HARVARD T.H. CHAN SCHOOL OF PUBLIC HEALTH

HEIDELBERG INSTITUTE OF GLOBAL HEALTH

UNIVERSITY OF KWAZULU-NATAL
INYUVESI YAKWAZULU-NATALI

MUHAS

MAKERERE UNIVERSITY

UNIVERSITY OF GHANA

Data Science Initiative for Africa (DSI-Africa)

Climate Change, Food Systems and Planetary Health

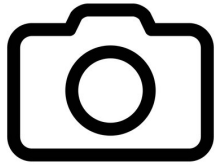
23 July 2024

Ina Danquah

Optimal learning atmosphere

For the online course, …

- Be seated in a quiet working environment
- Ensure stable internet access
- Keep on your cameras whenever possible
- Raise your (digital) hand when you have a question



Learning objectives

Week 1:

- Familiarizing with the course program and getting to know each other
- **Statistical approaches to identifying climate change impacts** on agriculture, **diet and nutrition**, including basic constructs of food system metrics
- Adaptive planning using data science and technology

Week 2:

- Refreshing epidemiology with a focus on food systems
- Operationalize sustainable nutrition using anthropometry, dietary patterns, and yield estimates
- Calculate constructs of sustainable nutrition and agriculture, incl. remote sensing

WASHA TAKWIMU
WORKING ON APPLICATIONS FOR DATA SCIENCE AND HEALTH IN AFRICA

Outline

Day	Week 1, 22 – 26 July (online)	Facilitator
Mon	Exploratory spatial analysis and model evaluation Reading: Rainfall patterns related to dietary habits	G Kallah-Dagadu Students
Tue	Hackathon: Climate Change solutions in your country Theoretical concepts: Climate change impacts on nutrition and diets Practical: Calculate rainfall pattern related to dietary habits Theoretical concepts: Nutrition and food systems	G Kallah-Dagadu I Danquah I Danquah I Madzorera
Wed	Hackathon: Climate change solutions in your country Theoretical concepts: Dietary pattern construction Calculation of food system metrics	G Kallah-Dagadu I Danquah I Madzorera
Thu	Technological innovations for sustainable agriculture Trends, scenarios and resilience planning	S Barteit S Barteit
Fri	Hackathon presentations Heat-2-Harvest project	Students S Barteit

Concepts of climate change impacts on nutrition and diets

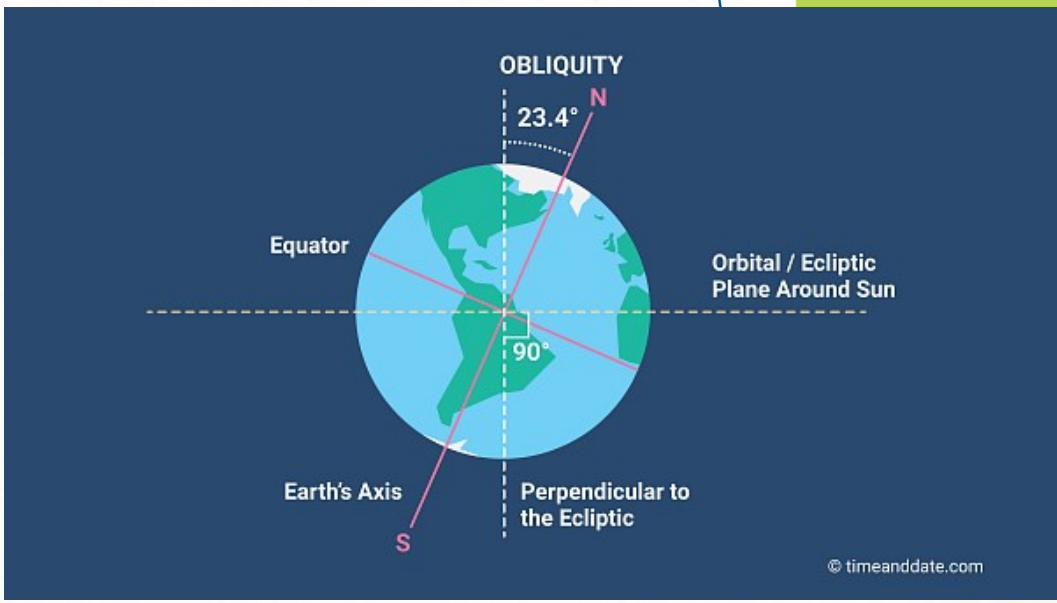
- Climate or weather ?
- Epidemiology in health sciences
- Challenges for research into climate change impacts on nutrition and diets
- Potential methodological approaches
  - Sampling
  - Metrics
  - Dynamics
- Summary
- Practical exercise

Optional reading

- Haines A & Ebi K. The imperative for climate action to protect health. New Eng J Med 2019;380:263-273.
- Romanello M et al. The 2023 report of the Lancet Countdown on health and climate change: the imperative for a health-centred response in a world facing irreversible harms. Lancet 2023;402(10419):2346-2394.
- Climate Change 2023: Synthesis Report. Contribution of Working Groups I, II and III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, H. Lee and J. Romero (eds.)]. IPCC, Geneva, Switzerland, pp. 35-115.
- Mank I et al. The Impact of Rainfall Variability on Diets and Undernutrition of Young Children in Rural Burkina Faso. Front Public Health 2021;9:693281.

Climate or weather?

- *Klimatos* = inclination of the globe
  → climate zones
- Climate = statistical description of weather (temperature, precipitation, windspeed, etc.) over a long period (at least 30 years)
- Coupling of different earth systems: hydro-, cryos-, bios-, lithosphere



Climate or weather?

Susanne Crewell (geophysics and meteorology):

"Climate describes what you expect and weather is what you get."

or

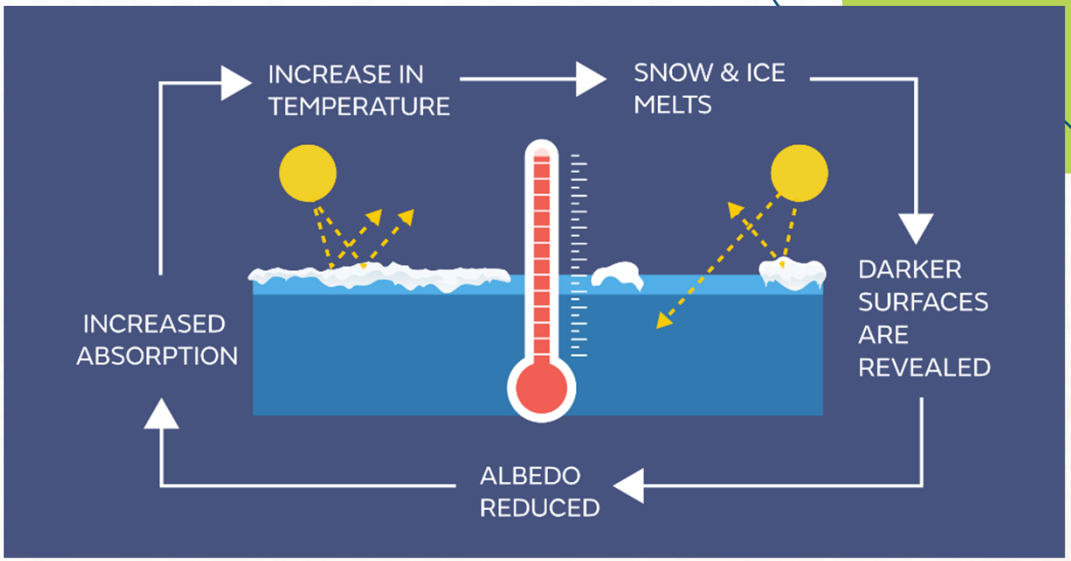
"Climate change is the disease,

and weather is the symptom."

Weather Warnings

Climate change

- Changes are not always linear and amplified by feedback loops.
- Example: Ice-Albedo effect



Man-made climate change:

- 50% CO2 (carbon doxide)
- CH4 (methane)
- N2O (nitrogen oxide)
- FKW, HFKW, SF6, NF3 (fluorinated GHGs)

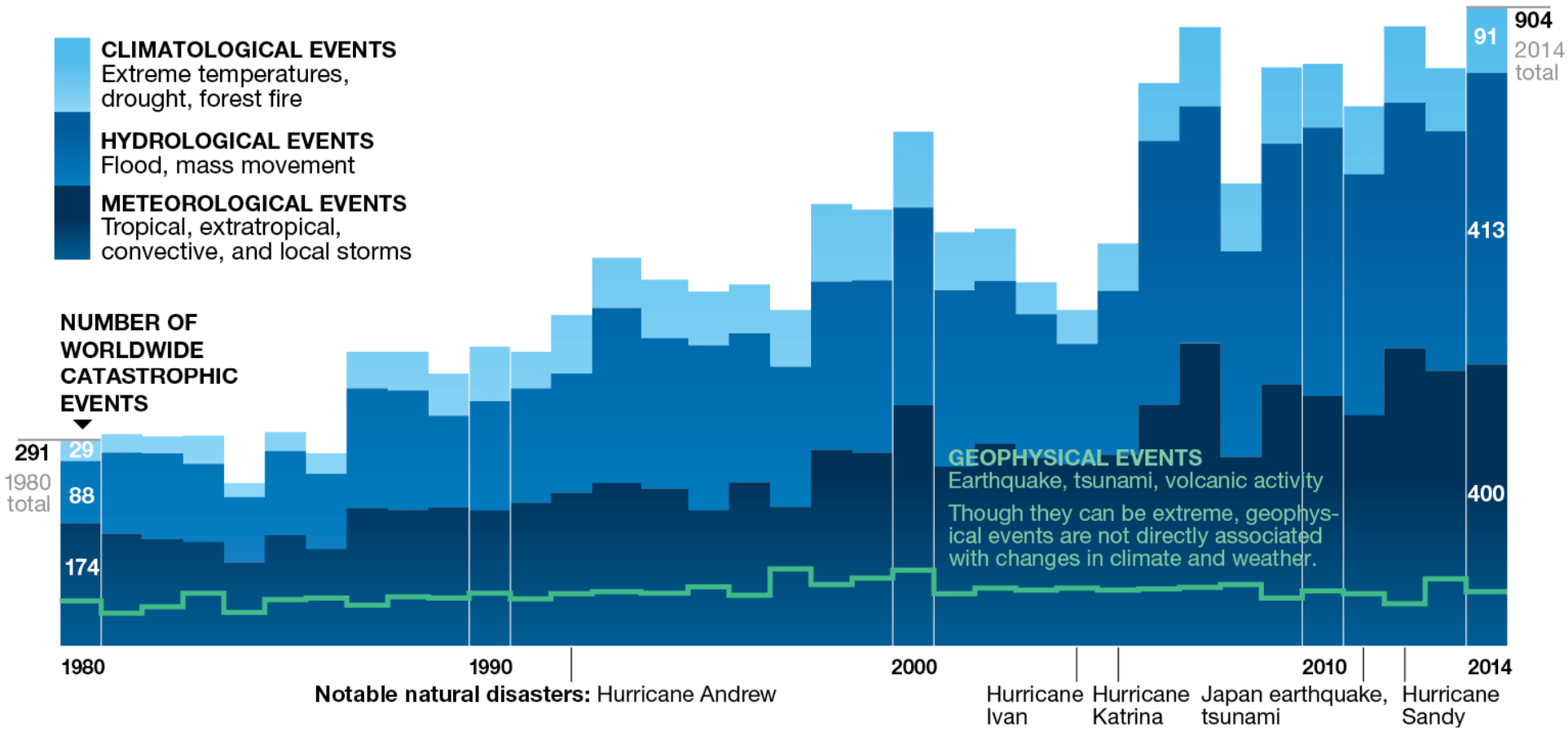
Source: https://www.metoffice.gov.uk/research/climate/cryosphere-oceans/sea-ice/index

Weather indicators

- Temperature
- Precipitation / rainfall
- Humidity
- Wind speed
- Solar radiation
- Surface water
- Soil moisture etc.

Source: www.cch-africa.de/population-cohorts/

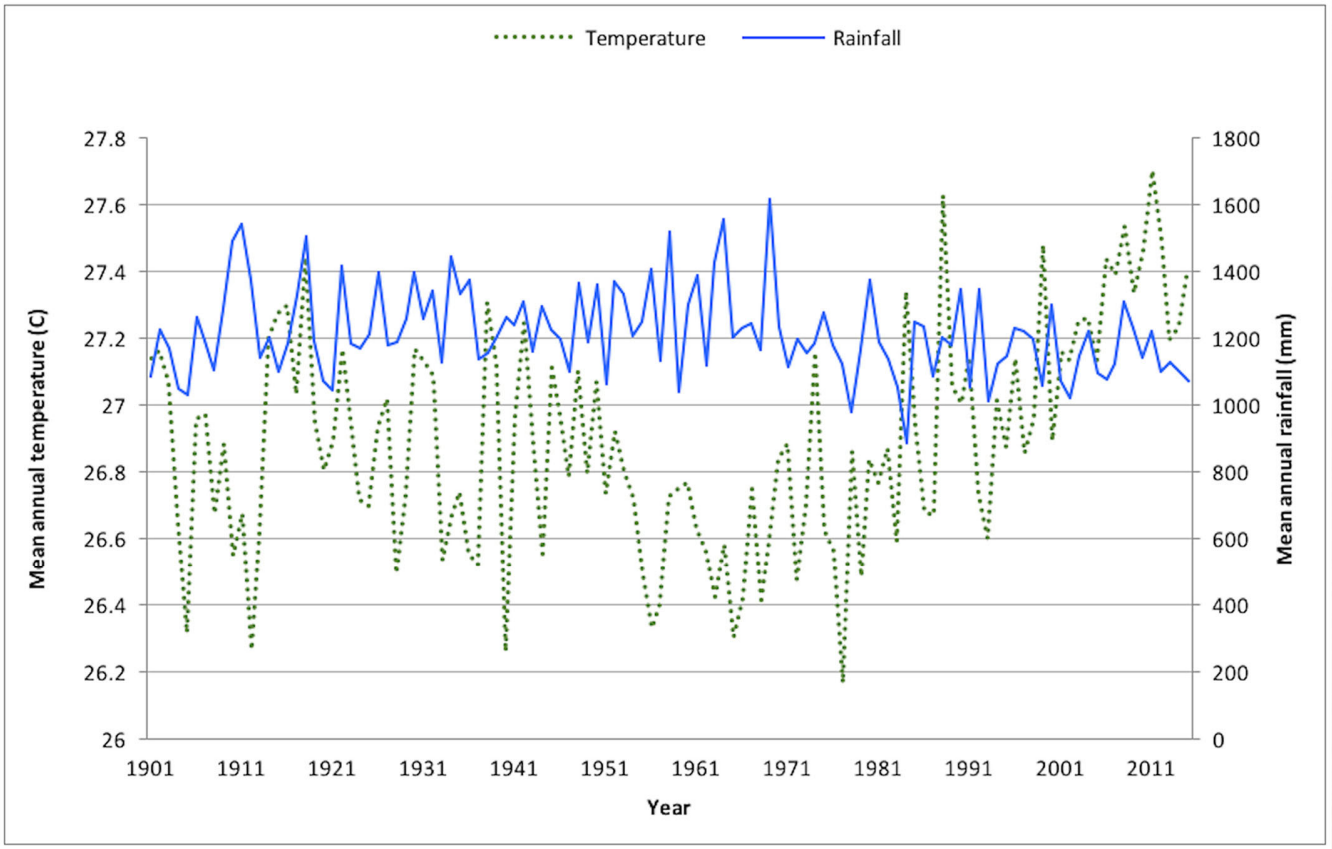
Weather events



Source: IPCC AR5, 2014

Climate change in Ghana

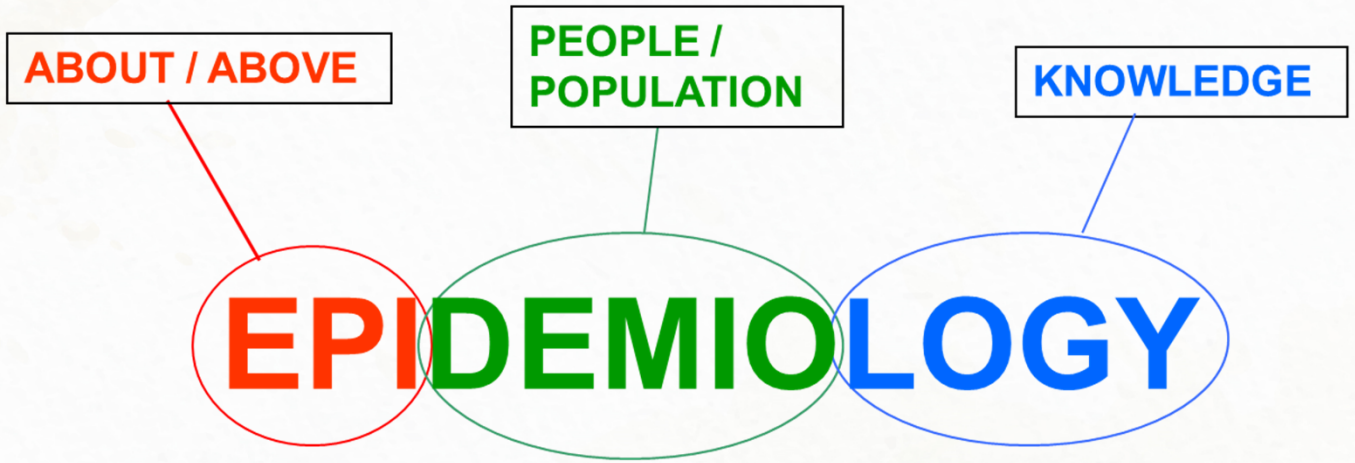
Increase in mean decadal temperature by 0.6°C from 26.8°C (1900–1910) to 27.4°C (2006–2015)



Decrease in mean annual rainfall by since 1970s

Source: Abbam T et al. Earth and Space Science 2018

Epidemiology in health sciences



= the basic science for Public Health

Epidemiology in health sciences

	Micro	Meso	Macro
	Cell	Patient	Population
Analogy			
Research	Genetics, Molecular biology, Microbiology	Clinical Studies	**Epidemiology**
Practice	Genetic consultations, Clinical Microbiology	Clinical Medicine	**Public Health**

Three tasks of epidemiology

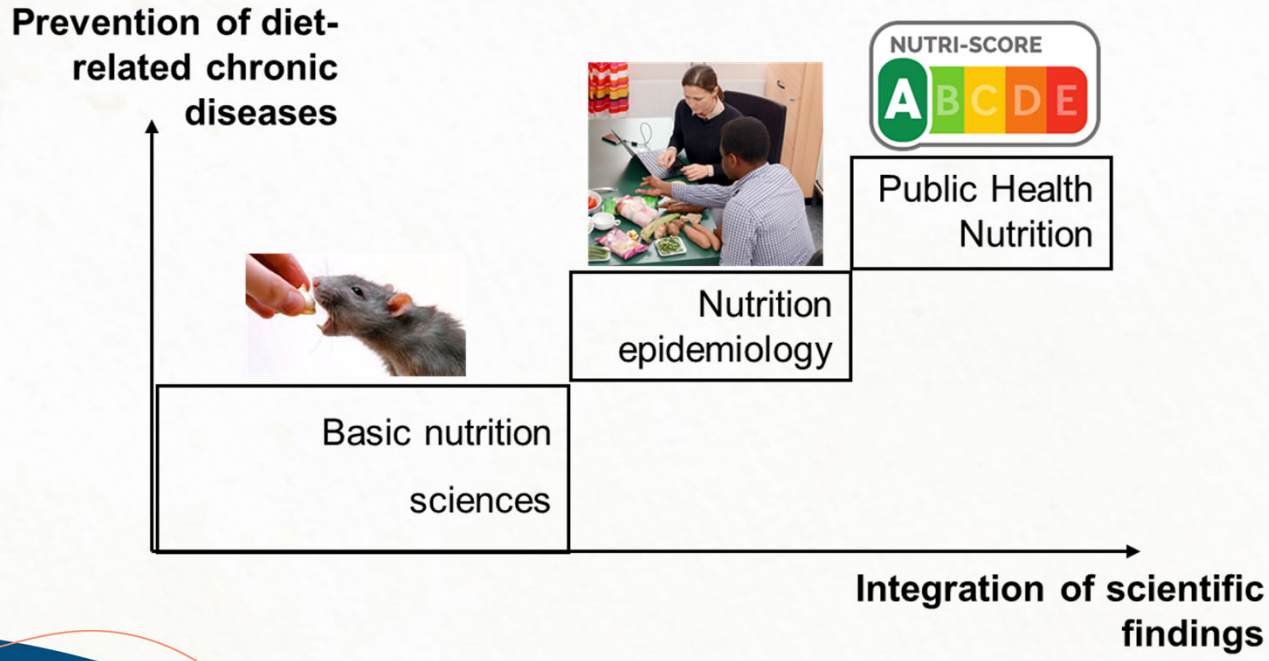
1. Quantitative description

2. Inference: associations → causes

3. Disease control: planning and evaluating interventions

Nutrition epidemiology

Levels of prevention in nutrition science



Source: Boeing & Kroke. Aktuel Ernaehr Med 2000

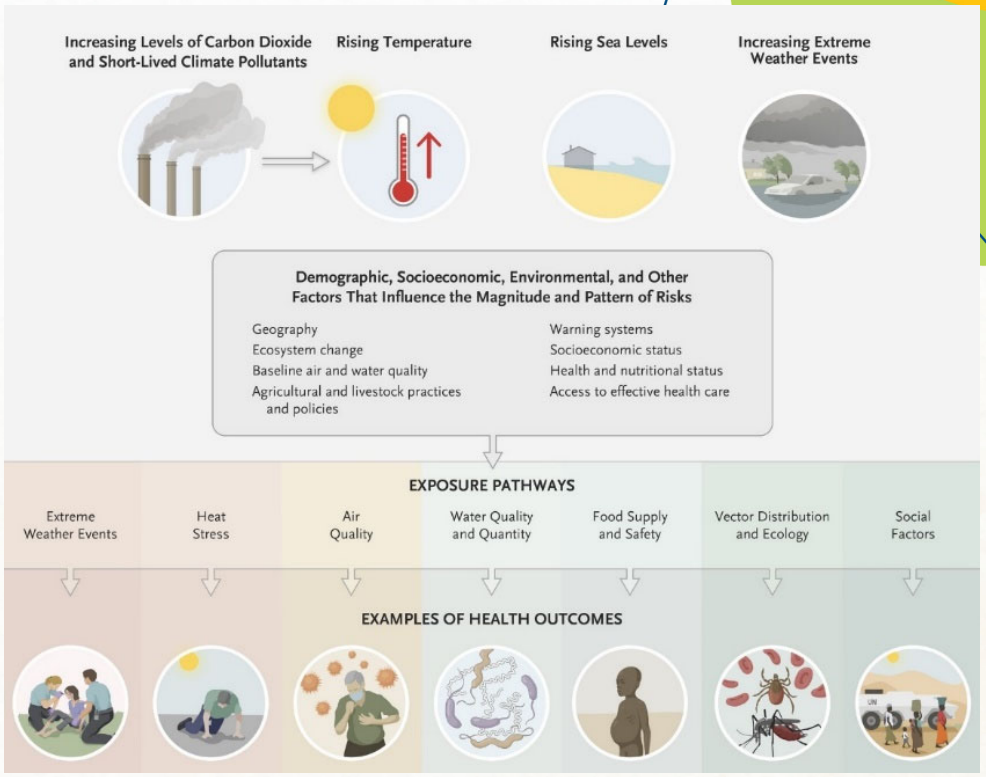
Summary – climate change and nutrition epidemiology

- Climate change: long-term weather changes
- Epidemiology: Describe, Inference, Control
- Nutrition epidemiology: basic science for public health nutrition

→ Challenges ?

Challenges in establishing nutrition and health impacts – Aetiological

- Multi-variable nature of weather (temperature, rainfall etc.
- Indirect nature of impacts on health – mediated through behaviour, social systems, environmental factors
- Contextuality of impacts – health system capacity, socio-economics, baseline disease burden



Source: Haines & Ebi, NEJM 2019

Challenges in establishing nutrition and health impacts – Methodological

- Previous work mainly in agriculture and economics
- Previous work in areas with high adaptive capacity and high emissions
- Spatial and temporal resolutions of data differ
- Levels of data aggregation differ

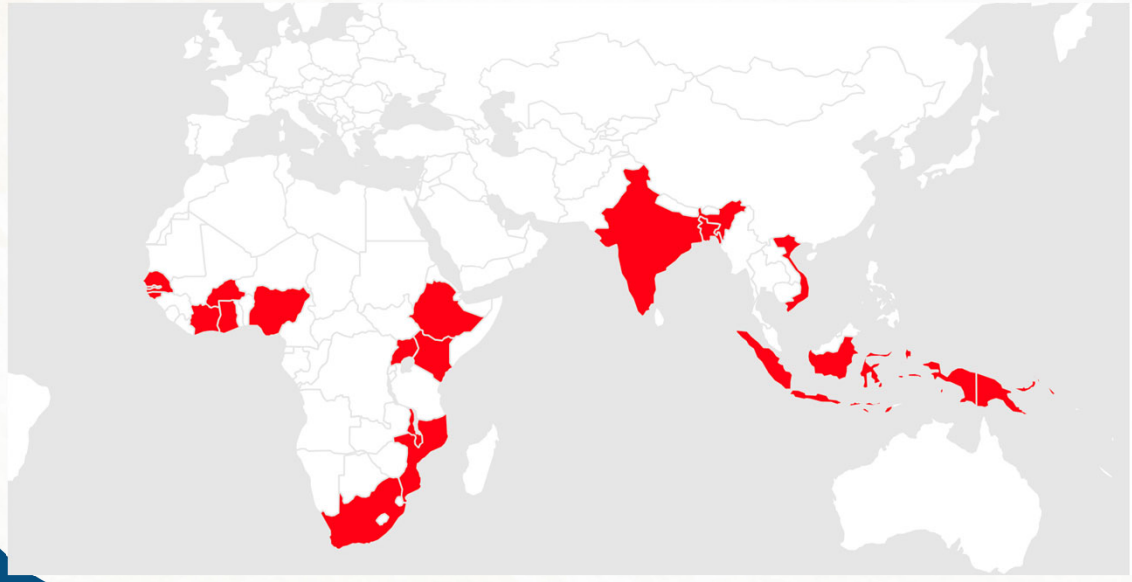
Publications on climate change and health (1992-2015)

Source: Verner et al. Global Health Action 2016

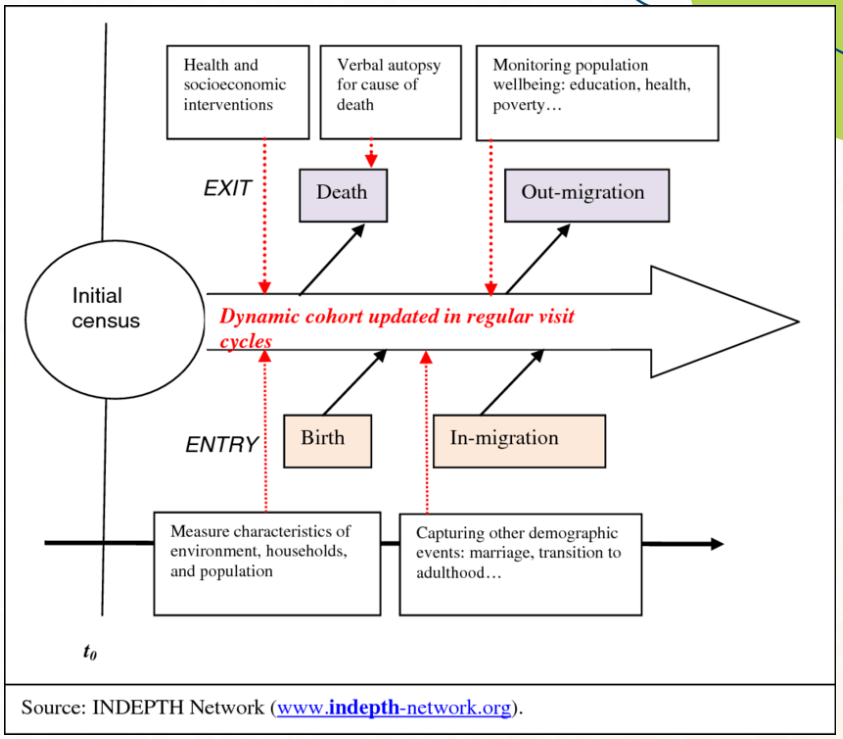
Approaches to sampling

Over 50 Health and Demographic Surveillance Systems (HDSS)

in 24 low- and middle-income countries



Sources: http://www.indepth-network.org/about-us
Herbst et al. Global Health Action 2021

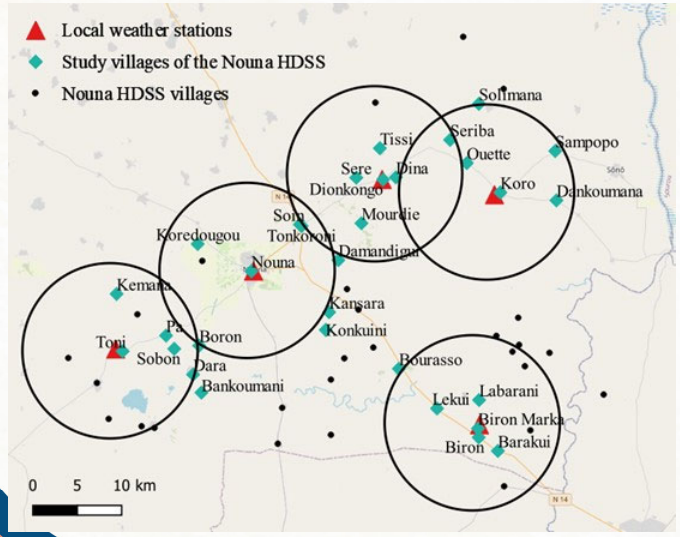


Source: INDEPTH Network (www.indepth-network.org).

Approaches to sampling

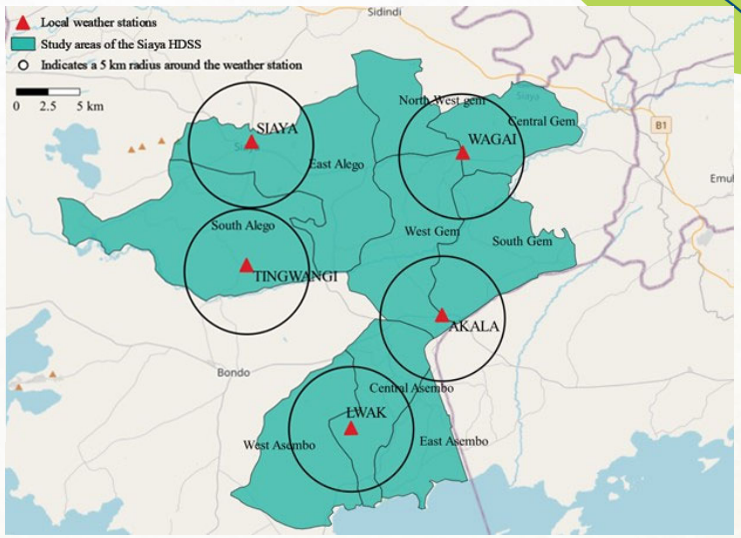
DFG-funded Research Unit "Climate change and health in sub-Saharan Africa"

5 weather stations at each site, sampling proportionate to population size, 6 years



Burkina Faso

Kenya



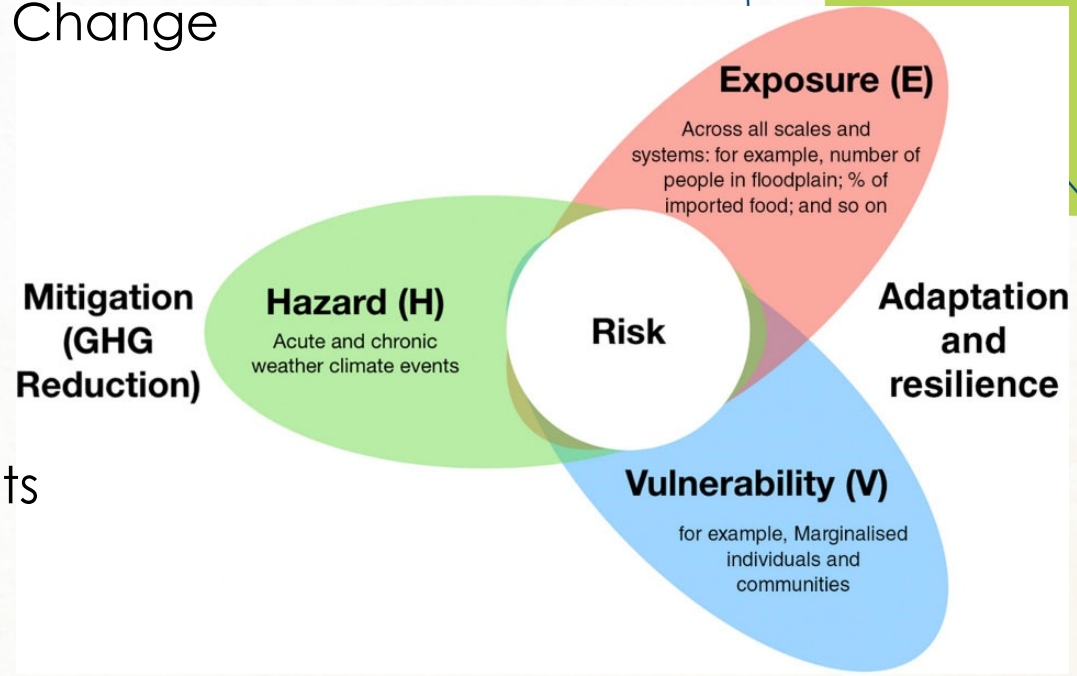
Source: Mank et al. Trials 2022

Helpful metrics – The Lancet Countdown

Tracking Progress on Health and Climate Change

(47 indicators)

- impacts, exposure & vulnerabilities
- Adaptation, planning & resilience
- mitigation actions & health co-benefits
- economics & finance
- public & political engagement



Source: IPCC 2018

Helpful metrics – The Lancet Countdown

HEALTH HAZARDS, EXPOSURES, AND IMPACTS

1.1.5 HEAT-RELATED MORTALITY

In 2018-2022, people experienced on average 86 days of health-threatening high temperatures annually. 60% of such temperatures were made more than twice as likely to occur by human-caused climate change.

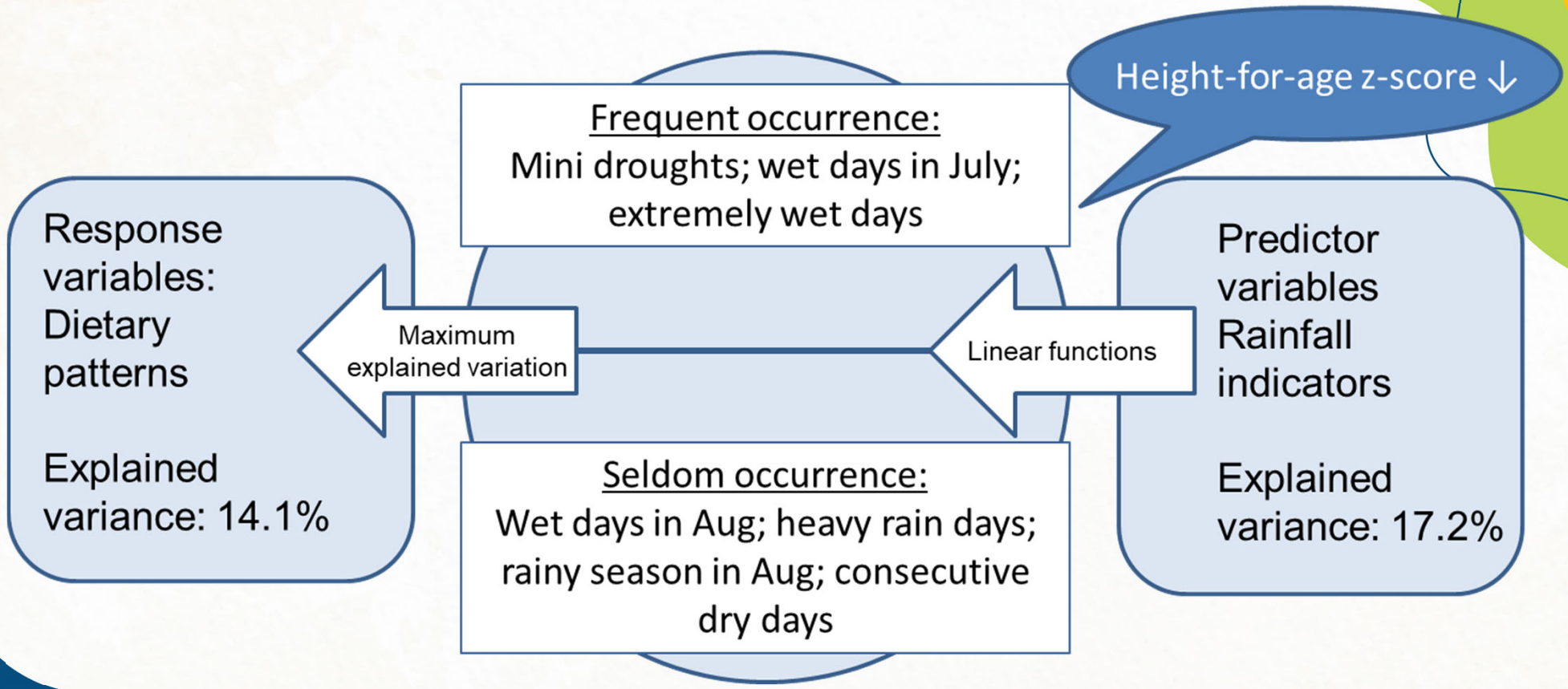
1.3.1 DENGUE

The transmission potential for dengue by Aedes aegypti and albopictus increased by 42.7% and 39.5%, respectively.

1.4 FOOD SECURITY AND UNDERNUTRITION

The higher frequency of heatwave days and drought months in 2021 compared to 1981–2010, is associated with 127 million more people experiencing moderate or severe food insecurity.

Dimension reduction techniques



Source: Mank et al. Front Public Health 2021

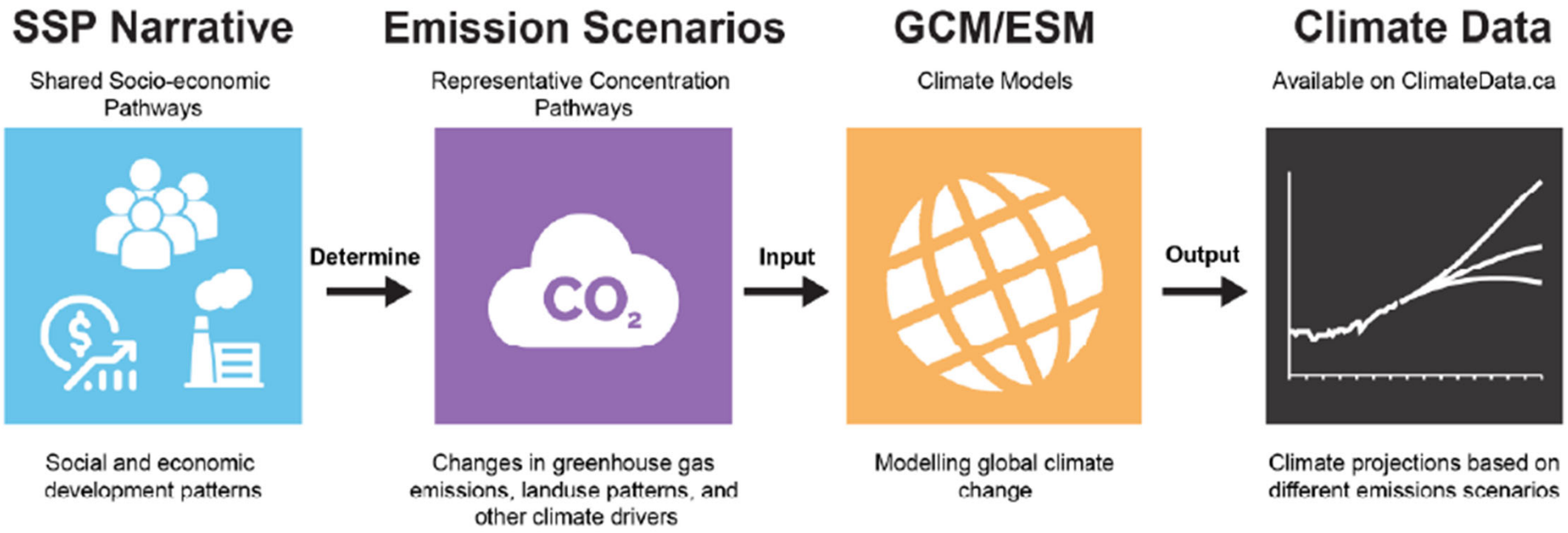
Dimension reduction techniques

Practical exercise

Dynamics of impacts

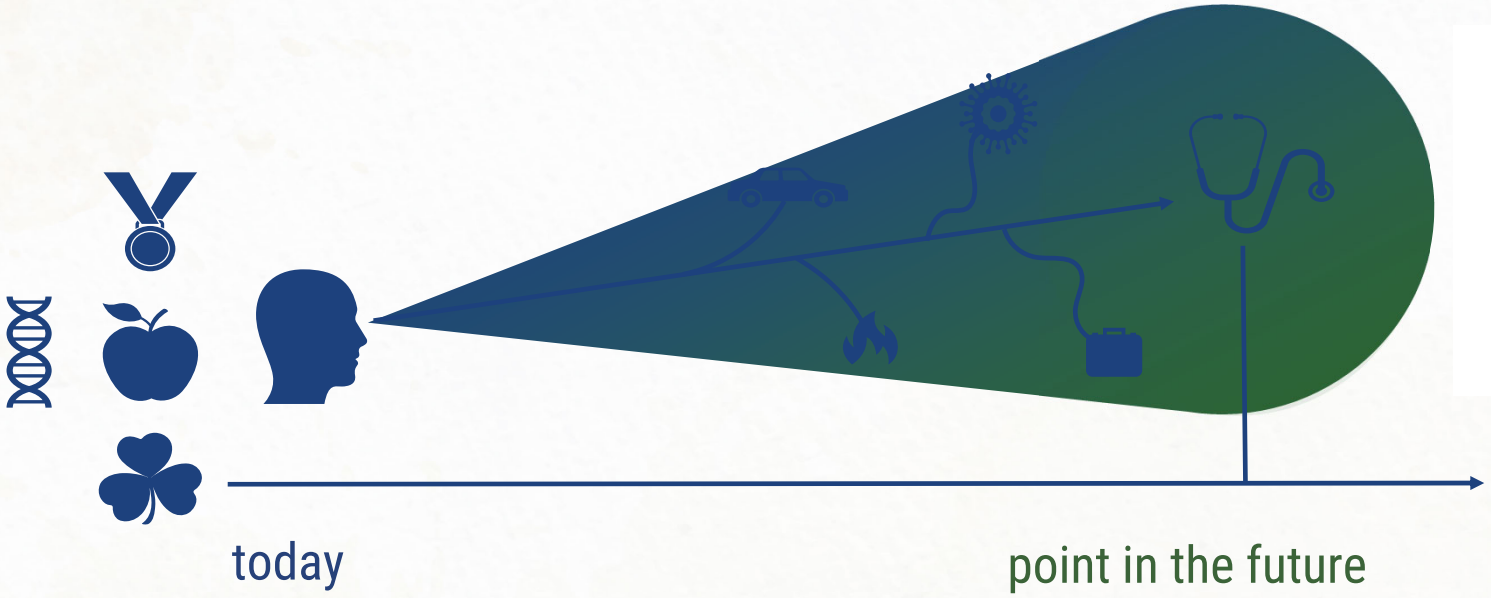
- Dealing with the future: projections, trend extrapolation, forecasting, Delphi surveys, expert opinions, simulations, scenario development
- Futurology: helps to determine long-term and resilient strategies for achieving Sustainable Development Goals (SDGs)
- Many different scenarios can lead to many potential futures

Dynamics of impacts – projections



Source: www.climatedata.org/resource

Dynamics of impacts – backcasting



Source: Jungmann M 2021

Dynamics of impacts – backcasting

Source: Jungmann M 2021

Summary – Climate change impacts

- Challenges: differences in concepts, scales, and data aggregation
- Methods: long-term, representative observations for health (HDSS) coupled with geographically downscaled weather and climate data
- Metrics: Lancet Countdown indicators, dimension reduction techniques
- Dynamics: scenario analysis to incorporate key uncertainties

Practical exercise

Dimension reduction technique:

Identification of rainfall patterns explaining variations in dietary patterns among young children living in north-western Burkina Faso (Reduced Rank Regression, RRR)

Practical exercise – Ingredients

- Literature by Mank et al. 2021

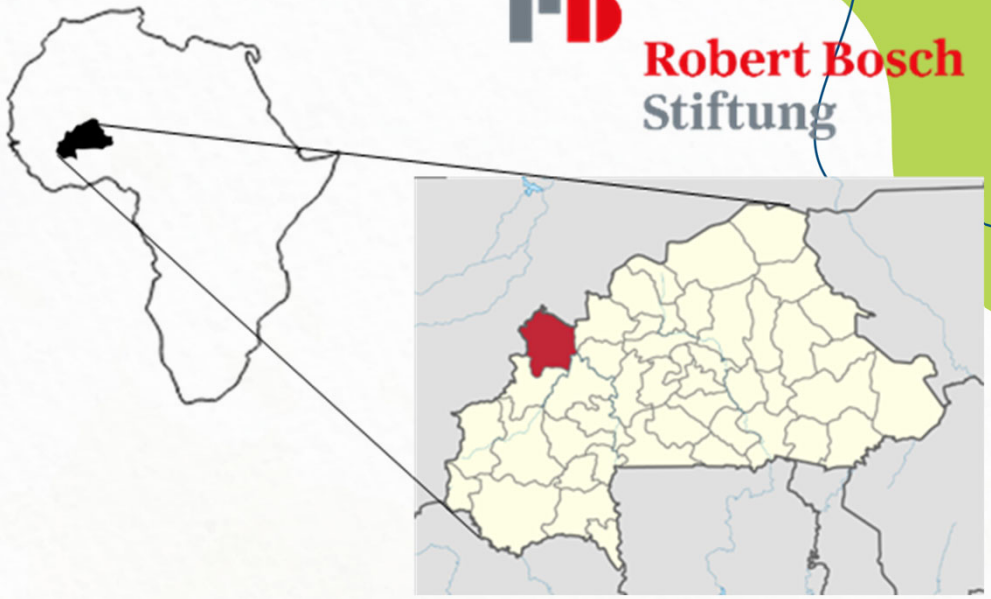

The Impact of Rainfall Variability on Diets and Undernutrition of Young Children in Rural Burkina Faso

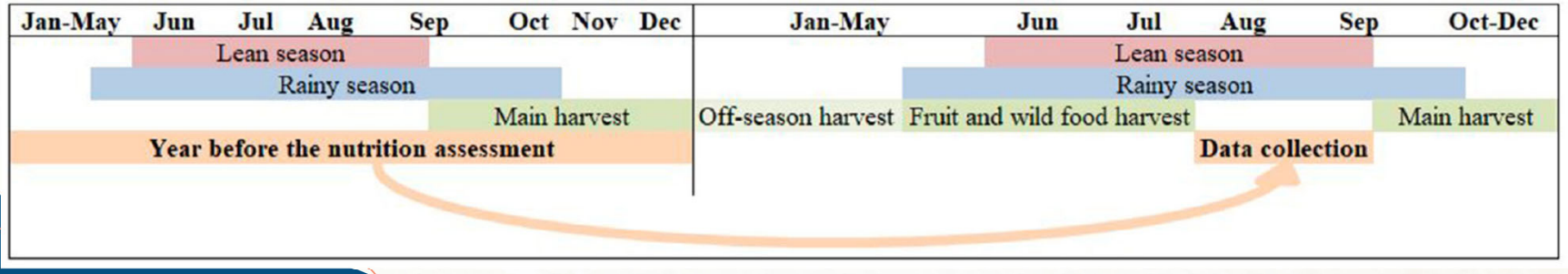
Isabel Mank[1*], Kristine Belesova[2], Jan Bliefernicht[3], Issouf Traoré[4,5], Paul Wilkinson[2], Ina Danquah[1†] and Rainer Sauerborn[1†]

- Dataset NutriClim
- Codebook NutriClim
- R code for Reduced Rank Regression

Practical exercise – Study design

- Subsistence farming
- Income per capita : 670 USD/year
- 1 rainy season
- 514 children aged <5 years
- 2 x 12 rainfall indicators
- 3 dietary pattern scores





Practical exercise – Code book

Suffixes:

- 1ybb – 1 year before birth
- yb – year of birth
- 1ybs – 1 year before survey
- ys – year of survey

Rainfall indicators: →

ID (unit)	Indicator name	Definitions
PRCPTOT (mm)	Annual total wet-day precipitation	Annual total PRCP in wet days (RR>=1mm)
PRCPano (SD)	Total precipitation anomalies	Yearly total prec. difference from the mean value
SDII (mm/day^{-1})	Simple daily intensity index	Annual total precipitation by number of wet days (PRCP>=10mm)
R10 (days)	Number of heavy precipitation days	Annual count of days when PRCP>=10mm
R20 (days)	Number of very heavy precipitation days	Annual count of days when PRCP>=20mm
R25 (days)	Number of very heavy precipitation days	Annual count of days when PRCP>=25mm
CDD (days)	Consecutive dry days	Maximum number of consecutive days with RR<1mm
CWD (days)	Consecutive wet days	Maximum number of consecutive days with RR>=1mm
R95p (mm)	Very wet days	Annual total PRCP when RR>95th percentile
R99p (mm)	Extremely wet days	Annual total PRCP when RR>99th percentile
RS_Length (Lws, days)	Duration wet season	Length of the wet season
CDD_ws (days)	Mini-drought	Max. number of consecutive dry days (RR<1 mm) during wet season

Practical exercise – Code book

Dietary pattern scores:

- DP1_diet_score – Dietary pattern score 1 (market-based diet)
- DP2_diet_score – Dietary pattern score 2 (legume-based diet)
- DP3_diet_score – Dietary pattern score 3 (vegetable-based diet)

TABLE 2 | Rotated factor loadings of food items for the three dietary patterns among 1,439 children aged <5 years in the Nouna HDSS area.

Food groups	DP1 Market-based diet	DP2 Legume-based diet	DP3 Vegetable-based diet
Pasta	**0.57***	0.24	0.10
Eggs	**0.56***	−0.07	0.05
Poultry	**0.55***	−0.03	0.09
Sweets	**0.52***	0.19	0.25
Bread	**0.49***	0.07	0.06
Beverages	**0.46***	−0.11	0.01
Rice	**0.45***	0.40	0.03
Cassava	**0.41***	0.06	−0.09
Soumbala	0.05	**0.60***	0.09
Oils and fats	−0.01	**0.57***	**0.42***
Dark green leaves	0.26	**0.46***	0.03
Peanuts	0.35	**0.41***	−0.06
Millet	−0.09	**0.41***	−0.03
Tea	0.10	**0.41***	0.02
Okra	−0.05	0.05	**0.70***
Tomatoes	0.08	−0.02	**0.66***
Eggplant	0.07	0.14	**0.64***
Maize	0.09	−0.17	**0.46***
Coffee	0.21	0.04	**0.43***
Fish	0.16	0.29	**0.42***
Meat	0.38	0.37	−0.03
Cabbage	0.37	0.13	−0.08
Cowpea beans	0.27	0.02	0.28
Animal milk	0.26	0.30	0.12
Onions	0.25	0.39	−0.09
Fruits	0.25	0.11	0.19
Couscous	0.20	0.24	0.02
Groundnuts	0.18	0.13	−0.13
Mother's milk	0.02	−0.36	−0.03
Sorghum	−0.08	0.27	0.01
Explained variance	**9.88%**	**8.28%**	**7.87%**

**Food groups with factor loadings of ≥\|0.40\| indicate relevant contributions to the DPS.*

Practical exercise – Procedures

- Read in your dataset
- Check the rainfall indicators → 2 x 12 indicators
- Check the dietary pattern scores → 3 dietary pattern scores
- Apply the RRR code to the rainfall indicators as predictor variables and dietary pattern scores as response variables

Practical exercise – Results

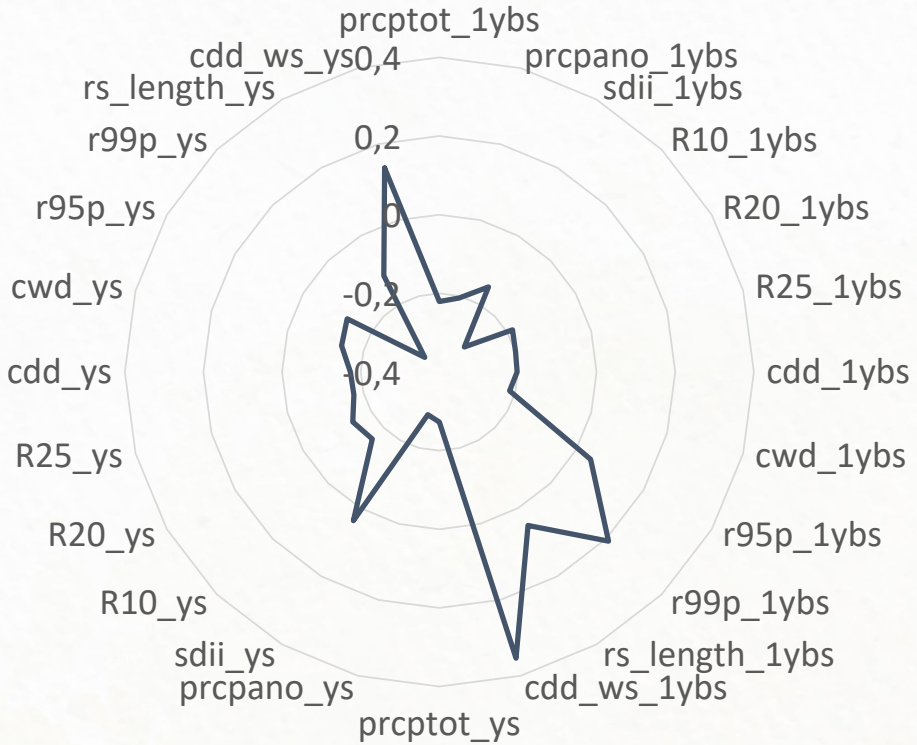
Table 1. Explained variation of dietary pattern scores

Explained variation	**Dietary pattern 1**	**Dietary pattern 2**	**Dietary pattern 3**
Rainfall pattern	10.62%	7.62%	24.32%

Practical exercise – Results

Table 2/Figure 1. Factor loadings of rainfall indicators

Year of the survey



Year before the survey

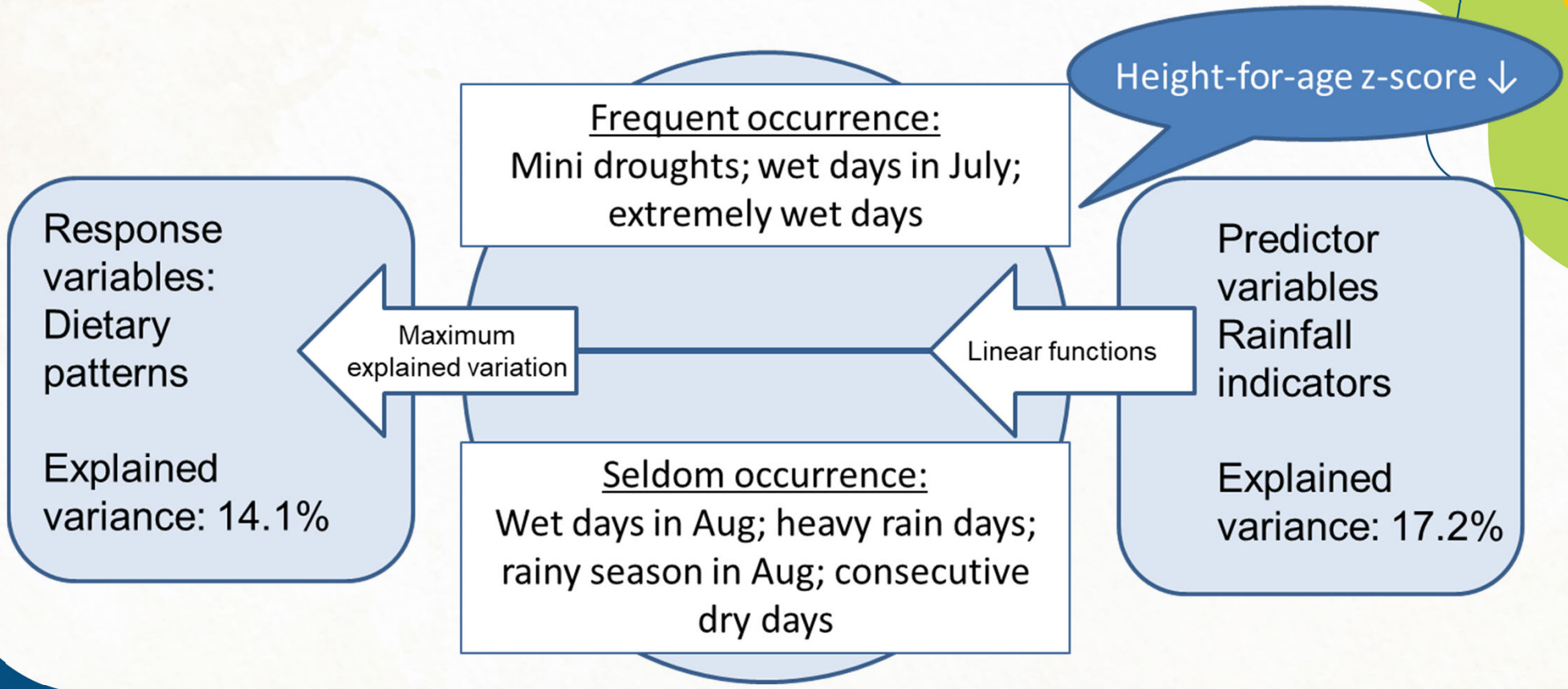
Practical exercise – Results

- Sort by factor loadings
- Flag loadings > |0.25|
- Characterize the precipitation/rainfall pattern

… frequent occurrence of SDII_ys and seldom occurrence of R99p_ys.

Indicator	Factor loading
r99p_ys	**-0,347597**
R10_1ybs	**-0,310293**
prcpano_ys	**-0,287625**
prcptot_ys	**-0,272661**
sdii_ys	**0,036712**
r95p_1ybs	**0,044126**
cdd_ws_1ybs	**0,353444**
prcptot_1ybs	-0,220792
cwd_1ybs	-0,214899
prcpano_1ybs	-0,205416
cdd_1ybs	-0,202145
rs_length_1ybs	0,050885
r99p_1ybs	0,208321
R25_1ybs	-0,199284
R20_1ybs	-0,185316
R25_ys	-0,174966
cdd_ys	-0,173855
R10_ys	-0,159114
sdii_1ybs	-0,150141
R20_ys	-0,145778
cwd_ys	-0,142441
r95p_ys	-0,129521
rs_length_ys	-0,117318
cdd_ws_ys	0,137093

Practical exercise – Results summary



Source: Mank et al. Front Public Health 2021