World Health Organization

Technical Webinar Series Climate Change and Health

Quantitative approaches for Vulnerability & Adaptation assessments: Sensitivity analyses and projecting future health risks of climate change

17 July 2024

9:30 – 11:00 CEST

15:00 – 16:30 CEST

WHO Technical Webinar Series

https://www.who.int/teams/environment-climate-change-and-health/climate-change-and-health/country-support/webinars

Date & time (CEST)	Topic*
24th April 2024	Getting started: climate change and health vulnerability & adaptation assessments
30th April 2024	WHO as an Accredited Implementing Entity of the Adaptation Fund; Accessing AF funding for Climate Change and Health
15th May 2024	WHO Operational Framework for building climate resilient and low carbon health systems
12th June 2024	Developing a Health National Adaptation Plan: Introduction
19th June 2024	GIS and risk mapping in climate change and health vulnerability & adaptation assessments
10th July 2024	Climate resilient and environmentally sustainable health care facilities
17th July 2024	Quantitative approaches for Vulnerability & Adaptation assessments: sensitivity analyses and projecting future health risks of climate change
18th Sept 2024	Integrating health in NDCs and LT-LEDS
25th Sept 2024	Developing a Health National Adaptation Plan: Quality criteria for HNAPs
16th Oct 2024	Conducting a gender analysis for climate change and health vulnerability & adaptation assessments

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Interpretation

AM session: English, French and Arabic
PM session: English, French and Spanish

To activate interpretations (in English):

1. Click on the interpretation icon.
2. Select ”English”
3. **Optional :** mute original audio

Pour activer les interprétations (en français):

1. Cliquez sur l'icône d'interpretation
2. Sélectionnez ”Français”
3. **Facultatif :** couper le son d'origine

Para activar interpretación (en español)

1. Haga clic en el icono de interpretación.
2. Seleccionar ”Español”
3. **Opcional:** silenciar el audio original

لتفعيل التفاسير باللغة العربية

1. اضغط على أيقونة التفسير.
2. اختر "العربية"
3. اختياري: كتم الصوت الأصلي

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AM Session

Agenda

Time	Agenda item	Speaker
9:30 – 9:35 (5 minutes)	Welcome and Housekeeping	**Dr Amy Savage,** Technical Officer, Climate Change and Health Unit, WHO
9:35 – 9:45 (10 minutes)	Opening and setting-the-scene	**Dr Diarmid Campbell-Lendrum,** Head, Climate Change and Health Unit, WHO
9:45 – 10:15 (30 minutes)	Introduction to quantitative modelling in V&As	**Dr Adugna Woyessa Gemeda**, Epidemiologist and Senior Researcher, Ethiopian Public Health Institute (EPHI)
10:15 – 10:25 (10 minutes)	Country experience 1: Mozambique	**Prof Genito Maure,** Eduardo Mondlane University Mozambique
10:25 – 10:35 (10 minutes)	Country experience 2: Austria	**Mag Ilonka Horváth**, Senior Health Expert, Competence Centre for Climate and Health Austria
10:35 – 10:55 (20 minutes)	Discussion and Q&A	Moderated by Dr Adugna Woyessa Gemeda
10:55 – 11:00 (5 minutes)	Close webinar	**Dr Amy Savage**

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PM Session

Agenda

Time	Agenda item	Speaker
15:00 – 15:05 (5 minutes)	Welcome and Housekeeping	**Dr Amy Savage,** Technical Officer, Climate Change and Health Unit, WHO
15:05 – 15:15 (10 minutes)	Opening and setting-the-scene	**Dr Diarmid Campbell-Lendrum,** Head, Climate Change and Health Unit, WHO
15:15 – 15:45 (30 minutes)	Introduction to quantitative modelling in V&As	**Dr Adugna Woyessa Gemeda**, Epidemiologist and Senior Researcher, Ethiopian Public Health Institute (EPHI)
15:45 – 15:55 (10 minutes)	Country experience 1: Mozambique	**Prof Genito Maure,** Eduardo Mondlane University Mozambique
15:55 – 16:05 (10 minutes)	Country experience 2: Canada	**Dr Peter Berry**, Climate Change and Health Office, Health Canada
16:05 – 16:25 (20 minutes)	Discussion and Q&A	Moderated by Dr Adugna Woyessa Gemeda
16:25 – 16:30 (5 minutes)	Close webinar	**Dr Amy Savage**

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Opening and setting-the-scene

Dr Diarmid Campbell-Lendrum
Unit Head, Climate Change and Health Unit, WHO

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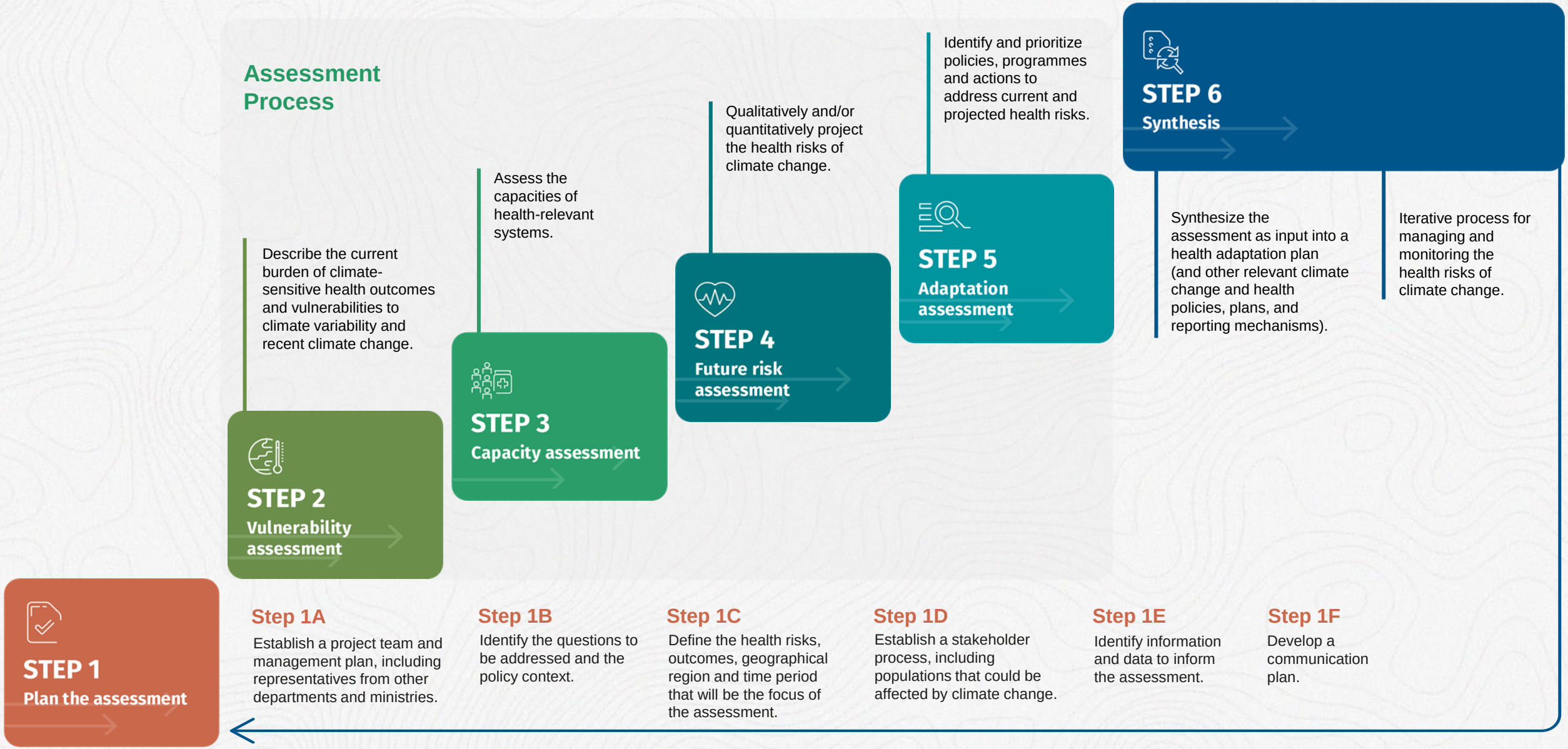
Assessment Process



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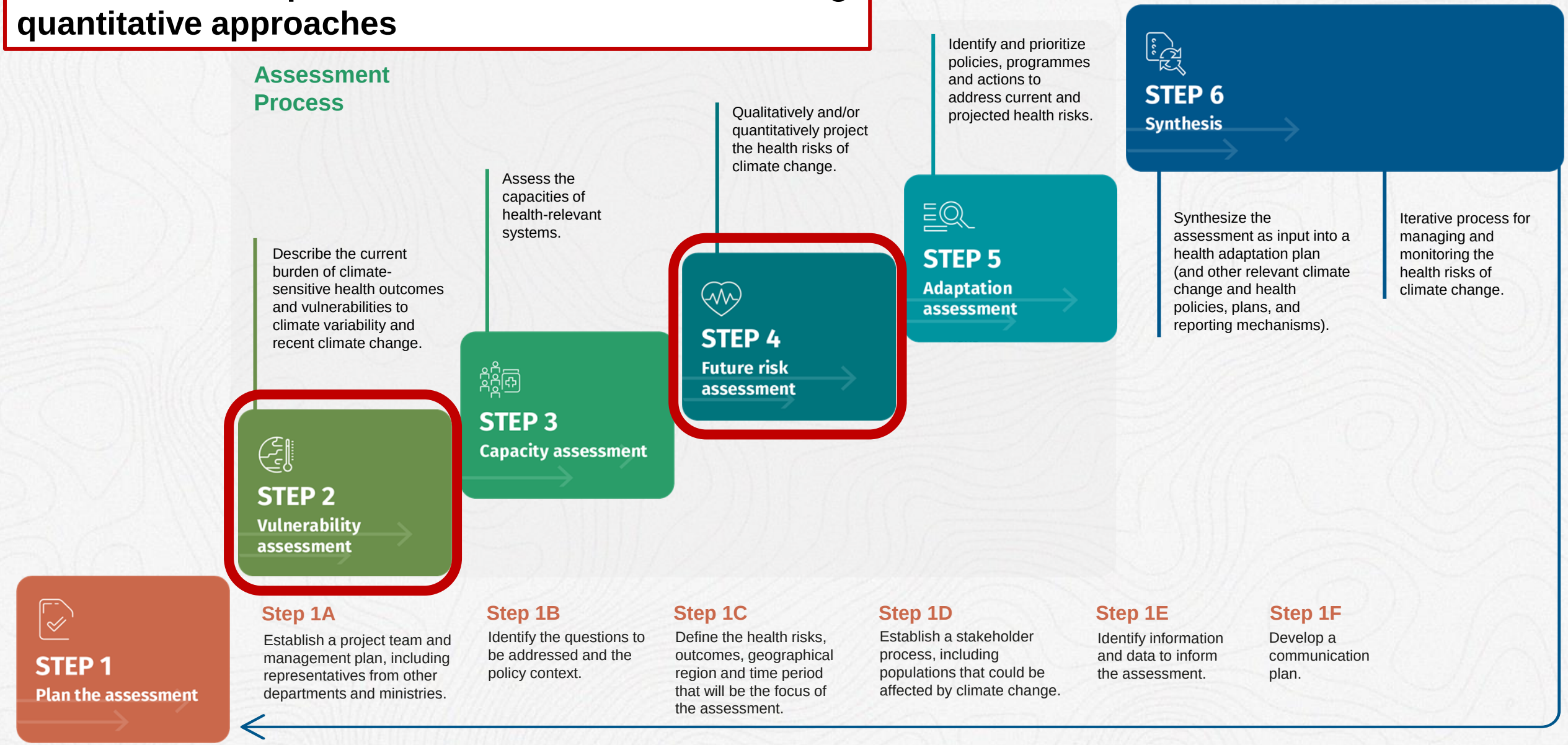
Most relevant steps in the V&A assessment for using quantitative approaches



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Climate change and health vulnerability and adaptation assessment. Geneva: World Health Organization; 2021.

STEP 4

Future risk assessment

Step 4A

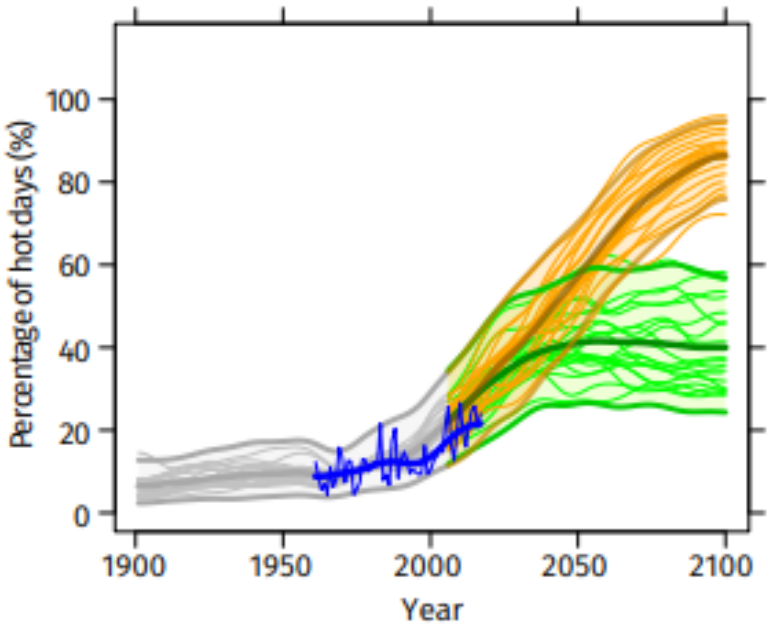
Describe how current health risks could change under diverse scenarios of climate change and development

Step 4B

Future climate of Madagascar (example):

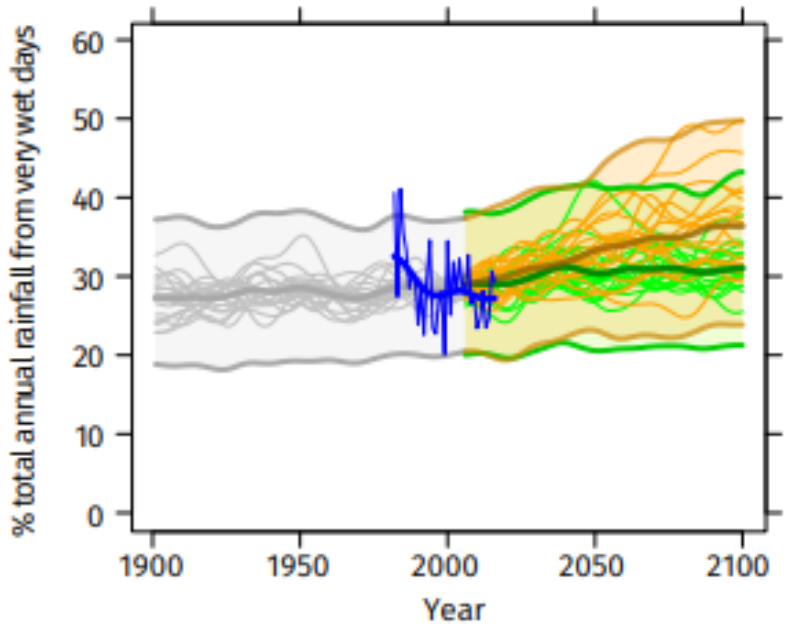
More high temperature extremes

FIGURE 3: Percentage of hot days ('heat stress'), 1900–2100



Increase in extreme rainfall

FIGURE 4: Contribution to total annual rainfall from very wet days ('extreme rainfall' and 'flood risk'), 1900–2100



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STEP 4
Future risk assessment

Step 4A

Step 4B

Estimate the possible additional burden of adverse health outcomes due to climate change

Quantitative approaches: **MODELLING**

Example: WHO Quantitative Risk Assessment (2014)

Projected cause-specific mortality in 2030 and 2050 for heat-related mortality in older adults, mortality associated with coastal flooding, mortality associated with diarrheal diseases in children aged under 15 years, malaria, dengue, and undernutrition

- **Med-high** emissions scenario
- **Three development futures** (base case, high economic growth, no growth)
- **Counterfactual:** population growth and economic development, but with baseline (1961–1990) climate

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Step 4A

Step 4B

Estimate the possible additional burden of adverse health outcomes due to climate change

Quantitative approaches: **MODELLING**

WHO Quantitative Risk Assessment (2014)

Example:

Total additional deaths due to climate change:

- Med-high emissions scenario
- Base socioeconomic scenario

Additional deaths attributable to climate change, under A1b emissions and the base case socioeconomic scenarios, in 2050

Region	Undernutrition	Malaria	Diarrhoeal disease	Heat
World	**84 697** (-29 203 to 163 989)	**32 695** (22 786 to 40 817)	**32 955** (14 914 to 49 151)	**94 621** (70 775 to 126 684)

Total 250,000 + deaths per year between 2030 and 2050
(conservative estimate)

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WHO: World Health Organization. WHO guidance to protect health from climate change through health adaptation planning. 2014 Available at: https://www.who.int/publications/i/item/9789241507691

Step 4A

Step 4B

Estimate the possible additional burden of adverse health outcomes due to climate change

Qualitative approaches: SCENARIOS

- **Scenarios are NOT predictive nor forecasts of what will happen but they**
  - Are hypothetical storylines produced using structured methods to visualize plausible alternative future conditions.
  - Help organize information and provide insights based on a broad body of current knowledge.
  - Are judged on their ability to inform decision-processes NOW, rather than whether a forecast was right or wrong.

Qualitative approaches: EXPERT JUDGEMENT

- Based on current knowledge of expected changes in climate and other health determinants.
- Including: literature, published models etc.
- For example, the possible geographical expansion of a disease vector, together with socioeconomic data can be used to estimate increased disease risk.

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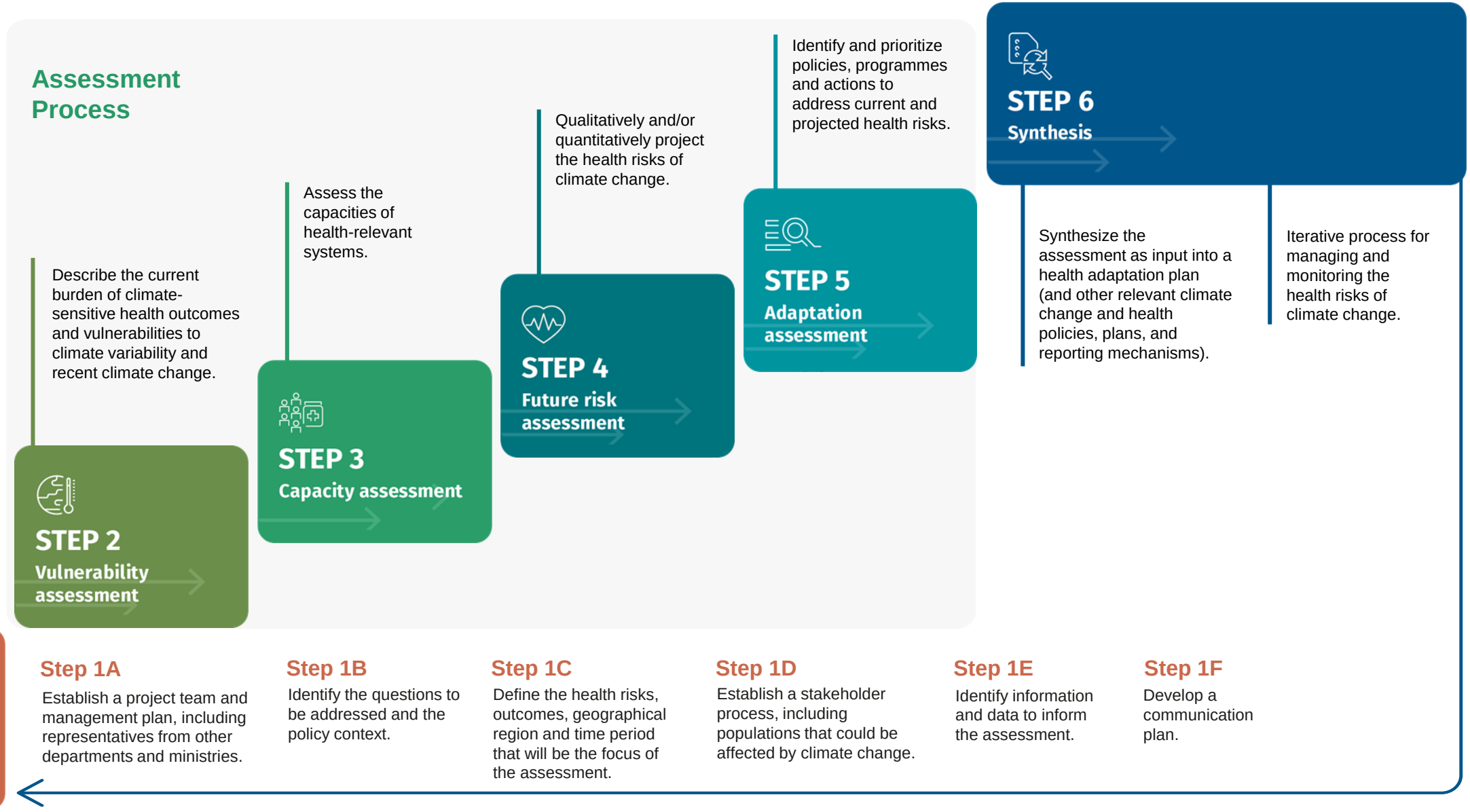
Quantitative Approaches for Vulnerability and Adaptation Assessments: Sensitivity Analysis and Projecting Future Health Risks of Climate Change

ADUGNA WOYESSA

Ethiopian Public Health Institute

Assessment Process



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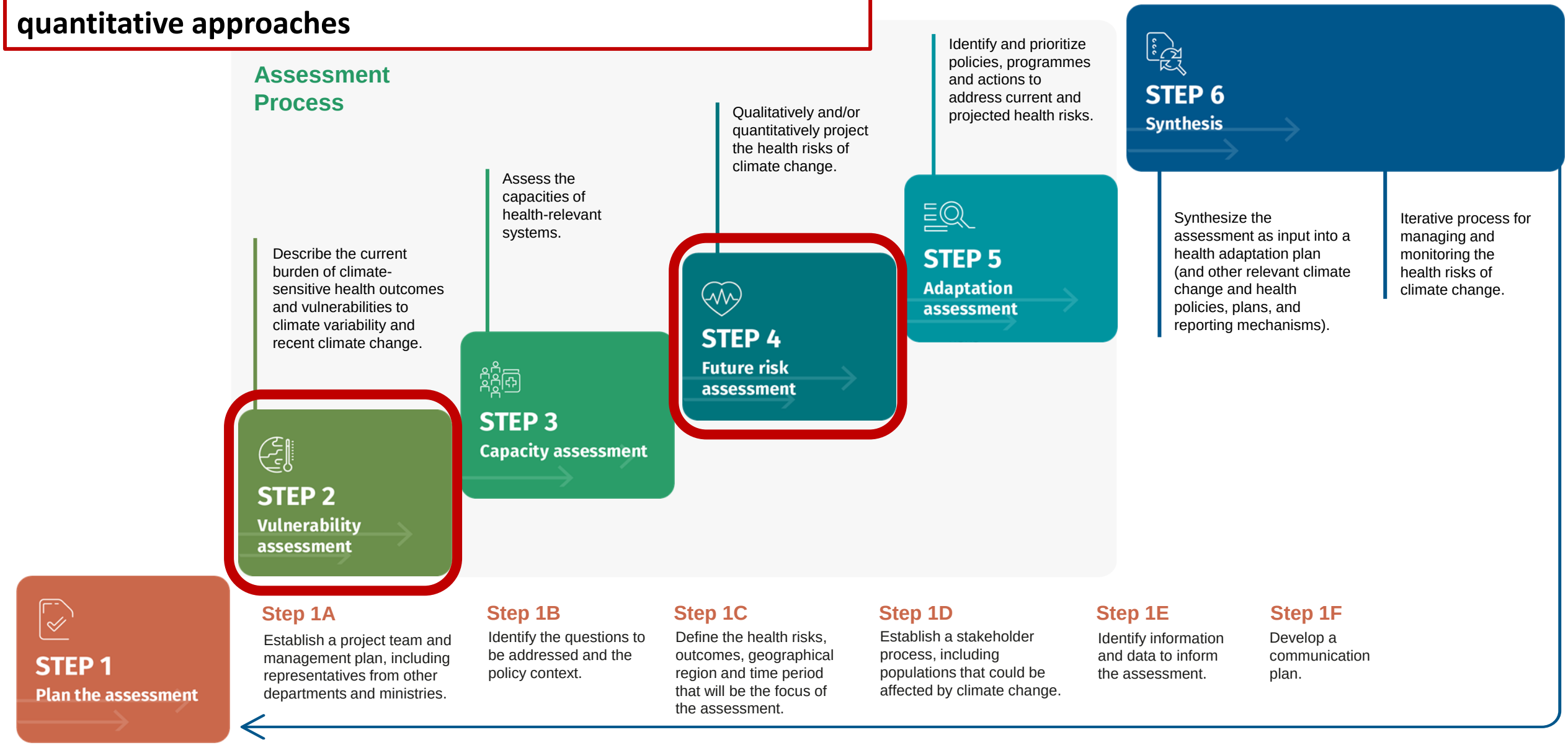
Most relevant steps in the V&A assessment for using quantitative approaches



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What is sensitivity analysis? Why is it important for V&As?

We measure the sensitivity, or **degree to which climate determines the occurrence and spatial distribution of health outcomes**.

What is sensitivity analysis? Why is it important for V&As?

The Key Objectives of Sensitivity Analysis

1) Identifying Important Factors:

- By analyzing sensitivity, we can pinpoint which input variables exert the most influence on the model's outputs. This identification helps prioritize resources and attention towards critical factors.

2) Understanding Model Behaviour:

- Sensitivity analysis provides insights into how changes in specific variables affect the overall behaviour of a model or system. It helps reveal relationships and dependencies that might not be apparent otherwise.

3) Enhancing Decision-making:

- With a clearer understanding of sensitivity, decision-makers can make more informed choices. They can focus on adjusting or controlling influential variables to achieve desired outcomes or mitigate risks effectively.

In essence, sensitivity analysis is a powerful tool for exploring and quantifying the relationships between inputs and outputs in models and systems. It provides valuable insights into the factors driving uncertainty and variability, empowering decision-makers to navigate complexity and optimize outcomes effectively.

The measurement of sensitivity analysis involves quantifying and assessing the impact of changes in input variables on the output of a model or system.

https://www.edupristine.com/blog/all-about-sensitivity-analysis/

What is sensitivity analysis? Why is it important for V&As?

Considerations for the analysis

- Are data available?
- Is it reliable?
- Costs
- Spatial and temporal resolution
- Capacity to compare data
- Can quantitative methods be used?
- Are there other resources available?
- Is expert consultation needed to plan the analysis?

AT A MINIMUM: analysis of the relationships between health data and averages of core weather variables (e.g. temperature, precipitation, relative humidity, and extreme weather events and patterns) can be explored.

What variables to consider?

Data on seasonal and historical trends of key climate hazard variables may include maps of weather and climate conditions and impacts such as location and dates of floods, droughts, hurricanes, wildfires, sea-level rise, rainfall, and temperature patterns

Where to find data?

- National data are available from the WHO Global Health Observatory
- Information may also be available from national datasets
- Climate and health risk maps and surveys conducted by nongovernmental organizations, universities, and others

What is sensitivity analysis? Why is it important for V&As?

Common definitions & concepts used in the Sensitivity Analysis

Model: a numerical procedure (often implemented in a computer program) that simulates the behaviour of an environmental system

Input: factor any element that can be changed before model execution, and output a variable that is obtained after the model execution.

Output: the entire range of temporal and spatial variables produced by the model simulation and a summary variable that is obtained by a scalar function of the simulated time series.

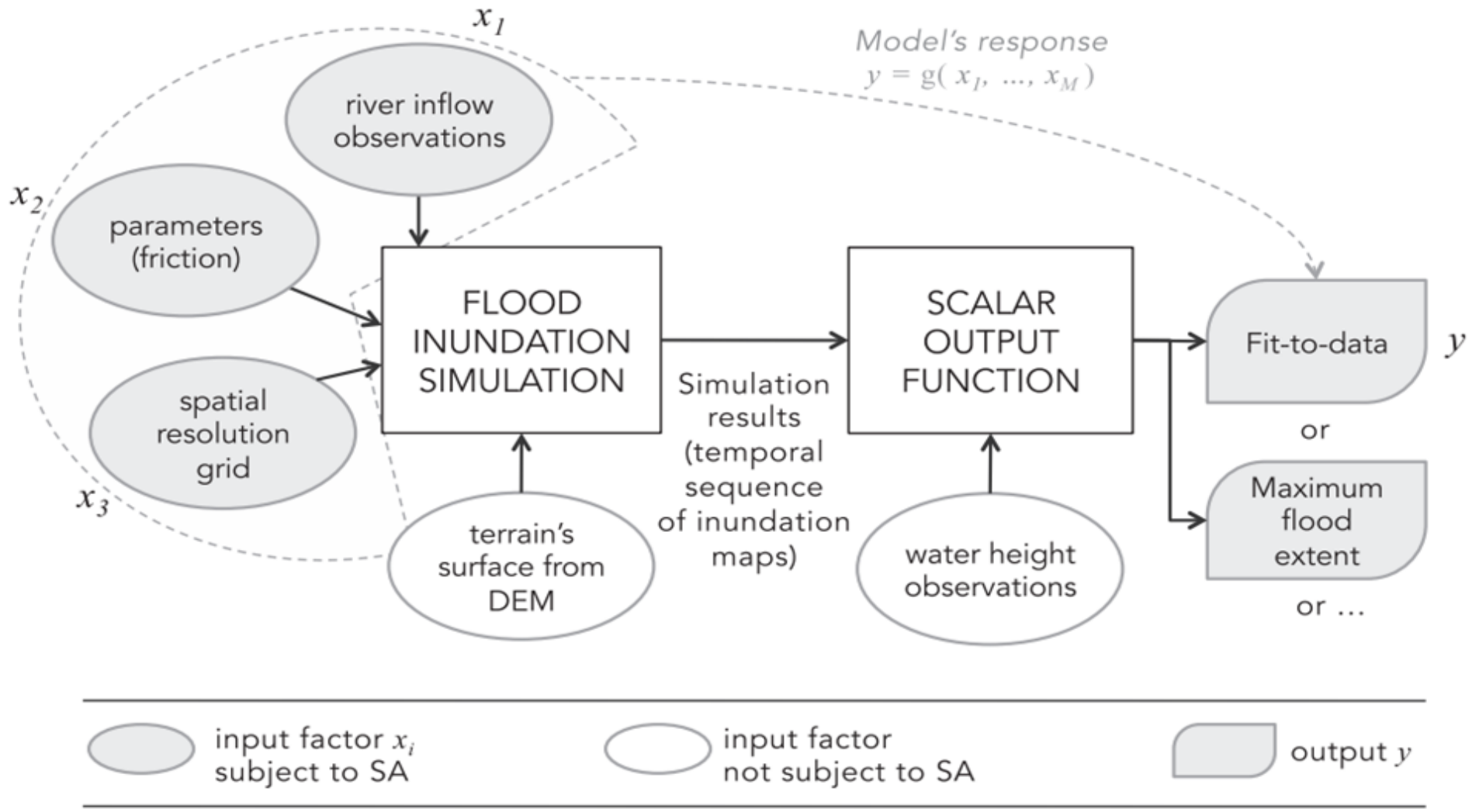


Fig. 1. Example of input factors and output definition for the SA of a (dynamic) flood inundation model.

Typical questions addressed by Sensitivity Analysis

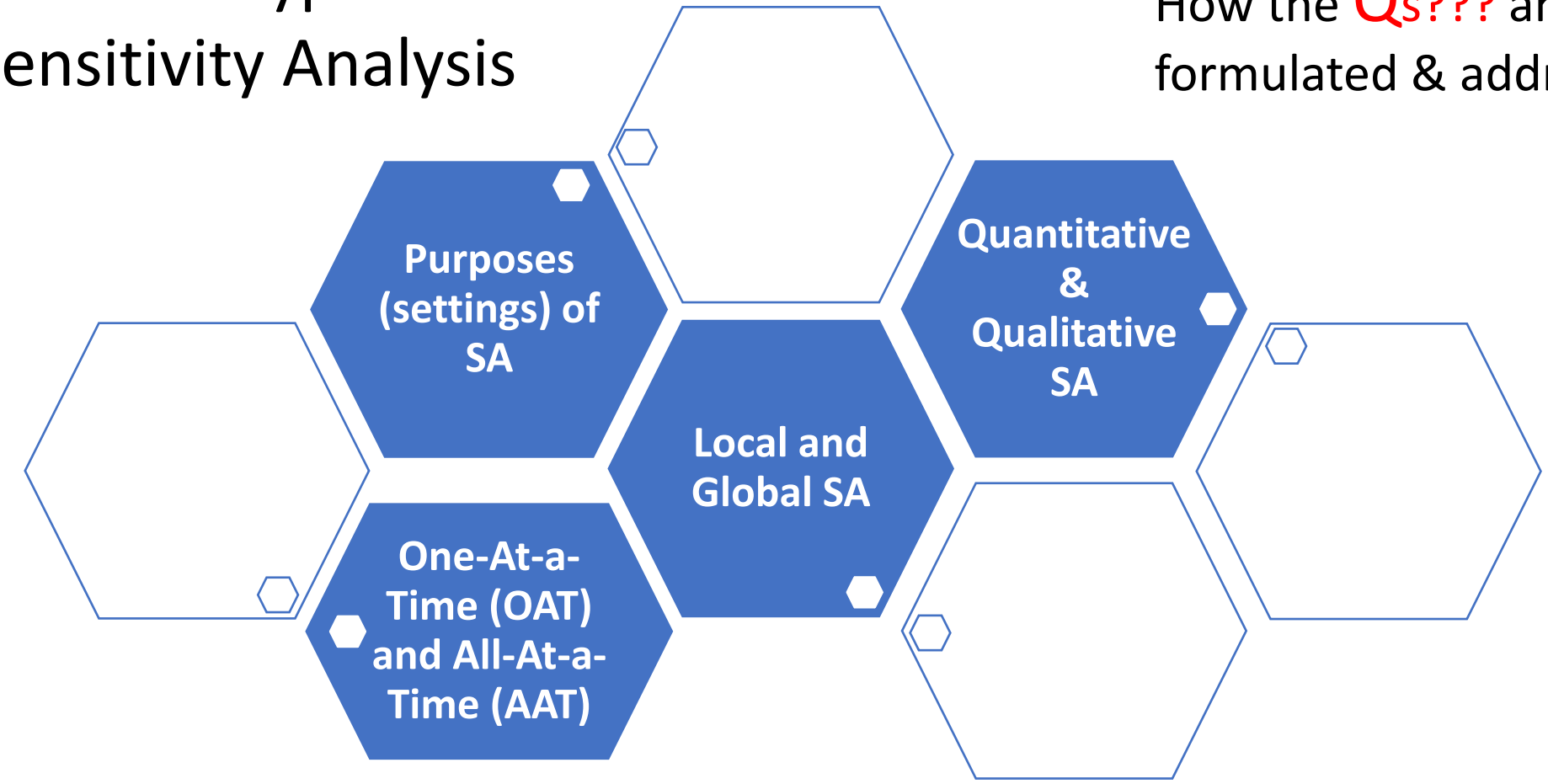
What input factors cause the **largest** variation in the output?

Is there any factor whose variability has a negligible effect on the output?

Are there interactions that amplify or dampen the variability induced by individual factors?

Different types of Sensitivity Analysis

How the Qs??? are formulated & addressed



Three purposes (or 'settings'

Ranking (or Factor Priorization) aims at generating the ranking of the input factors x_1, x_2,…, x_M according to their relative contribution to the output variability.

Screening (or Factor Fixing) aims at identifying the input factors, if any, which have a negligible influence on the output variability.

Mapping aims at determining the region of the input variability space that produces significant, e.g. extreme, output values.

Other SA settings

- direction (or sign) of change
- presence of interactions between input factors

SA and uncertainty analysis

SA and model calibration

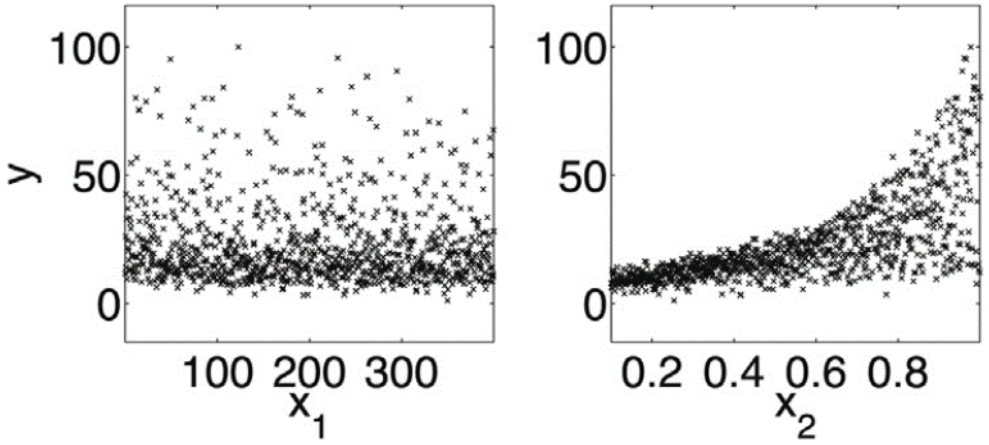
SA is closely connected to the process of model calibration

SA and model diagnostic evaluation

SA, dominant controls analysis & robust decision-making

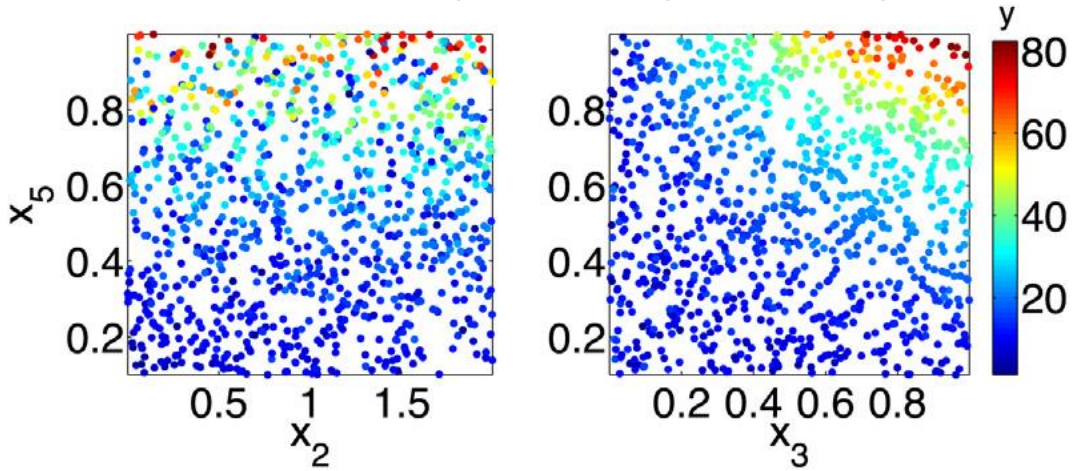
Examples of Visualization tools for global SA

Visualize input/output samples



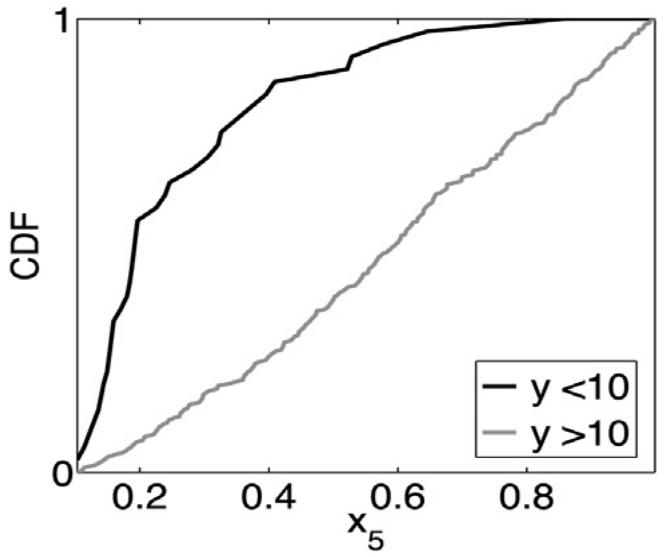
Scatter plots (or **dotty plots**): Uniformly scattered points (L): low sensitivity (to x_1 here); emergence of patterns (R): high sensitivity. Useful for screening and ranking.

Visualize input/output samples



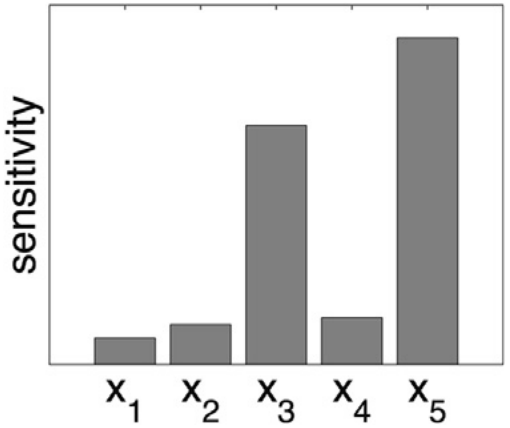
Coloured scatter plots: Useful to detect interactions, which are highlighted by the emergence of colour patterns (R).

Regional Sensitivity Analysis



Empirical cumulative distribution function of the input samples associated with output values above/below a given threshold. One plot per input factor. The larger the distance between the two distribution functions, the more influential the factor. This plot can be also used to determine sub-ranges of the input factor that have no influence on the output above/below the threshold: these are the sub-ranges where the distribution functions are either zero or one (e.g. x5 > 0:8 for y>10 in this example). Useful for ranking and mapping

Visualize sensitivity indices



Bar plot. Value of sensitivity index for different input factors.

OBJECTIVE

Federal Democratic Republic of Ethiopia

Ministry of Health

Vulnerability and Adaptation Assessment of Health to Climate Change in Ethiopia

Major Objective: To assess **vulnerability** of population and the health system in Ethiopia to the impacts of climate related risks and weather variability, and in response, develop appropriate national health adaptation strategies.

- **Specific Objectives**:
  - Define level and distribution of vulnerability
  - Determine the **association** between climate change and priority health issues (nutrition, vector-borne diseases, disasters, occupational health and water related diseases).

Ethiopia's V&A Report (2015)

Vulnerability factors: Table, next page (Ethiopia's V&A Report 2015)

Vulnerability factors, health determinants, profiles, and indicators used for HVI analysis using the IPCC framework. (Ethiopia, MoH, V&A, 2015)

Vulnerability	Health Determinants	Profiles	Indicators	Unit of Measurements
Exposure	**Climate**	**1.Climate**	Change in temperature	Changes over time, oC
			Change in precipitation	Changes over time, mm
		2.Hazard	Occurrence of Extreme events (drought, Flooding)	# of population supported with PSPN
				# of events & affected population over the last 20 years
Sensitivity	**Natural capital**	**3.Ecosystem**	Suitability of the area for the CSDs	% of the area prevalent to the CS health issues
		4.Demography	proportion of population who are vulnerable	% of young children, women & elderly, exposed workforce
				% HHs in the exposed area
Adaptive capacity	**Financial capital**	**5.Wealth**	Health care financing	wealth profile
				Per capita govt. expenditure on health
				% Budget of national budget allocated to health
	Physical Capital	**6.Technology & Medicine**	Critical systems, infrastructure & equipment safety	Status of health facility systems (electricity, Telecommunication, water supply, Waste Mgt., fuel station, medical gases, ventilation equipment & supply, & access)
		7.Infrastructure	Health care	Physical infrastructures status
				# and type of HFs
				Health coverage
				safe water coverage & trend
	Human Capital		Water & sanitation	Latrine coverage
				Physical infrastructure status; # and type of HFs; Health Coverage;
				Health care Waste Mgt
		8.Community	HR for health	Health professional (MD, Nur., Midwives midwives) proportion per population by geographic area
				# of HEWs/5K by admin unit
				# of HAD/5 HHS
		9.Social	Social Determinants of Health	Male # Education (%)
				Female # Education (%)
				Safe water coverage
				Latrine coverage (%)

DATA TYPES & SOURCES

Health data and information: health and health related indicators of the MoH

- Raw data on morbidity/mortality
  - Malaria, diarrheal diseases, meningitis, and schistosomiasis and leishmaniasis
    - Malaria data from 2004 to 2014
  - Yellow fever, dengue fever, rift valley fever, trachoma, and anthrax
- Health human resources and Infrastructure
- Ethiopia Service Provision Assessment Plus Survey 2014 (ESPA+)
  - Health, Climate and Population data were organized by region.

Climate data and information: monthly temp and rainfall raw data from EMI/NMA

- Monthly mean weather data (Tmax & Tmin; and rainfall) for 1996-2014.
  - average minimum and maximum monthly temperature, rainfall and relative humidity
  - Analyze association of some of the epidemic diseases and climate

Population data: Population data from Ethiopian Statistics Service/CSA

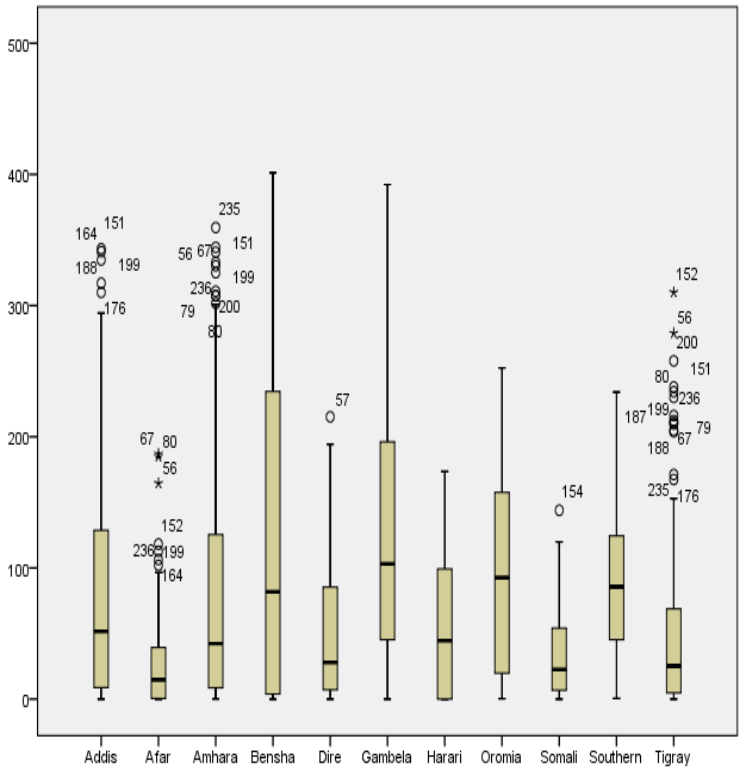
What is sensitivity analysis and why is it important for V&As?

- Limitations:
  - **Aggregated** data from different sources, which has the potential to mask evident variations within the regions especially those that are exhibiting **diverse** geographical and ecological characteristics.
    - For example, Oromia, Amhara and SNNPR have vast and heterogeneous ecological features which were aggregated in this particular analysis due to lack of evidences for the inter-regional variation.
- Lack of appropriate and quality data for disease cases

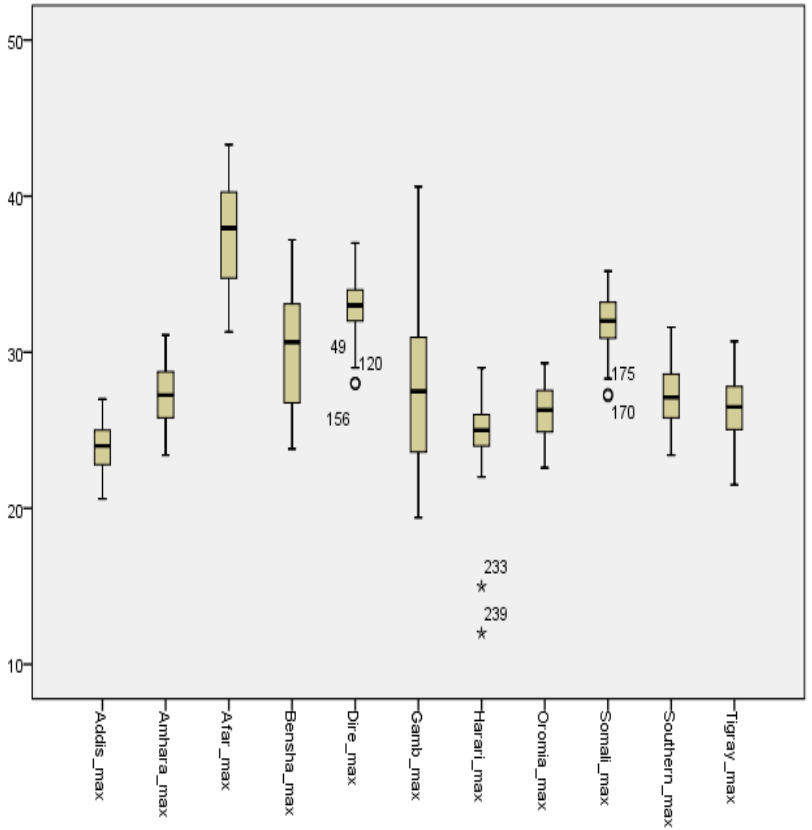
DATA MANAGEMENT, ANALYSIS & INTERPRETATION

- Data cleaning and quality control, standardization, exported to excel: Biostatistician and GIS expert
- Data were transported to excel: calculate percentages and show trends as well as differences between regions
- Descriptive: frequency, tables, box plot and time series plot was used to see the nature of the data
- Assessed the association of historical trend of rainfall and temperature with health outcomes (morbidity and mortality)
- Time Series Model fitting was done by automatic model selection (SPSS v. 20).
- Forecasting the upcoming five years, 2015-2020; fitted Generalized Linear Model (GLM), ARIMA
- Data Analysis: SPSS and ArcGIS

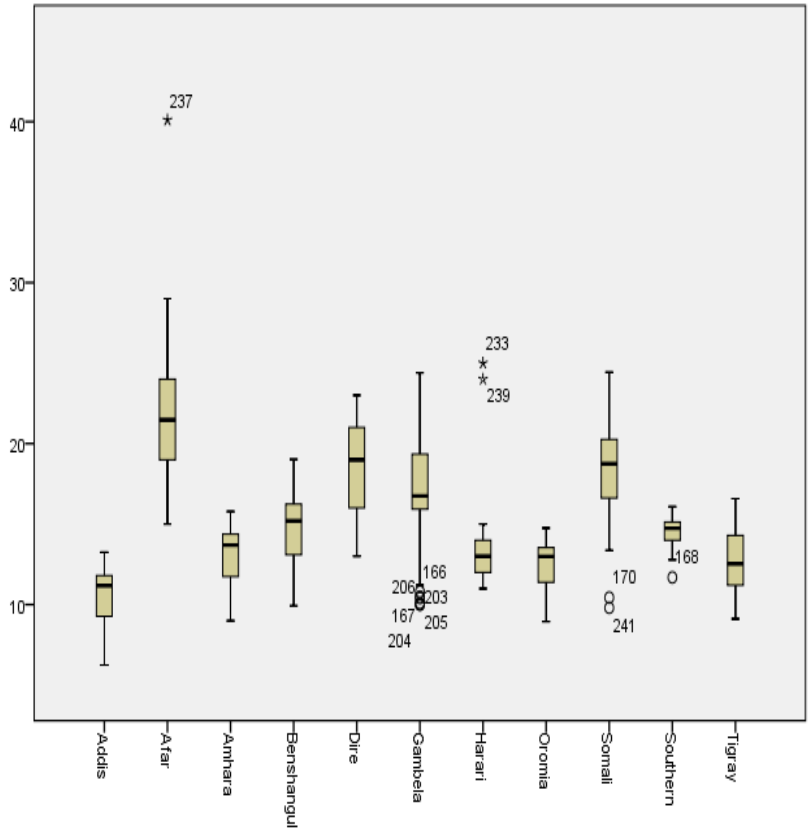
DESCRIPTIVE ANALYSIS: distribution of numerical data & skewness by displaying the data quartiles (or percentiles) and averages.



Box Plot for mean monthly rainfall (1994 – 2014) by region



Box Plot for mean monthly Max temp (1994 – 2014) by region



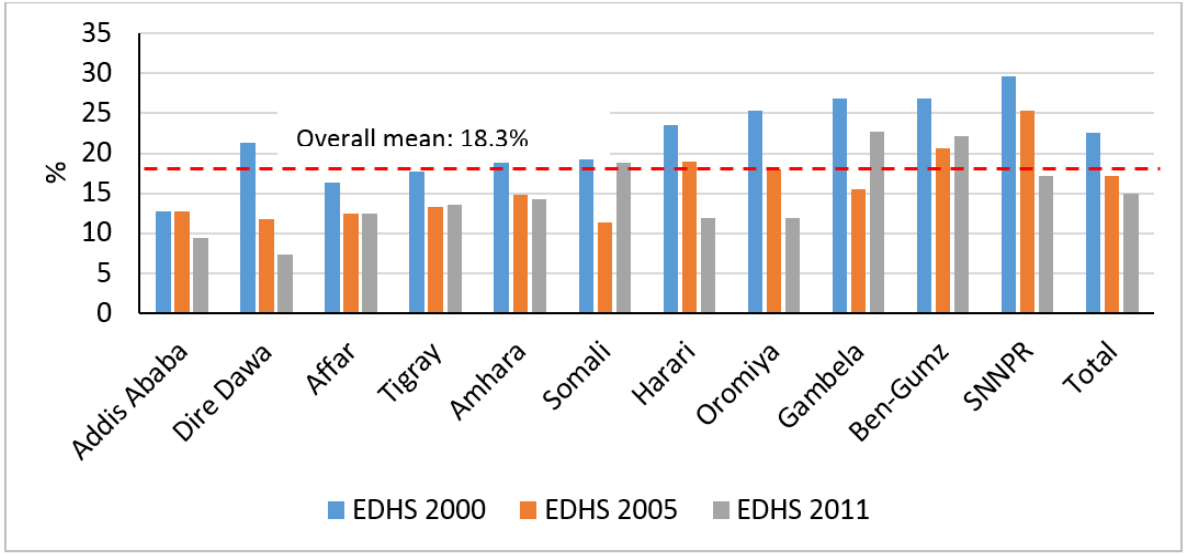
Box plot for Monthly Mean Minimum Temperature (1994 – 2014) by Region

DESCRIPTIVE ANALYSIS

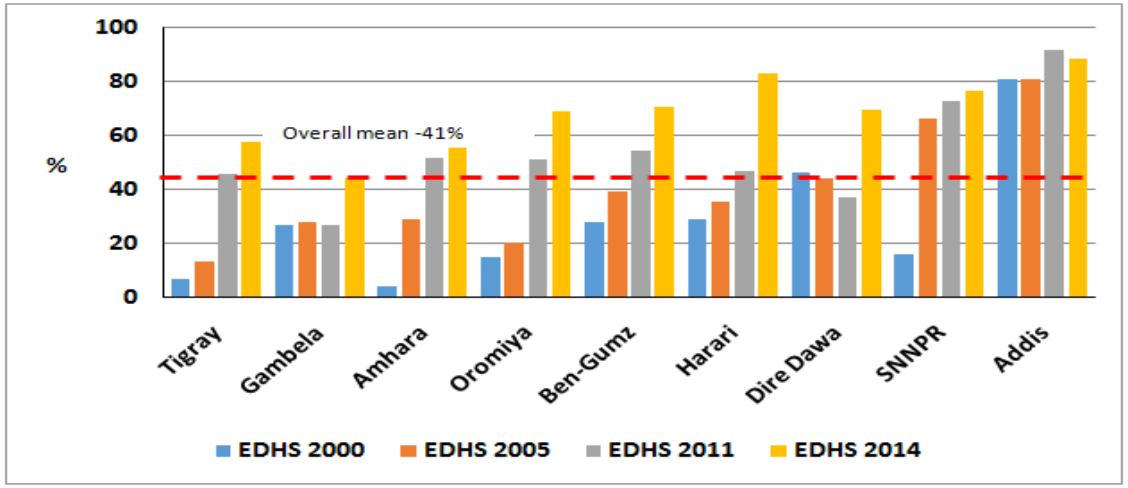
Historical events of drought, Ethiopia (1965-2010)

El Niño Years	Drought/ Famine	Regions Affected	Impact on human life and property
1965	1964-1966	Tigray and Wollo	About 1.5 million people affected
1972-1973	1973-1974	Tigray and Wollo	0.2 million people and 30% of livestock dead
	1978-79	Southern Ethiopia	1.4 million
	1982	Northern Ethiopia	2 million People affected
1982-1983	1983-1984	Ethiopia	8 million affected
1986-87	1987-1988	Ethiopia	7 million people affected
1991-92	1990-1992	North, Eastern, Southeastern Ethiopia	About 0.5 million people affected
1993	1993-94	Tigray and Wollo	7.6 People affected
2000		Ethiopia	About 10.5 million people affected
2002/2003	2002/2003		13 million people in need of food assistance
	2005-2006	Somali region	1.75 million people need food assistance
2006-2007	2007-2008	Arsi, West Arsi, and West Shoa	3.4 million people need emergency food relief
2009-2010	2009-2010	Eastern and Southern Tigray, Eastern Amhara, Eastern Oromia, Somali, SNNP, Gambella	5.2 million people require emergency food assistance

Source: Adapted from MDGs Country Draft Report, 2010.



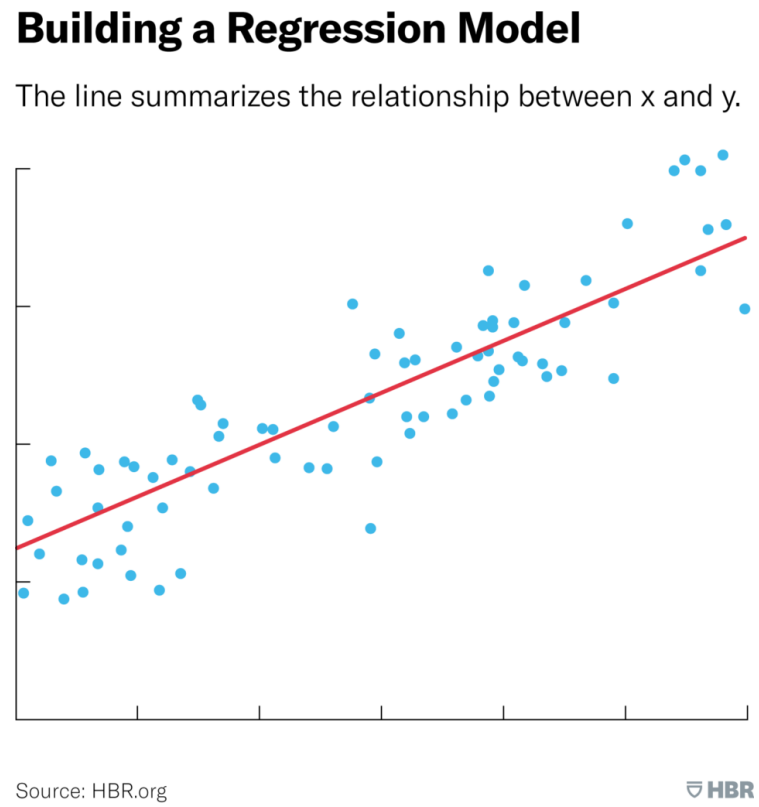
Prevalence of diarrhea among under-five children by Region, Ethiopia, (EDHS 2000, 2005, 2011)



Percent distribution of access to sanitation by Region, EDHS 200-2014

Association of climate change and health outcomes: Regression analysis

- Regression analysis is a way of mathematically sorting out which of those variables does indeed have an impact.
- It answers the questions:
  - Which factors matter most?
  - Which can we ignore?
  - How do those factors interact with one another?
  - And, perhaps most important, how certain are we about all these factors?
- *dependent variable* — the main factor that you're trying to understand or predict
- *independent variables*— the factors you suspect have an impact on your dependent variable.



Association of climate change and diarrhea

- The association between rainfall and diarrhea was negative in Afar and Dire Dawa. There was about **7.6%** and **6.3%** decline of diarrhea for every 1 mm of rainfall in Afar and Dire Dawa, respectively.
- Declining rainfall in either absolute amount or in frequency is very much related to shortage of water that can be used for proper hygiene and sanitation at household level.
- Perhaps, the amount of water at household level in Afar and Dire Dawa might have been a factor for the increasing trend of diarrhea.

Region	Rainfall	Relative humidity	Max temperature	Min temperature
	Rate Ratios (95%CI)	Rate Ratios (95%CI)	Rate Ratios (95%CI)	Rate Ratios (95%CI)
Addis Ababa	1.042 (1.041, 1.042)*	0.845 (0.843, 0.847)*	2.855 (2.781, 2.931)*	6.291 (6.158,6.426)*
Amhara	1.020 (1.020, 1.021)*	-	0.543 (0.539, 0.548)*	1.414 (1.401,1.438)*
Afar	0.924 (0.921,0.927)*	1.023 (1.019,1.027)*	1.202 (1.16,1.246)*	1.287 (1.278,1.295)*
Benishangul_G	-	0.927 (0.925,0.929)*	0.817 (0.800,0.835)	-
DireDawa	0.937 (0.934,0.939)*	1.267 (1.254,1.281)*	0.687 (0.659,0.717)*	0.267 (0.257, 0.277)*
Gambella	1.004 (1.004,1.0041)	-	1.068 (1.066, 1.070)	0.92 (0.968,0.975)*
Harari	0.992 (0.991,0.993)*	0.889 (0.885,0.894)*	0.705 (0.687,0.723)*	0.634 (0.620,0.648)*
Oromia	1.032 (1.031.1.032)*	0.825 (0.824, 0.826)*	-	1.129 (1.120,1.139)*
SNNPR	1.059 (1.059, 1.060)	0.966 (0.965, 0.966)	3.547 (3.515, 3.579)*	-
Somali	1.032 (1.031,1.033)*	0.845 (0.842, 0.847)*	0.979 (0.963, 0.995)**	1.204 (1.188, 1.220)*
Tigray	-	0.992 (0.991,0.994)*	0.825 (0.812,0.838)*	1.497 (1.472,1.523)*

*p<0.0001; **p<0.001

Health Vulnerability Index

- **Vulnerability Index** measures a country's **exposure**, **sensitivity** and **ability to adapt** to the impact of climate change.

Ethiopia's 2015 V&A Report

- The final vulnerability indexes for the regions have been calculated by combining all the three components of exposure, sensitivity and adaptive capacity.
- The results produce measures of exposure, sensitivity, and adaptive capacity, which all differ systematically across regions.

Region	Exposure	Sensitivity	Adaptive Capacity	HVI
Addis Ababa	0.120	0.230	0.650	-0.122
Afar	0.450	0.930	0.240	0.195
Amhara	0.260	0.720	0.377	-0.084
Ben-Gum	0.640	0.800	0.365	0.220
Dire Dawa	0.180	0.680	0.543	-0.247
Gambella	0.690	0.870	0.369	0.279
Harari	0.360	0.740	0.650	-0.215
Oromia	0.130	0.740	0.328	-0.147
SNNPR	0.430	0.800	0.389	0.033
Somali	0.510	0.830	0.208	0.251
Tigray	0.290	0.800	0.410	-0.096
Average	0.369	0.740	0.412	0.006
Max	0.690	0.930	0.650	0.279
Min	0.120	0.230	0.208	-0.247

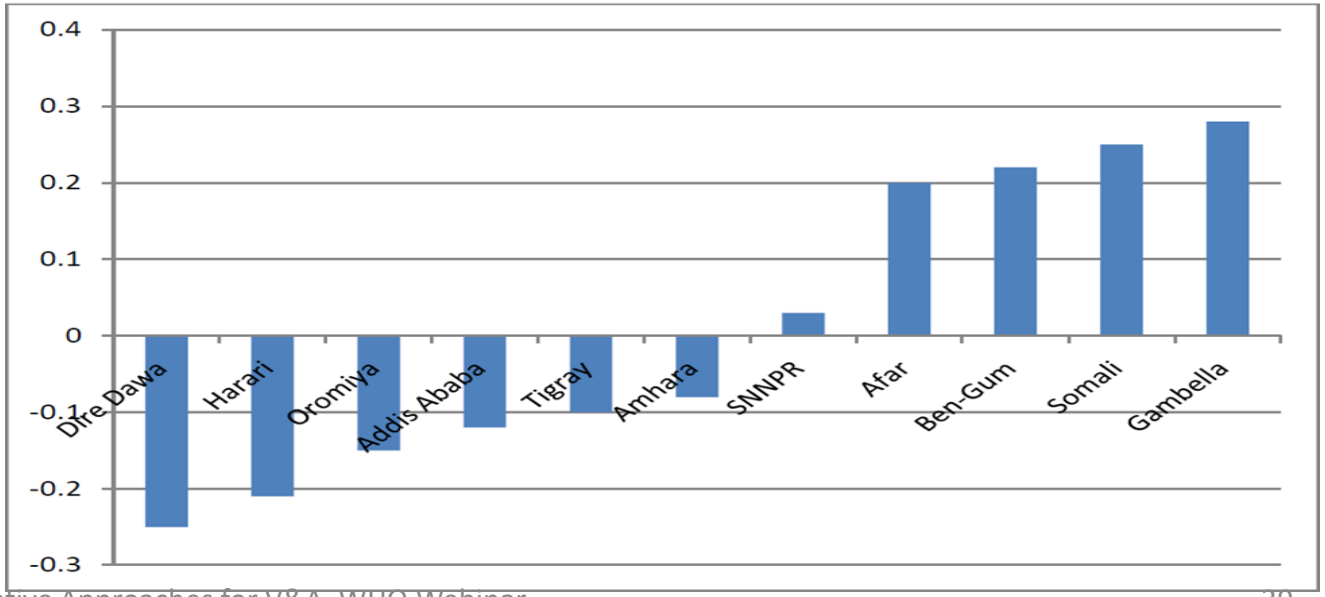
Vulnerability baseline: Calculating the HVI

- Because each of the sub-components is measured on a different scale, it was first necessary to standardize each as an index to a common scale.
- Standardized/conversion using Human Development Index to calculate the life expectancy index, which is the ratio of the difference of the actual life expectancy and a pre-selected minimum, and the range of predetermined maximum and minimum life expectancy (UNDP, 2008).

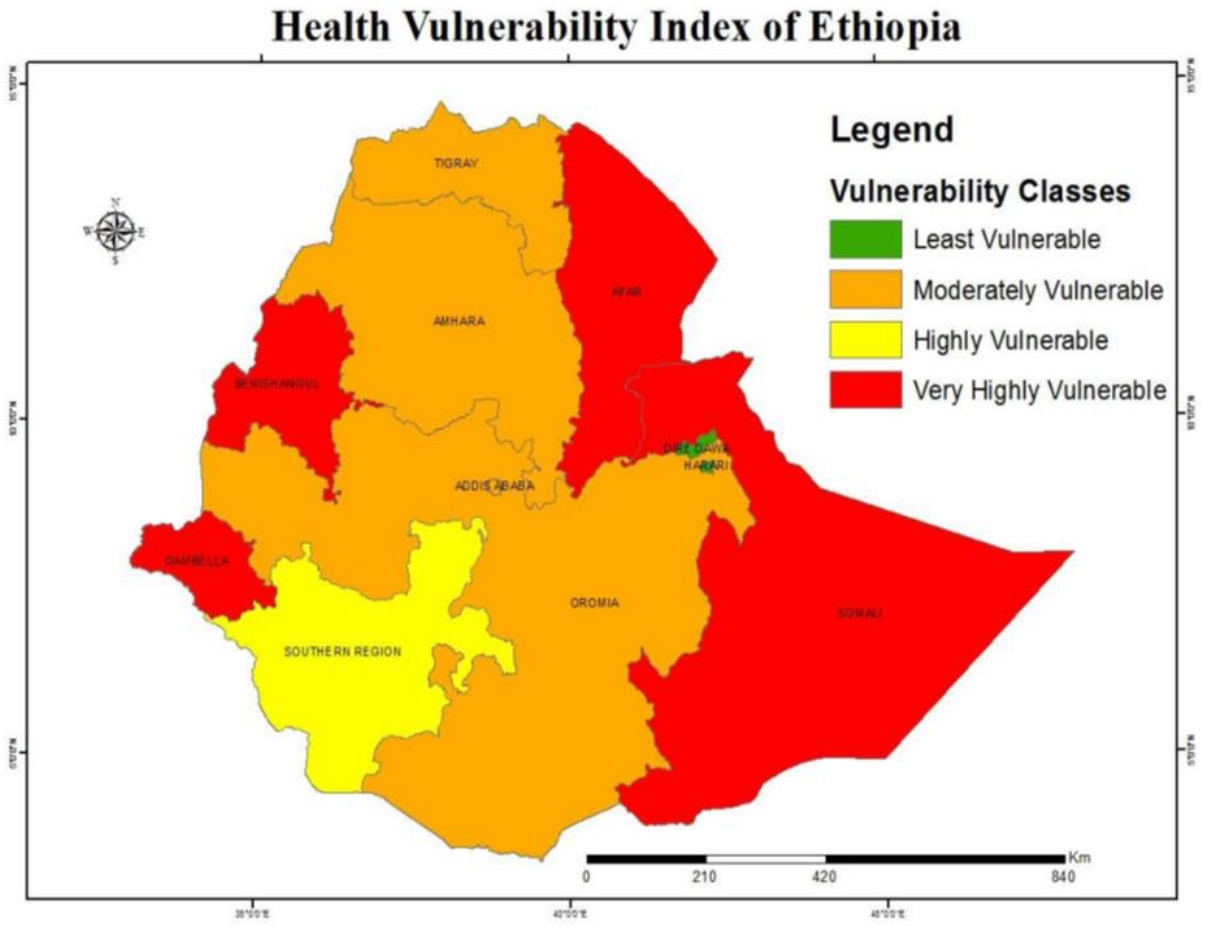
What is the benefit of having a Health Vulnerability Index in the context of a V&A?

- Estimating HVI concluded
  - 0.6 % (Harari and Dire Dawa): least vulnerable to CSDs.
  - 49.95 % (Oromia, Addis Ababa, Amhara and Tigrai): moderately vulnerable
  - 10.35% (SNNP): highly vulnerable,
  - 39.5 % (Afar, B-Gumuz, Somali and Gambella): very high relative vulnerability.

vulnerability classes	Regions	Area coverage (KM2)/%		Population (mlns)/%	
Least Vulnerable	Dire Dawa and Harari	1901	0.6	0.635	0.74
Moderately Vulnerable	Oromia, Addis Ababa, Amhara andTigrai	565875	49.95	59.562	69.48
Highly Vulnerable	SNNP	117263	10.35	17.403	20.3
Very HighlyVulnerable	Afar, Benishangul-Gumuz, Somali and Gambella	447855	39.95	8.129	9.48

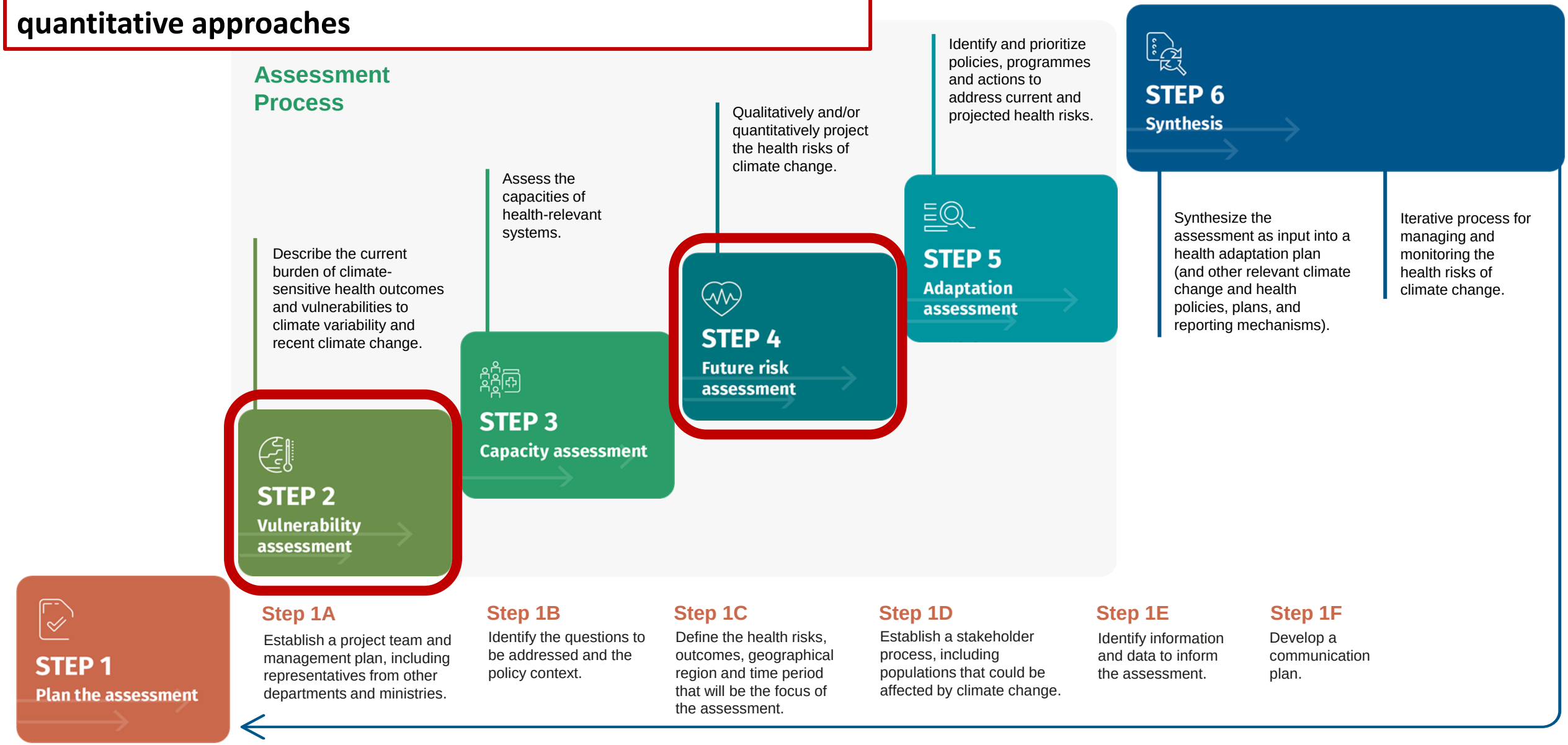


What is the benefit of having a Health Vulnerability Index in the context of a V&A?



- Developing its own adaptation strategies
- Coping capacity describes what could be implemented now to minimize negative effects of climate variability and change.
- Increasing the adaptive capacity of a population – increasing the ability of countries, communities and individuals to effectively and efficiently cope with the changes and challenges of climate change.

Most relevant steps in the V&A assessment for using quantitative approaches



Quantitatively and/or qualitatively project the health risks of climate change

Describe how current health risks could change under diverse scenarios of climate change and development.

Estimate the possible additional burden of adverse health outcomes due to climate change.

Scenarios are used to explore possible futures

Scenarios are composed of:

Pathways of GHG emissions

Development Pathways

Pathways of mitigation policies

Projections of health risks generally rely on combining:

Pathways of greenhouse gas emissions (RCPs)

+

Development pathways (shared socioeconomic pathways)

Projecting future health risks of climate change: Time series analysis

What is Time Series Analysis?

- Time series analysis is a statistical method used to analyze a sequence of data points collected over regular time intervals.
  - Time as the independent variable
- TSA aims to identify trends, seasonal patterns, and other underlying structures to make forecasts and informed decisions based on the temporal data.

Significance of Time Series

- Analyzing the historical dataset and its patterns
- Understanding and matching the current situation with patterns derived from the previous stage.
- Understanding the factor or factors influencing certain variable(s) in different periods.

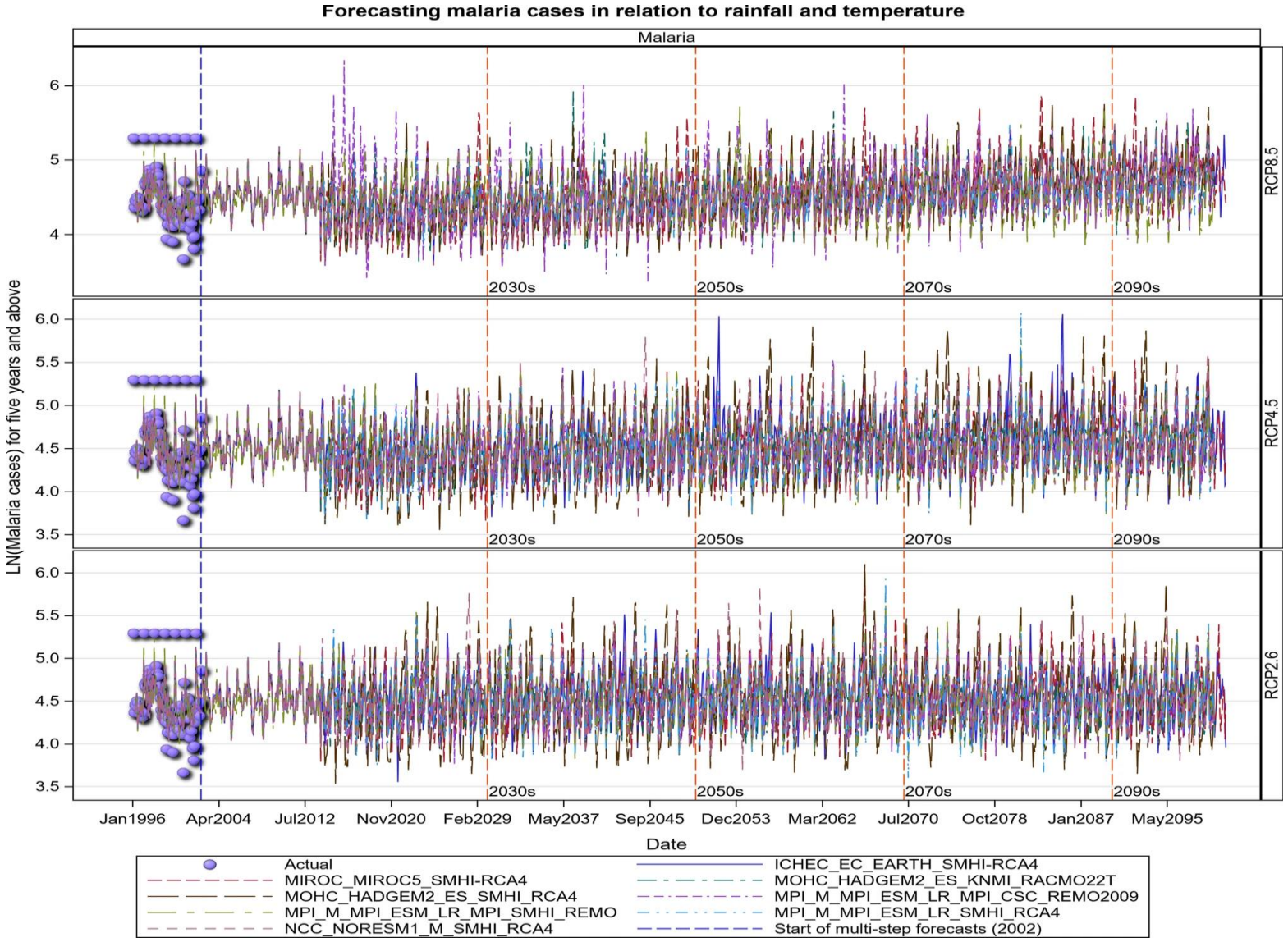
Projecting future health risks of climate change: Time series analysis

Limitations of Time Series Analysis?

Be careful of below-mentioned limitations during the data analysis.

- Similar to other models, the missing values are not supported by TSA
- The data points must be linear in their relationship
- Data transformations are mandatory, so they are a little expensive.
- Models mostly work on Uni-variate data.

Forecasting the Potential Effects of Climate Change on Malaria in the Lake Victoria Basin Using Regionalized Climate Projections



Malaria cases among 5-year old's and above projected for Muleba hospital, Tanzania, for the period 2006–2100 under the RCP2.6, RCP4.5 and RCP8.5 scenarios, using an ensemble of 8 General Circulation Models

Country experience: Quantitative approaches in V&As

Prof Genito Maure
Eduardo Mondlane University Mozambique

World Health Organization

Quantitative Approaches for Vulnerability Adaptation Assessment

Ministério da Saúde
Direcção Nacional de Saúde Pública

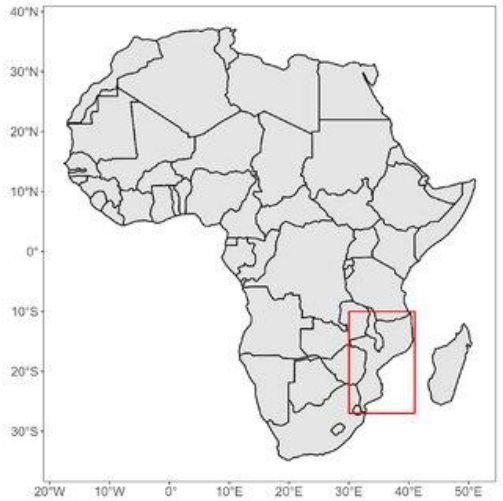
INSTITUTO NACIONAL DE SAÚDE
MOÇAMBIQUE

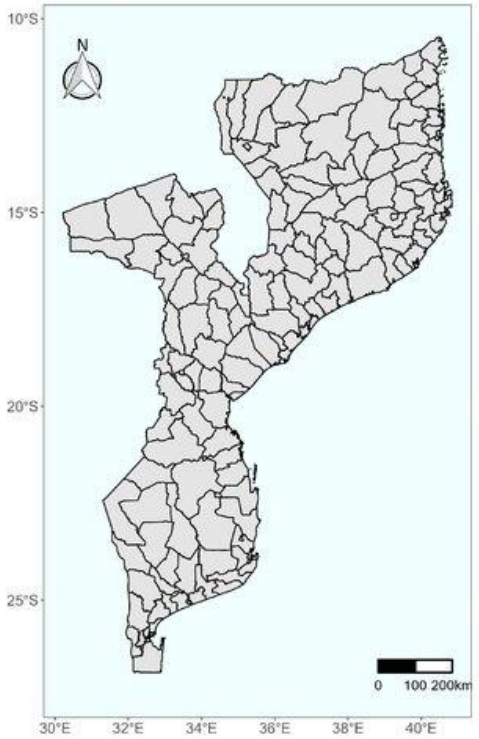
World Health Organization

UNIVERSIDADE
EDUARDO
MONDLANE

Genito Maure, PhD | genito.maure@uem.ac.mz
UEM - Faculty of Sciences

1. Justification



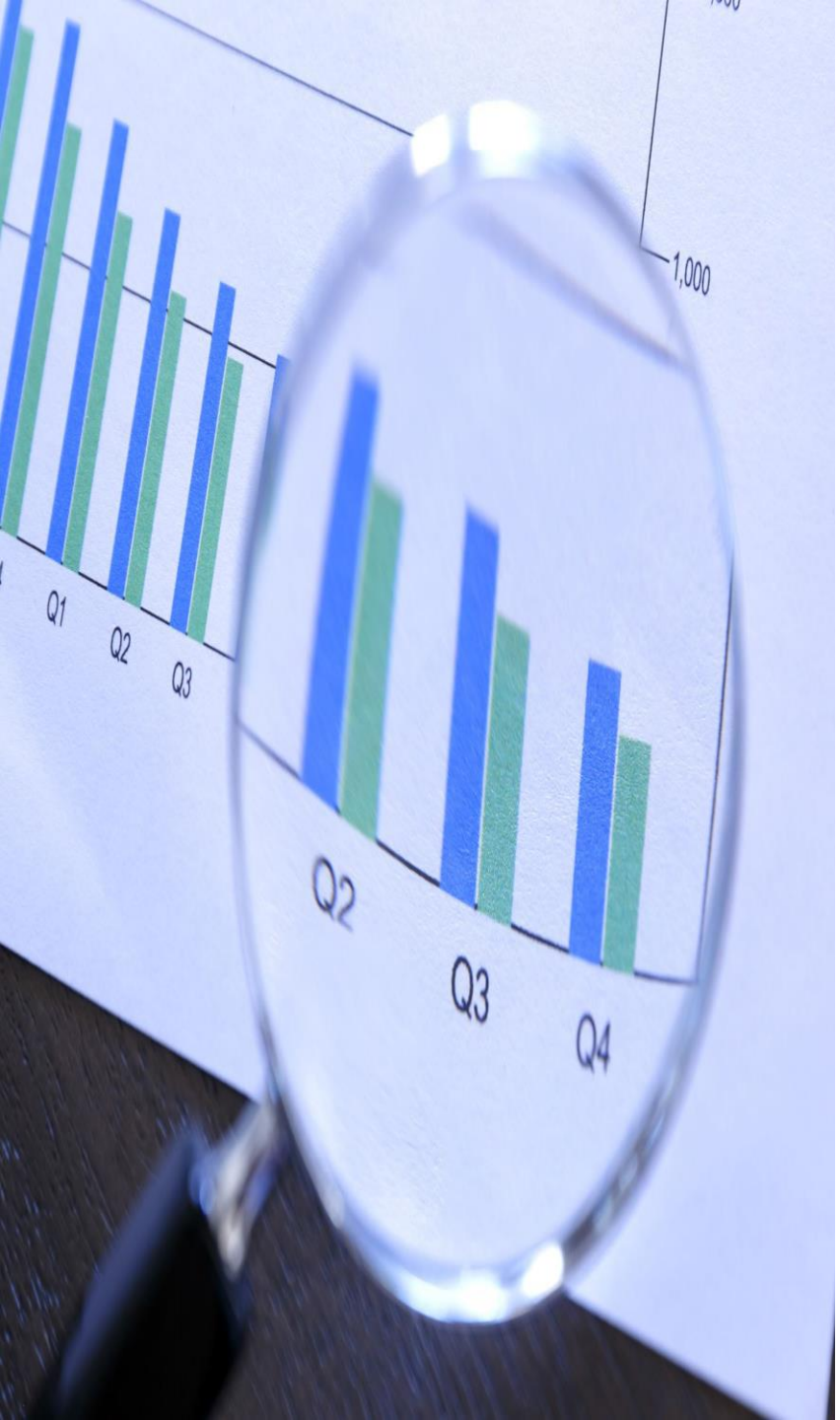


Due to its geographical location, **Mozambique** is **highly vulnerable** to the adverse impacts of Climate Change (CC) and variabilty.

The **burden of disease** in the country is **dominated** by communicable diseases, especially some c**limate-sensitive diseases** such as malaria, diarrhoea, and cholera.

Climate projections indicate that Mozambique will experience an **increase in temperatures**, a **delay** in onset of the rainy season, and an **increase** in the **frequency and intensity of extreme weather events**, which will bring additional pressure and challenges to the health sector.

The country has adhered to several international commitments, among them is to produce the **National Health Adaptation Plan to Climate Change** (HNAP).



2. Objectives

2.1. General Objective:

- Assess the vulnerability and adaptation needs of the health sector to climate change in Mozambique to provide a scientific baseline for the development of the National Health Adaptation Plan (HNAP).

2.2. Specific Objectives:

- Develop a sustainable methodology for assessing and monitoring the vulnerability of the health sector to climate change in Mozambique through the Health Vulnerability Index (HVI).
- Identify the geographical areas most vulnerable to climate change in Mozambique in the health sector using the HVI.
- Conduct a qualitative assessment of the impact of climate change on two emerging diseases: dengue and chikungunya.
- Propose recommendations to strengthen the health system's preparedness to respond to the impacts of climate change.
- Identify research needs and information gaps.

3. Methodology

- Recommended Methodology by the WHO for Determining the Health Vulnerability Index (HVI) and quantification for each district of the country - first time in Mozambique.
- Vulnerability is defined according to three parameters (IPPC, 2007):
  - **Exposure** (E): The magnitude of the rate of change of climatic parameters over time, and the occurrence and frequency of extreme climatic events.
  - **Sensitivity** (S): The degree to which the natural and social systems on which the population's health status depends are sensitive to climatic changes.
  - **Adaptive Capacity** (CA): The set of institutional and social skills and resources that enhance the ability to adapt to climatic variation over time and to extreme events.

$$HVI = (E\text{-}CA)xS$$

3. Methodology (Cont.)
Components and indicators

Sub-indices	Components	Indicators
Exposure	1. Changes in Temperature, Precipitation, and Relative Humidity	Changes in mean temperatura 1979-2016
		Change in annual mean precipitation 1979-2016
		Change in average relative humidity 1979-2016
	2. Occurrence of Extreme Events: Droughts, Floods, and Cyclones	# of extreme drought events 1979-2019
		# of extreme flood events 1979-2019
		# of extreme cyclone events 1979-2019
Sensitivity	3. Ecosystem / Geography - Risks	Occurrences of cholera outbreaks
		Occurrence of food insecurity episodes
	4. Demographics and Vulnerable Population	Population density
		Children aged 0-4 in the total population
		Children aged 5-15 in the total population
		Women in the total population
		Elderly (over 60 years old) in the total population
	5. Proportion of the Vulnerable Population due to Health Conditions	HIV positivity rate
		Rate of all forms of reported TB cases
		# of cases of moderate and severe acute malnutrition
		# of reported malaria cases
		# of reported diarrheal diseases cases

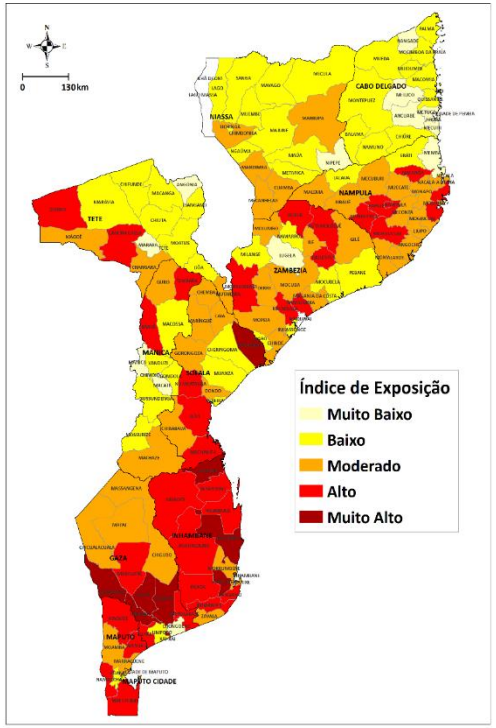
3. Methodology (Cont.)

Components and indicators

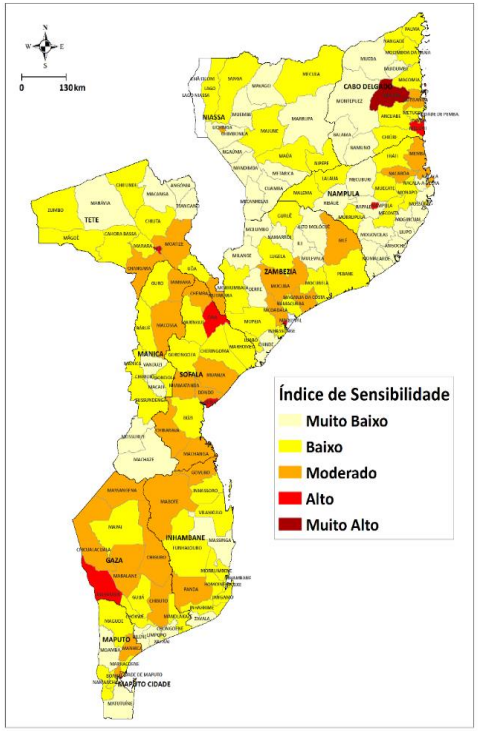
Sub-indices	Components	Indicators
Adaptive Capacity	6. Financial Resources	Per capita expenditure on public sector health
	7. Access to Health Services	Number of inhabitants per health unit
		Percentage of the population living within the coverage radius of a health unit
	8. Health Human Resources	Medical staff per 100,000 inhabitants
		Nursing staff per 100,000 inhabitants
		Maternal and Child Health (SMI) obstetric staff per 100,000 inhabitants
		Number of inhabitants per Community Health Worker (APE)
	9. Water and Sanitation	Percentage of the population with access to safe water sources
		Percentage of the population with access to safe latrines
	10. Social Determinants of Health	Literacy rate, women
		Percentage of women with complete primary education
		Percentage of women with complete secondary education
		Literacy rate, men
		Percentage of men with complete primary education
		Percentage of men with complete secondary education
		Expenditure per household

4. Results

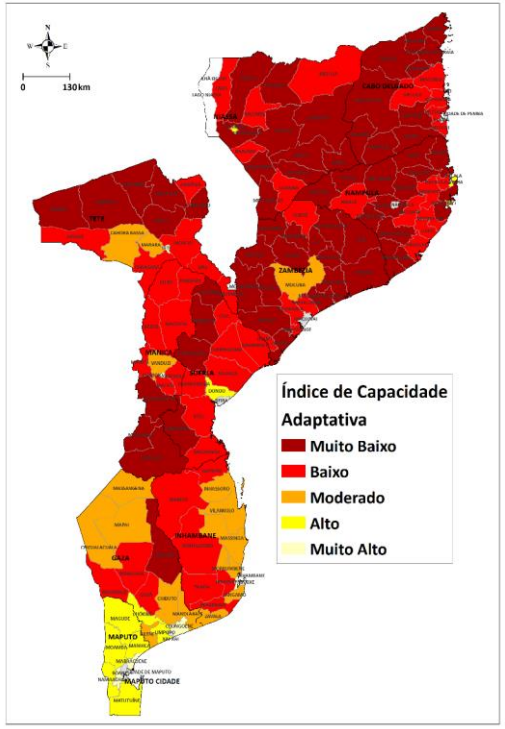
Exposure, Sensitivity and Adaptive Capacity



- **High to very high in 42** districts (27.6% territory; 25.6% population)
- **Southern region** exposed to cyclones, droughts, floods
- 8/9 most exposed districts are in Gaza and Inhambane



- **High to very high in 12** districts (2.3% territory, 10% population)



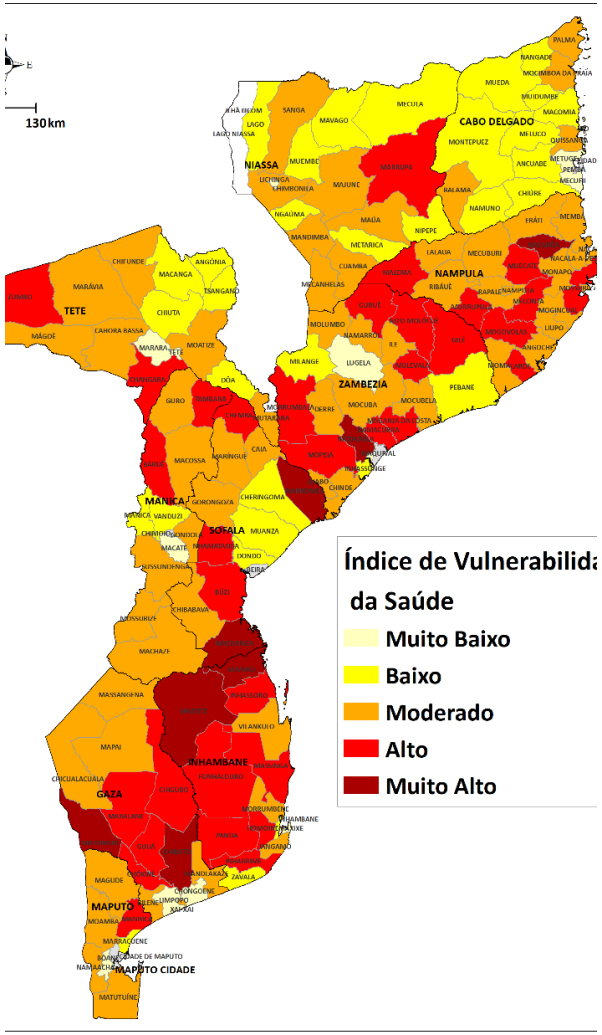
- **Low to very low in 113** districts (83.5% territory; 65.5% population)
- **High urban/rural inequity.** All urban districts have high/very high AC.
- **Worst performance: *WASH*** Access to Health Services components

4.4. Health Vulnerability Index (HVI)

- **High to very high** HVI in **42** districts (**31.8%** territory, **24.1%** population).

- **Eight (8) districts with very high HVI** (from highest):
    - Govuro
    - Massingir
    - Marromeu
    - Machanga
    - Nacaroa
    - Mabote
    - Chibuto
    - Nicoadala

- **15 of the 20 least vulnerable districts are urban (75%)**



5. Conclusions

Exposure: The Southern region of the country is simultaneously exposed to three extreme climatic events (cyclones, droughts and floods).

Sensitivity: high or very high in 12 districts (2.3% territory, 10% population), including **urban districts** in the cities of **Maputo**, **Beira**, **Nampula**, **Quelimane**, and **Tete**.

Adaptive Capacity: Generalised low to very low Adaptive Capacity (83.5% territory, 65.5% population)

- Large urban/rural inequity. Urban areas have higher AC
- AC is r**elatively higher in the south** and **lower in the northern** half of the country (Zambézia, Tete, Nampula, Cabo Delgado, and Niassa).
- Of the five (5) components of the AC Index, WASH to Health Services have the **worst performance** – *These components are highly sentitive to **Cyclones***

5. Conclusions

HVI: Mimics the behaviour of AC and updated index maps can be used for **planning**, **preparation**, and **allocation** of specific **resources** for each event by district and by component.

An **objective** and scientific **baseline** for the **development** of the **National Adaptation Plan** for the Health Sector (HNAP) to climate change is established.

6. Limitations of the Methodology

- Mostly related to the **existence**, **availability**, and **quality** of data:
  - **Poor coverage** of the national **meteorological** network and discontinuities in the historical series of climate data.
  - **Lack of systematic recording**/specific **reports** of **extreme events**, and classification according to **magnitude**.
  - **District** data from the 2017 INE census not available (for some indicators, data from the 2007 census were used).
  - **WASH data** from DNAAS not available at the district level.
  - **Limited flexibility** in **sharing sectoral data**, reports, and information in the contacted institutions
  - Non-existence of a single database integrating MB and SIS-MA.

7. Recommendations

Use the HVI methodology as a foundation for a **sustainable** model of assessment and monitoring of vulnerability to climate change in the health sector in Mozambique, and **build the capacity for it to be regularly updated.**

Ensure cross-sector integration and utilization of the Vulnerability Assessment in internal planning processes (PESS, PES, Programs, Contingency Plans, etc.), and in the allocation of health resources

Use this study as a basis for the H-NAP.

Ensure **data integration** from Modulo-Basico to SIS-MA, to allow better analysis

Develop a **contingency plan** for the health sector to respond to disasters, including SOP, using HVI, informed by INAM forecasts

7. Recomendations (Cont.1)

Map health infrastructures according to the type of risk

Integrate robustly epidemiological **surveillance** with climate platforms (including for emerging **emerging diseases)**

Standardise platform for data collection to ensure continuity and sustainability even under emergencies

Strengthen the entomological surveillance of arbovirus vectors. It can be linked to the activities of the PNCM to optimise resources.

7. Recomendações (Cont.2)

Integração de conteúdos programáticos de mudanças climáticas e doenças emergentes no **curriculo de de formação** de quadros técnicos da saúde, cursos de pós-graduação, cursos de curta duração sectoriais específicos, etc.

Reforçar **actividades dirigidas de formação continua e supervisão** priorizando as áreas mais vulneráveis identificadas para cada risco.

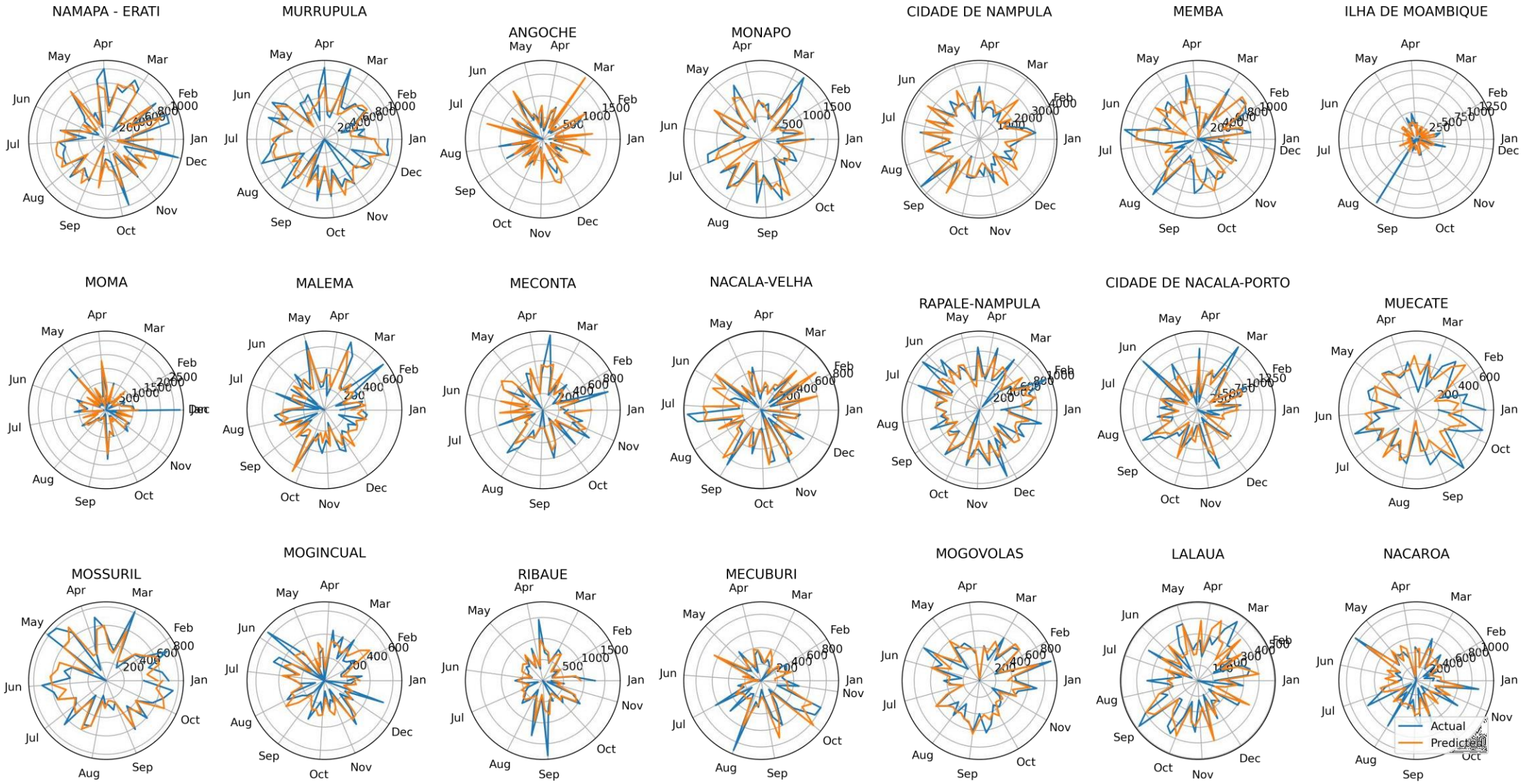
Promover **parcerias e coordenação** entre diferentes actores (governo, agências das Nacoes Unidas e de cooperação, NGOs, instituições, etc.) trabalhando na área das MC em Moçambique.

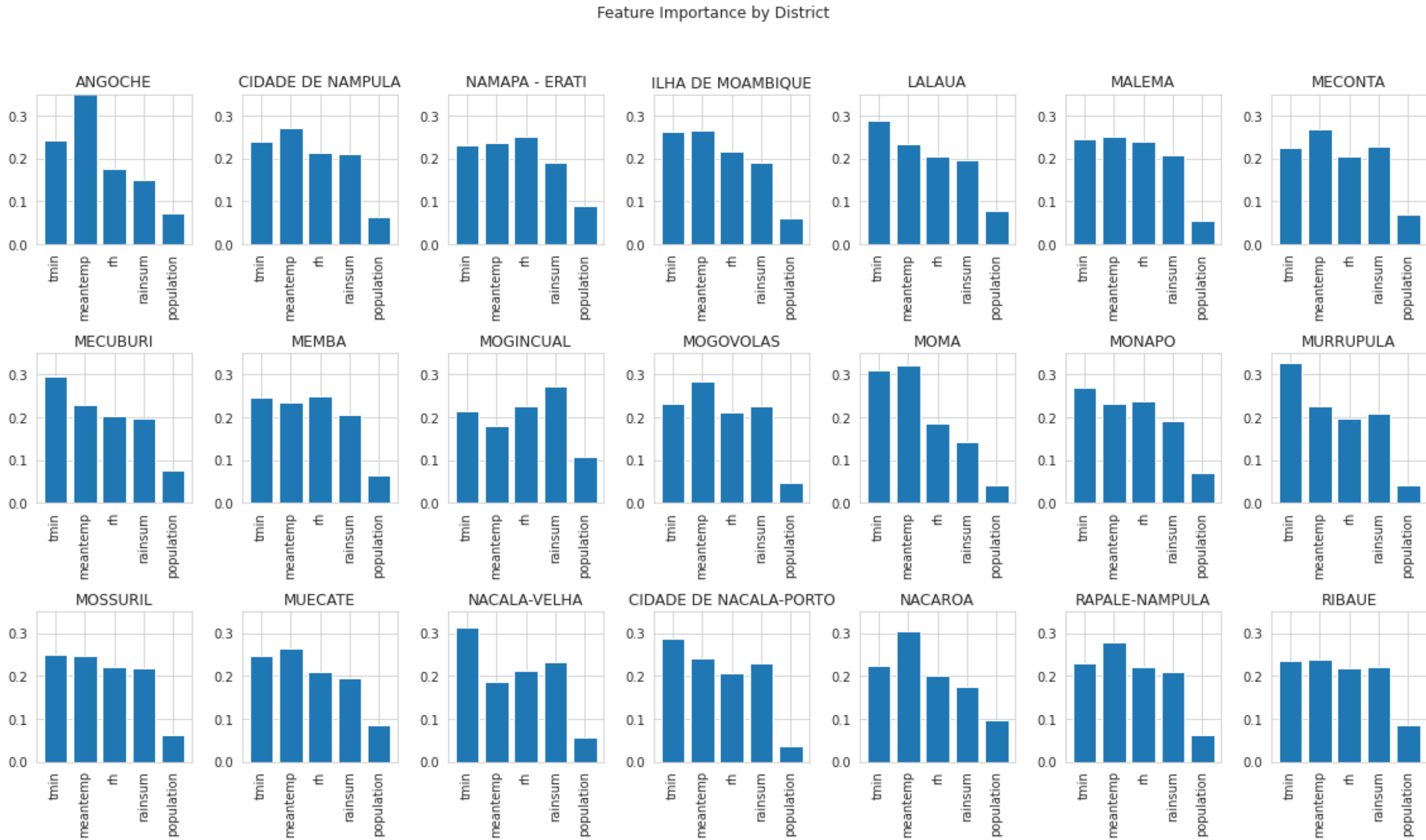
Realizar estudos acerca da vulnerabilidade da saúde a **outras componentes das MC**, tais como poluição do ar.

Realizar estudos mais aprofundados em diferentes áreas sobre dengue, chikungunya e outras **doenças emergentes**

Additional material

AI-based ability to 'mimic' observed patterns




Feature Importance by District
ANGOCHE
CIDADE DE NAMPULA
NAMAPA - ERATI
ILHA DE MOAMBIQUE
LALAUA
MALEMA
MECONTA
MECUBURI
MEMBA
MOGINCUAL
MOGOVOLAS
MOMA
MONAPO
MURRUPULA
MOSSURIL
MUECATE
NACALA-VELHA
CIDADE DE NACALA-PORTO
NACAROA
RAPALE-NAMPULA
RIBAUE
0.0
0.1
0.2
0.3
tmin
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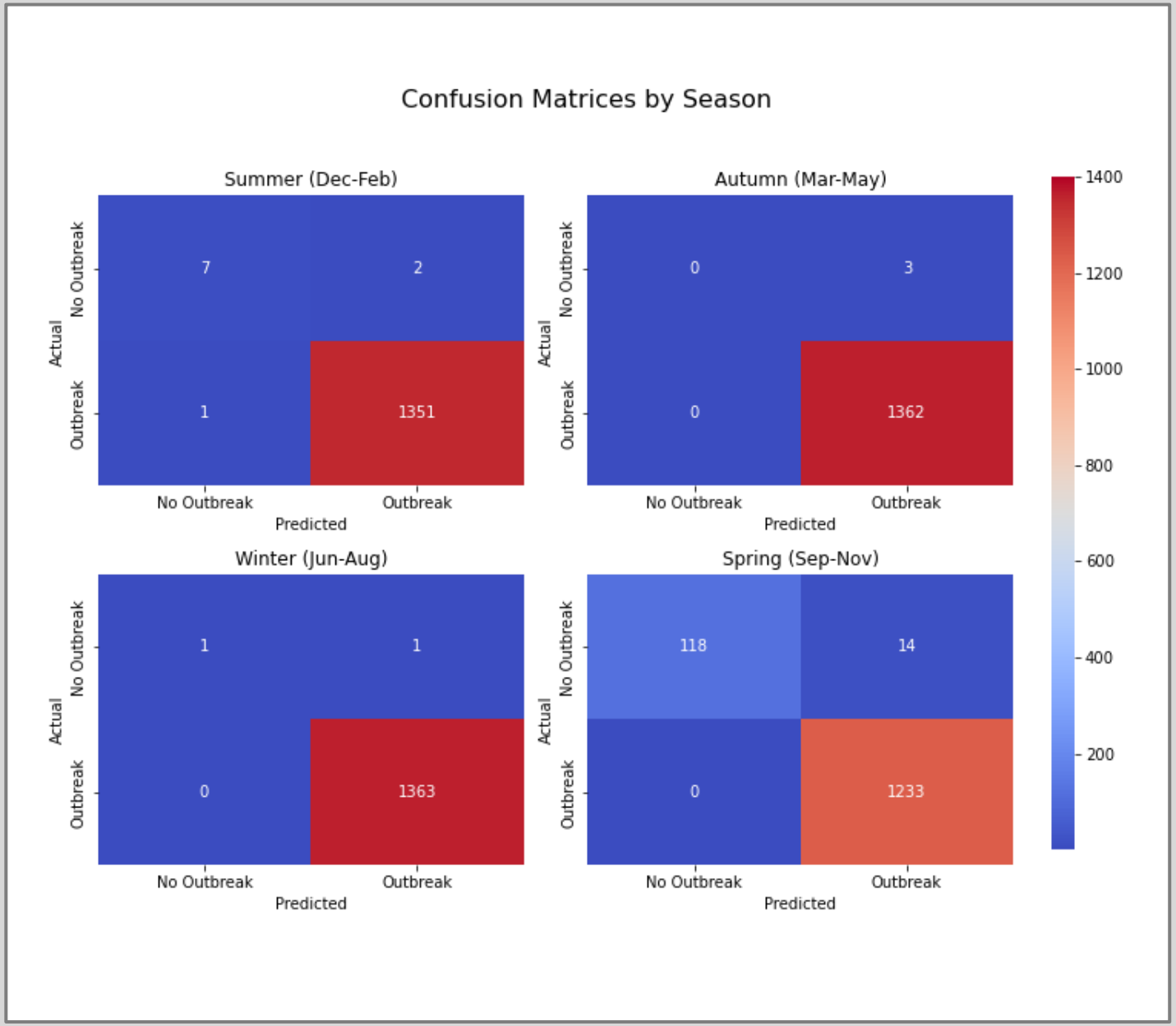
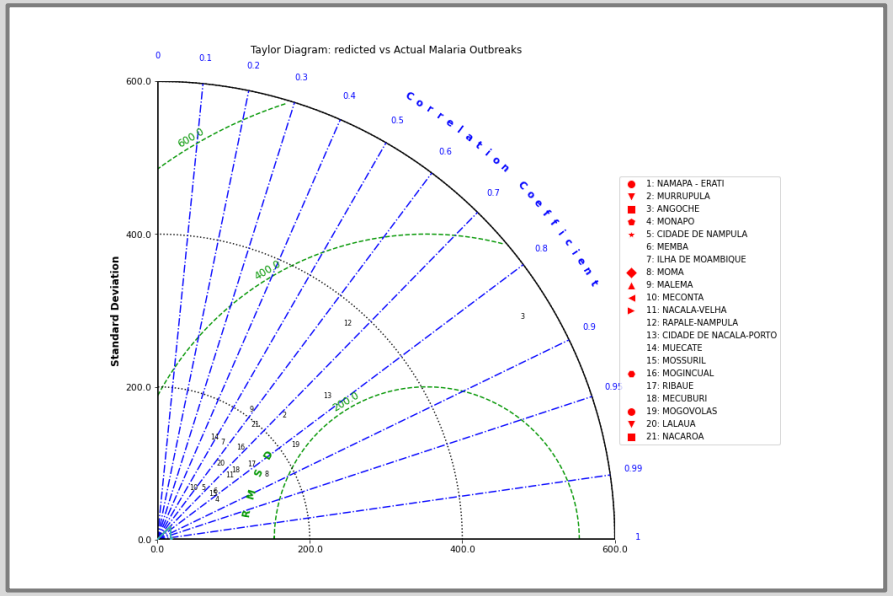
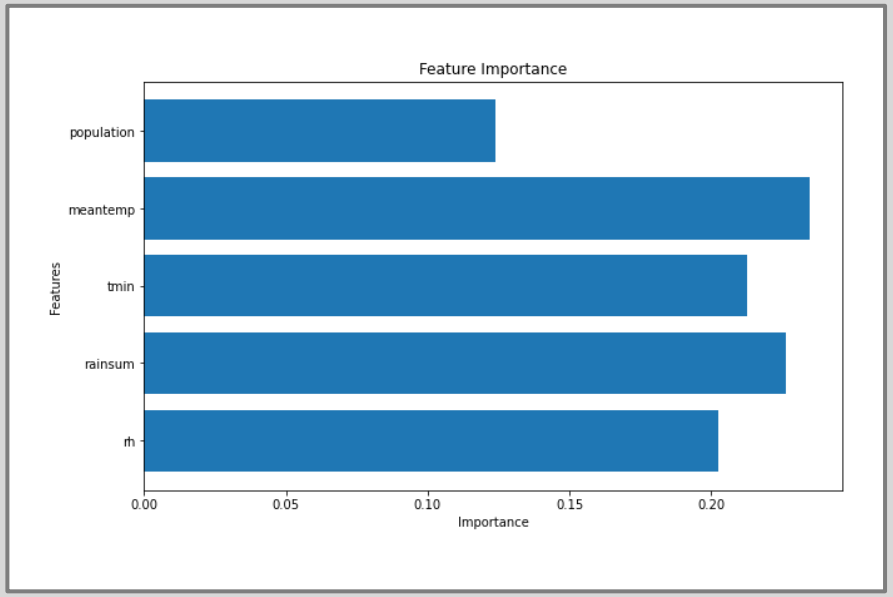

Confusion Matrices by Season
Summer (Dec-Feb)
Autumn (Mar-May)
Winter (Jun-Aug)
Spring (Sep-Nov)
Actual
No Outbreak
Outbreak
Predicted
7
2
1
1351
0
3
0
1362
1
1
0
1363
118
14
0
1233
1400
1200
1000
800
600
400
200


Taylor Diagram: redicted vs Actual Malaria Outbreaks
Correlation Coefficient
Standard Deviation
1: NAMAPA - ERATI
2: MURRUPULA
3: ANGOCHE
4: MONAPO
5: CIDADE DE NAMPULA
6: MEMBA
7: ILHA DE MOAMBIQUE
8: MOMA
9: MALEMA
10: MECONTA
11: NACALA-VELHA
12: RAPALE-NAMPULA
13: CIDADE DE NACALA-PORTO
14: MUECATE
15: MOSSURIL
16: MOGINCUAL
17: RIBAUE
18: MECUBURI
19: MOGOVOLAS
20: LALAUA
21: NACAROA


Feature Importance
population
meantemp
tmin
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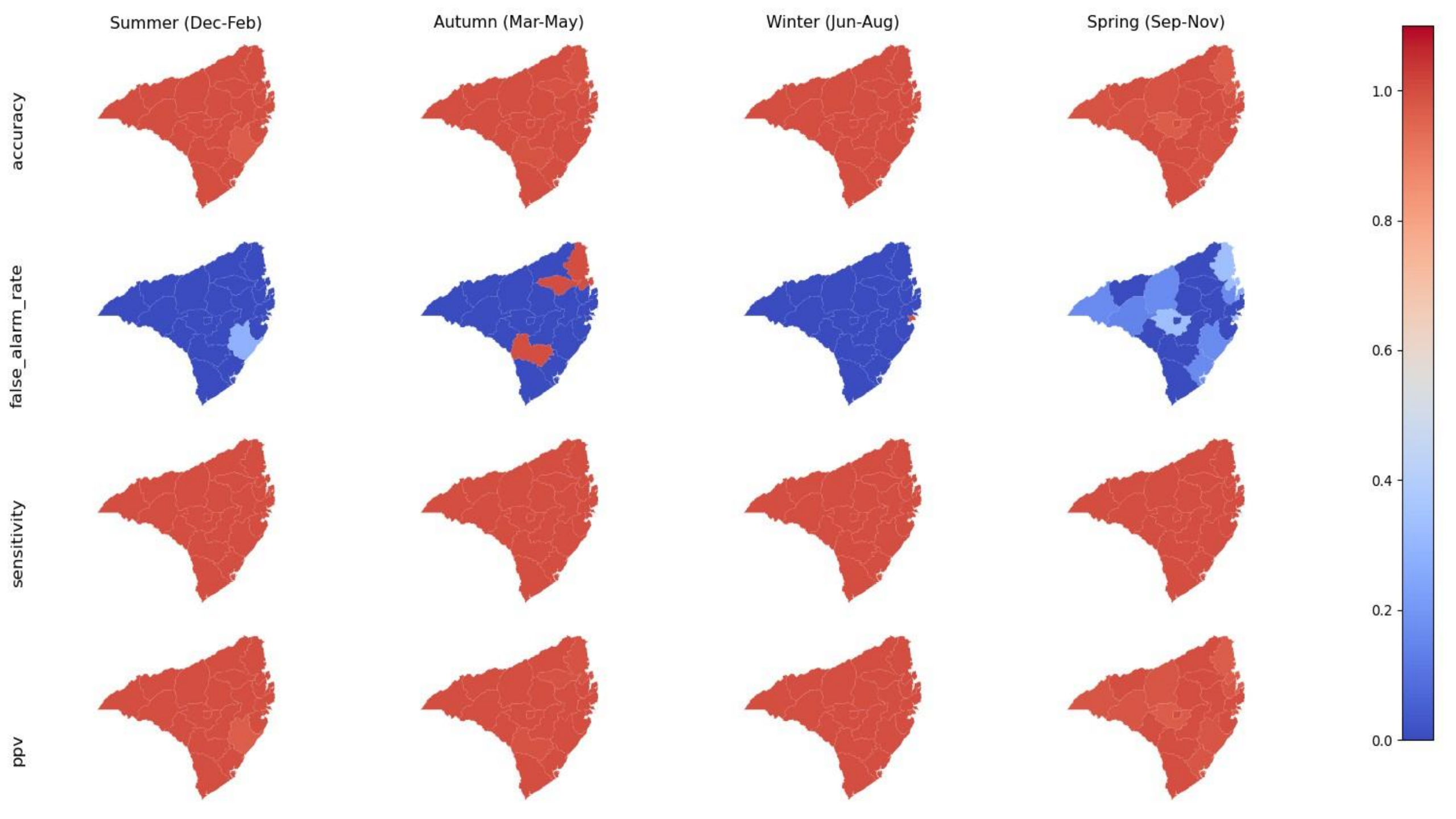
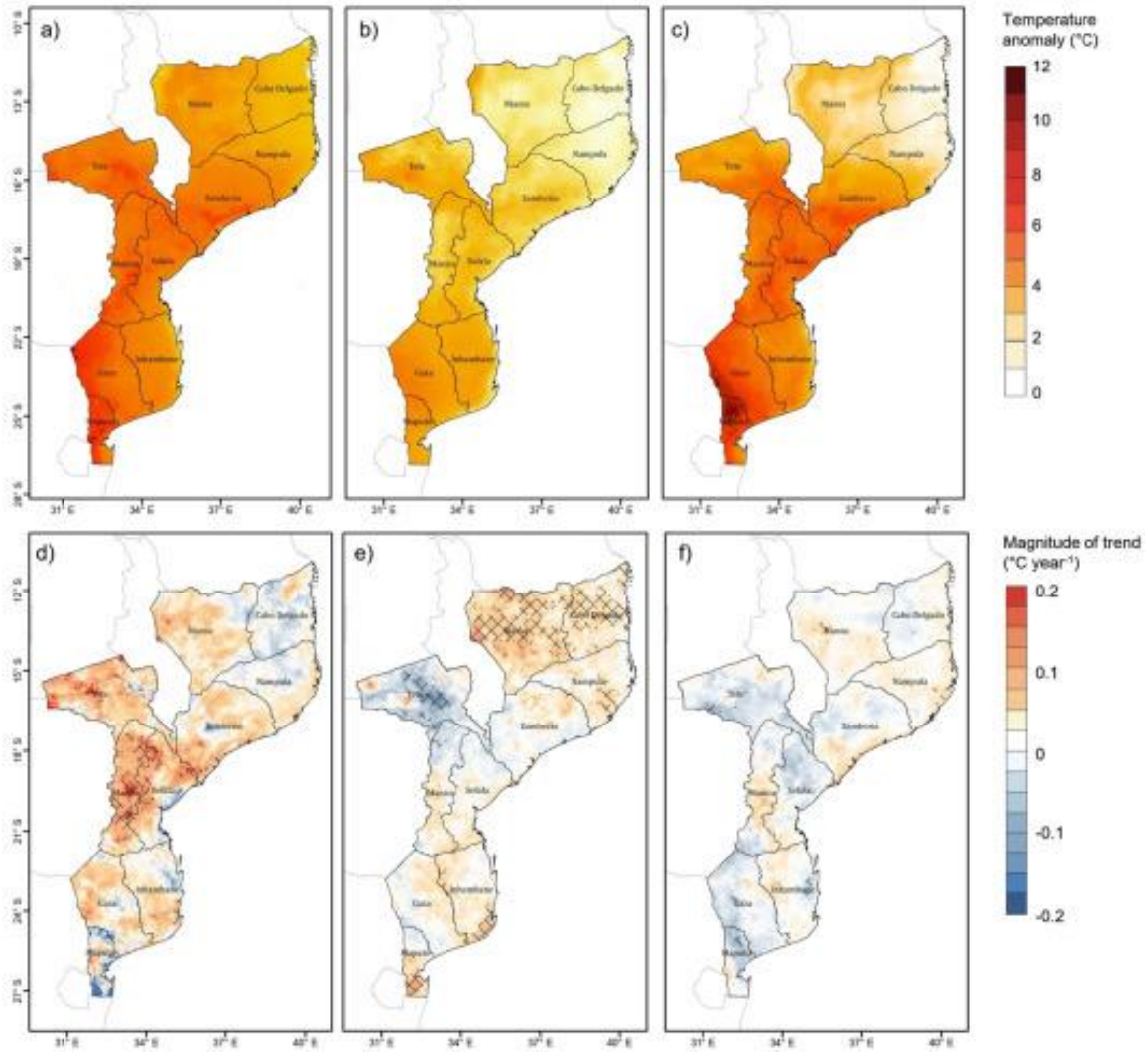
rh
Features
Importance
0.00
0.05
0.10
0.15
0.20


Summer (Dec-Feb)
Autumn (Mar-May)
Winter (Jun-Aug)
Spring (Sep-Nov)
accuracy
false_alarm_rate
sensitivity
ppv
1.0
0.8
0.6
0.4
0.2
0.0

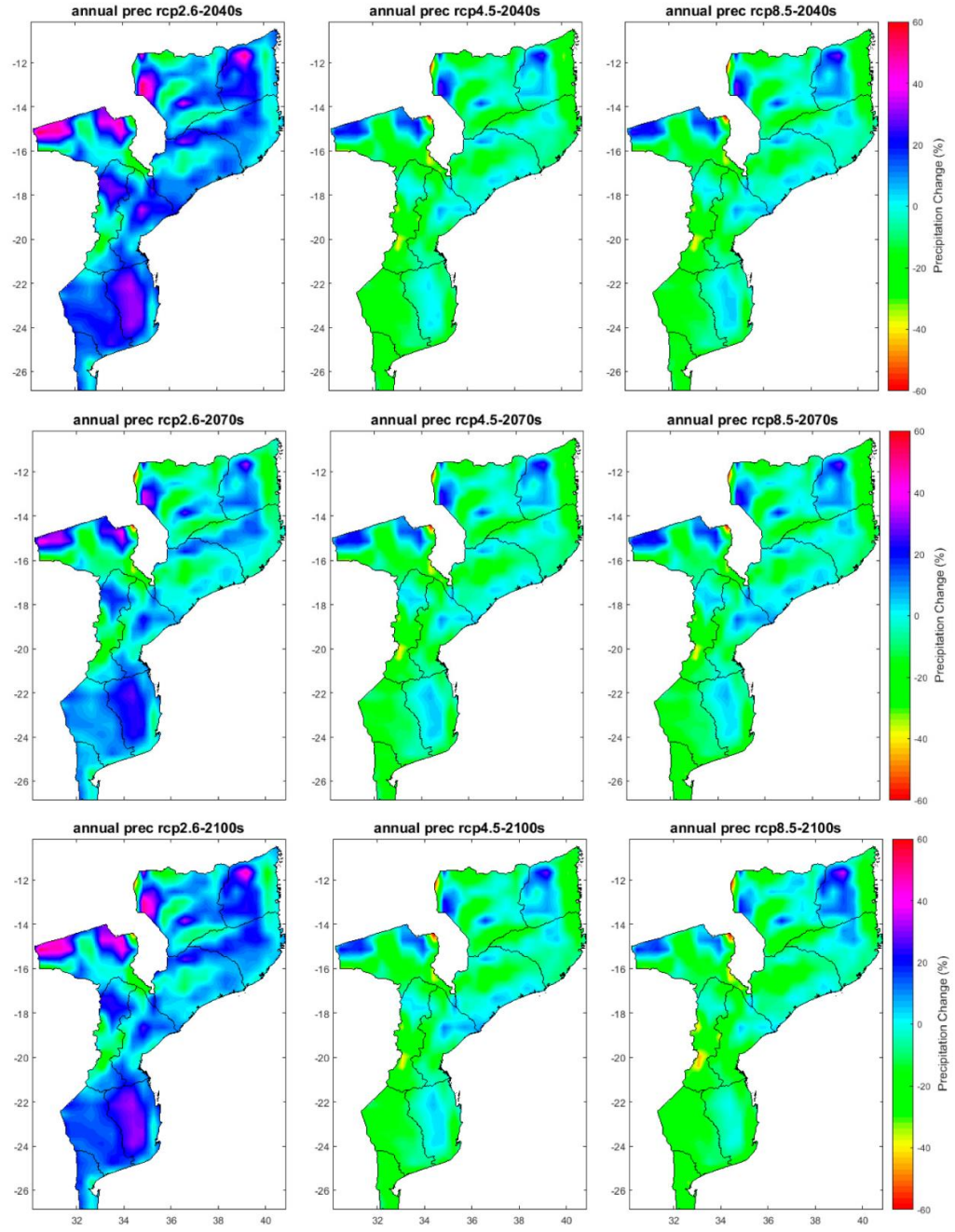
Heatwaves in Mozambique 1983–2016: Characteristics, trends and city-level summaries using high-resolution CHIRTS-daily

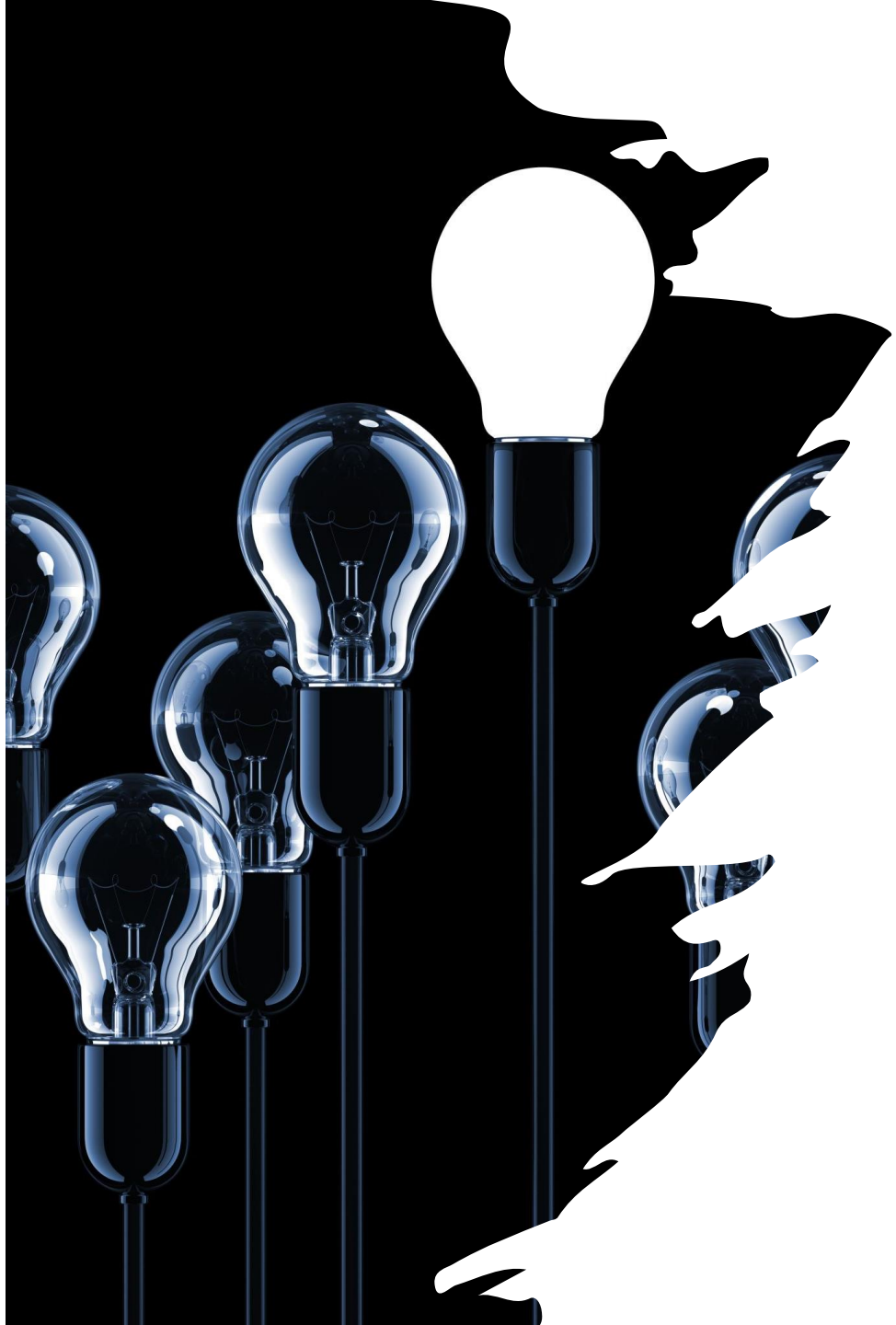


Marghidan et al,
WCE 2018

Change in Precipitation under RCPs

Mavume et al,
Atmos 2021





We cannot chance exposure and we can hardly change sensitivity, but we can change Adaptive Capacity

MUITO OBRIGADO PELA ATENÇÃO!

Country experience: Quantitative approaches in V&As

AM Session

Mag Ilonka Horváth
Senior Health Expert, Competence Centre for Climate and Health Austria

World Health Organization

Gesundheit Österreich GmbH

Competence Center Climate and Health
Agenda Health Promotion

Country Experience 2: Austria

Systematic Climate & Health Vulnerability Assessment

Ilonka Horváth and Felix Durstmüller

WHO CCH Technical WEBINAR SERIES

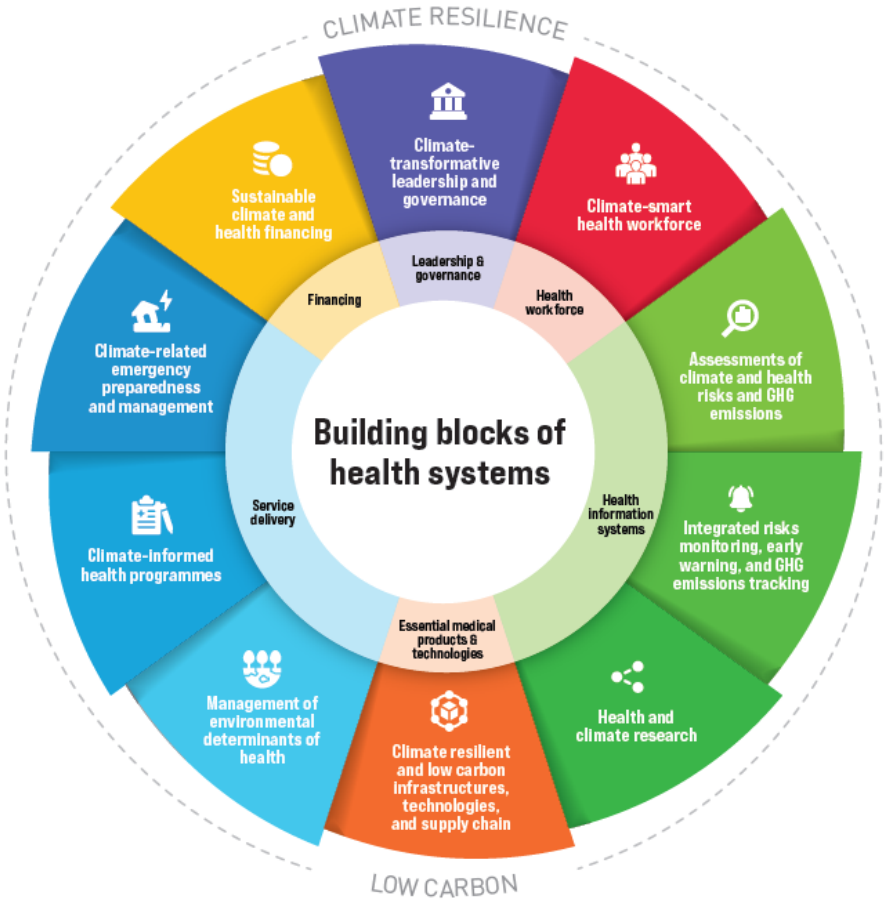
Quantitative approaches for Vulnerability & Adaptation assessments: Sensitivity analyses and projecting future health risks of climate change

17 July 2024

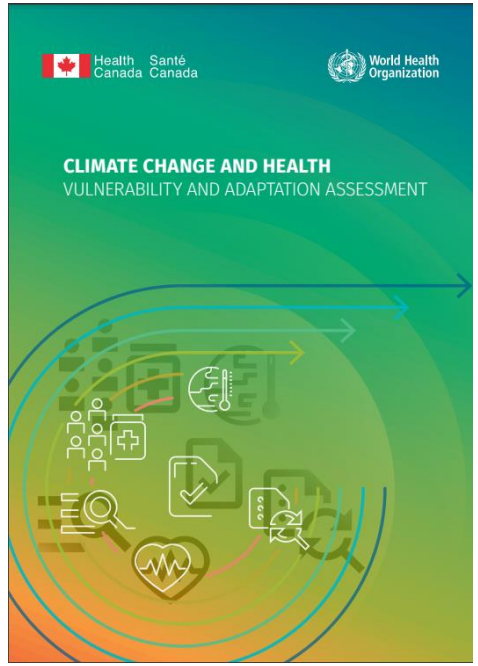
Agenda Health Promotion

Federal Ministry
Republic of Austria
Social Affairs, Health, Care and Consumer Protection

Climate Resilient Health Systems



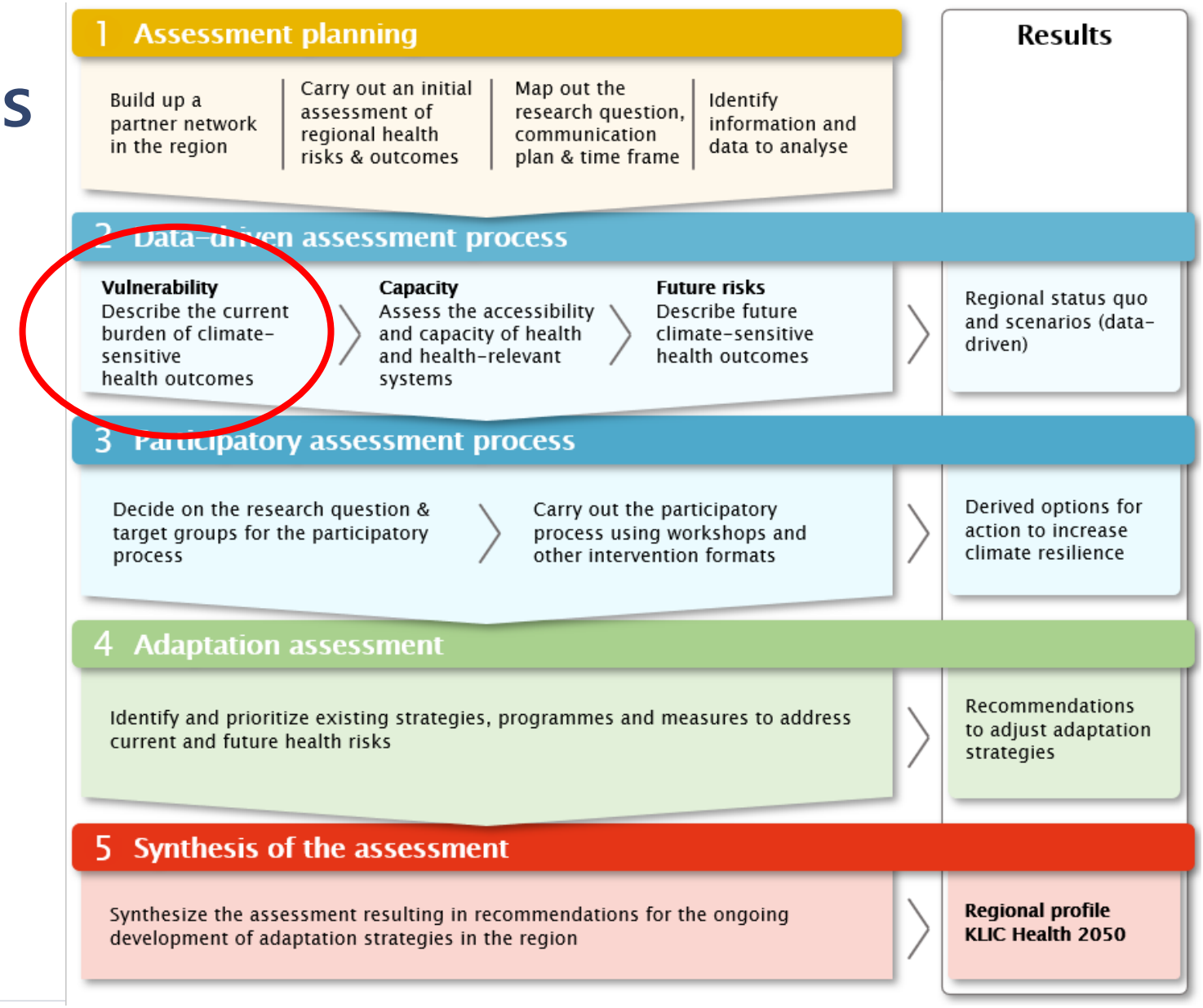
Source: WHO (2023). Operational framework for building climate resilient and low carbon health systems.



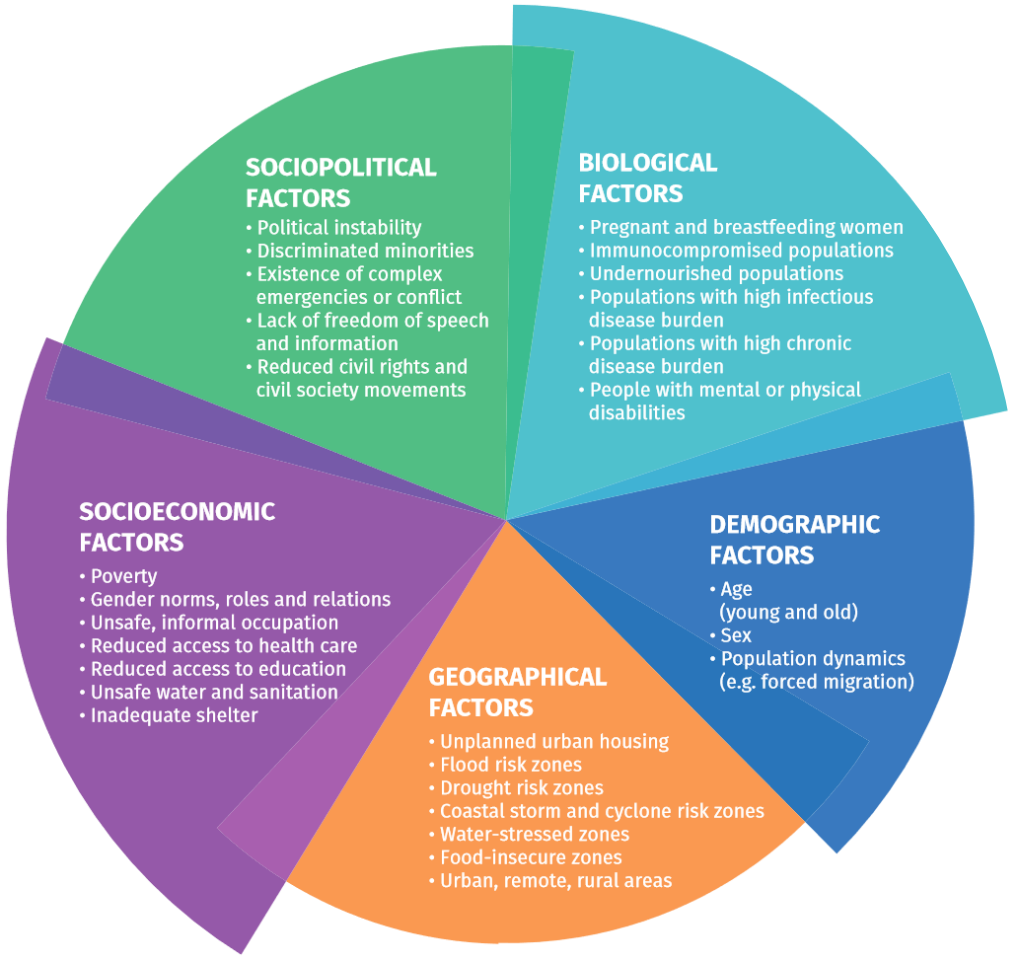
Source: World Health Organization. (2021). Climate change and health: vulnerability and adaptation assessment.

Climate-Resilience Check Health 2050 for Austrian regions and municipalities

KLIC Health process



Vulnerability Assessment (WHO framework)



Source: World Health Organization. (2021). Climate change and health: vulnerability and adaptation assessment.

Vulnerability assessment

Describe the current burden of climate-sensitive health outcomes and vulnerabilities to climate variability and recent climate change

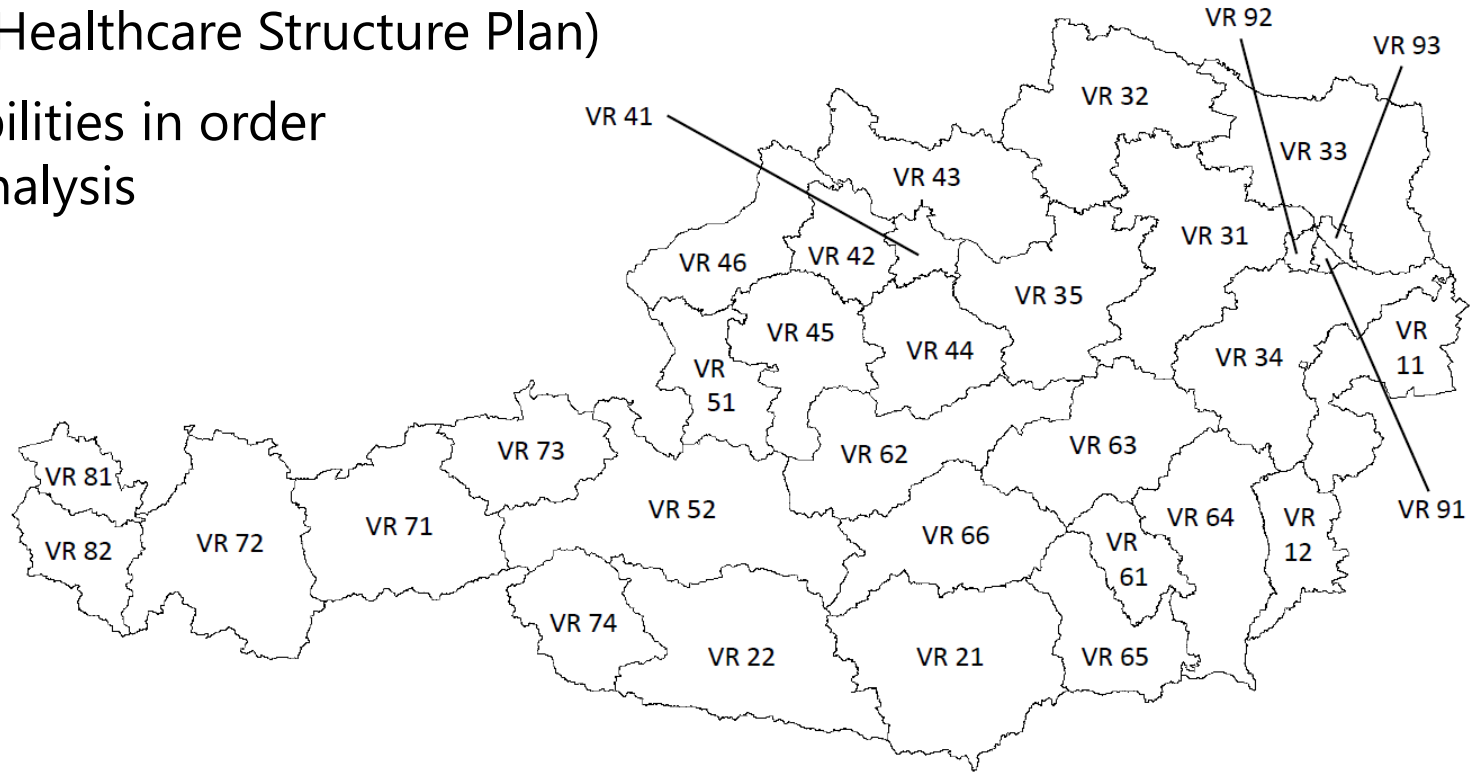
Aims of quantitative analysis

- calculating quantitative values for each indicator in relation to population or geographical area of region
  - conscious decision not to generate indices (as they potentially “hide” specific vulnerabilities)
- calculating Austrian average as a baseline for comparison of regions
- values for regions as deviation from Austrian average
- creating visualizations: geographical maps & circular barplots

Challenge 1

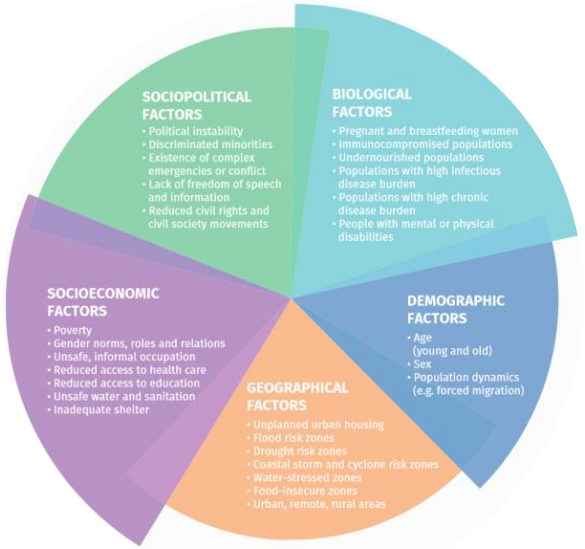
Spatial reference for data analysis

- **Austrian „Health Care Regions“**
  (as defined by the Austrian Healthcare Structure Plan)
- to map small-scale vulnerabilities in order to enable a differentiated analysis
- trade-off between small-scale geographic resolution and data availability



Challenge 2

Data mapping: technically



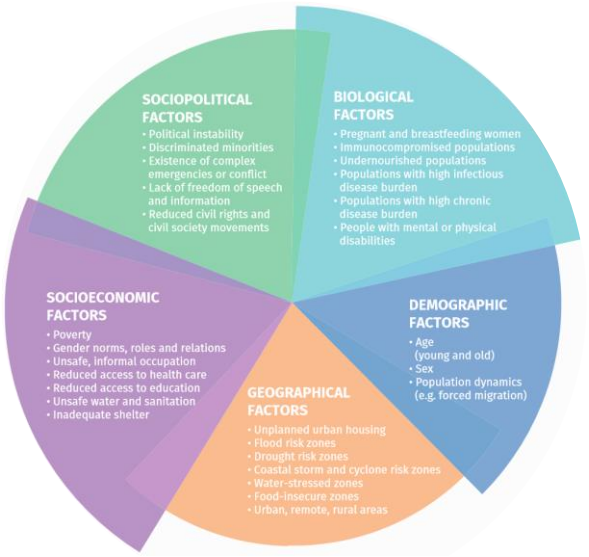
5 dimensions of vulnerability

Described by various vulnerability factors

Identify indicators to describe the factor

Challenge 2

Data mapping: practically



1) Validating of **applicability** of suggested vulnerability factor

2) Identifying **suitable indicator(s)** that represents specific vulnerability factor

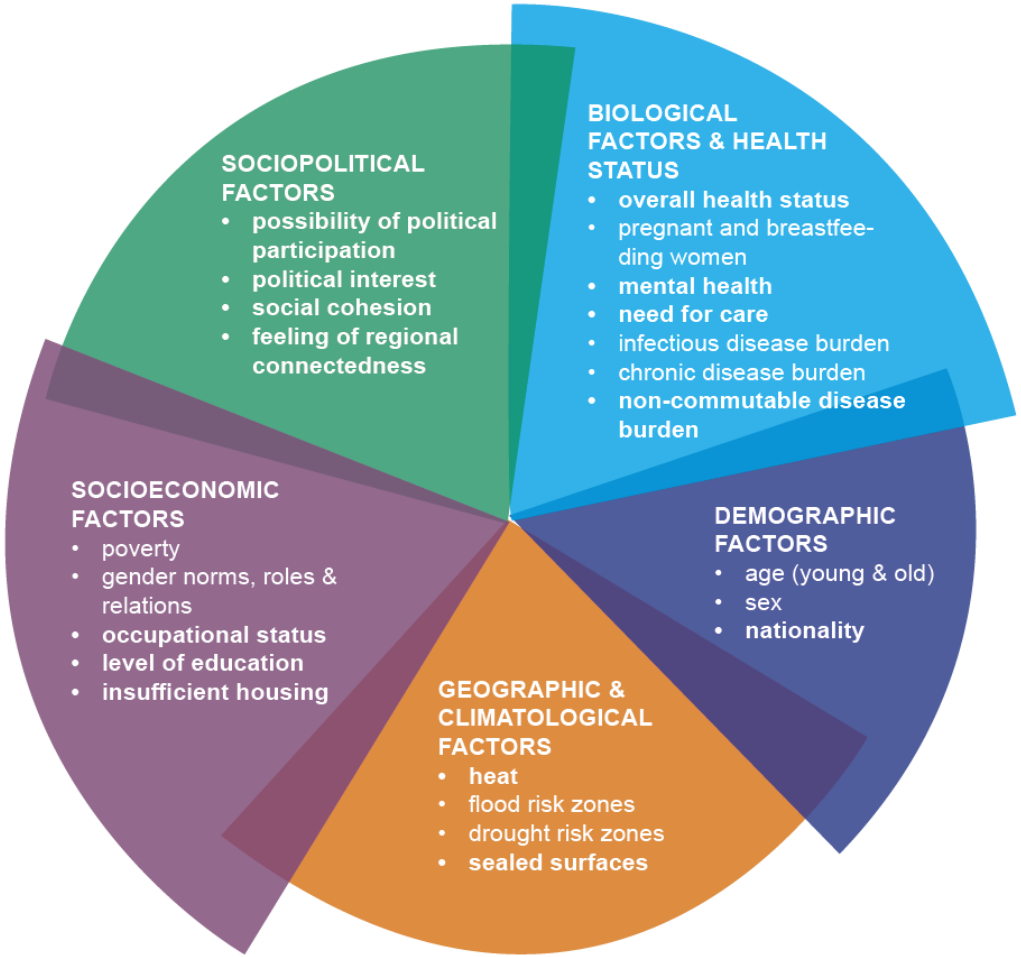
3) Validating **data availability** of indicator on regional level

Criteria for indicators

- quantitatively measurable
- represent broad areas of the society (not limited to small groups)
- reflect either current or structural situation
- statistically robust for small-scale spatial analysis

Adapted set of vulnerability factors

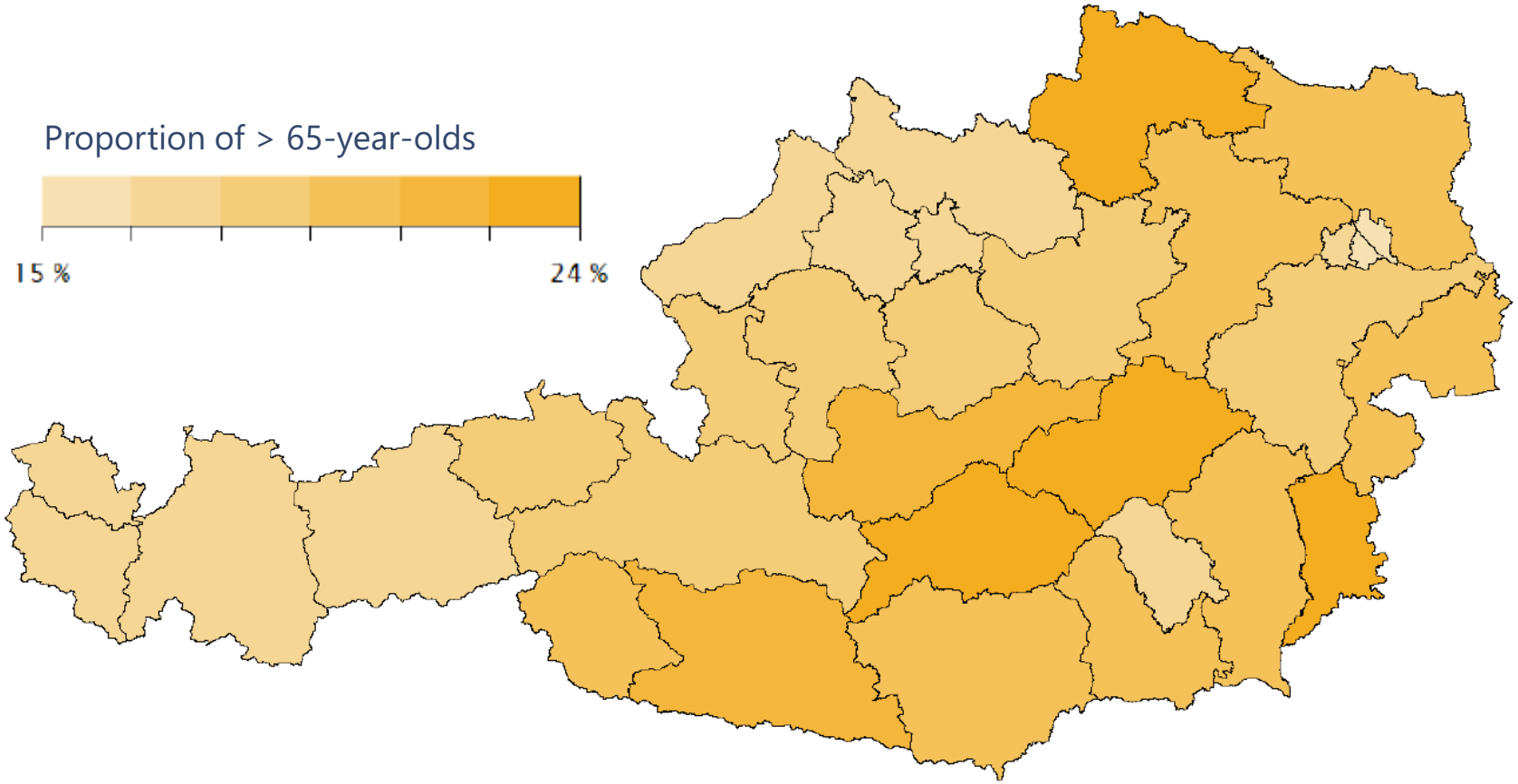
Based on **applicability** of factor and **availability** of indicators on regional level



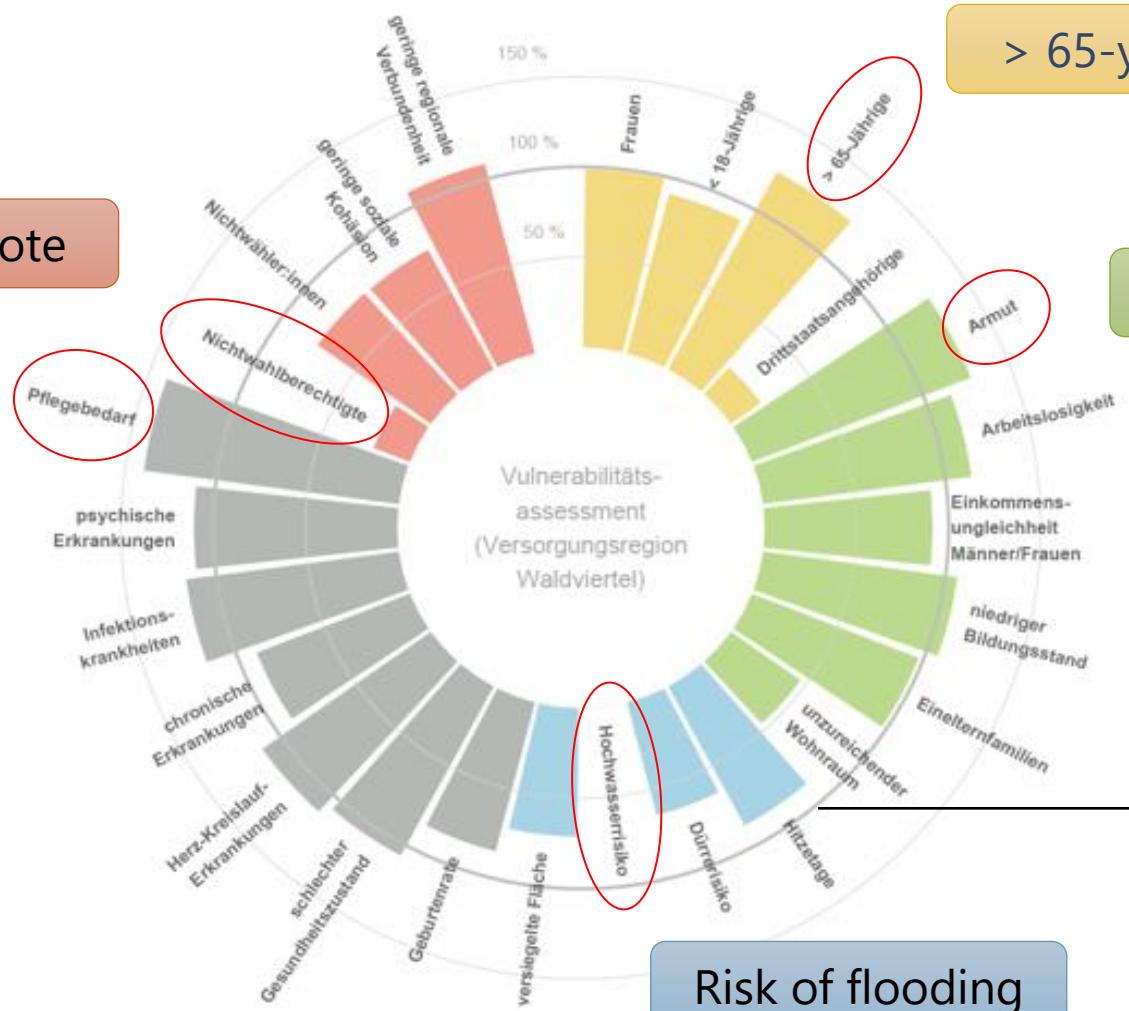
In total:

- 5 dimensions
- 23 vulnerability factors
- 25 indicators
- 11 different data sources

Visualization 1: Geographical Maps



Visualization 2: regional vulnerability



> 65-year-olds

Non-eligible to vote

Poverty

In need of care

Austrian average

Risk of flooding

Key:
Yellow: demographic factors
Green: socio-economic factors
Blue: geographic and climatological factors
Grey: biological factors and health status
Red: socio-politcal factors

Conclusions

- acknowledgment of **complexity of vulnerabilities and health inequalities**
- **adaption to national context**
- **challenges** on three levels:
  - Applicability of factors
  - Derivation of suitable indicators
  - Data availability on regional level
- **multi-disciplinary team**
- future **health status of population will largely depend on how current adaption strategies are successful** in reducing climate-sensitive health outcomes

Contact

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Country experience: Quantitative approaches in V&As

PM Session

Dr Peter Berry

Climate Change and Health Office, Health Canada

World Health Organization

Health Canada Santé Canada

Canada

Canadian Experience with Quantitative Approaches for Vulnerability & Adaptation Assessments

Peter Berry Ph.D.
Climate Change and Health Office
Health Canada

World Health Organization
Climate Change and Health
Technical Webinar Series
July 17, 2024

YOUR HEALTH AND SAFETY... OUR PRIORITY.

Outline

- Health risks to Canadians from climate change
- Quantitative methods to understand climate change risks and adaptation options
- Experience with quantitative approaches for V&As in Canada

Due to Canada's vast geography, people in Canada experience a range of impacts that affect health

YT Flooding (2021)

The Government of Yukon mounted the largest flood relief effort in territory's history, due to flooding in Carmacks, Teslin, Lake Laberge, and Southern Lakes region.

Ft. McMurray Wildfires (2016)

Increased PTSD, depression, generalized anxiety disorder and insomnia. 20,000 sought mental health services.

SK Drought and Mental Health

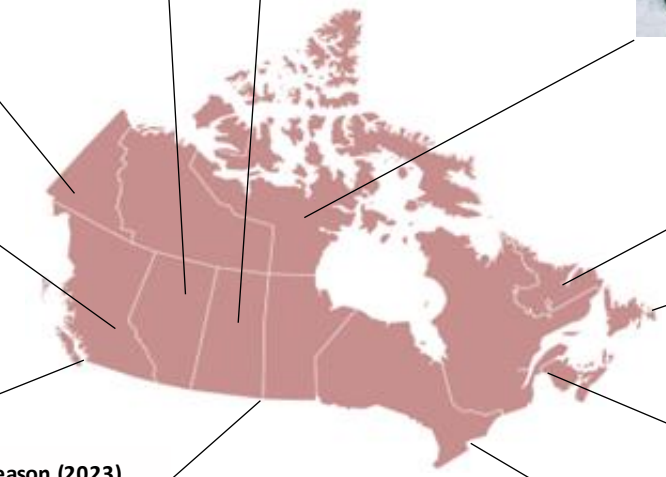
Farmers across Saskatchewan are feeling the overwhelming mental and financial stress due to poor harvests as dry conditions persist.

Northern Food Insecurity

Food insecurity and mental health issues increasing in the North and ecosystem changes in species distribution affecting country food supply.

Hurricane Fiona (2022)

Hurricane Fiona resulted in health impacts, including fatalities, widespread flooding, power and telecommunications outages, and unprecedented demand for emergency services.



Western Heat Dome (2021)

619 heat-related deaths in B.C., 66 estimated heat-related deaths in Alberta. Many who died were aged 50 or older, had chronic health conditions. The majority of deaths happened inside people's homes.

Extreme Snowfall (2020)

Extreme snowfall resulted in the City of St. John's declaring a State of Emergency for eight days. Emergency and urgent services at five health facilities were delayed, while all other services at these sites were canceled for a few days, resulting in interruptions of appointments and surgeries.

BC Landslides (2021)

Extreme precipitation event in November 2021 triggered landslide on Highway 99 near Lillooet, B.C., resulting in 5 deaths.

2023 Wildfire Season (2023)

Historic wildfire season across Canada. 5 deaths, including 4 firefighters, and one 9 year-old boy due to an asthma attack from the wildfire smoke.

Lyme Disease

The incidence of Lyme disease cases has increased in Canada over recent years, as the geographic range of ticks that carry the Lyme disease bacteria has expanded.

Sainte-Marthe-sur-le-Lac Floods (2019)

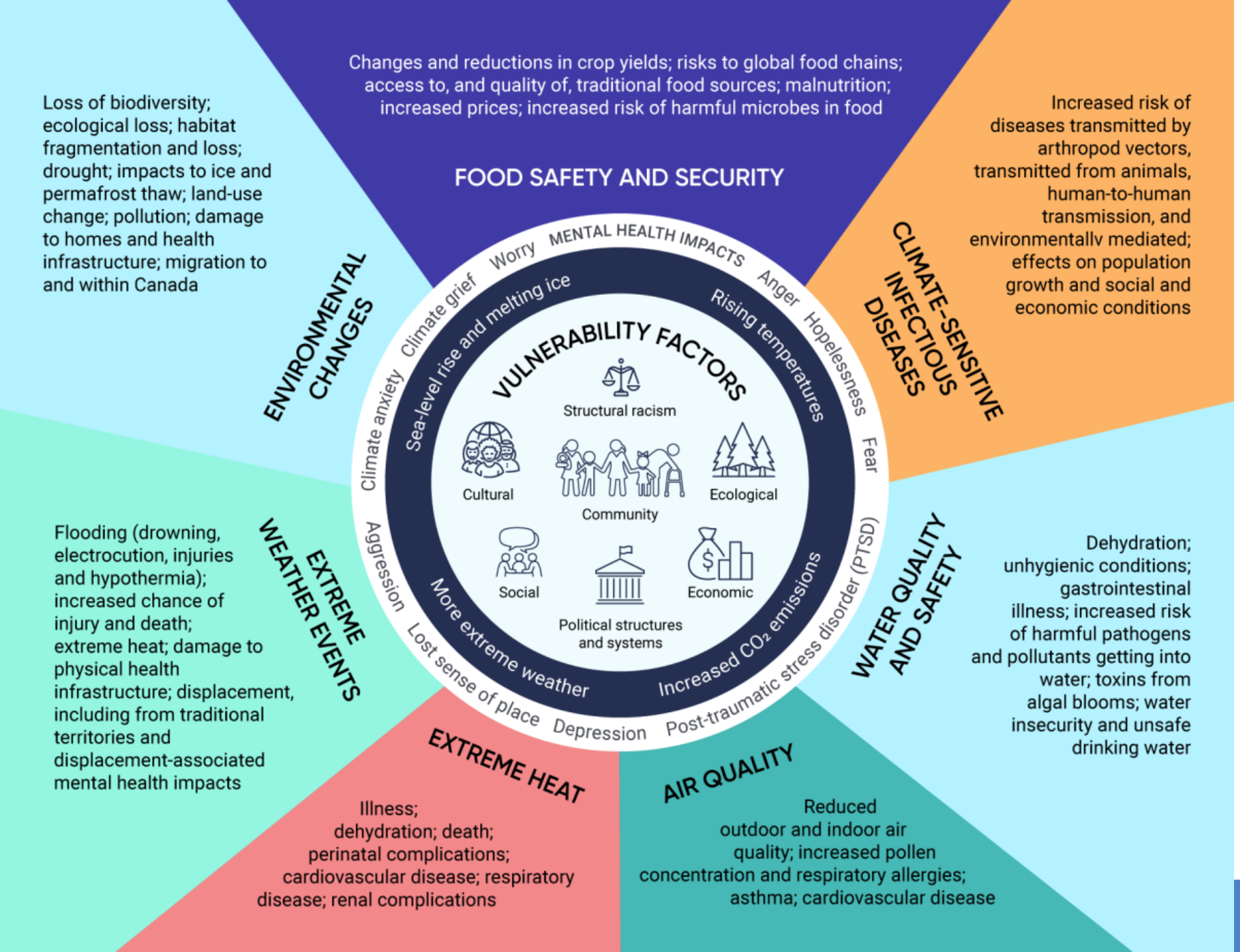
During a period of exceptional spring flooding, a dike bordering Sainte-Marthe-sur-le-Lac gave way. 6,000 residents evacuated. 1 year post-flood, half of victims reported moderate to severe symptoms of post-traumatic stress.

Risks of Climate Change To Health in Canada

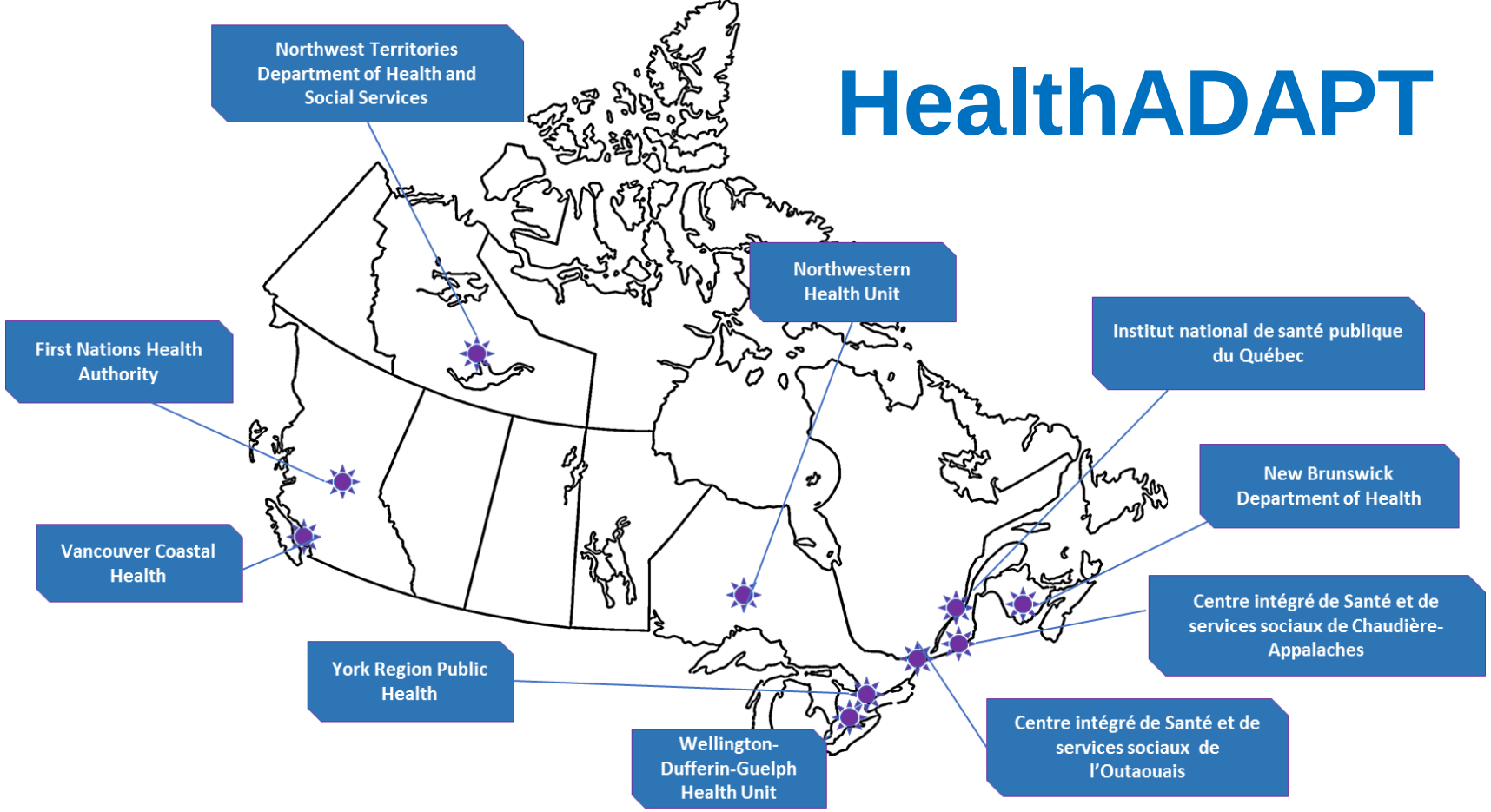
https://changingclimate.ca/health-in-a-changing-climate/

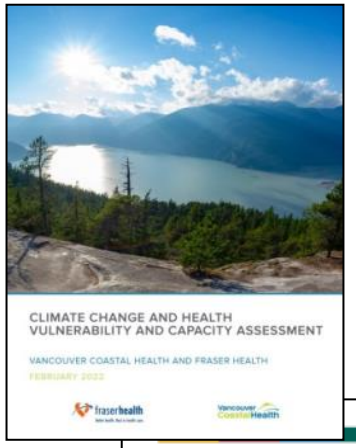
Charness et al., 2023

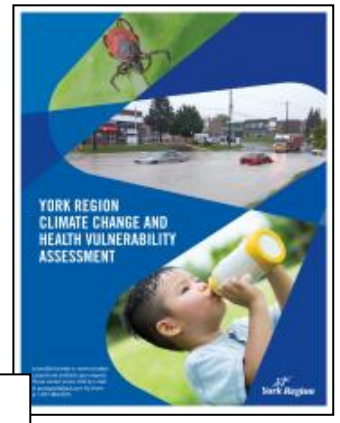
https://changingclimate.ca/synthesis/chapter/report/

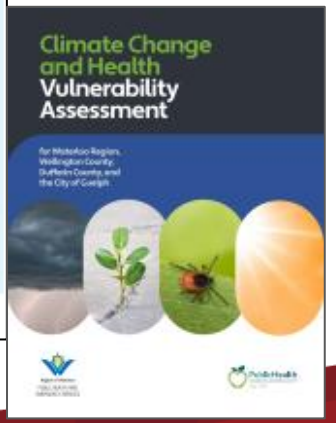


HealthADAPT









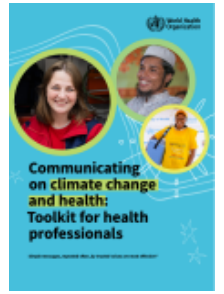
A **multi-year program** introduced in 2018, to support 10 projects at local, regional, and provincial and territorial levels of the Canadian health sector to prepare for and respond to the impacts of climate change.

https://www.canada.ca/en/health-canada/programs/health-adapt.html
https://www.york.ca/newsroom/campaigns-projects/climate-change-and-health
https://www2.gnb.ca/content/dam/gnb/Departments/h-s/pdf/en/HealthyEnvironments/yourhealthR1.pdf
https://wdgpublichealth.ca/reports/climate-change-and-health-vulnerability-assessment

Framework for Health Assessment and Adaptation in Canada

https://www.who.int/publications/i/item/9789240048102

https://www.who.int/publications/i/item/9789240057906



Berry et al., 2022

https://www.canada.ca/en/health-canada/services/publications/healthy-living/climate-health-adapt-vulnerability-adaptation-assessments-workbook.html

https://www.who.int/publications/i/item/9789240036383

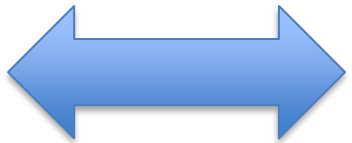
Methods for Conducting a V&A

Assessments require close collaboration among researchers and experts from a wide range of disciplines applying many tools and methods. Examples include:

Quantitative Methods

- Environmental epidemiology (e.g., short and long time-series studies, ecological studies)
- Geographical information systems
- Climate change, population and socioeconomic projections and scenarios
- Climate and health modelling (e.g., biological models of infectious disease transmission)
- Cost-benefit analysis
- Surveys

Indigenous Knowledges

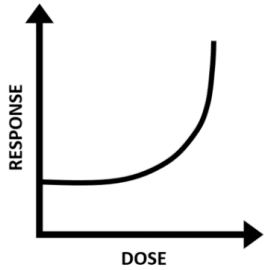


Qualitative Methods

- Interviews
- Single event case studies
- Focus groups
- Participatory workshops
- Expert consultations
- Narrative inquiry
- Visual and art-based methods

EXAMPLE: Why Model How Climate Change Impacts the Health of Canadians?

Models of health risks posed by climate change fulfill diverse purposes helping Canadians prepare for a rapidly warming climate:



To **understand exposure–response relationships**, such as the health effects of heat and high temperatures

To enhance the effectiveness of **early warning systems**, to more severe events expected with climate change

To **look into the future** to understand the health implications of different climate projections including stresses to health systems

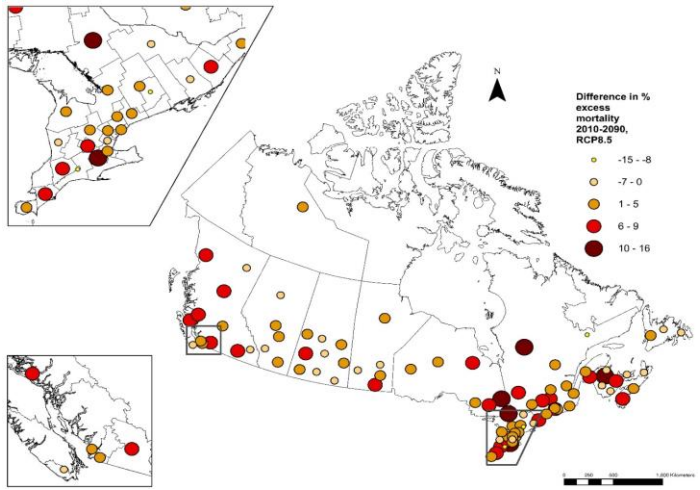
To **assess health costs and benefits** related to climate change, climate adaptation policies and climate mitigation strategies

Considerations for Climate and Health Modelling

Key challenges and gaps for climate change and health modelling:

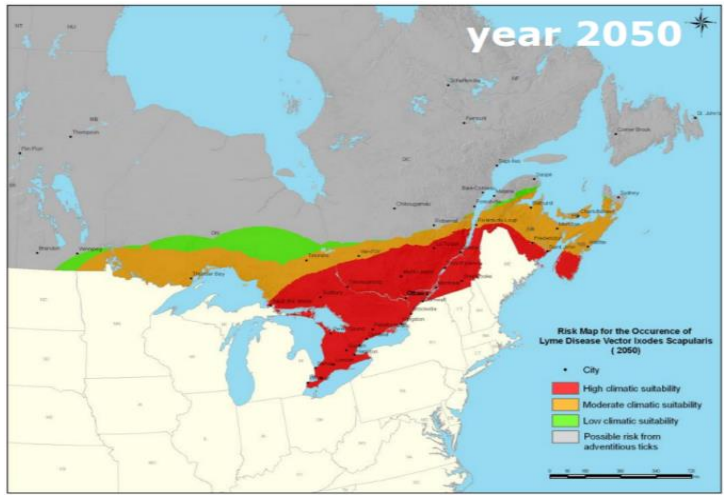
- **Insufficient data** over long-enough time periods
- Long-term health data sets are held by **provinces and territories**. Even when some data sets are available, it is challenging to gain access to sufficient data to produce **national-level** modelling
- Lack of robust understanding of **non-linear processes** linking climate factors to health outcomes to develop useful models
- Models are needed for **each health outcome** of concern (e.g. Lyme disease, malaria, mental health, heat morbidity & mortality) in order project overall human health and **health system** impacts
- Sufficient financial **resources**, expertise, and time are needed for this work

Modelling the Future Health Impacts of Extreme Heat



Hebbern et al., 2022

Projecting the Expansion of *Ixodes scapularis* in Canada



Ogden at al., 2008

Research to Build Climate Resilient Individuals and Health Systems

Estimate the Future Effects of a Warming Climate on Exposure to *V. parahaemolyticus*

Harper et al., 2022

Image: http://www.bccdc.ca/health-info/diseases-conditions/vibrio-parahaemolyticus

Estimating health benefits of GHG emissions reductions

Egyed et al., 2022

Moving Forward to Protect Health

- ✓ *Scaling-up health adaptation actions requires robust science and evidence*
- ✓ *Quantitative methods used in V&As provide needed information to decision makers*
- ✓ *Special efforts need to focus on communicating the results of V&As in a meaningful, tailored and timely manner*
- ✓ *Health authorities can build their capacity to increase knowledge of health risks and adaptation options*

Photo Credit: Sabrine Dinia

FOR MORE INFORMATION

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WHO Technical Webinar Series

https://www.who.int/teams/environment-climate-change-and-health/climate-change-and-health/country-support/webinars

Date & time (CEST)	Topic*
24th April 2024	Getting started: climate change and health vulnerability & adaptation assessments
30th April 2024	WHO as an Accredited Implementing Entity of the Adaptation Fund; Accessing AF funding for Climate Change and Health
15th May 2024	WHO Operational Framework for building climate resilient and low carbon health systems
12th June 2024	Developing a Health National Adaptation Plan: Introduction
19th June 2024	GIS and risk mapping in climate change and health vulnerability & adaptation assessments
10th July 2024	Climate resilient and environmentally sustainable health care facilities
17th July 2024	Quantitative approaches for Vulnerability & Adaptation assessments: sensitivity analyses and projecting future health risks of climate change
18th Sept 2024	Integrating health in NDCs and LT-LEDS
25th Sept 2024	Developing a Health National Adaptation Plan: Quality criteria for HNAPs
16th Oct 2024	Conducting a gender analysis for climate change and health vulnerability & adaptation assessments

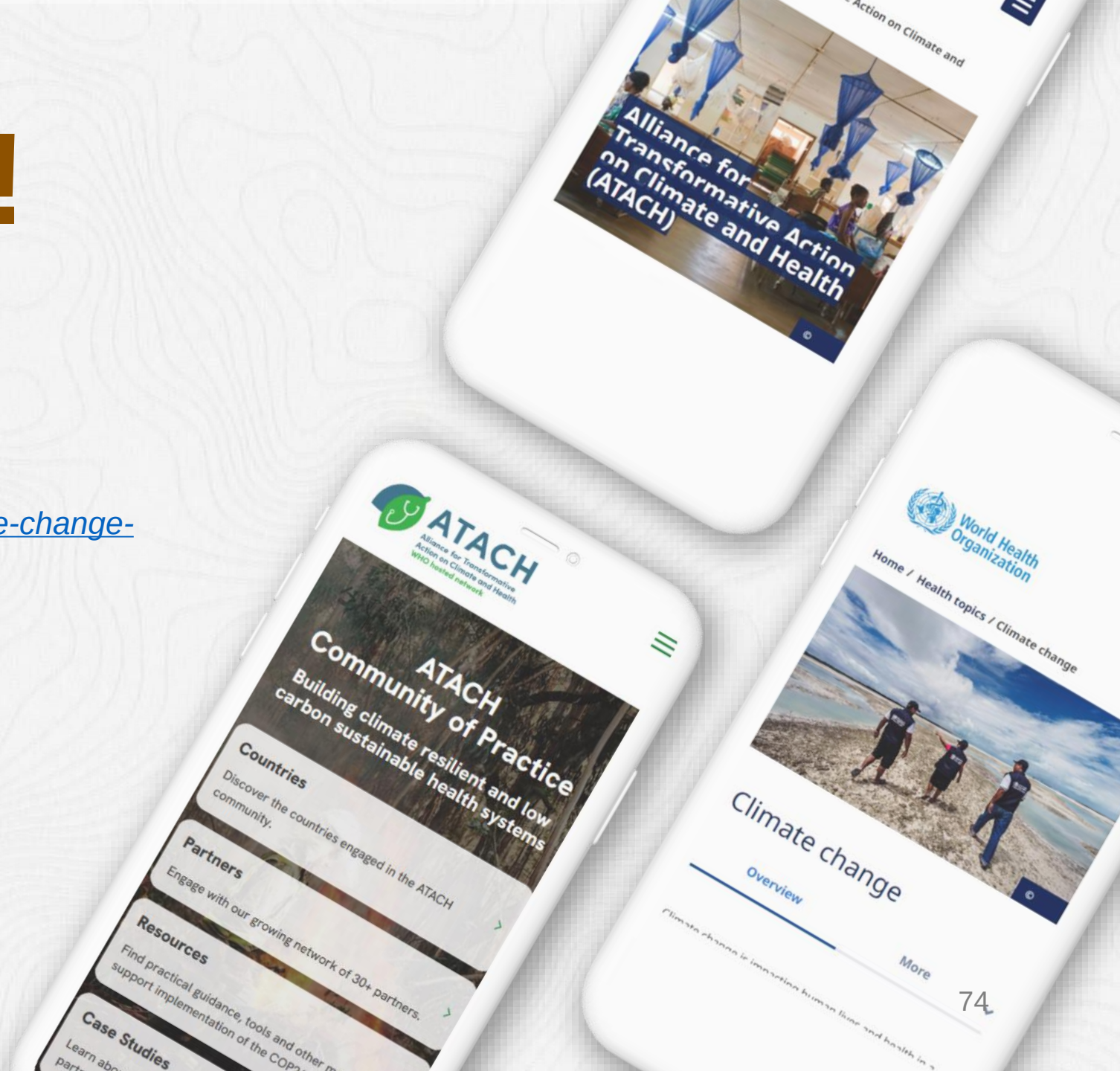
World Health Organization

Thank You!

ATACH Community of Practice
https://www.atachcommunity.com/

Climate Change
https://www.who.int/teams/environment-climate-change-and-health/climate-change-and-health

Email: healthclimate@who.int



World Health Organization