Potsdam Institute for Climate Impact Research

PIK

Attributing child undernutrition from agricultural deficits to climate change in Burkina Faso

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ISIMIP Workshop,
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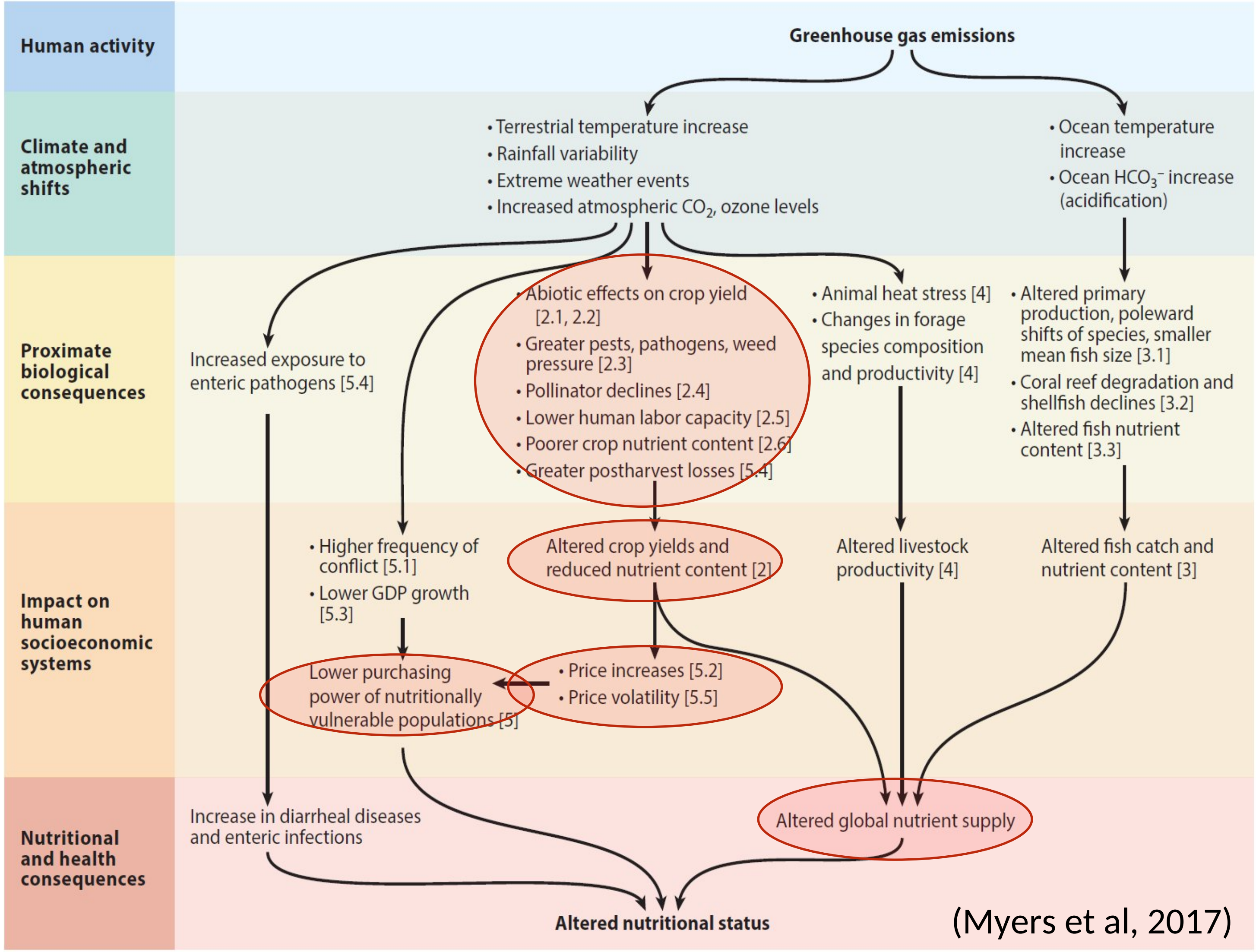
Potsdam, Germany

Leibniz Association

Motivation

- ➢ Stunting affects 148.1 million children under age 5 (22.3%)
- ➢ Complex multi-level causation of undernutrition
- ➢ Climate change expected to impact undernutrition via multiple pathways, including changes in crop yields



(Myers et al, 2017)

Research objectives

Objective I

Assess the association between **interannual food crop yield variation and child undernutrition in Burkina Faso**

Objective II

Quantify past and current impacts of **climate change on the production of main crops** in the country

Objective III

Quantify **past and current impacts of climate change** on child undernutrition via changes in crop yields in the country

21.8 % of children <5 are stunted
40.1% of people live on < $1.90 a day
80 % of the population is employed in agriculture

Data sources

> Climate data

- ATTRICI, ISIMIP3a simulation round
- temperature and precipitation re-analysis dataset: 20CRV3-ERA5
- Factual and counterfactual scenarios (Mengel, et. al, 2021)

> Crop yields data

- Annual harvest area and production data for sorghum, millet and maize from Burkina Faso Ministry of Agriculture and Hydro-Agricultural Development (MAAH); Provinces: 45; Time period: 1984-2022

> Population data

- child anthropometry data [height, weight, age] (n= 29,837)
- 5 waves of the Burkina Faso Demographic Health Surveys (1993, 1999, 2003, 2010, 2021)
- Birth period: 1988-2021

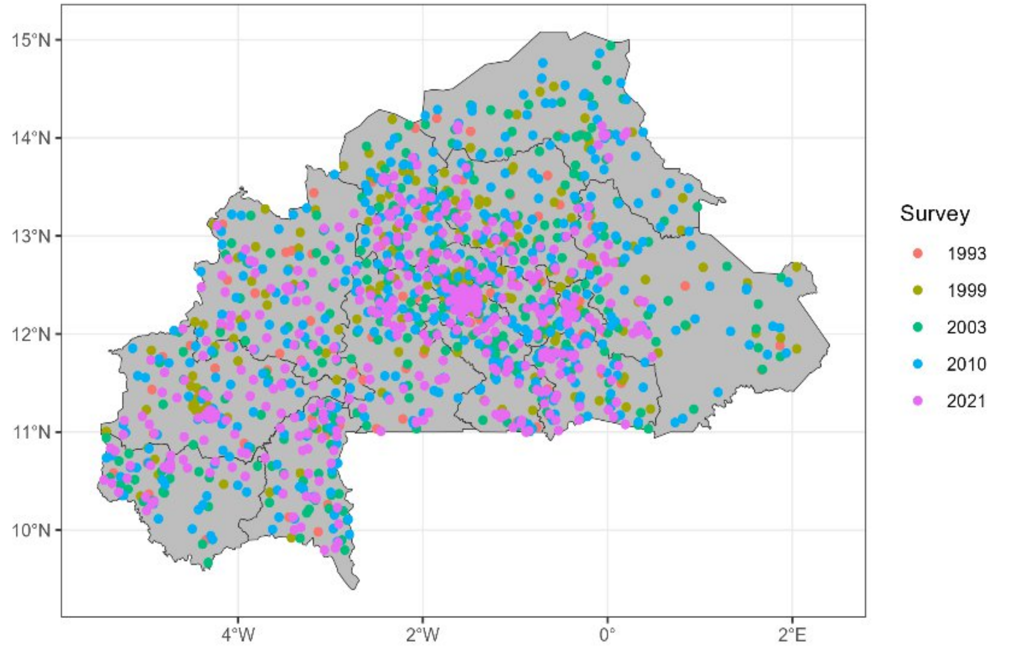
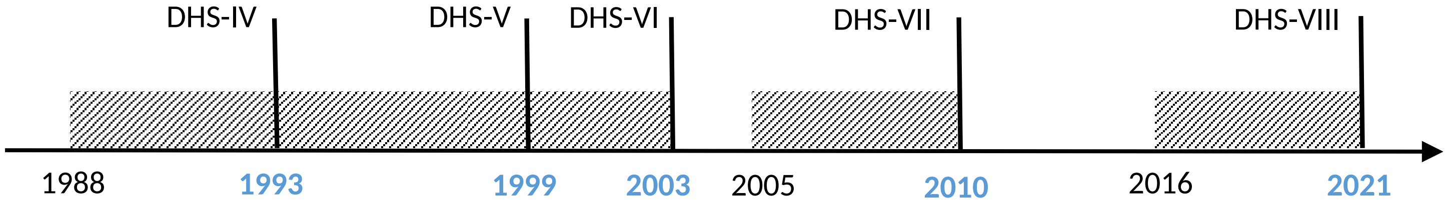
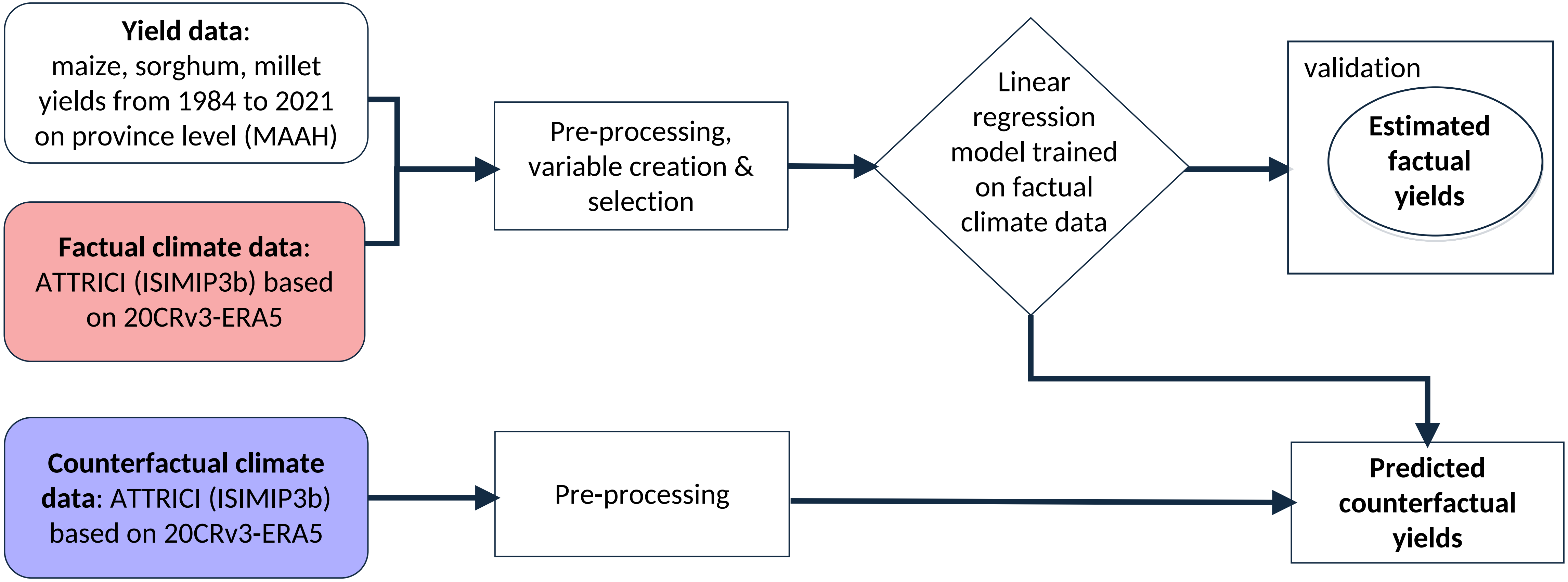


Figure 1: Geographical location of DHS clusters for Burkina Faso by survey round



Methods > Stage 1
Climate impact attribution for crop yields



> The statistical crop model is trained on factual (observationally derived) climate data and predicts counterfactual yields.

Methods > Stage 2
Epidemiological analysis

➢ Exposure variable

$$CropYieldsAnomaly_{j,i} = \sum_{j=1}^{j} \frac{\mathrm{y_{i,j}} - \overline{\mathrm{y}}_{\mathrm{j}}}{SD_j} * \frac{h_{i,j}}{h_{tot_i}}$$

$\bar{y}_j$ – mean yield (kg/ha) of crop *j* for the period 1984-2021
y_{ij} – yield of crop *j* in year *i*
$h_{i,j} / h_{tot_i}$ – share of harvest of crop *j* in all 3 crops in year *i*
SD_j – standard deviation in crop yields for the period 1984-2021

➢ Exposure windows

i) 12 months before conception:
ii) In-utero
iii) Infancy
  - Birth to 6 months
  - Birth to 11 months
  - Birth to 23 months
  - 6 months to 23 months

iv) First 1000 days of life (in-utero + birth to 23 months)

v) Prior to survey interview:
  - 6 months prior
  - 12 months prior
  - 24 months prior

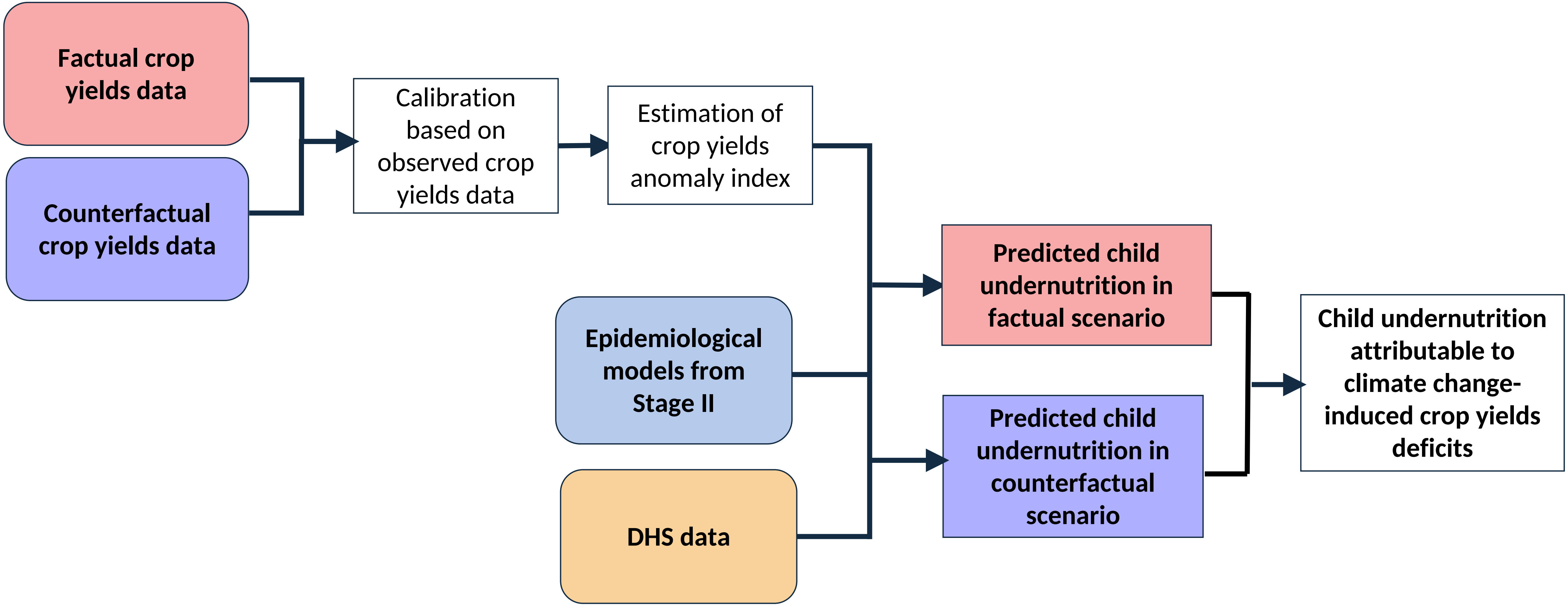
➢ Outcome variables

- Child stunting (0 or 1) based on height-for-age z-score (HAZ)
- Child Wasting (0 or 1) based on weight-for-height z-score (WHZ)
- Underweight (0 or 1) based on weight-for-age Z-score (WAZ)

➢ Model

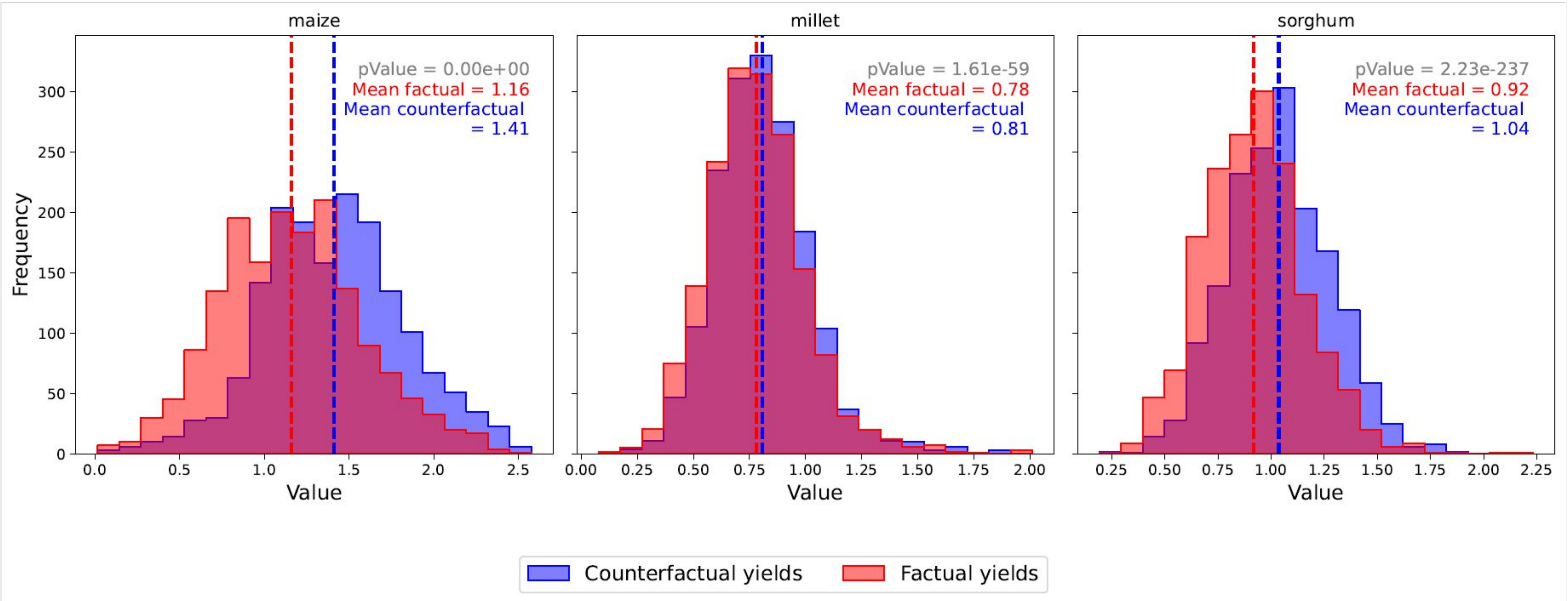
- Logistic regression
- fixed effect for region, survey year and season of birth, adjustment for individual and household covariates

Methods > Stage 3
Health impact attribution



Results

Results > Stage I
Climate change impacts on crop yields



Results > Stage II
Association between crop yields anomaly index and risk of child stunting, wasting and underweight

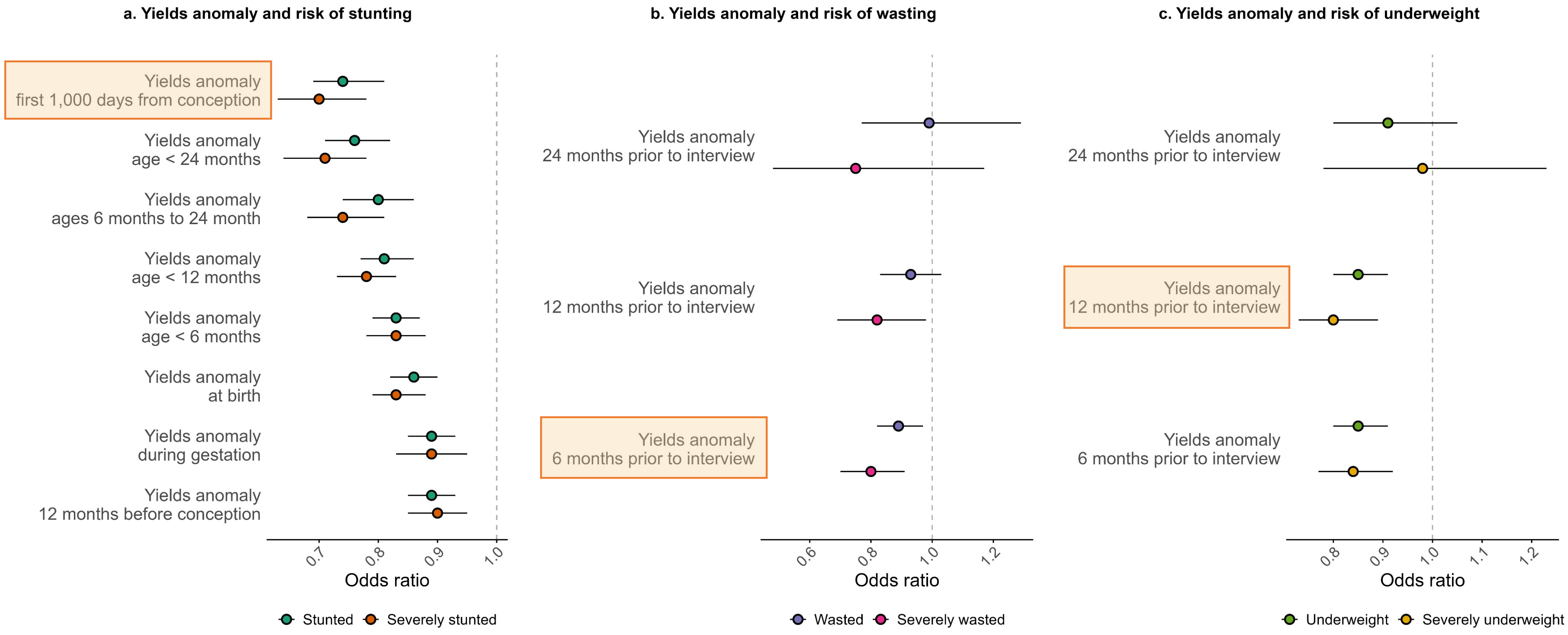


Figure 2: Association between child stunting, wasting, underweight and crop yields anomaly index at different developmental windows of exposure

Results > Stage III
Impacts of climate change on child undernutrition via changes in crop yields

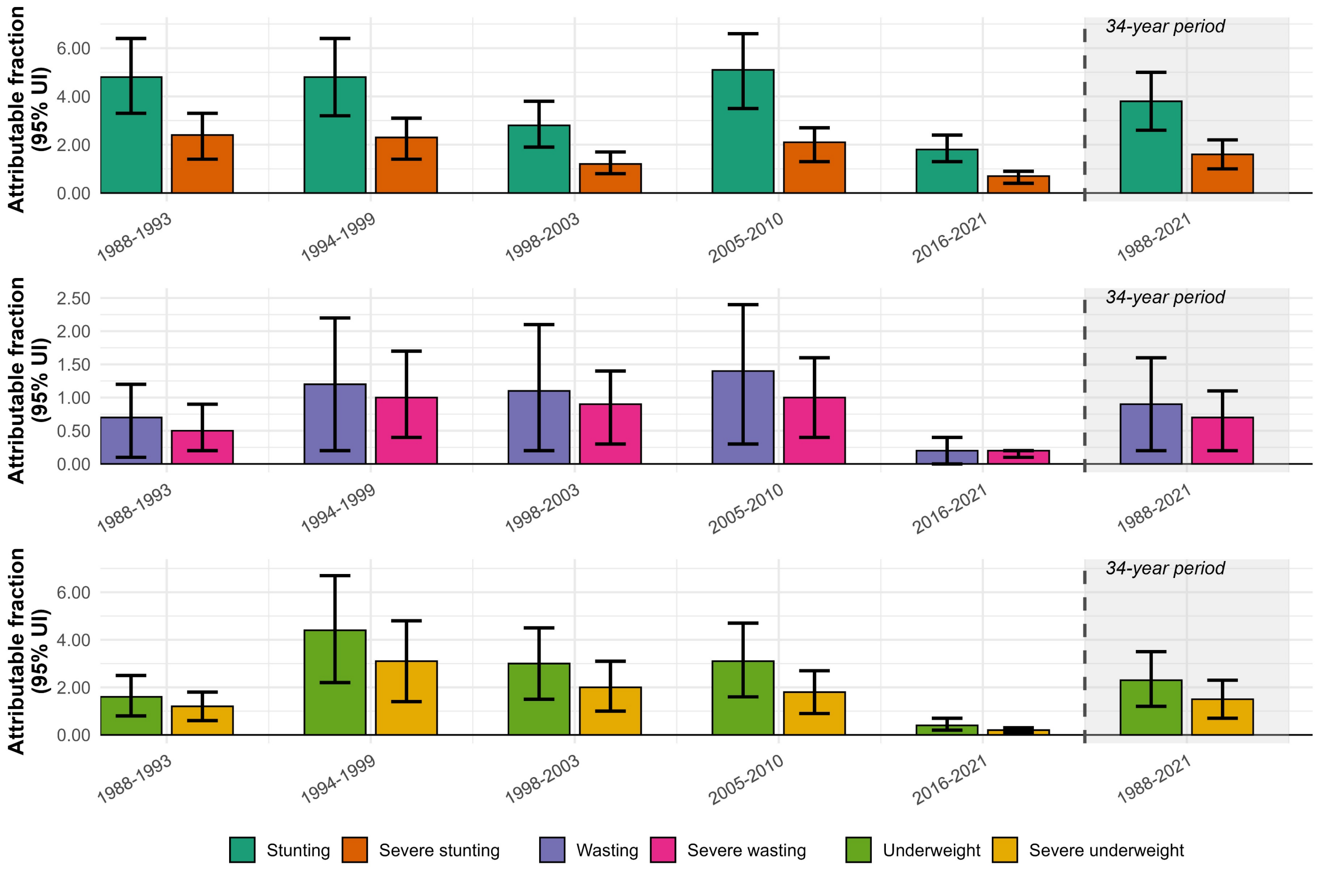


Figure 3: Share of child stunting, wasting and underweight (95% uncertainty interval (UI)) attributable to climate change-induced crop yields deficits by survey round and for the whole period.

- **3.8%** (UI: 2.6%, 5%) of **child stunting** and **1.6%** (UI: 1 %, 2.2 %) of **severe child stunting** during 1993-2021 can be attributed to climate change-induced crop yield deficits.
- **0.9%** (UI:0.2%, 1.6%) of **child wasting** and **0.7%** (UI: 0.2%, 1.1%) of **severe child wasting** can be attributed to climate change-induced crop yield deficits.
- **2.3%** (UI: 1.2%, 3.5%) of **child underweight** and **1.5%** (UI: 0.7%, 2.3%) of **severe child underweight** can be attributed to climate change-induced crop yield deficits.

Results > Stage III
Impacts of climate change on child undernutrition via changes in crop yields

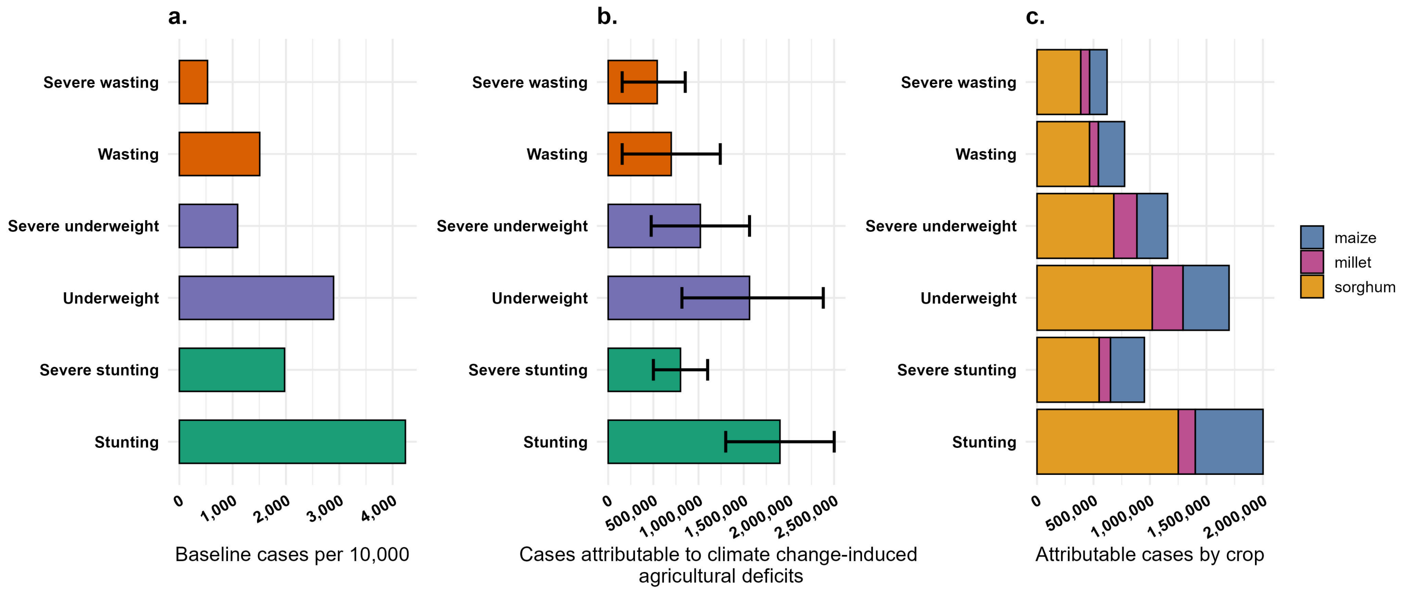


Figure 4: Child stunting, wasting and underweight cases **a**. at baseline (per 10,000) , **b.** attributable to climate change-induced agricultural deficits, **c.** attributable to climate change-induced agricultural deficits by crop for the period 1988-2021.

- **Total cases attributable to climate change-induced agricultural deficits 1993-2021**
  child stunting: 1.9 (95%UI: 1.3, 2.5) million
  child wasting: 0.7 (95%UI: 0.2, 1.2) million
  child underweight: 1.6 (95%UI: 0.8, 2.3) million

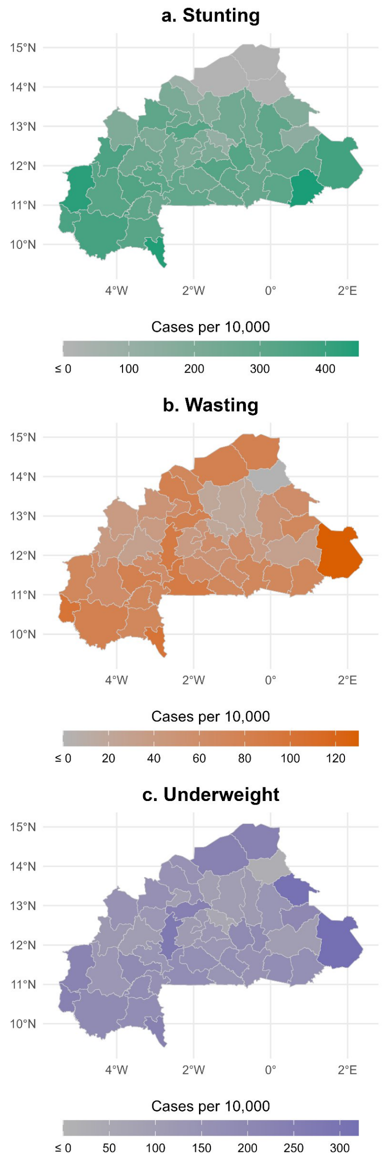


Figure 5: Rates of child **a.** stunting, **b.** wasting and **c.** underweight (per 10,000) at province level for the period 1993-2021.

Summary and limitations

SUMMARY

- A **clear climate signal** in annual variation in **maize and sorghum yields**, while millet has been relatively more resilient
- Exposure to positive crop yield anomalies during in-utero and infancy reduces risk of child stunting
- Exposure to positive crop yield anomalies during 6-12 months prior to interview reduces risk of child wasting and underweight
- **3.8% of child stunting**, **2.3% of child underweight** and **0.9% of child wasting** can be traced back to the impacts of climate change on food crop production between 1993-2021

LIMITATIONS

- We model only three food crops and cash crops are not considered
- Aggregate district-level crop production data
- Domestic trade flows and post-harvest losses are not considered
- Uncertainty estimates only based on parameters in epidemiological analysis
- The model accounts only for food availability and production, but not for other dimensions of food security (e.g., access and utilization).

Thank you!

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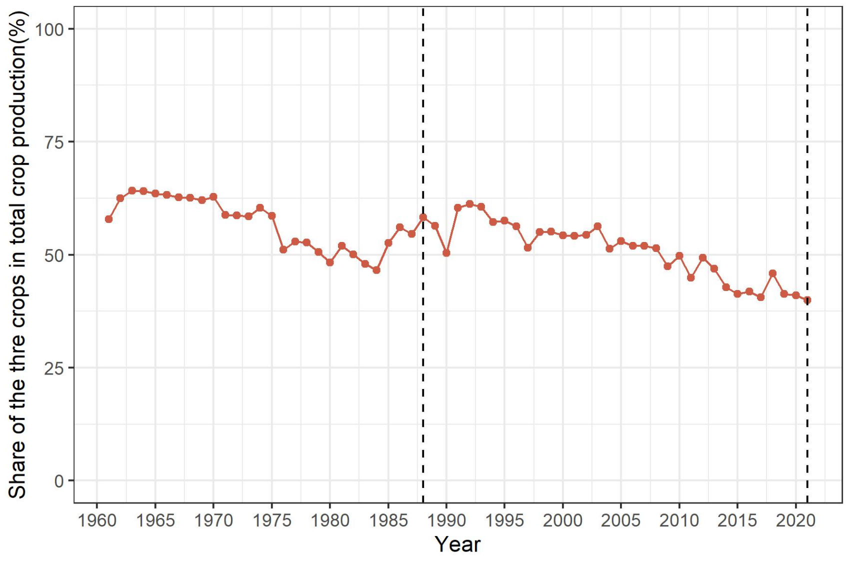
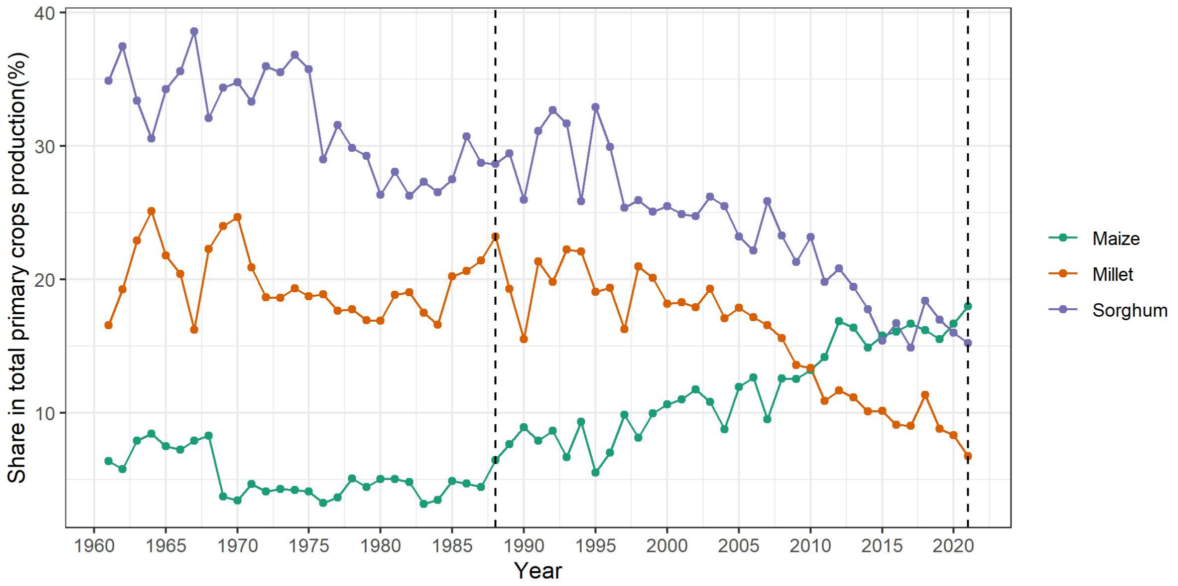
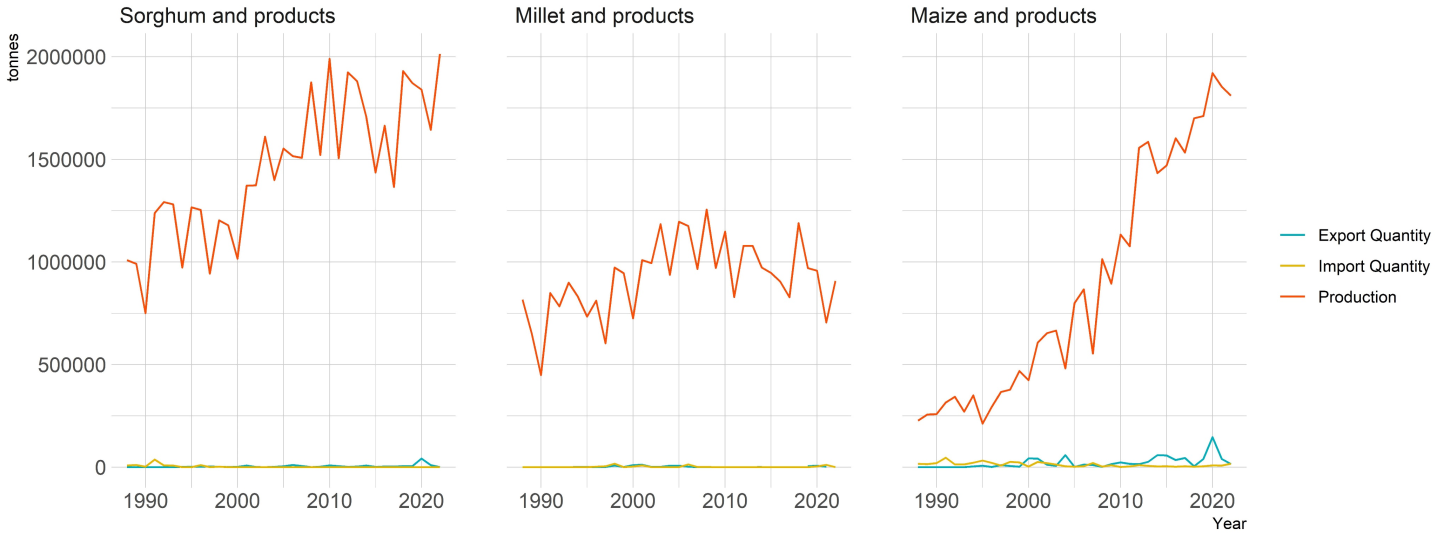
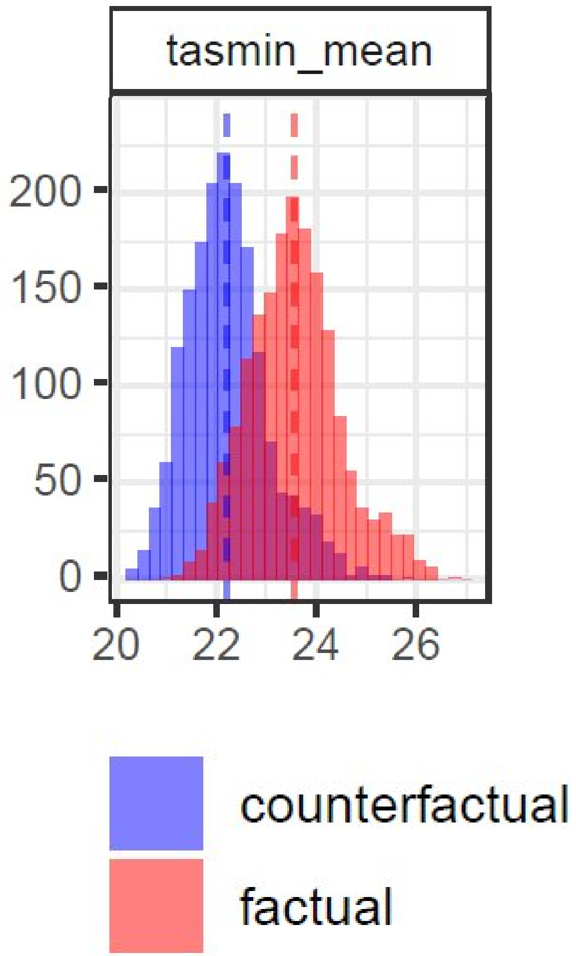
Additional slides


Share of the thre crops in total crop production(%)
100
75
50
25
0
1960 1965 1970 1975 1980 1985 1990 1995 2000 2005 2010 2015 2020
Year

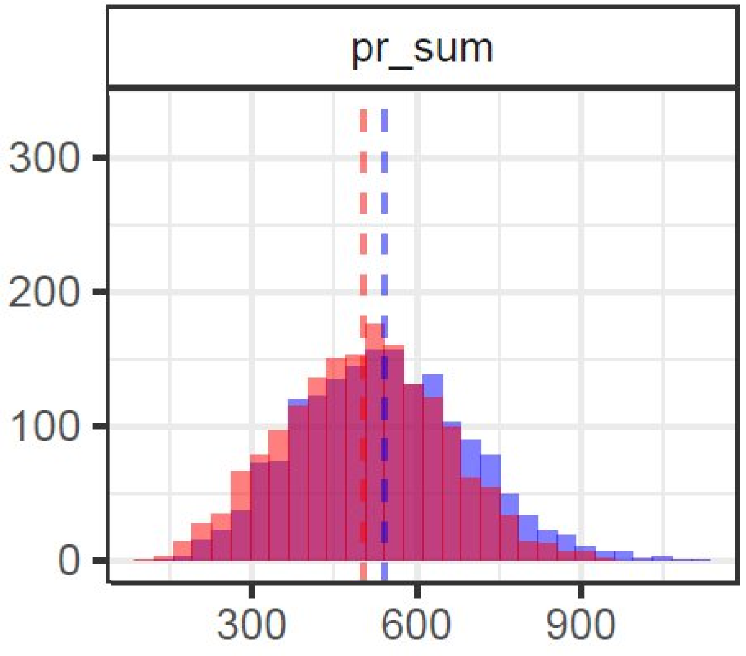

Share in total primary crops production(%)
40
30
20
10
1960 1965 1970 1975 1980 1985 1990 1995 2000 2005 2010 2015 2020
Year
Maize
Millet
Sorghum


Sorghum and products
Millet and products
Maize and products
tonnes
2000000
1500000
1000000
500000
0
1990 2000 2010 2020
Year
Export Quantity
Import Quantity
Production

Results > Stage I
Factual and counterfactual climate



> Observed climate change has increased temperatures, e.g. growing-season mean of daily minimum temperature by 1.6°C on average (1984–2021)

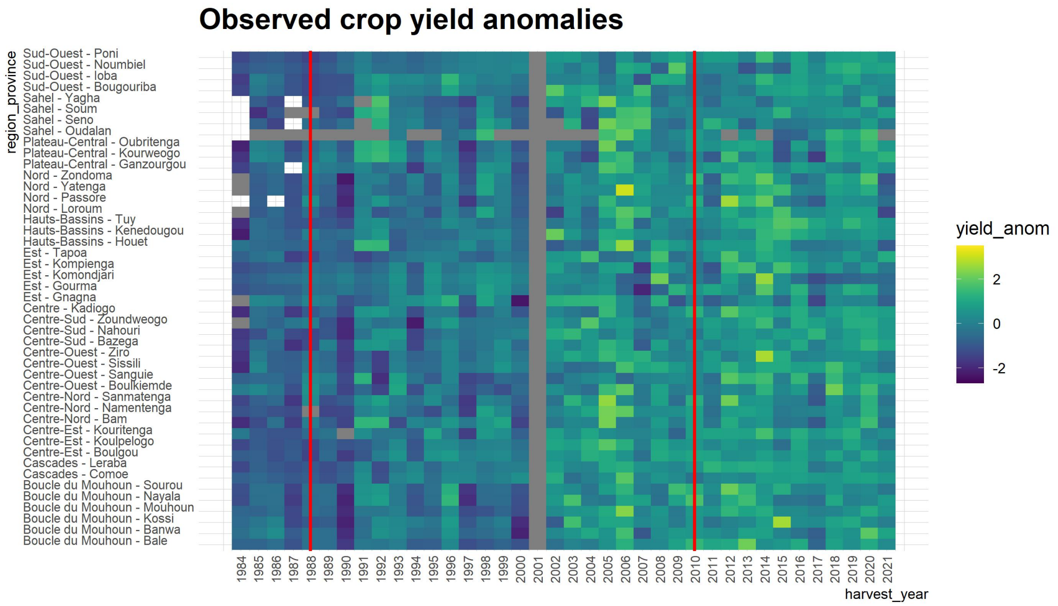


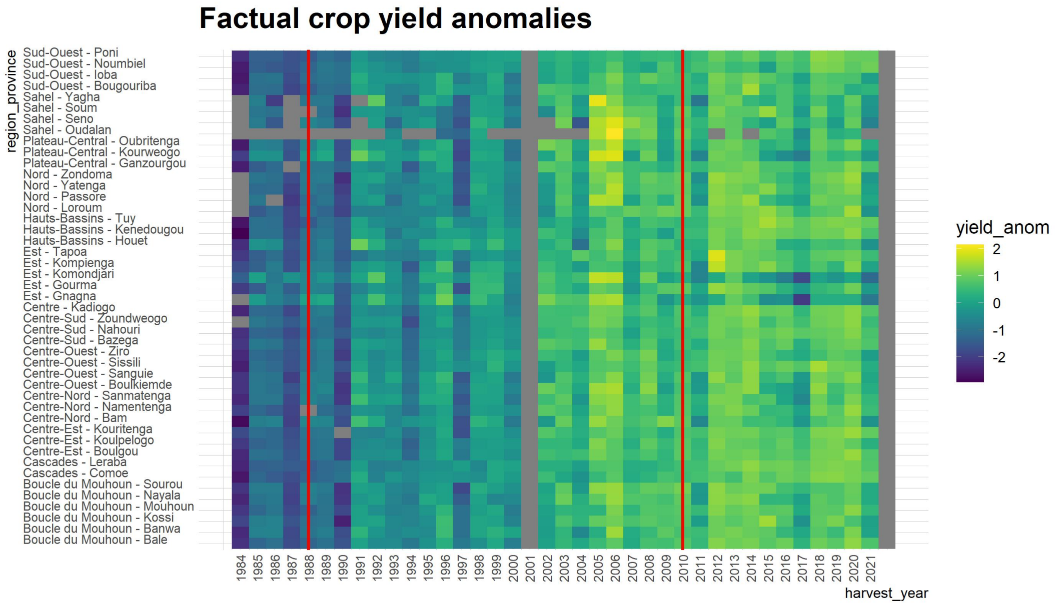
> Observed climate change has decreased precipitation (small signal)

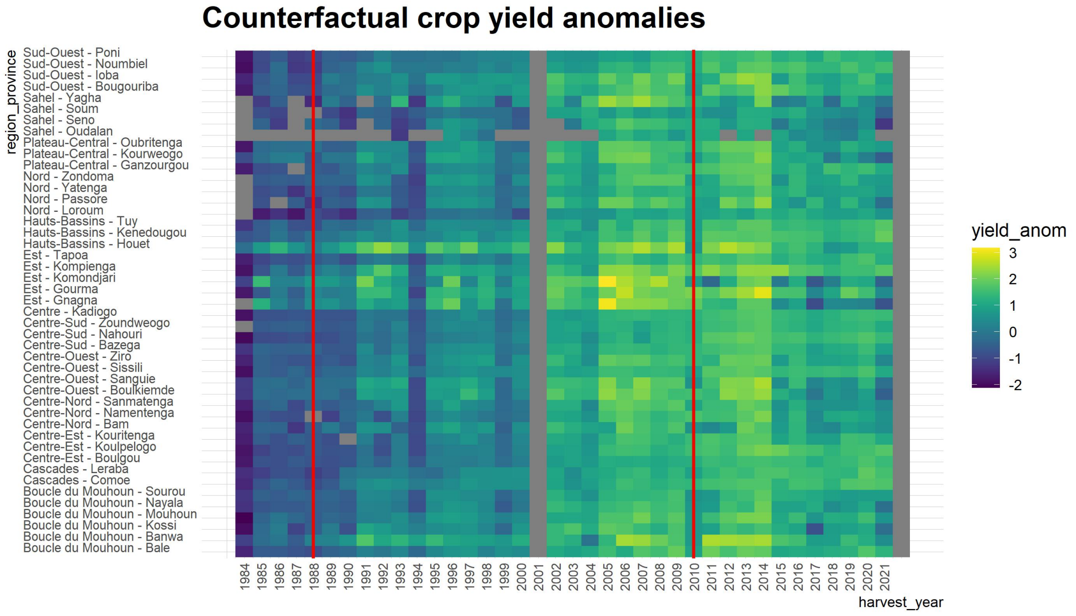
page

Climate variable	Abbreviation	Mean		Min		Max	
		Factual	Counterfactual	Factual	Counterfactual	Factual	Counterfactual
Mean daily mean temperature in °C	tas_mean	27.83	26.10	25.12	23.59	31.95	30.76
Mean daily range between maximum and minimum temperature in °C	tasrange_mean	8.07	7.74	6.42	6.06	10.96	10.81
Number of days with daily maximum temperatures above the 95th percentile of the daily maximum temperature of the reference period (1984 - 2013)	tasmax_p95	36.83	34.20	32.02	29.78	41.62	39.77
Number of days with daily minimum temperatures below the 5th percentile of daily minimum temperature of the reference period (1984 - 2013)	tasmin_p05	22.09	20.64	20.23	19.08	24.37	23.33
Precipitation sum in mm	pr_sum	506.55	543.96	104.18	139.62	959.85	1113.40
Number of days with precipitation sums equal or below 1mm	pr_b1mm	50.37	44.69	15.00	13.00	95.75	85.75

Table 1: Climate variables used as input for the crop model. All variables were calculated for the crop-specific growing seasons for maize , the most produced cereal crop in the past 5 years.


Observed crop yield anomalies
region_province
Sud-Ouest - Poni
Sud-Ouest - Noumbiel
Sud-Ouest - Ioba
Sud-Ouest - Bougouriba
Sahel - Yagha
Sahel - Soum
Sahel - Seno
Sahel - Oudalan
Plateau-Central - Oubritenga
Plateau-Central - Kourweogo
Plateau-Central - Ganzourgou
Nord - Zondoma
Nord - Yatenga
Nord - Passore
Nord - Loroum
Hauts-Bassins - Tuy
Hauts-Bassins - Kenedougou
Hauts-Bassins - Houet
Est - Tapoa
Est - Kompienga
Est - Komondjari
Est - Gourma
Est - Gnagna
Centre - Kadiogo
Centre-Sud - Zoundweogo
Centre-Sud - Nahouri
Centre-Sud - Bazega
Centre-Ouest - Ziro
Centre-Ouest - Sissili
Centre-Ouest - Sanguie
Centre-Ouest - Boulkiemde
Centre-Nord - Sanmatenga
Centre-Nord - Namentenga
Centre-Nord - Bam
Centre-Est - Kouritenga
Centre-Est - Koulpelogo
Centre-Est - Boulgou
Cascades - Leraba
Cascades - Comoe
Boucle du Mouhoun - Sourou
Boucle du Mouhoun - Nayala
Boucle du Mouhoun - Mouhoun
Boucle du Mouhoun - Kossi
Boucle du Mouhoun - Banwa
Boucle du Mouhoun - Bale
1984 1985 1986 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021
harvest_year
yield_anom
2
0
-2

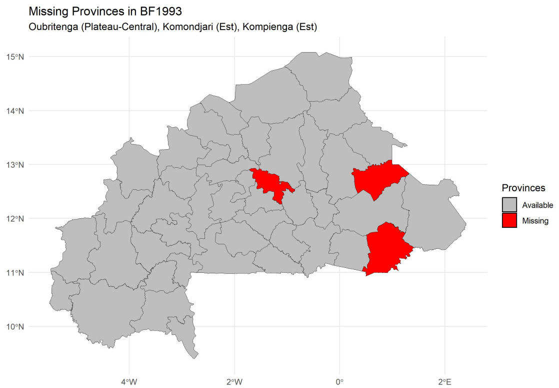

Factual crop yield anomalies
region_province
Sud-Ouest - Poni
Sud-Ouest - Noumbiel
Sud-Ouest - Ioba
Sud-Ouest - Bougouriba
Sahel - Yagha
Sahel - Soum
Sahel - Seno
Sahel - Oudalan
Plateau-Central - Oubritenga
Plateau-Central - Kourweogo
Plateau-Central - Ganzourgou
Nord - Zondoma
Nord - Yatenga
Nord - Passore
Nord - Loroum
Hauts-Bassins - Tuy
Hauts-Bassins - Kenedougou
Hauts-Bassins - Houet
Est - Tapoa
Est - Kompienga
Est - Komondjari
Est - Gourma
Est - Gnagna
Centre - Kadiogo
Centre-Sud - Zoundweogo
Centre-Sud - Nahouri
Centre-Sud - Bazega
Centre-Ouest - Ziro
Centre-Ouest - Sissili
Centre-Ouest - Sanguie
Centre-Ouest - Boulkiemde
Centre-Nord - Sanmatenga
Centre-Nord - Namentenga
Centre-Nord - Bam
Centre-Est - Kouritenga
Centre-Est - Koulpelogo
Centre-Est - Boulgou
Cascades - Leraba
Cascades - Comoe
Boucle du Mouhoun - Sourou
Boucle du Mouhoun - Nayala
Boucle du Mouhoun - Mouhoun
Boucle du Mouhoun - Kossi
Boucle du Mouhoun - Banwa
Boucle du Mouhoun - Bale
1984 1985 1986 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021
harvest_year
yield_anom
2
1
0
-1
-2


Counterfactual crop yield anomalies
region_province
Sud-Ouest - Poni
Sud-Ouest - Noumbiel
Sud-Ouest - Ioba
Sud-Ouest - Bougouriba
Sahel - Yagha
Sahel - Soum
Sahel - Seno
Sahel - Oudalan
Plateau-Central - Oubritenga
Plateau-Central - Kourweogo
Plateau-Central - Ganzourgou
Nord - Zondoma
Nord - Yatenga
Nord - Passore
Nord - Loroum
Hauts-Bassins - Tuy
Hauts-Bassins - Kenedougou
Hauts-Bassins - Houet
Est - Tapoa
Est - Kompienga
Est - Komondjari
Est - Gourma
Est - Gnagna
Centre - Kadiogo
Centre-Sud - Zoundweogo
Centre-Sud - Nahouri
Centre-Sud - Bazega
Centre-Ouest - Ziro
Centre-Ouest - Sissili
Centre-Ouest - Sanguie
Centre-Ouest - Boulkiemde
Centre-Nord - Sanmatenga
Centre-Nord - Namentenga
Centre-Nord - Bam
Centre-Est - Kouritenga
Centre-Est - Koulpelogo
Centre-Est - Boulgou
Cascades - Leraba
Cascades - Comoe
Boucle du Mouhoun - Sourou
Boucle du Mouhoun - Nayala
Boucle du Mouhoun - Mouhoun
Boucle du Mouhoun - Kossi
Boucle du Mouhoun - Banwa
Boucle du Mouhoun - Bale
1984 1985 1986 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021
harvest_year
yield_anom
3
2
1
0
-1
-2

Provinces with missing data in DHS

- **BF1993:**

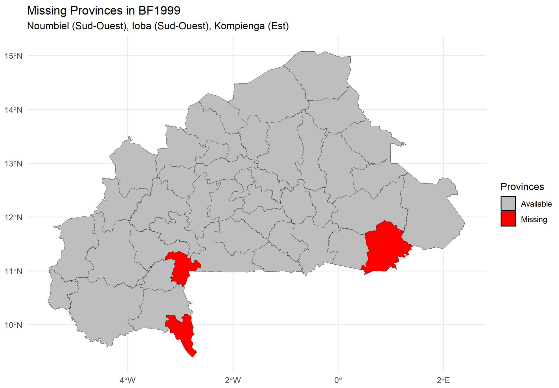
Oubritenga: Plateau-Central region
Komondjari: Est region
Kompienga: Est region



- **BF2003:** no missing data
- **BF2010:** no missing data

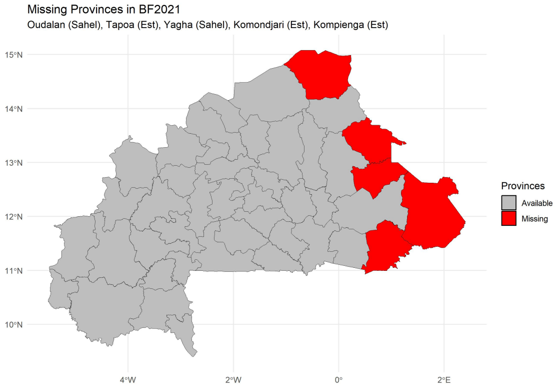
- **BF1999:**

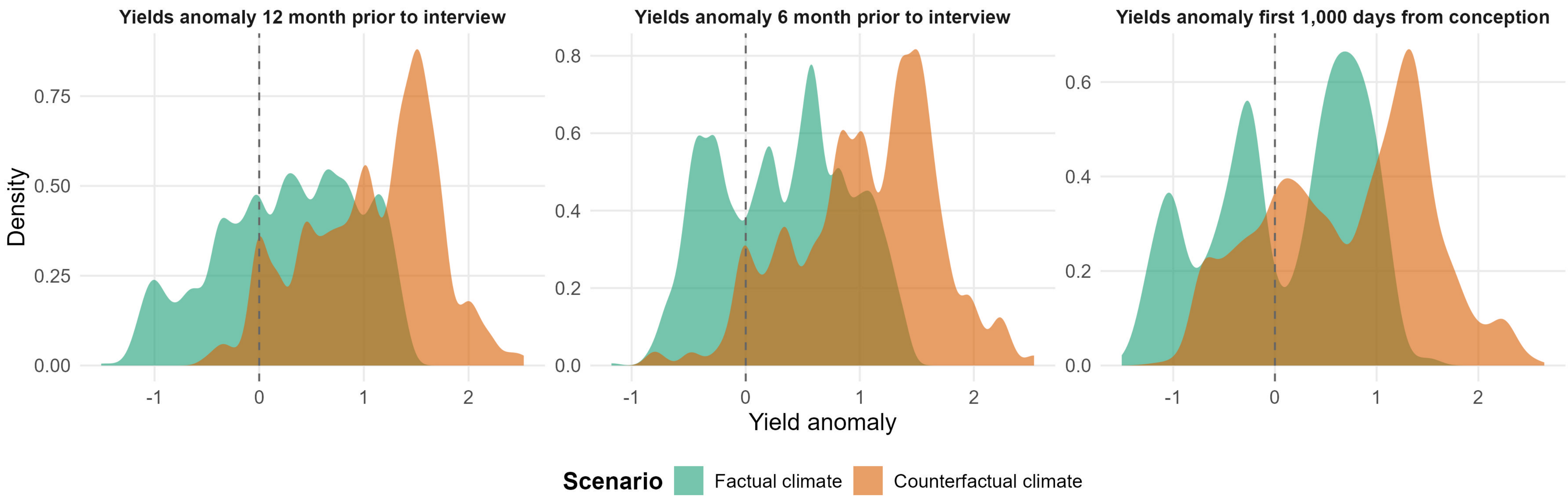
Noumbiel: Sud-Ouest region
Ioba: Sud-Ouest region
Kompienga: Est region

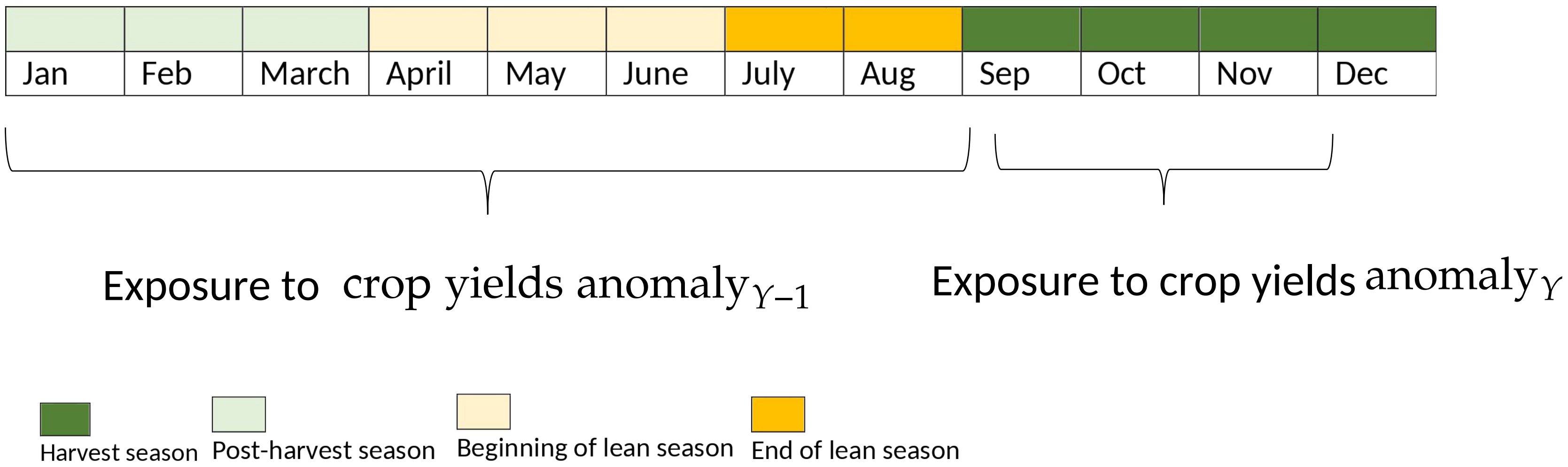


- **BF2021:**

Oudalan: Sahel region
Tapoa: Est region
Yagha: Sahel region
Komondjari: Est region
Kompienga: Est region




Yields anomaly 12 month prior to interview
Yields anomaly 6 month prior to interview
Yields anomaly first 1,000 days from conception
Density
Yield anomaly
Scenario
Factual climate
Counterfactual climate


Jan
Feb
March
April
May
June
July
Aug
Sep
Oct
Nov
Dec
Exposure to crop yields $anomaly_{Y-1}$
Exposure to crop yields $anomaly_{Y}$
Harvest season
Post-harvest season
Beginning of lean season
End of lean season