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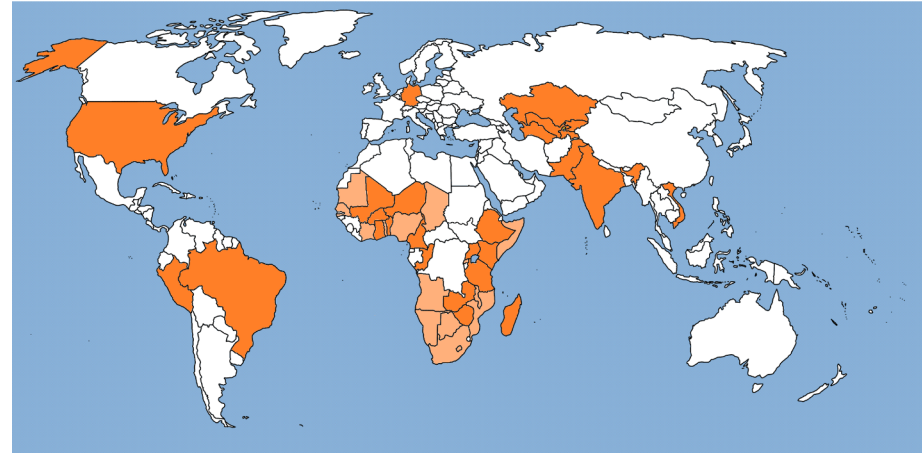


Climate Change Impacts on Ethiopian Agriculture: Evidence from Crop Models

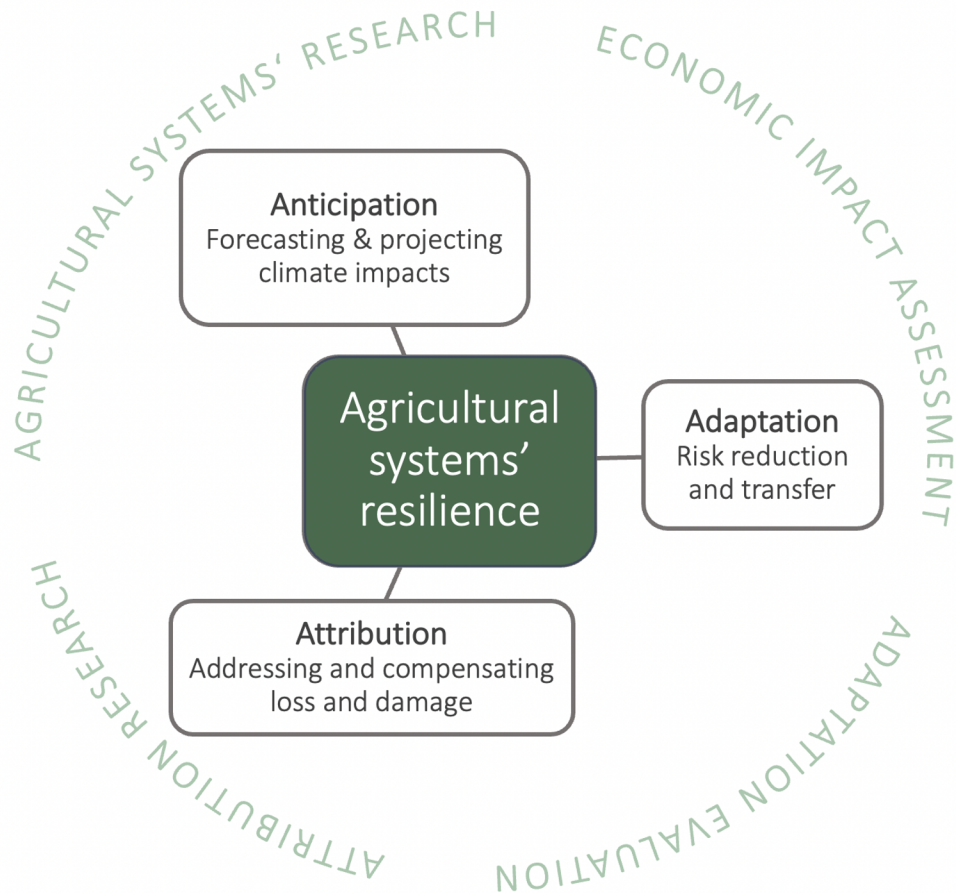
- Working Group Adaption in Agricultural Systems -

Working Group: Adaptation in Agricultural Systems

- RD Climate Resilience -



Project Countries



Methods

- **Semi-empirical/Statistical** models with process-based components, causal discovery algorithms and machine-learning
- **Process-based crop models** (e.g. SWIM, LPJmL, DSSAT, APSIM) to capture bio-physical relationships
- **Econometric methods** to analyze household survey data and randomized control trials



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Our Research on Ethiopia

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The importance of different land tenure systems for farmers' response to climate change: A systematic review

Lisa Murken^{a,*}, Christoph

^a Potsdam Institute for Climate Impact Research
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ARTICLE INFO

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Climate change adaptation
Vulnerability
Agriculture
Risk
Land ownership

1. Introduction

Globally, almost one billion pe

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Climate Risk Analysis for Identifying and Weighing Adaptation Strategies in Ethiopia's Agricultural Sector

Federal Ministry for Economic Cooperation and Development

POTSDAM INSTITUTE FOR CLIMATE IMPACT RESEARCH

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Climate Risk Analysis for Identifying and Weighing Adaptation Strategies in Ethiopia's Agricultural Sector



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LETTER

Dynamic vulnerability of smallholder agricultural systems in the face of climate change for Ethiopia

Roopam Shukla^{1,*}, Stephanie Gleixner¹, Amsalu Woldie Yalew², Bernhard Schauberg¹, Diana Sietz¹ and Christoph Gornott^{1,2}

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Keywords: climate change, spatio-temporal, vulnerability, smallholder, agriculture, Ethiopia

Supplementary material for this article is available online

Abstract

Assessing vulnerability to climate change and extremes is the first step towards guiding climate change adaptation. It provides the basis to decide 'what' adaptation measures are needed 'where'. Vulnerability which is defined as a function of exposure, sensitivity, and adaptive capacity, differs spatially and evolves temporally. Therefore, it is imperative to understand the dynamics of vulnerability at sub-national scales to be prepared for and respond to current and future climatic risks. This paper focuses on Ethiopia where a sub-national understanding of vulnerability dynamics in smallholder agriculture systems is missing to date. The paper assesses the vulnerability of crop-based smallholder systems in Ethiopia for the past (1996–2005), current (2006–2015), and two future (2036–2045 and 2066–2075) climate scenarios using an indicator-based approach. The future scenarios are based on two Representative Concentration Pathways (RCPs) RCP 2.6 and RCP 6.0 from four general circulation models. Results show the emergence of highly vulnerable zones that were missing in the past scenario. With Paris agreement pathway, keeping global warming under 2°C (RCP 2.6), reduction in vulnerability of 10% of the zones is noted in far future (2066–75) as compared to RCP 6.0 where the exposure increases, making 30% of the zones highly vulnerable. The projected increase in exposure to climatic hazards will worsen the vulnerability of smallholder agricultural systems in future unless the current adaptation deficit is sufficiently addressed. This study maps the temporal dynamics of vulnerability unlike the prevailing snapshot assessments at subnational-level for Ethiopia. The study seeks to assist the decision-making process to build resilience to climate change in Ethiopia and other low-income countries with similar geophysical and socio-economic conditions.

1. Introduction

Studies have illustrated the severe impacts of climate change and extremes in Sub-Saharan Africa (SSA) and heightened concerns for food security (Boyd *et al.* 2013, Pierson *et al.* 2019). Among the SSA countries, Ethiopia is subject to high climate variability and climatological hazards that have negatively influenced the agricultural sector in the past decades (Sietz *et al.* 2017, Kamali *et al.* 2018, Conway *et al.* 2019). Projected changes indicate further increase in frequency and intensity of climate extremes, such as droughts, floods, and hot days and nights (McSweeney *et al.* 2020). As a low-income country, there are noted

Federal Ministry for Economic Cooperation and Development



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Climate Risk Profile: Ethiopia

Summary

This profile provides an overview of projected climate parameters and related impacts on different sectors in Ethiopia until 2080 under different climate change scenarios (called Representative Concentration Pathways, RCPs). RCP2.6 represents the low emissions scenario in line with the Paris Agreement; RCP6.0 represents a medium to high emissions scenario. Model projections do not account for effects of future socioeconomic impacts.

Agriculture, biodiversity, health, infrastructure and water are highly vulnerable to climate change. The need for adaptation in these sectors should be represented in the German development cooperation portfolio in Ethiopia.

Depending on the scenario, temperature in Ethiopia is projected to rise by between 1.6 and 3.7 °C by 2080, compared to pre-industrial levels, with higher temperatures and more temperature extremes projected for the

Agro-ecological zones might shift, affecting ecosystems, biodiversity and crop production. Models project regionally varying changes in species richness and tree cover in response



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Climate change and specialty coffee potential in Ethiopia

Abel Chemura^{1,2,3}, Bester Tawona Mudereri^{2,3}, Amsalu Woldie Yalew^{4,5} & Christoph Gornott^{4,5}

Current climate change impact studies on coffee have not considered impact on coffee typicities that depend on local microclimatic, topographic and soil characteristics. Thus, this study aims to provide a quantitative risk assessment of the impact of climate change on suitability of five premium specialty coffees in Ethiopia. We implement an ensemble model of three machine learning algorithms to predict current and future (2030s, 2050s, 2070s, and 2090s) suitability for each specialty coffee under four Shared Socio-economic Pathways (SSPs). Results show that the importance of variables determining coffee suitability in the combined model is different from those for specialty coffees despite the climatic factors remaining more important in determining suitability than topographic and soil variables. Our model predicts that 27% of the country is generally suitable for coffee, and of this area, only up to 30% is suitable for specialty coffees. The impact modelling showed that the combined model projects a net gain in coffee production suitability under climate change in general but losses in five out of the six modelled specialty coffee growing areas. We conclude that depending on drivers of suitability and projected impacts, climate change will significantly affect the Ethiopian specialty coffee sector and area-specific adaptation measures are required to build resilience.

Agricultural commodities face substantial risk from climate change because of their sensitivity to and dependence on weather variables¹. One such commodity is coffee, a crop and beverage of importance in international trade. The two species of coffee with economic importance are the Robusta coffee (*Coffea canephora* Pierre) and Arabica coffee (*Coffea arabica* Linnaeus). Arabica coffee has relatively higher demand (over 70% of the world coffee market) due to its higher beverage quality². Work for producing Arabica coffee, classified on the basis of (i) between latitude 20° N and 25° S at altitudes ranging sensitive to climatic factors than robusta coffee and thus is because Arabica coffee is grown in specific climatic ar diversity³. As such, there is evidence that climate change and increasing the risks of pests and disease^{4,5}. These 25 to 30 million smallholder coffee farmers who produce Arabica coffee are strongly influenced by local climatic (i.e. elevation, slope angle and aspect), and edaphic (soil give the coffee distinctive characteristics specific to prod to each region and thus difficult to replicate, and slight m but impact studies on this important aspect are missing, is planted in different areas, the profiles will be different⁶ detected by chemical traces^{7–9}. As such, grading an on the roast appearance and cup quality (flavour, fragrance and colour), the density of beans and number of defects by the geographic characteristics (climate, altitude and to some extent the preparation (washed or unwashed) origin as proxies of product and process quality have ge The demand for specialty coffee is increasing across wo with lower quality coffees to create instant coffees. This smallholder communities to receive a premium price of

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WEATHERING RISK

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AGRICULTURE

B-EPI-CC

Climate Risk Profile for Eastern Africa

Climate change is likely to cause damage to the infrastructure sector in Eastern Africa including major roads and urban areas. Roads are the backbone of the region's transportation network and essential in linking farmers and markets. Investments will need to be made into building climate-resilient roads and other infrastructure to maintain agricultural supply chains and foster economic growth.

Agro-ecological zones (AEZs) in Eastern Africa might shift, affecting ecosystems, biodiversity and crop production. Models project varying trends for species richness and tree cover, depending on the region and scenario.

The population share affected by at least one heatwave per year is projected to rise from 1.6% in 2000 to 30.4% under RCP6.0 in 2080. More frequent heatwaves will negatively affect underlying health conditions, especially those of vulnerable groups. Without adaptation, heat-related mortality is estimated to increase by a factor of more than 4 by 2080.

Climate impacts are likely to exacerbate existing vulnerabilities and increase human mobility, thus serving as a risk multiplier for conflict in an already politically fragile region. Women, children as well as poor, sick and elderly people will be disproportionately affected by climate impacts.



atmosphere



Article

Did ERA5 Improve Temperature and Precipitation Reanalysis over East Africa?

Stephanie Gleixner^{1,*}, Terferi Demissie^{2,3} and Guiliat Tefera Diro⁴

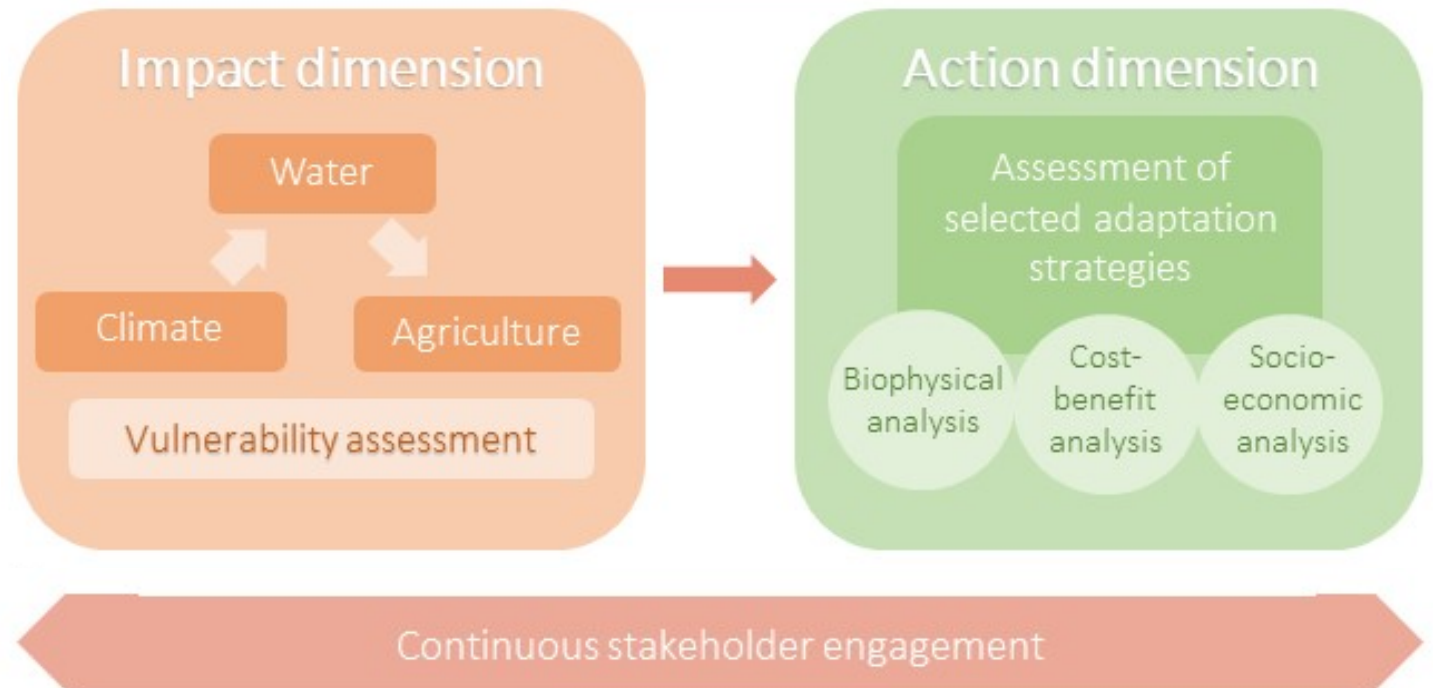
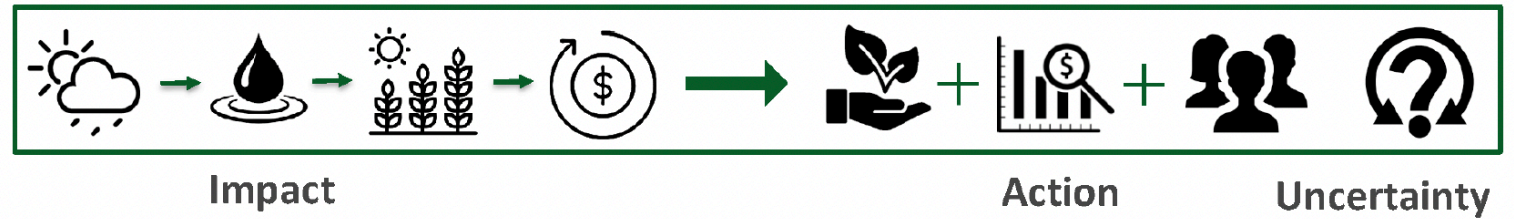
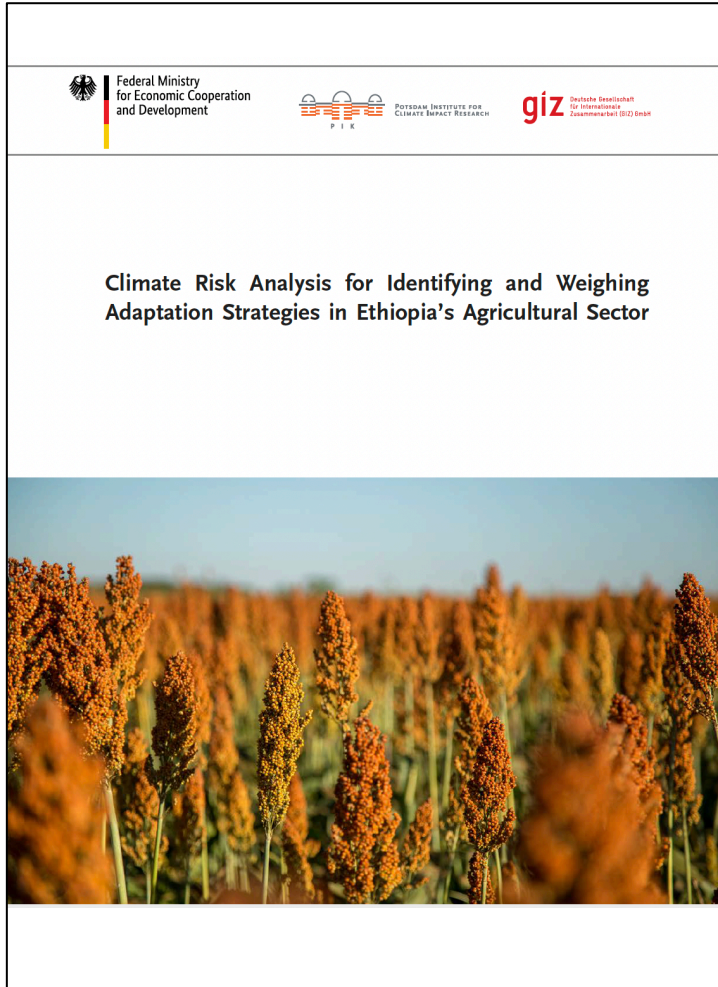
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² CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS), East Africa, P.O. Box 5689, Addis Ababa 1000, Ethiopia; t.demissie@cgiar.org
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* Correspondence: gleixner@pik-potsdam.de

Received: 5 August 2020; Accepted: 14 September 2020; Published: 17 September 2020

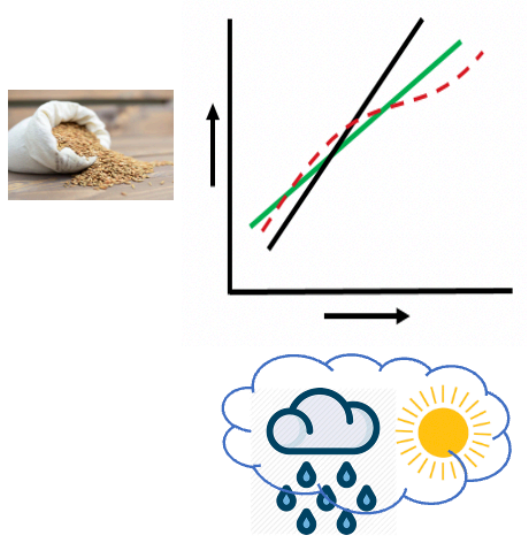


Abstract: Reanalysis products are often taken as an alternative solution to observational weather and climate data due to availability and accessibility problems, particularly in data-sparse regions such as Africa. Proper evaluation of their strengths and weaknesses, however, should not be overlooked. The aim of this study was to evaluate the performance of ERA5 reanalysis and to document the progress made compared to ERA-Interim for the fields of near-surface temperature and precipitation over Africa. Results show that in ERA-Interim the climatological biases in temperature and precipitation are clearly reduced and the representation of inter-annual variability is improved over most of Africa. However, both reanalysis products performed less well in terms of capturing the observed long-term trends, despite a slightly better performance of ERA5 over ERA-Interim. Further regional analysis over East Africa shows that the representation of the annual cycle of precipitation is substantially improved in ERA5 by reducing the wet bias during the rainy season. The spatial distribution of precipitation during extreme years is also better represented in ERA5. While ERA5 has improved much in comparison to its predecessor, there is still demand for improved products with even higher resolution and accuracy to satisfy impact-based studies, such as in agriculture and water resources.

AGRICA Climate Risk Report - Concept



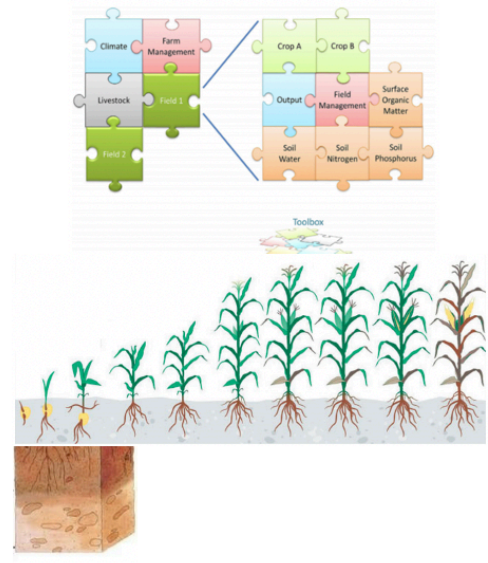
AGRICA Climate Risk Report – Agricultural Impacts of Climate Change



Statistical crop model AMPLIFY



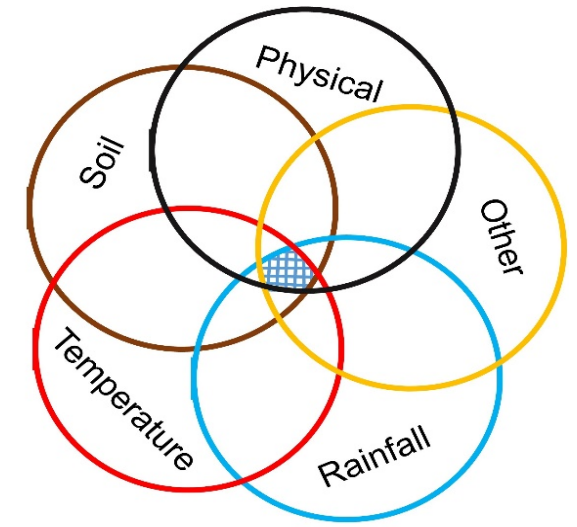
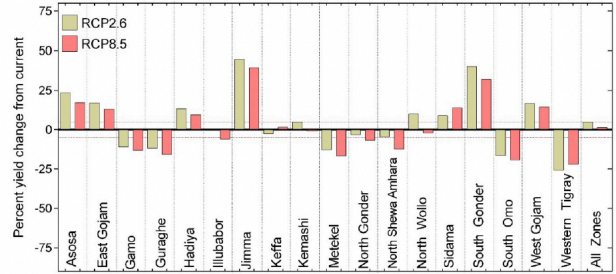
Weather explains 55-89% of year-to-year variability of nationally aggregated yield



Process-based crop model APSIM



Projected Changes in Maize Yield



Ensemble of ML Suitability Models



Decrease in suitability for Maize, Wheat and Teff. Increase in suitability for Sorghum.

AGRICA Climate Risk Report – Assessment of Adaptation Strategies

Adaptation strategy	Irrigation	Switching crops	Agroforestry	Fodder and feed improvement	Insurance
Risk response	Risk mitigation	Risk mitigation	Risk mitigation	Risk mitigation	Risk transfer
Risk mitigation potential	High	High	High ²	High	No risk mitigation
Cost effectiveness	Medium	Medium	High	High	Risk transfer
Risk gradient	Risk-independent	Risk-specific	Risk-specific	Risk-independent	(Weather) risk specific
Upscaling potential	High	Medium	Medium-high	High	Medium
Development co-benefits	High	Medium	High	High	Medium
Potential maladaptive outcomes	High	Medium	Low	Medium	Medium
Stakeholder interest	High	High	High	High	Low
Institutional support requirements	Medium	Medium	Medium	Medium	High

Focus on staple crops!

Changes in Coffee Suitability

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Climate change and specialty coffee potential in Ethiopia

Abel Chemura^{1,2,3}, Bester Tawona Mudereri^{2,3}, Amsalu Woldie Yalew^{3,4} & Christoph Gornott^{1,5}

Current climate change impact studies on coffee have not considered impact on coffee typicities that depend on local microclimatic, topographic and soil characteristics. Thus, this study aims to provide a quantitative risk assessment of the impact of climate change on suitability of five premium specialty coffees in Ethiopia. We implement an ensemble model of three machine learning algorithms to predict current and future (2030s, 2050s, 2070s, and 2090s) suitability for each specialty coffee under four Shared Socio-economic Pathways (SSPs). Results show that the importance of variables determining coffee suitability in the combined model is different from those for specialty coffees despite the climatic factors remaining more important in determining suitability than topographic and soil variables. Our model predicts that 27% of the country is generally suitable for coffee, and of this area, only up to 30% is suitable for specialty coffees. The impact modelling showed that the combined model projects a net gain in coffee production suitability under climate change in general but losses in five out of the six modelled specialty coffee growing areas. We conclude that depending on drivers of suitability and projected impacts, climate change will significantly affect the Ethiopian specialty coffee sector and area-specific adaptation measures are required to build resilience.

Agricultural commodities face substantial risk from climate change because of their sensitivity to and dependence on weather variables¹. One such commodity is coffee, a crop and beverage of importance in international trade. The two species of coffee with economic importance are the Robusta coffee (*Coffea canephora* Pierre) and Arabica coffee (*Coffea arabica* Linnaeus). Arabica coffee has relatively higher demand (over 70% of the world coffee market) due to its higher beverage quality². Worldwide, there are five key agroecological zones suitable for producing Arabica coffee, classified on the basis of temperature and rainfall characteristics. These areas are between latitude 20° N and 25° S at altitudes ranging between 700 and 2000 m.a.s.l³. Arabica coffee is more sensitive to climatic factors than robusta coffee and thus is expected to be affected more by climate change⁴. This is because Arabica coffee is grown in specific climatic and biophysical envelopes coupled with a narrow genetic diversity⁵. As such, there is evidence that climate change is reducing area suitable for coffee^{6,7}, limiting yield⁸, and increasing the risks of pests and disease⁹⁻¹². These biophysical impacts eventually impinge on the livelihoods of 25 to 30 million smallholder coffee farmers who produce the majority of the world's coffee¹³.

In addition to the general requirements for Arabica coffee production, and perhaps most importantly, coffee quality profiles are strongly influenced by local climatic (rainfall, temperature, humidity and radiation), topographical (elevation, slope angle and aspect), and edaphic (soil depth, acidity/alkalinity and fertility) factors¹⁴⁻¹⁶. These give the coffee distinctive characteristics specific to production areas. The combination of these factors is unique to each region and thus difficult to replicate, and slight modifications will affect the eventual profile of the coffee, but impact studies on this important aspect are missing. The effect is such that even when the same coffee variety is planted in different areas, the profiles will be different¹⁶⁻¹⁸. This *terroir* influence in coffee is so strong that it can be detected by chemical traces¹⁹⁻²⁰. As such, grading and classification of coffee on the global market are based on the roast appearance and cup quality (flavour, fragrance, acidity and body), bean physiognomies (size, shape and colour), the density of beans and number of defects^{21,22}. All of these characteristics are heavily influenced by the geographic characteristics (climate, altitude and soils) of the area of cultivation, the botanical variety and to some extent the preparation (washed or unwashed)²³⁻²⁵. In addition, the use of geographical indicators of origin as proxies of product and process quality have grown immensely in the single-origin coffee markets^{26,27}. The demand for specialty coffee is increasing across world markets, especially as they are used also in blending with lower quality coffees to create instant coffees. This creates opportunities for coffee growing countries and smallholder communities to receive a premium price of about +20 to +50% compared to regular coffee beans^{28,29}.

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SPIEGEL Wissenschaft

Äthiopien

Klimawandel bedroht Anbau hochwertiger Kaffeesorten

Sie schmecken blumig, fruchtig oder würzig statt bitter. In Äthiopien wachsen einige besonders exquisite Kaffeebohnen, doch klimatische Veränderungen könnten die Anbauflächen reduzieren.

14.04.2021, 17:47 Uhr

TAGESSPIEGEL Anmelden ABO

Politik Internationales Berlin Gesellschaft Wirtschaft Kultur Wissen Gesundheit Sport Meinungen >

Coronavirus Archäologie Hochschulen Biomedizin Umwelt und Natur Weltall

Wissen | Kaffee für eine heiße Welt: Wilde Sorte soll Klimawandel trotzen

© gpaam / Deutscher Kaffeeverband

Kaffee für eine heiße Welt Wilde Sorte soll Klimawandel trotzen

In Äthiopien bedroht die globale Erwärmung den Kaffeeanbau mit herkömmlichen Sorten. Doch es gibt Ideen für Gegenmaßnahmen – und eine robuste Art als Alternative.

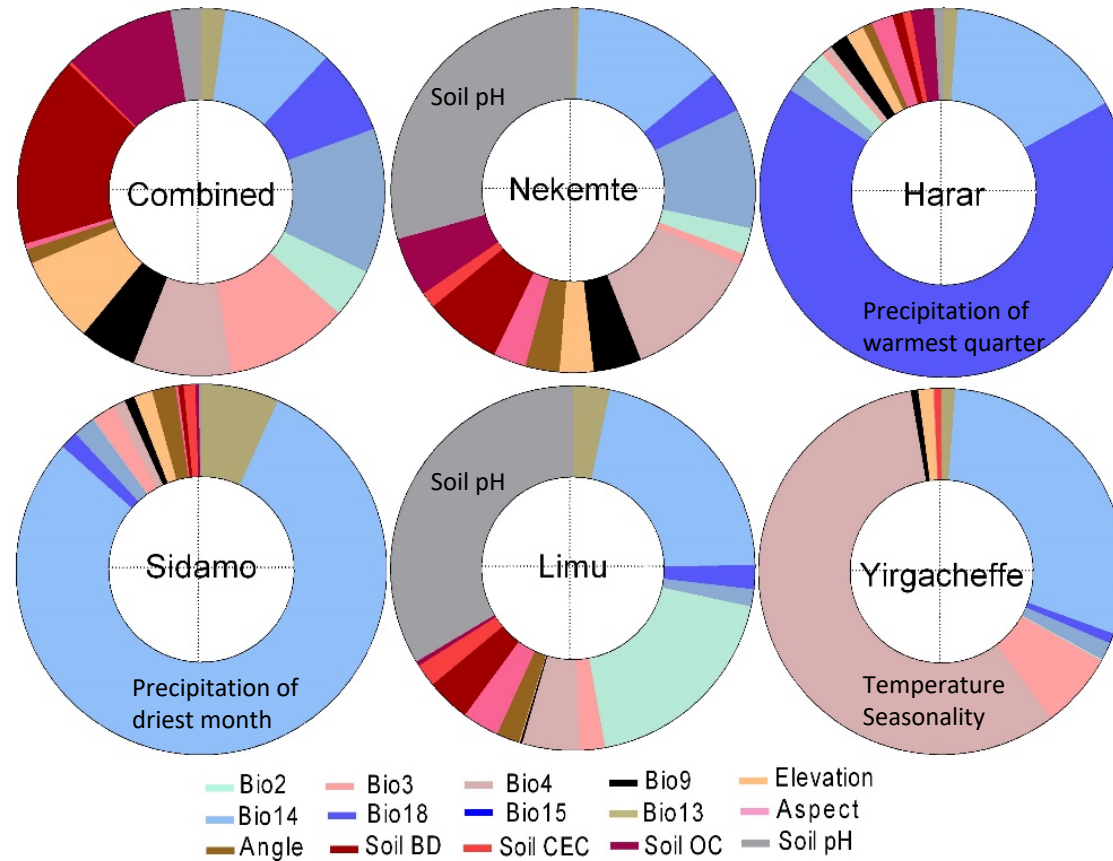
Climate Change Impacts in on speciality coffee



Focus on Yirgacheffe, Sidamo, Harar/Mocca, Nekemte and Limu

Influences on Coffee Suitability

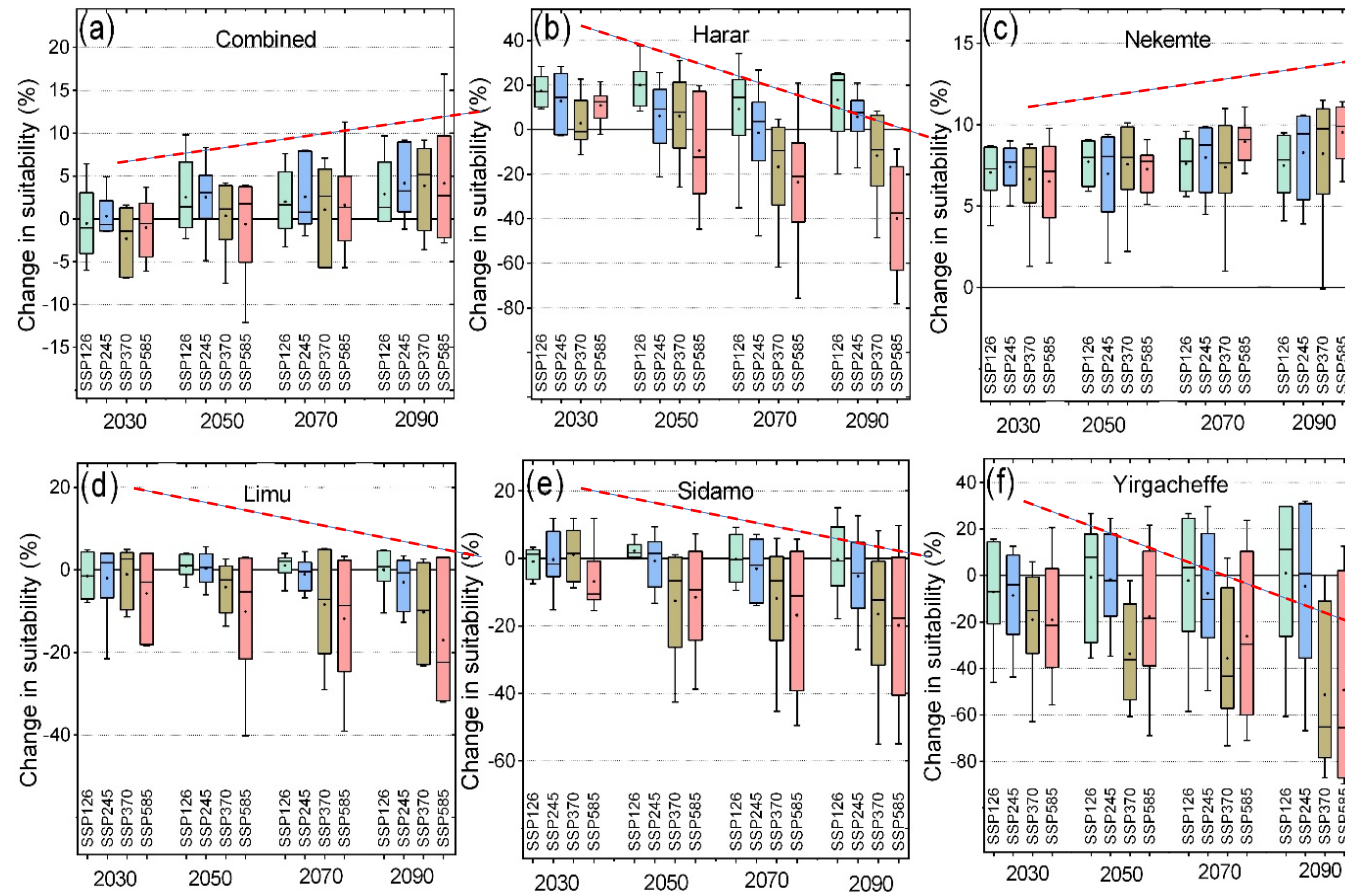
- What environmental and biophysical conditions are necessary for coffee in general and specialty coffee in particular?



No single dominant variable for suitability of coffee but for specialty coffees.

Future Changes in Coffee Suitability

- What environmental and biophysical conditions are necessary for coffee in general and specialty coffee in particular?
- How would future changes of these conditions change impact speciality coffee?



Deciding Resilience Pathways

- What environmental and biophysical conditions are necessary for coffee in general and specialty coffee in particular?
- How would future changes of these conditions change impact speciality coffee?
- How can these impacts be mitigated with adaptation?

Potential of Adaptation Measures

	Model Performance	Climate Change Impacts	Model Agreement	Top Change Contributors	Intensification	Agroforestry	Soil Fertility Management	Irrigation
Combined	●●●	●	●●	Bio14, Bio15, Bio3, Soil BD, Soil OC	-	-	-	-
Harar	●●	●●	●●●	Bio 18 ☁️	●●	-	-	●●
Nekemte	●●●	●	●●●	Bio14, Bio4, Soil pH	-	-	-	-
Limu	●●●	●●	●●	Bio14, Bio2, Soil pH	●●	●●●	●●	●●●
Sidamo	●●●	●●	●●	Bio14 ☁️	●	●	-	●●●
Yirgacheffe	●●●	●●●	●	Bio4 🌡️	●●●	●●●	●	●●●

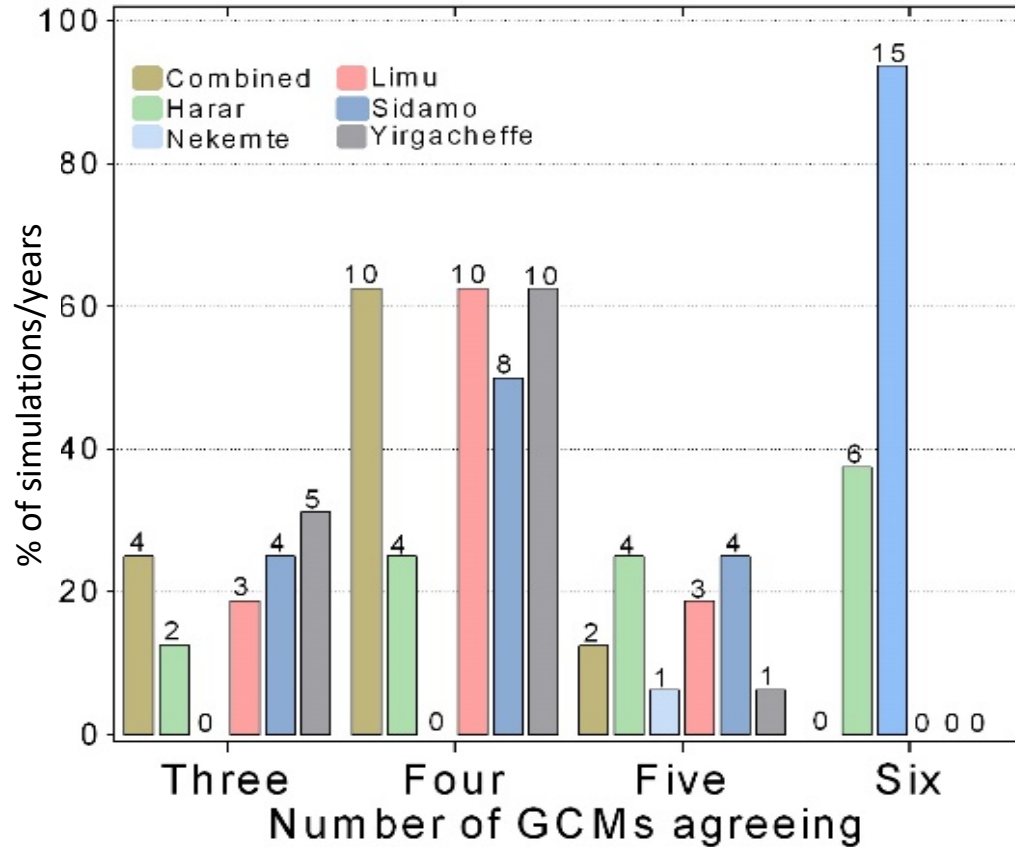
● low

●● medium

●●● high

B-EPICC era:

Continuing coffee research with focus on model agreement








- This study was based on six GCMs, how do results with other GCMs compare?
- How robust are results across emission pathways and time?
- Are results based on global warming levels more robust and informative?

B-EPICC era: Climate Risk Profile for East Africa












Brief for NDC and NAP implementation and climate risk-informed decision making:

- **Comprehensive:** Projected changes for climate and its impacts in five related sectors under two GHG emission scenarios
- **Coherent:** Climate and climate impact projections based on ISIMIP data
- **Concise:** 12 page document

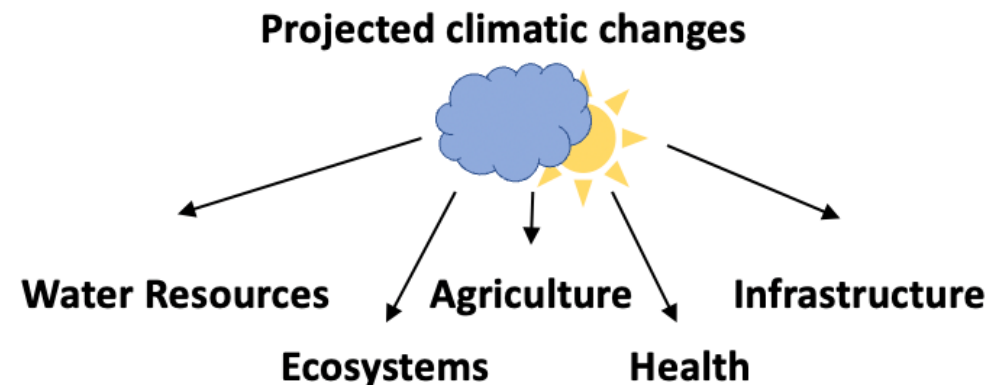






Climate Risk Profile for Eastern Africa

Summary

 <p>This profile provides an overview of projected climate parameters and related impacts on different sectors in Eastern Africa until 2080 under different climate change scenarios (called Representative Concentration Pathways, RCPs). RCP2.6 represents the low emissions scenario that aims to keep global warming likely below 2 °C above pre-industrial temperatures. RCP6.0 represents a medium to high emissions scenario that is likely to exceed 2 °C. Model projections do not account for effects of future socio-economic impacts, unless indicated otherwise.</p>	 <p>Climate change is likely to cause damage to the infrastructure sector in Eastern Africa including major roads and urban areas. Roads are the backbone of the region's transportation network and essential in linking farmers and markets. Investments will need to be made into building climate-resilient roads and other infrastructure to maintain agricultural supply chains and foster economic growth.</p>
 <p>Depending on the scenario, the air temperature over Eastern Africa is projected to rise by 1.7 to 3.9 °C compared to preindustrial levels, with the highest temperature increases in northern Sudan and northern Kenya. Very hot days will also increase, especially over Somalia, eastern Ethiopia and north-eastern Kenya.</p>	 <p>Agro-ecological zones (AEZs) in Eastern Africa might shift, affecting ecosystems, biodiversity and crop production. Models project varying trends for species richness and tree cover, depending on the region and scenario.</p>
 <p>Precipitation trends are uncertain and vary across Eastern Africa, with projections indicating an increase between 15 and 136 mm per year under RCP6.0. Precipitation amounts are expected to increase across the northern and central parts of the region and to decrease further south. Future dry and wet periods are likely to become more extreme.</p>	 <p>The population share affected by at least one heatwave per year is projected to rise from 1.6 % in 2000 to 10.4 % under RCP6.0 in 2080. More frequent heatwaves will negatively affect underlying health conditions, especially those of vulnerable groups. Without adaptation, heat-related mortality is estimated to increase by a factor of more than 4 by 2080.</p>
 <p>Under RCP6.0, sea levels are expected to rise by 43 cm along the coast of Eastern Africa until 2080. This threatens coastal communities and may cause saline intrusion in coastal waterways and groundwater reservoirs.</p>	 <p>Climate impacts are likely to exacerbate existing vulnerabilities and increase human mobility, thus serving as a risk multiplier for conflict in an already politically fragile region. Women, children as well as poor, sick and elderly people will be disproportionately affected by climate impacts.</p>
 <p>Water availability is driven by climatic and socio-economic factors. Projections show general increases in water availability, with varying intensities. However, per capita water availability will likely decline by 2080, mostly due to population growth.</p>	
 <p>Due to the changing climate, yields of cassava, groundnuts, millet, sorghum and rice are projected to benefit from CO₂ fertilisation. Maize and wheat yields show high levels of uncertainty and no clear trend. It is likely that yields will increase in some parts and decrease in other parts of the region.</p>	

* This climate risk profile is the product of a collaboration between Weathering Risk, the AGRICA project and the B-EPICC project at PIK. It draws on the methodology developed within the AGRICA project. Published in March 2023



B-EPICC era:

Impact of Soil pH on crop suitability

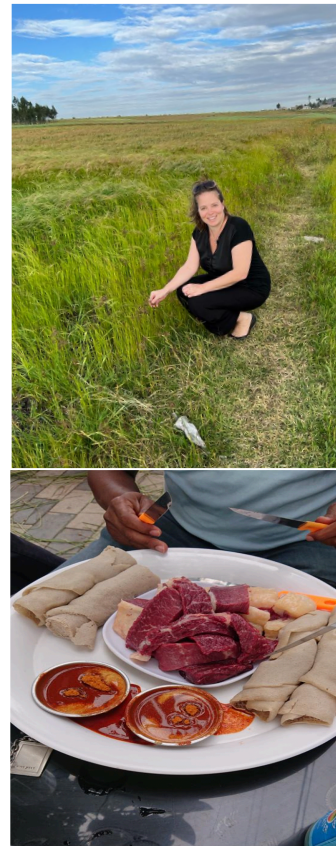
Presentation on Friday morning by Tamirat Jimma

B-EPICC era: Collaboration between PIK and ILRI

Research Stay 2020

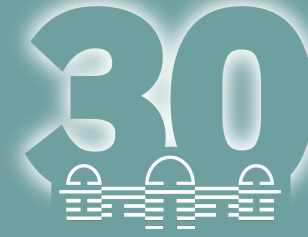


Research Stay 2022



Research Stay 2023





Celebrating 30 years of
integrated climate impact research
at the Potsdam Institute.



Thank you!

- Working Group Adaption in Agricultural Systems -