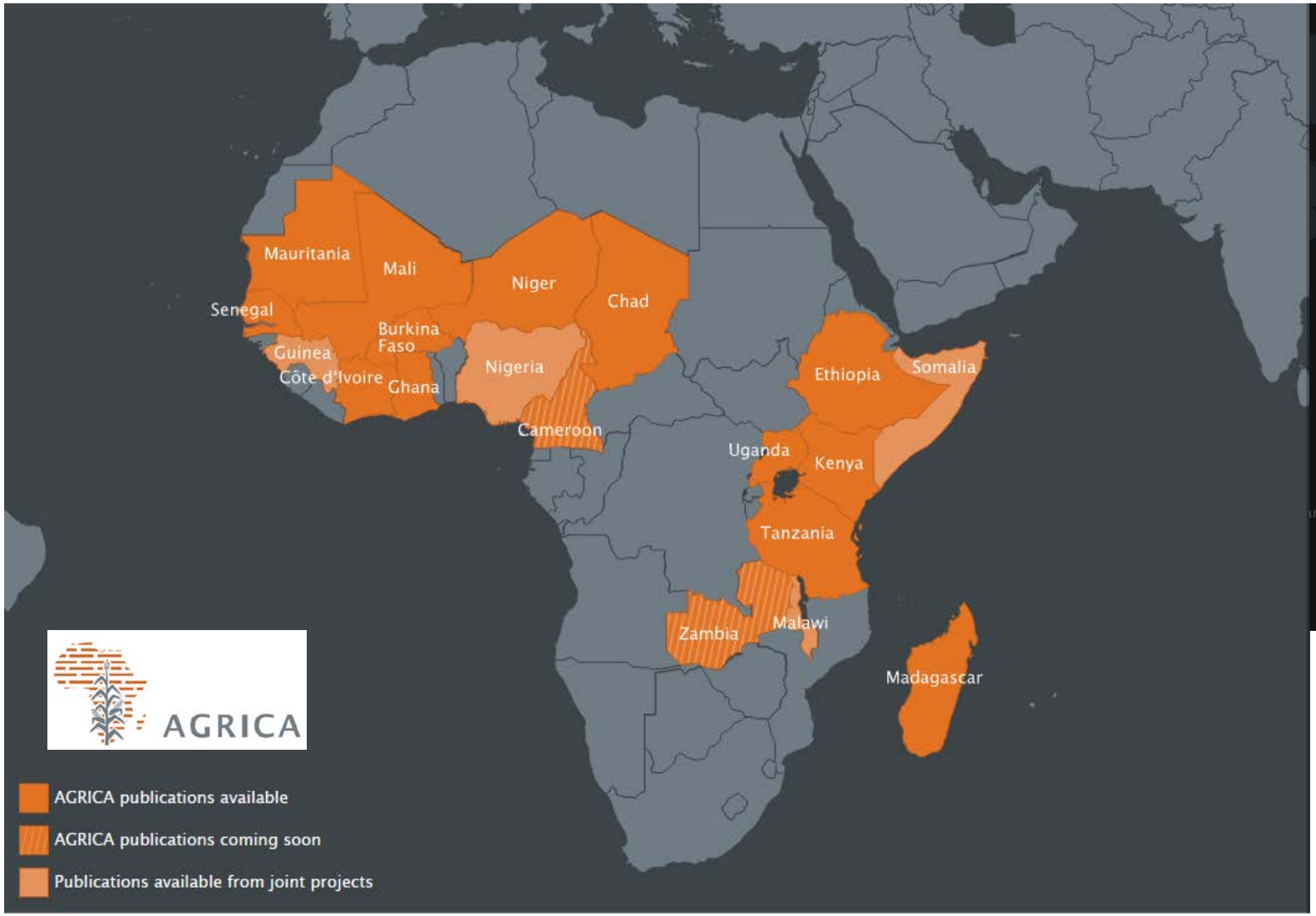
AGRICA

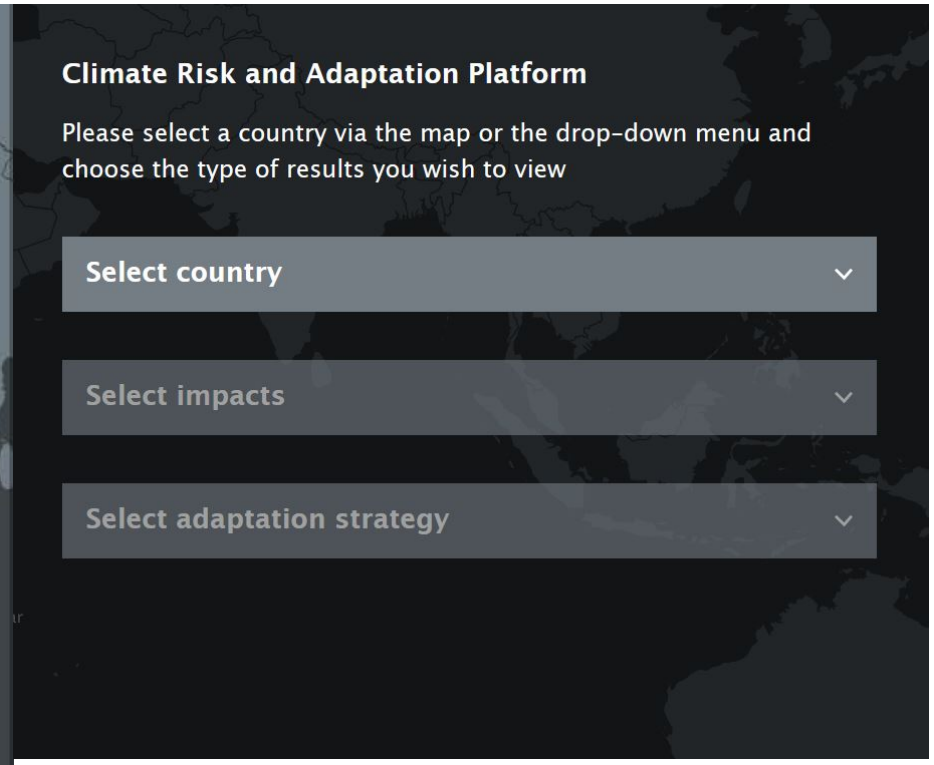
Key outputs and products:

- Comprehensive **Climate Risk Analyses** on climate impacts and agricultural adaptation strategies for sub-Saharan Africa
- **Climate Risk Profiles** – brief overview of sector specific assessments of climate risk based on ISIMIP data
- **Website** with interactive knowledge portal featuring key results: www.agrica.de

All Agrica slides are by courtesy of Prof. Christoph Gornott, PIK & University of Kassel

There is a large resource of climate risk profiles and analyses for Africa



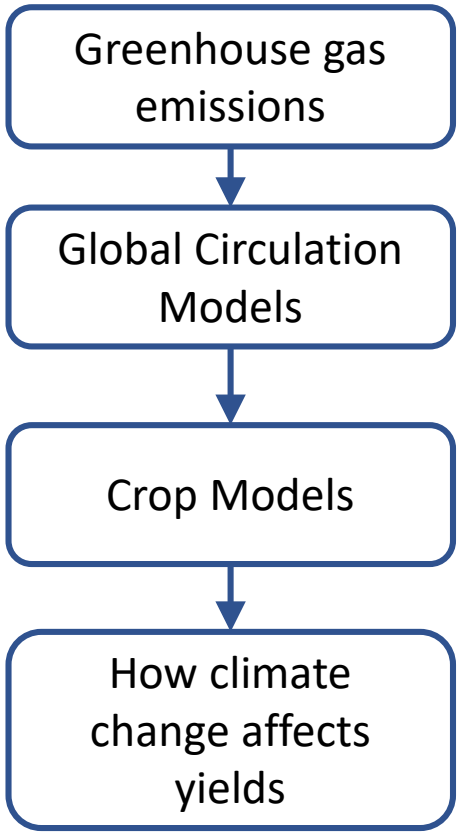


Available on **www.agrica.de**

Adaptation towards unknown unknowns

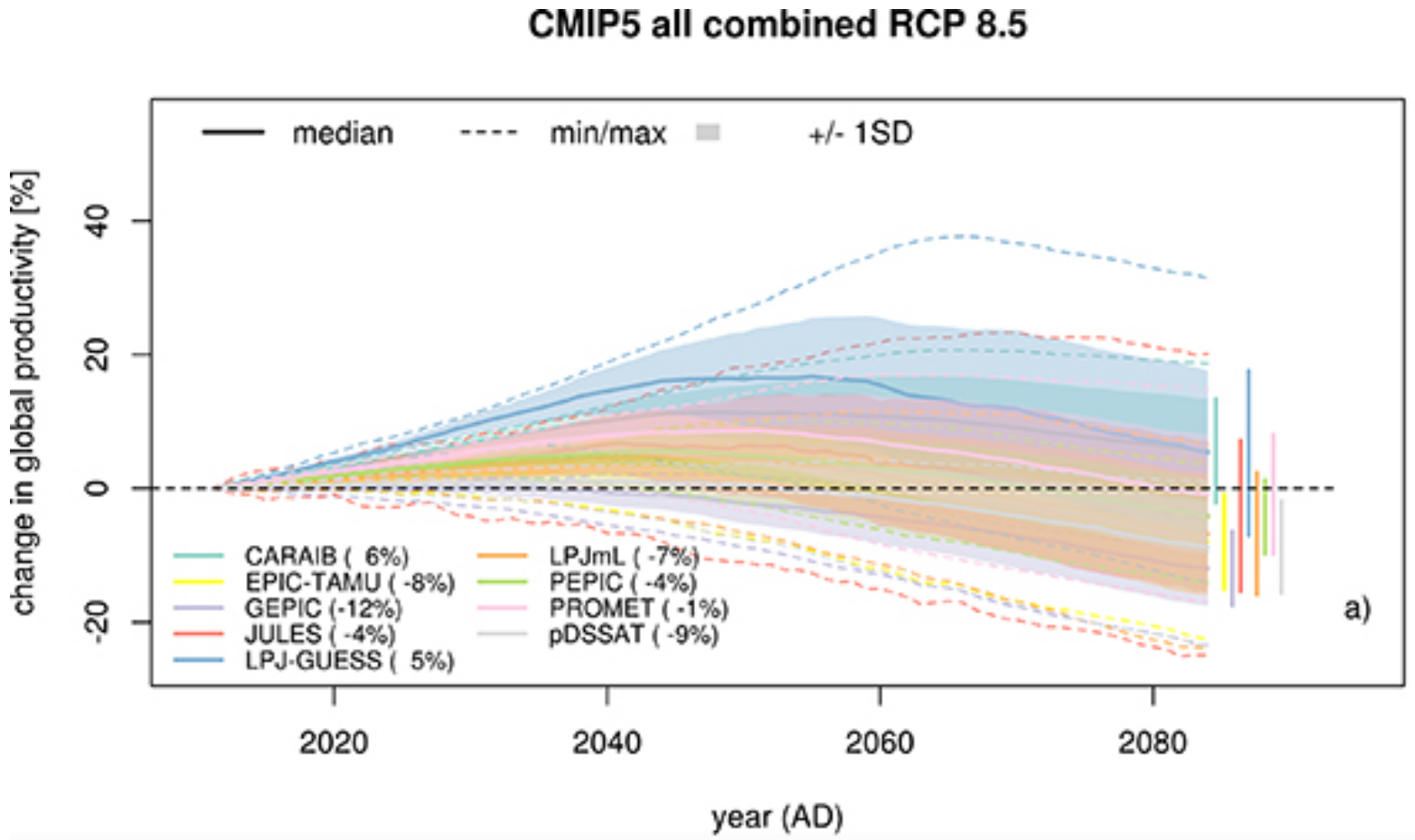
There is uncertainty on many levels

The usual climate impacts modelling pipeline is:



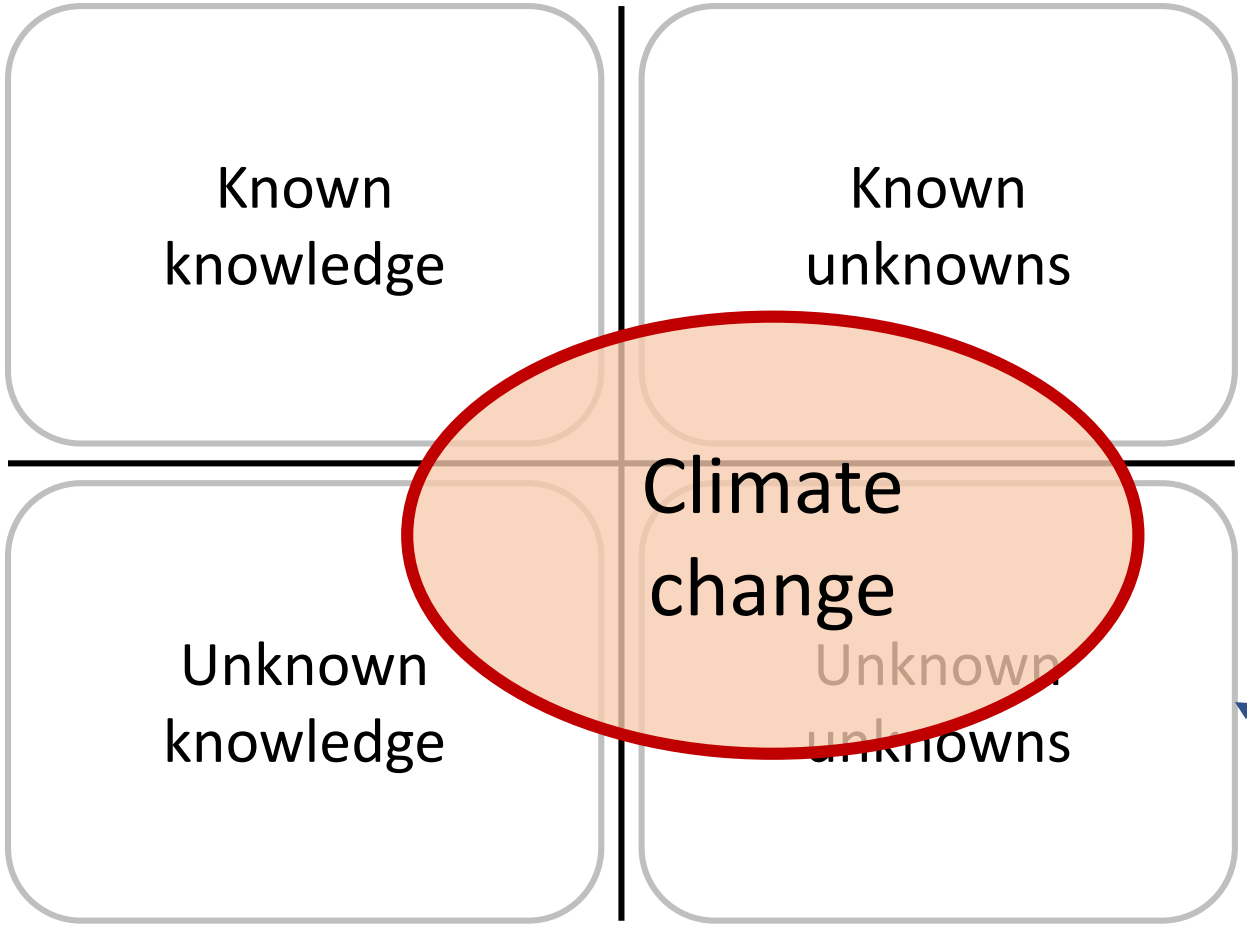
Uncertainty is present on all levels and may accumulate.

These uncertainties result in large ranges of possible futures, even when greenhouse gas trajectories are fixed:



Müller et al. (2021)

… and these only contain the uncertainties we know of – but there are more



Still, there is no excuse for not acting: there are many options where the past has shown that these are successful. We can start with these.

Apart from that, mitigation of climate change is crucial.

What can we do here?
1. Accept and hope
2. Do more research

Conclusion

Let us learn from each other for the coming challenges

There are many challenges awaiting for agriculture – in Africa, but also in Europe.

Luckily, there are also adaptation options to make agriculture more climate resilient.

We could learn from each other how to apply and enhance them – for example, in joint research projects.

Both Africa and Europe need science made in Africa.

Literature and image references

Literature references

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Image sources

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