

1st

RWANDA CLIMATE SCIENCE SYMPOSIUM 2025

Advancing Research And Networking

B1) OBSERVATION AND MODELLING OF CLIMATE CHANGE

13 May 2025, 14:00 – 16:00 P.M.

High-Resolution Climate Projection data for Climate Risk Assessment in Rwanda

By

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CLIMATE IMPACT RESEARCH



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Mathematical Sciences
RESEARCH & INNOVATION



Content

- Background
- Data & Methods
- Projected Changes
- Key message

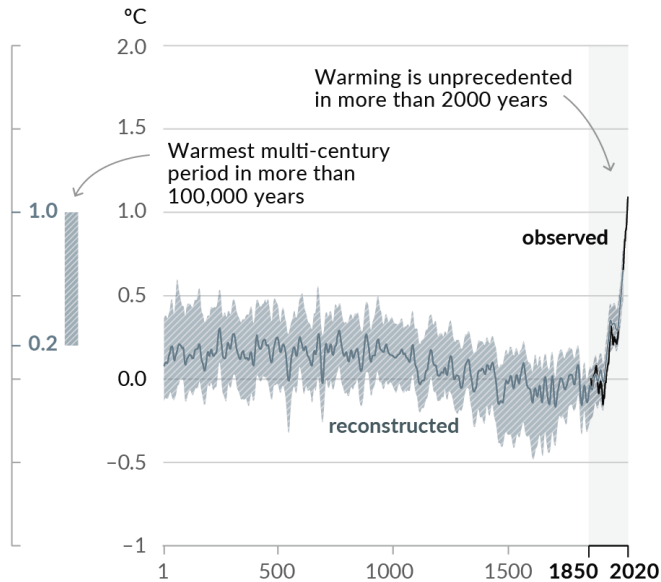


Introduction

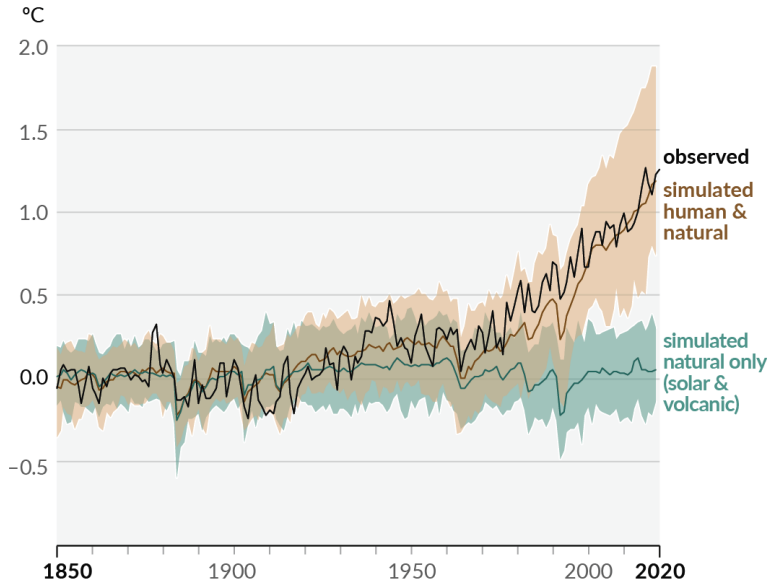
Human influence has warmed the climate at a rate that is unprecedented in at least the last 2000 years

Changes in global surface temperature relative to 1850–1900

(a) Change in global surface temperature (decadal average) as reconstructed (1–2000) and observed (1850–2020)



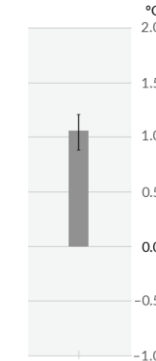
(b) Change in global surface temperature (annual average) as observed and simulated using human & natural and only natural factors (both 1850–2020)



Observed warming is driven by emissions from human activities, with greenhouse gas warming partly masked by aerosol cooling

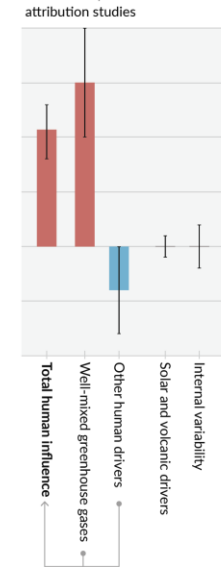
Observed warming

(a) Observed warming 2010–2019 relative to 1850–1900

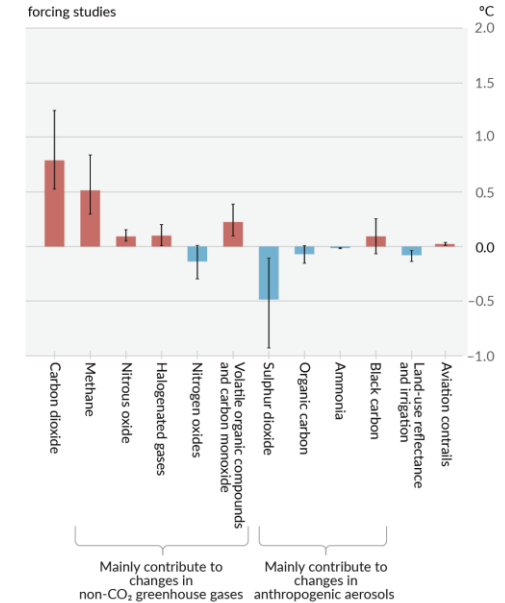


Contributions to warming based on two complementary approaches

(b) Aggregated contributions to 2010–2019 warming relative to 1850–1900, assessed from attribution studies



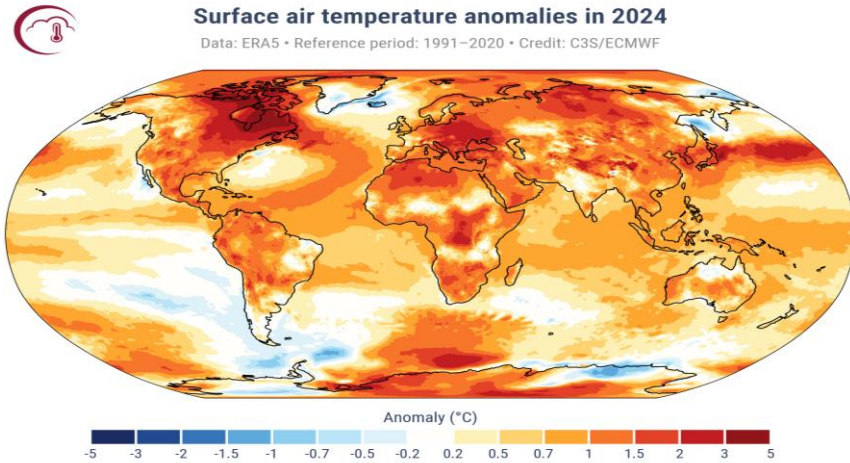
(c) Contributions to 2010–2019 warming relative to 1850–1900, assessed from radiative forcing studies



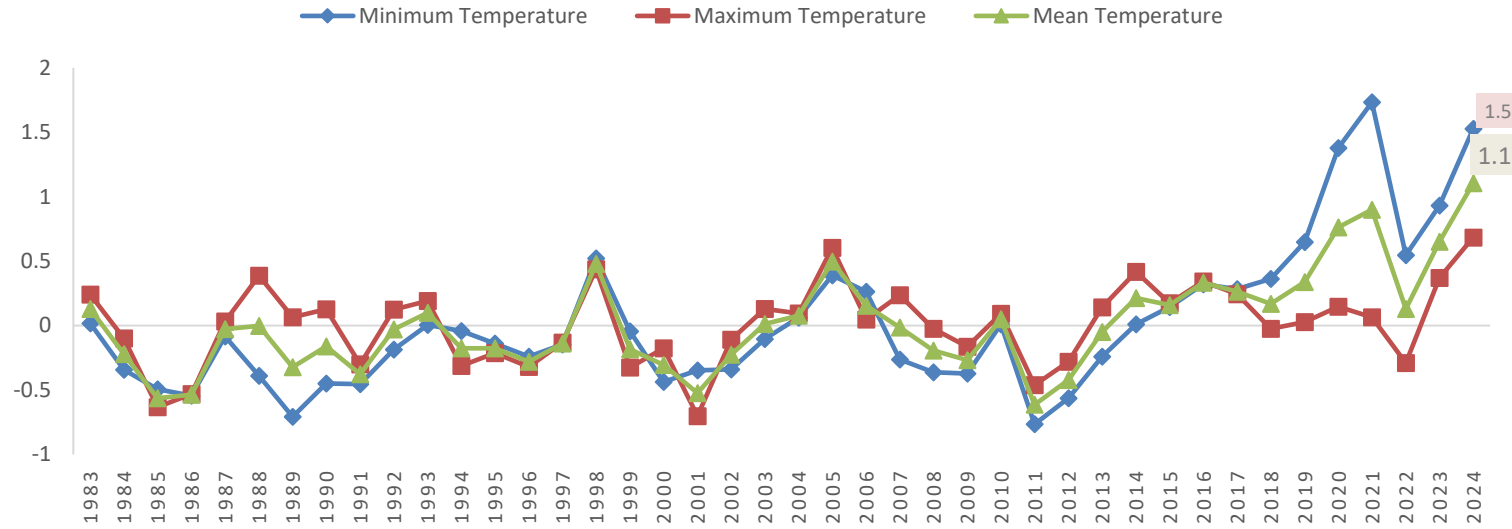
Source: IPCC-AR6 Report

Introduction

Global mean near-surface temperature



ANNUAL TEMPERATURE ANOMALIES IN RWANDA

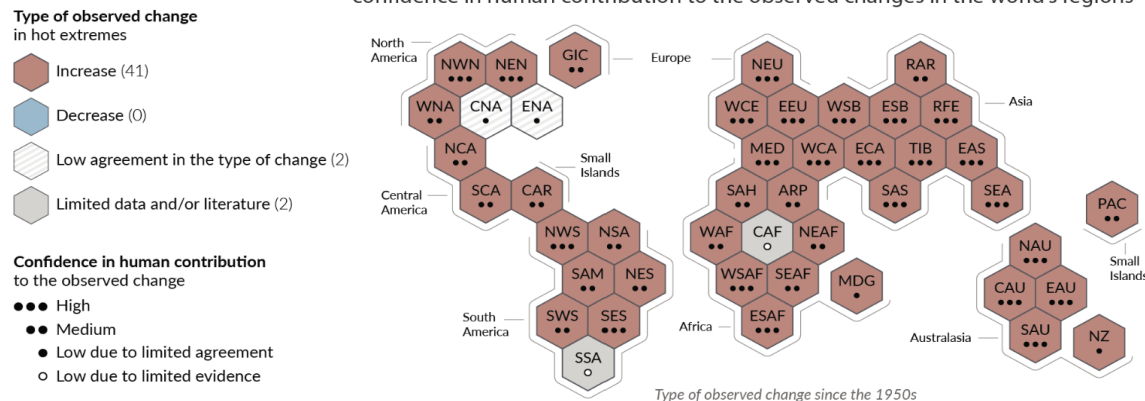


- The annually averaged global mean near-surface temperature in 2024 was $1.55 \text{ °C} \pm 0.13 \text{ °C}$ above the 1850–1900 average. This is the warmest year in the 175-year observational record, beating the previous record set only the year before (source 2024 Global State of Climate Report)
- Single year above 1.5 °C Long-term goals of the Paris Agreement are out of reach

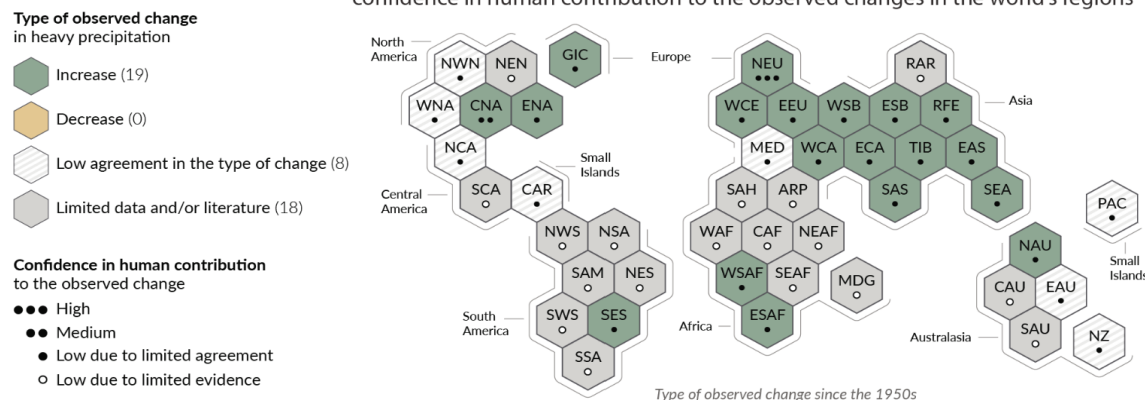
Introduction

Climate change is already affecting every inhabited region across the globe, with human influence contributing to many observed changes in weather and climate extremes

(a) Synthesis of assessment of observed change in **hot extremes** and confidence in human contribution to the observed changes in the world's regions



(b) Synthesis of assessment of observed change in **heavy precipitation** and confidence in human contribution to the observed changes in the world's regions



Global Climate Projection Models (GCMs) for regional and local predictions

Issue	Effect on Local Prediction
Coarse resolution	Misses local features and microclimates
Simplified physics	Uncertainty in precipitation, clouds, etc.
Model bias	Distorted climate statistics
Poor extremes representation	Underrepresents hazards like heatwaves, floods
Scenario/model variability	Wide uncertainty range in outcomes
Need for downscaling	Adds complexity and new uncertainties

A need for High resolution climate projections

Source: IPCC-AR6 Report

DATA & METHODS

Historical Gridded Rainfall and Temperature Datasets (1985-2014)



ENACTS & CHELSA

Future projections of Rainfall and Temperature Datasets (2015-2100)

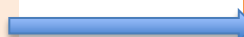


ISIMIP

9 Downscaled CMIP6 GCM Models under SSP1.26, SSP3.70 & SSP5.85



Bias-corrected and downscaled to 0.5°x0.5° resolution using trend preserving QM.



Data over Rwanda Domain were further downscaled to ~1*1km (30 arcsec) using V2. of Chelsa

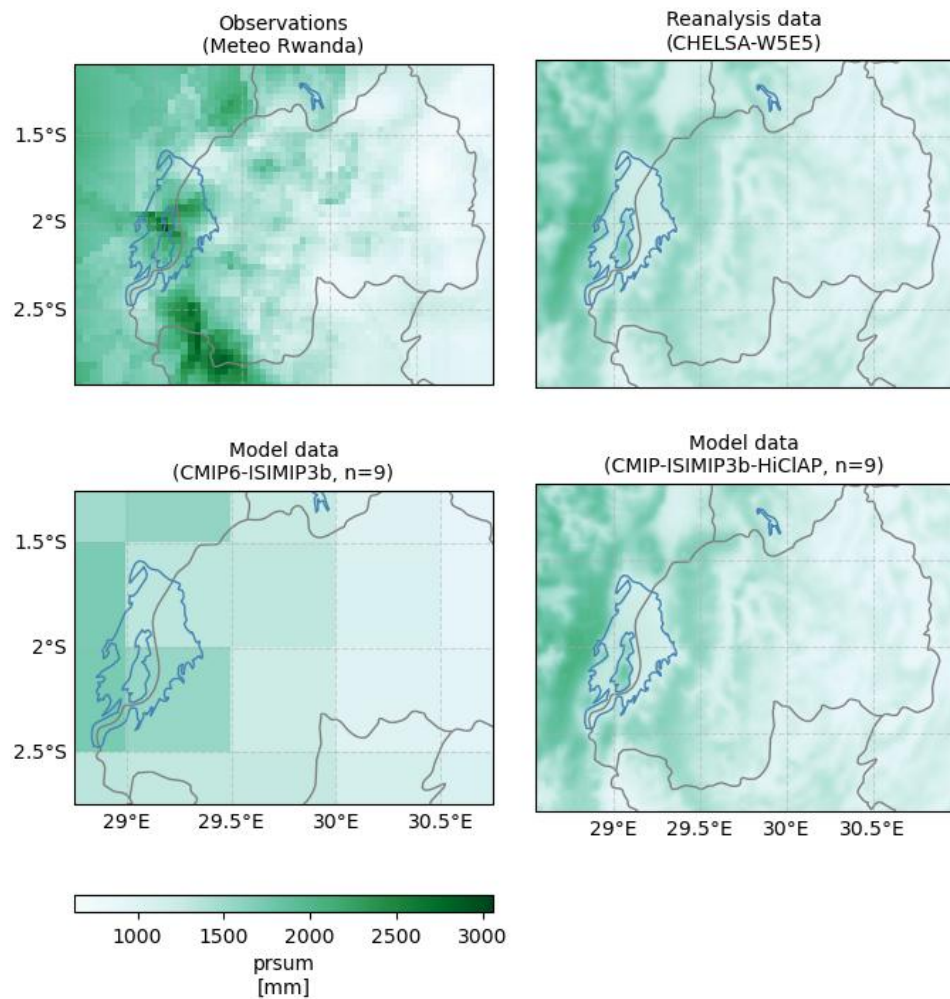
Climate Indices computed



Variable	Index
Temperature	Tmean
Heat	TX5x nTgt30degC
Precipitation	prsum
Extreme Precip	nprgtp95
Meteorological Drought	n5daydry ndry

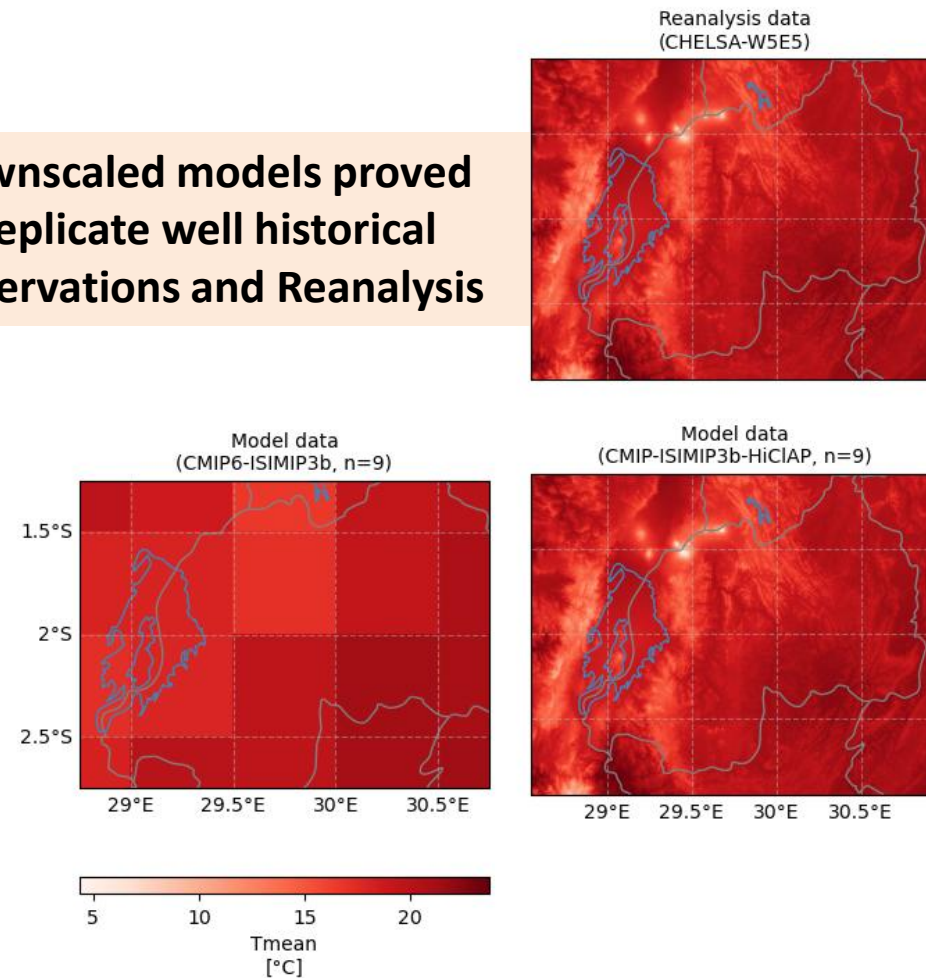
Model Evaluation

Spatial map of annual-sum daily precipitation (prsum) in Rwanda (1985-2014)



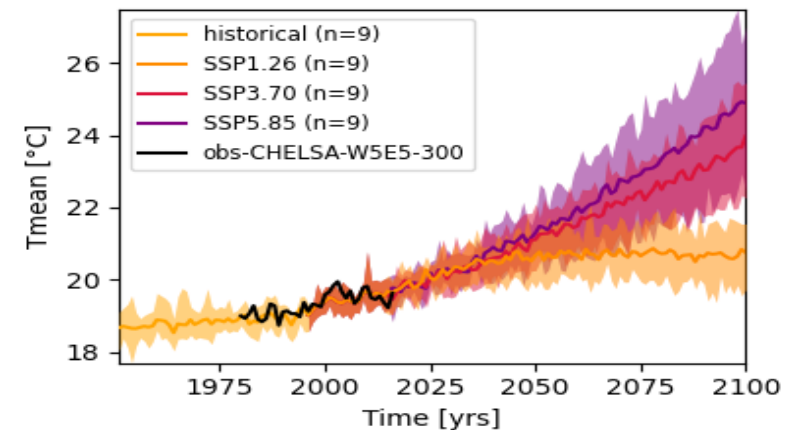
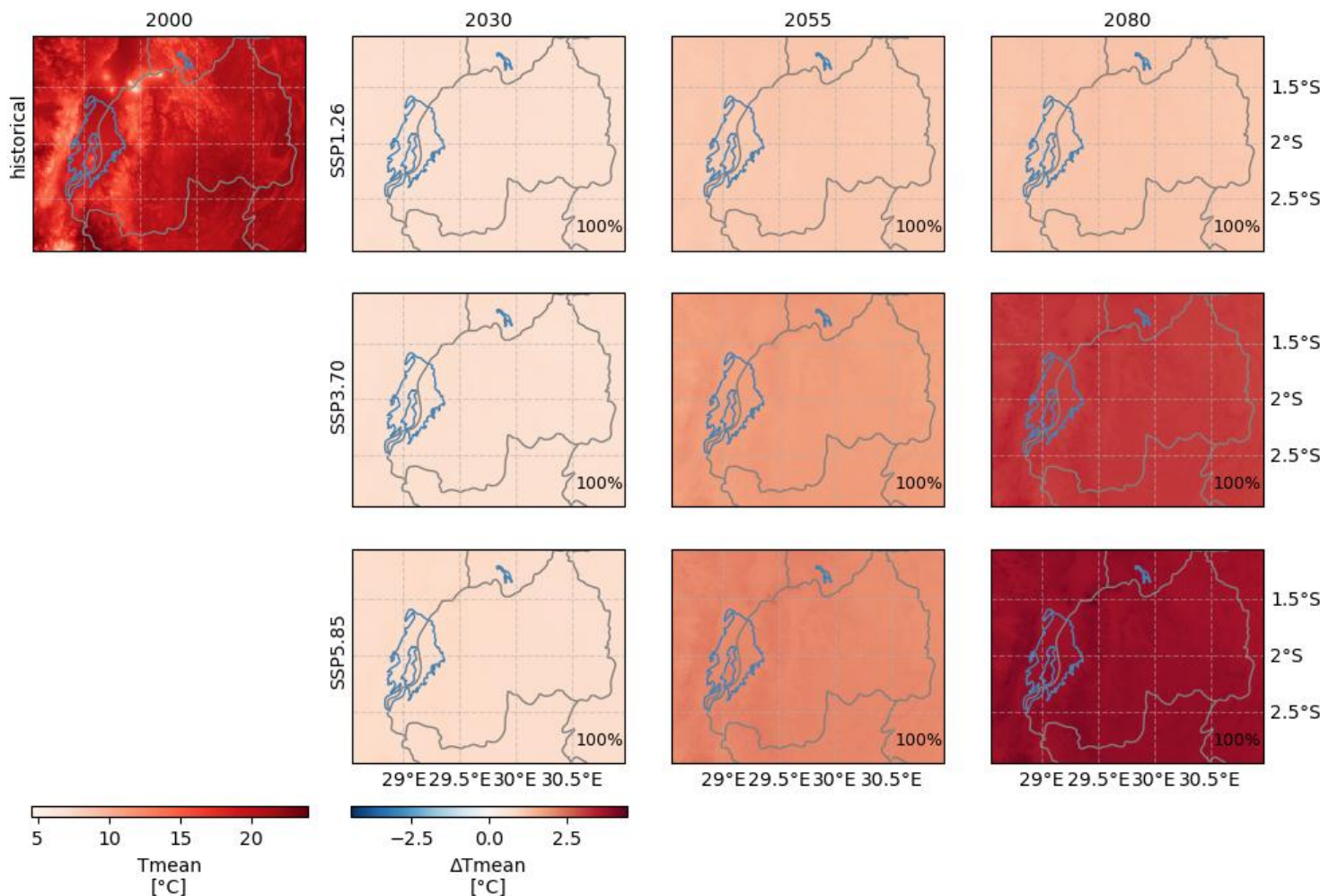
Spatial map of annual-mean daily-mean temperatures (Tmean) in Rwanda (1985-2014)

Downscaled models proved to replicate well historical observations and Reanalysis



Projected changes in temperature

Change of annual-mean daily-mean temperature (T_{mean}) between the baseline period (1985-2014) and those centred around 2030 (2015-2044), 2055 (2035-2064), and 2080 (2065, 2094)

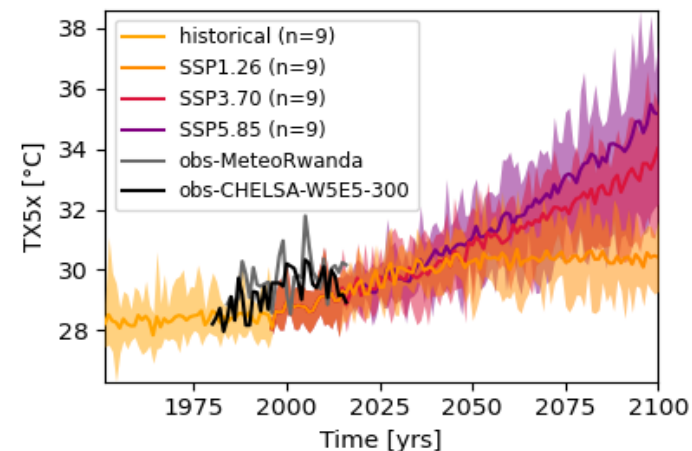
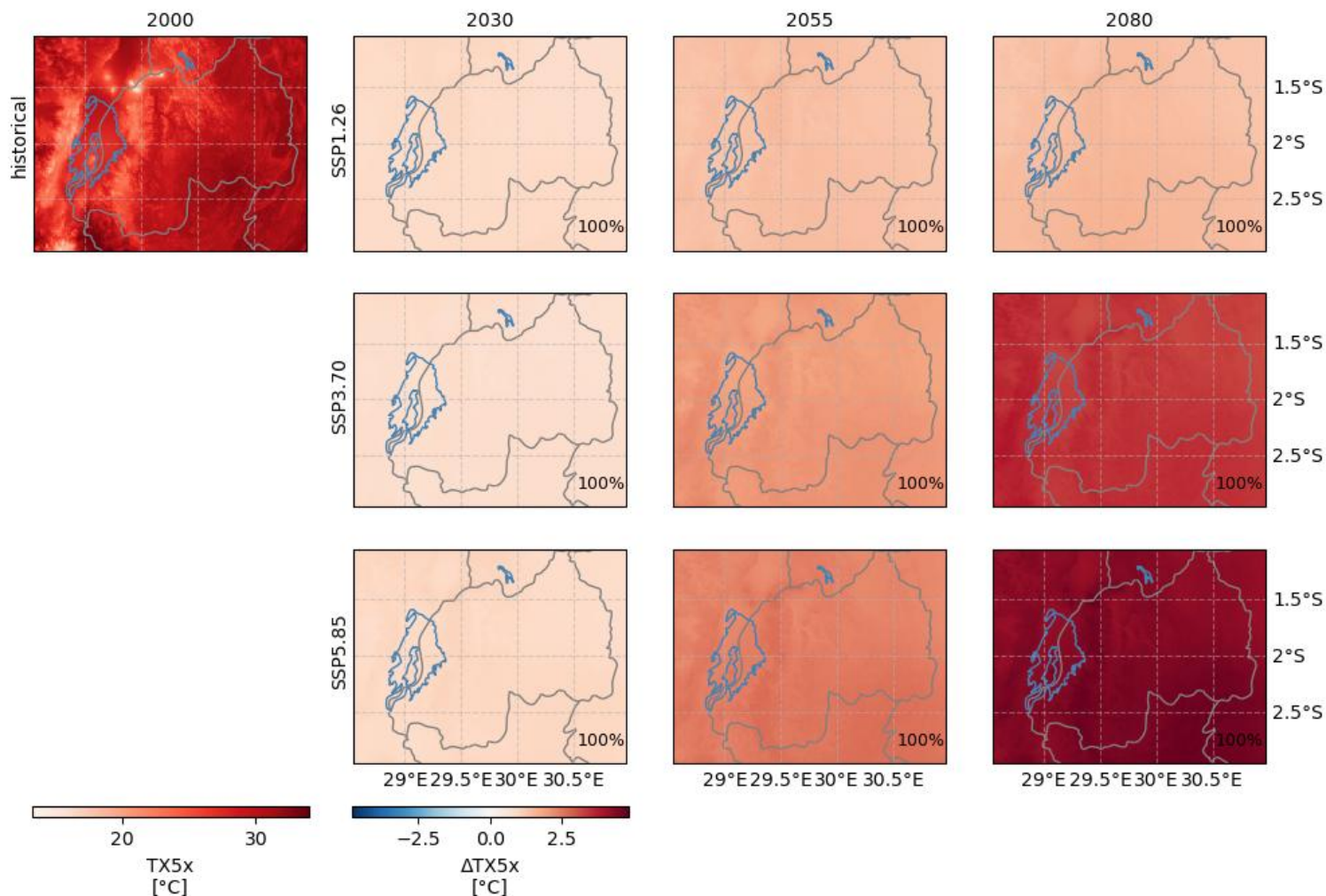


T_{mean}	Historical	Change to 2030	Change to 2055	Change to 2080
SSP1.26	19.28 ± 0.02 °C	0.93 ± 0.24 °C	1.38 ± 0.39 °C	1.43 ± 0.47 °C
SSP3.70		0.91 ± 0.26 °C	2.07 ± 0.44 °C	3.33 ± 0.69 °C
SSP5.85		1.01 ± 0.21 °C	2.36 ± 0.61 °C	4.08 ± 1.08 °C

Changes are highlighted in bold when their best estimate and the range given by the standard deviation do not overlap with zero, i.e., here considered as significant.

Projected changes in extreme temperature

Project changes in maximum daily maximum near-surface temperature during any consecutive 5-day period centered within the year/growing season

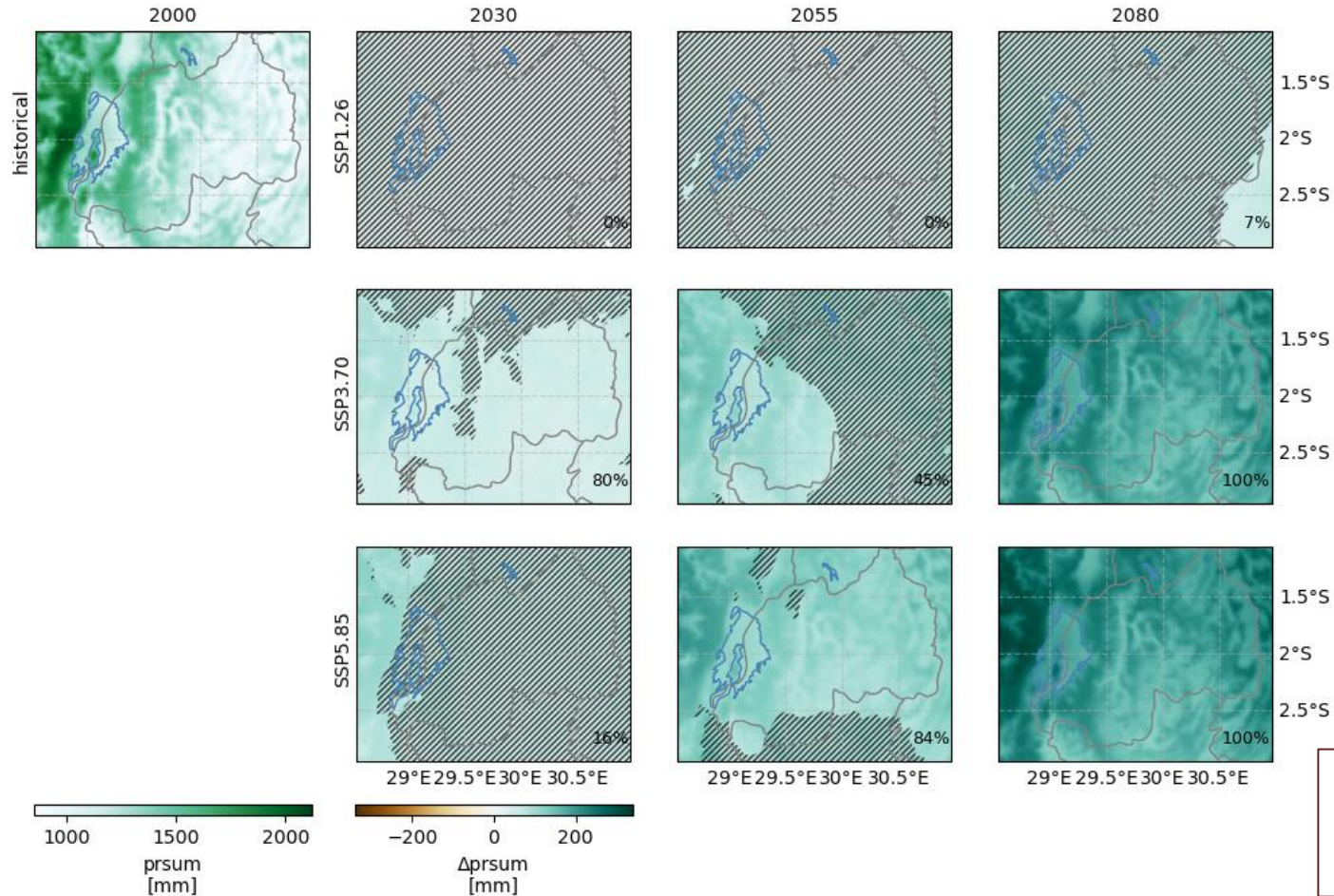


TX5x	Historical	Change to 2030	Change to 2055	Change to 2080
SSP1.26		1.12 ± 0.29 °C	1.60 ± 0.50 °C	1.68 ± 0.62 °C
SSP3.70	28.71 ± 0.14 °C	1.02 ± 0.45 °C	2.26 ± 0.57 °C	3.65 ± 0.87 °C
SSP5.85		1.17 ± 0.26 °C	2.67 ± 0.76 °C	4.64 ± 1.24 °C

- *temperature extremes increase more than temperature means*
- By 2080, hottest 5-day period per year could reach average values nearly 35.4°C

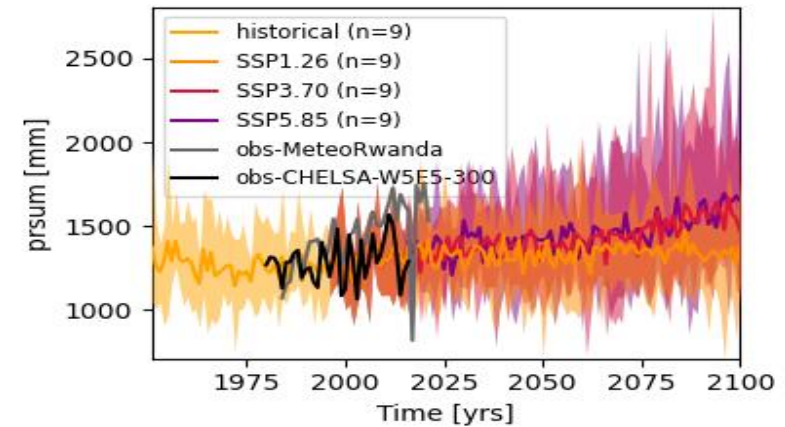
Projected changes in annual precipitation

Historical and projected changes in rainfall. Change of annual-sum daily precipitation (prsum) between the baseline period (1985-2014) and those centred around 2030 (2015-2044), 2055 (2035-2064), and 2080 (2065, 2094)



Quantification of prsum change.

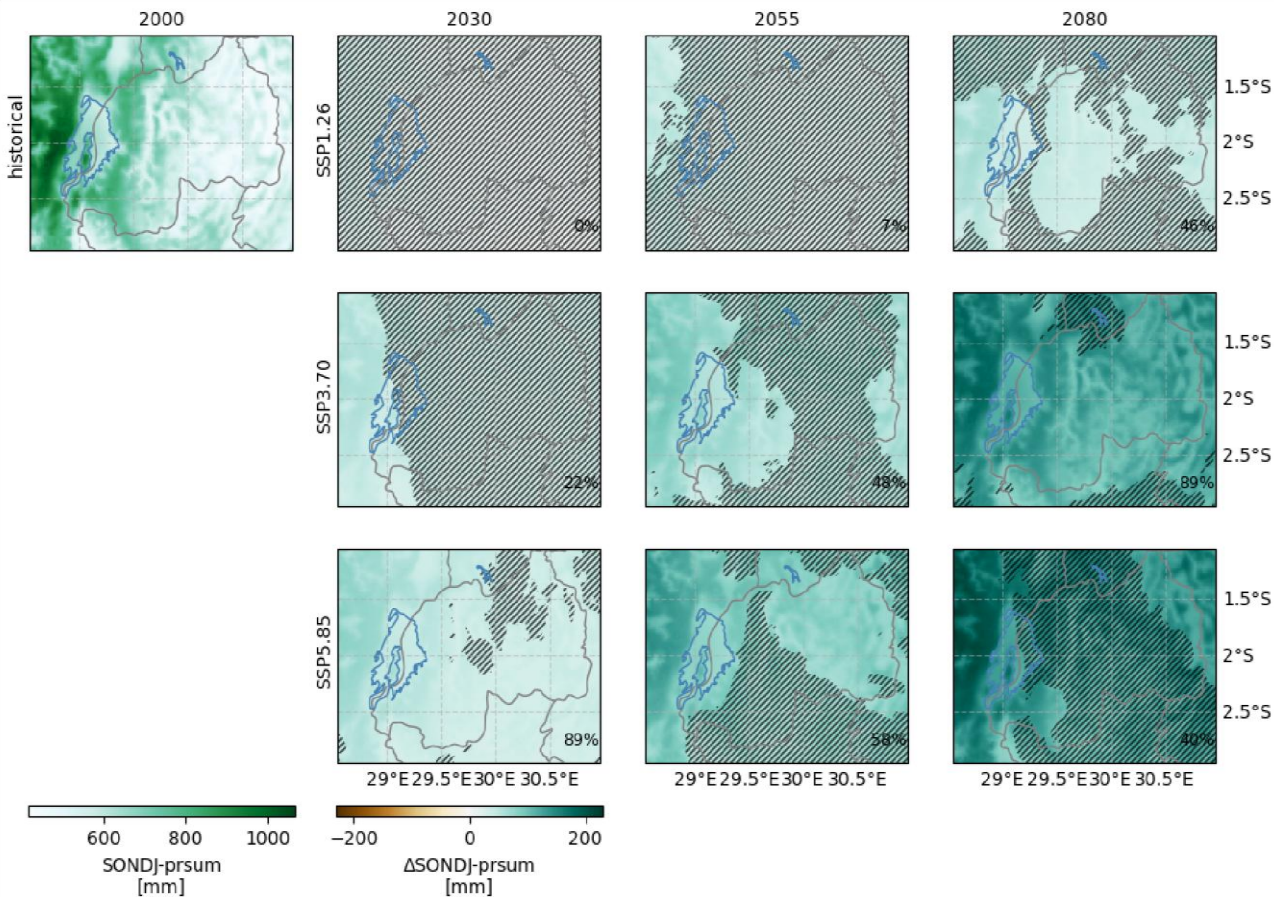
prsum	Historical	Change to 2030	Change to 2055	Change to 2080
SSP1.26	1281.7 ± 23.5 mm	37.8 ± 42.0 mm	51.2 ± 84.4 mm	71.3 ± 69.1 mm
SSP3.70		74.1 ± 58.2 mm	112.2 ± 118.9	215.5 ± 191.9
SSP5.85		84.4 ± 77.3 mm	138.0 ± 134.3 mm	222.9 ± 180.4



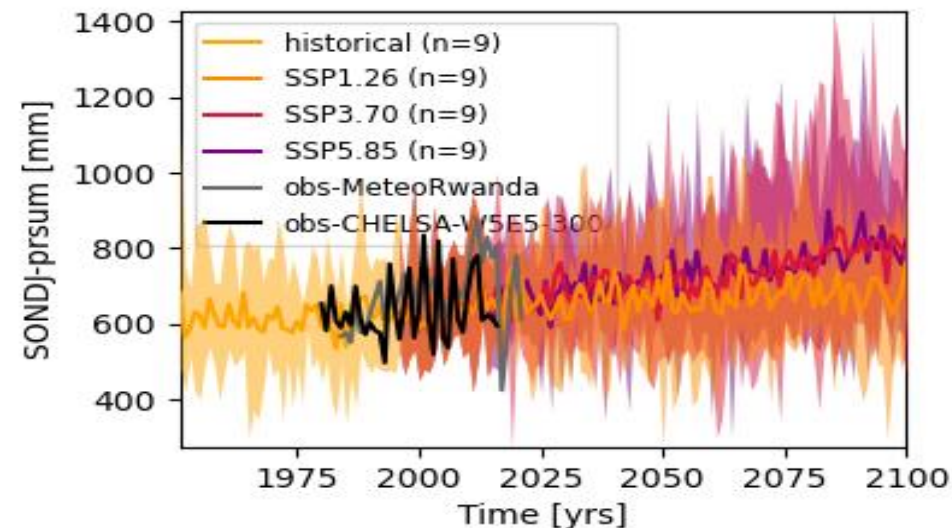
In the most ambitious mitigation scenario, there is limited model agreement on the sign of change (wetting or drying, in the annual average) and no significant change projected.

Projected changes in seasonal precipitation

Historical and projected changes in rainfall. Change of agricultural seasonal rainfall (SONDJ-prsum) between the baseline period (1985-2014) and those centred around 2030 (2015-2044), 2055 (2035-2064), and 2080 (2065, 2094)

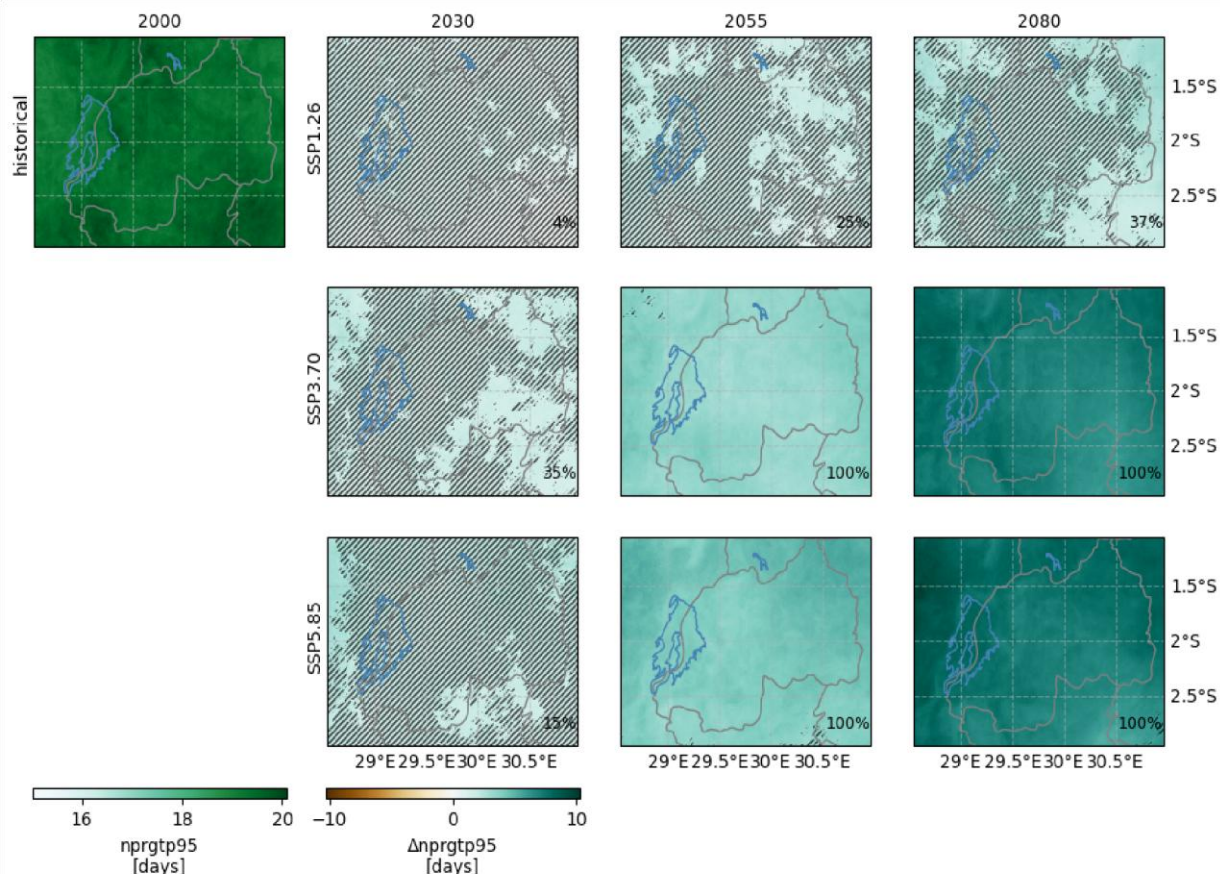


- Seasonal analysis shows that the increase in rainfall may fall more into the later months of the year.
- Total precipitation changes during the growing season are only projected for the later time periods under SSP3.70 and SSP5.85.



Projected changes in heavy precipitation

Historical and projected changes in heavy precipitation. But for the number of heavy-rainfall days (nprgtp95) between the baseline period (1985-2014) and those centred around 2030 (2015-2044), 2055 (2035-2064), and 2080 (2065, 2094)



- The number of heavy-rainfall days is highly variable
- Projected increases in heavy rainfall are significant for the 2055 and 2080 period in SSP3.70 and SSP5.85, with fewer spatial differences within Rwanda than for total precipitation.
- As for total precipitation, this increase in heavy-rainfall days is projected to occur in both growing seasons.

Quantification of changes in heavy precipitation.

nprgtp95	Historical	Change to 2030	Change to 2055	Change to 2080
SSP1.26	20.49 ± 1.06 days	0.02 ± 1.08 days	0.55 ± 2.10 days	1.16 ± 1.46 days
SSP3.70		-0.45 ± 1.42 days	1.53 ± 1.20 days	5.27 ± 3.38 days
SSP5.85		-0.39 ± 1.72 days	2.06 ± 1.81 days	5.33 ± 3.42 days

Key messages

- Significant increases in daily-mean temperature both annually and in the two growing seasons considered, in all climate change scenarios including the most ambitious SSP1.26
- Larger increases in annual/growing-seasonal maximum daily-maximum temperature are project, as is consistent with physical understanding.
- An increase in total annual precipitation is projected and especially in September-January rather than February-June, despite variability being generally larger for precipitation than for temperature.
- A steady increase in the number of heavy-rainfall days is visible in the SSP3.70 and SSP5.85 scenarios.
- Climate projections guides a adaptation strategies in:
 - Agriculture:** Crop choice, irrigation, pest control
 - Water Resources:** Dam design, allocation, drought plans
 - Health:** Disease trends, heat risk, infrastructure planning
 - Energy:** Hydro potential, demand forecasts, renewable feasibility
 - Urban Planning:** Infrastructure standards, zoning, flood control
 - Disaster Management:** Early warnings, evacuation, insurance
 - Governance:** Policy making, climate finance, international reporting



Thank You

This work has been sponsored by BMZ through the bilateral project MoE-GIZ NDC CD

*Presented by: Dr IYAKAREMYE Vedaste,
Division Manager of DOQCP at
METEO RWANDA*



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RWANDA CLIMATE SCIENCE SYMPOSIUM 2025

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D3) CLIMATE ACTION: ADAPTATION TO THE IMPACTS OF CLIMATE CHANGE

14 May 2025, 10:00 – 12:00 P.M.

Understanding Farmers' Knowledge, Perceptions, and Adaptation Strategies to Climate Change In Rwanda

Dr. Michel Rwema

AIMS RIC

Email: mrwema@aimsric.org



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Outline

- ❖ Introduction
- ❖ Methods
- ❖ Results
- ❖ Novelty
- ❖ Conclusion

Introduction

- ❖ **The Global Challenge of Climate Change:** Our world is facing an unprecedented challenge: climate change, driven by excessive greenhouse gas emissions. This is leading to rapid and pervasive changes across the Earth's systems – from the atmosphere to the oceans and the land we depend on [1].
- ❖ **Manifestations of a Changing Climate:** These changes are increasingly evident globally, taking the form of more frequent and intense heatwaves, heavier rainfall in some areas, prolonged droughts in others, and disruptions to essential growing seasons.
- ❖ **Agriculture: A Highly Vulnerable Sector:** Climate change significantly impacts agriculture through altered rainfall patterns (including droughts and floods), increased temperatures, and changes in growing seasons, leading to crop failures, reduced yields, food insecurity, and economic losses for farmers.

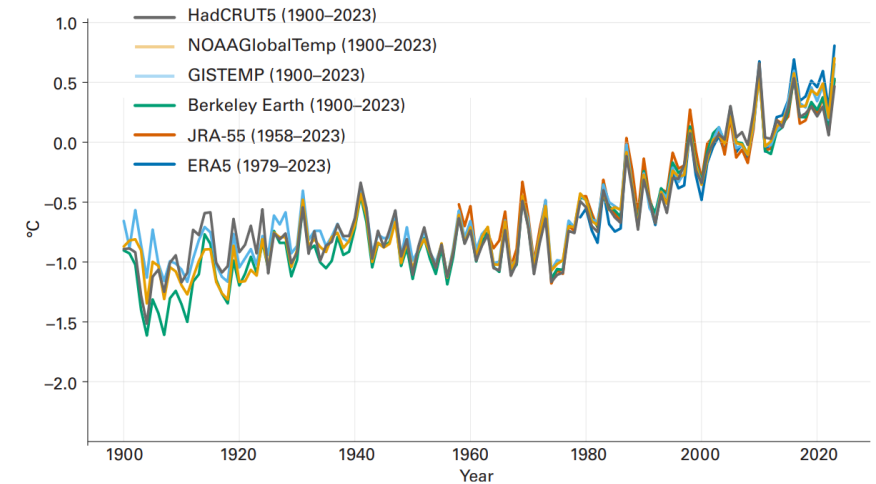


Figure: Temperature difference in °C with respect to the 1991–2020 climatological period for Africa from 1900 to 2023 [2].

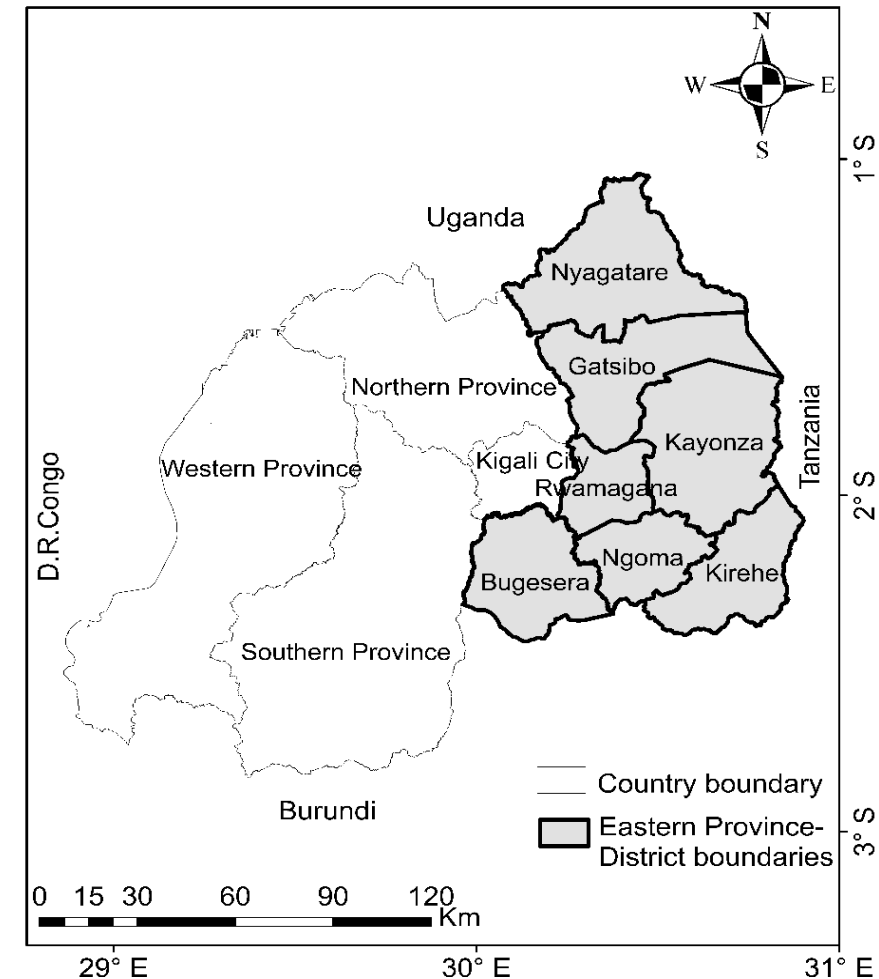
Background

- ❖ **Global Reality of Climate Change:** Climate change is no longer a future threat; it is already impacting all regions of the world in diverse and significant ways.
- ❖ **Rwanda: Experiencing Climate Extremes:** Rwanda is particularly vulnerable to a range of climate-related hazards, including:
 - Floods
 - Droughts
 - Landslides
 - Strong winds
- ❖ **Threat to Lives and Livelihoods:** These climate phenomena pose a significant threat to human lives, agricultural livelihoods, and national infrastructure in Rwanda and other countries with similar vulnerabilities.
- ❖ **The Importance of System Understanding:** To effectively address the challenges posed by climate change and make informed decisions, a deeper understanding of the systems within which we operate is crucial. This includes understanding climate trends, impacts, and the responses of affected populations.



Problem statement / Gaps

- ❖ **Limited Regional Focus in Climate Studies:** Existing research on Rwanda's climate change tends to concentrate on the national level or very localized areas. This often overlooks regions with distinct geographical characteristics and significant economic contributions, such as the Eastern Province [3, 4, 5, 6, 7].
- ❖ **Limitations in Existing Eastern Rwanda Studies:** The few studies that have specifically examined Eastern Rwanda have encountered limitations, either related to the available data or by leaving crucial aspects unexplored [8, 9].
- ❖ **Need for Disaster-Specific Climate Research:** There is a specific gap in research focusing on climate-related disasters like drought within Eastern Rwanda. Furthermore, the impact of climate change on farmer behavior in this region remains largely uninvestigated [10, 11].
- ❖ **Lack of Behavioral Analysis Among Farmers:** Current research lacks a detailed understanding of the behavioral differences among farmers in the Eastern Province concerning their perceptions and experiences of climate change.



Objectives

Main Objective:

- ❖ To comprehensively understand farmers' knowledge, perceptions, and adaptation strategies regarding climate change in the Eastern Province of Rwanda.

Specific Objectives:

- ❖ To assess farmers' awareness and perceptions of climate change and its impacts in the Eastern Province.
- ❖ To analyze historical meteorological data (1981-2021) to identify significant climate trends in the Eastern Province.
- ❖ To document and analyze the various adaptation strategies employed by farmers in response to perceived climate change.
- ❖ To identify the factors influencing farmers' adoption of different adaptation strategies.
- ❖ To explore the role of indigenous knowledge in climate-related decision-making.
- ❖ To determine the enabling factors and constraints affecting farmers' capacity to adapt to climate change.

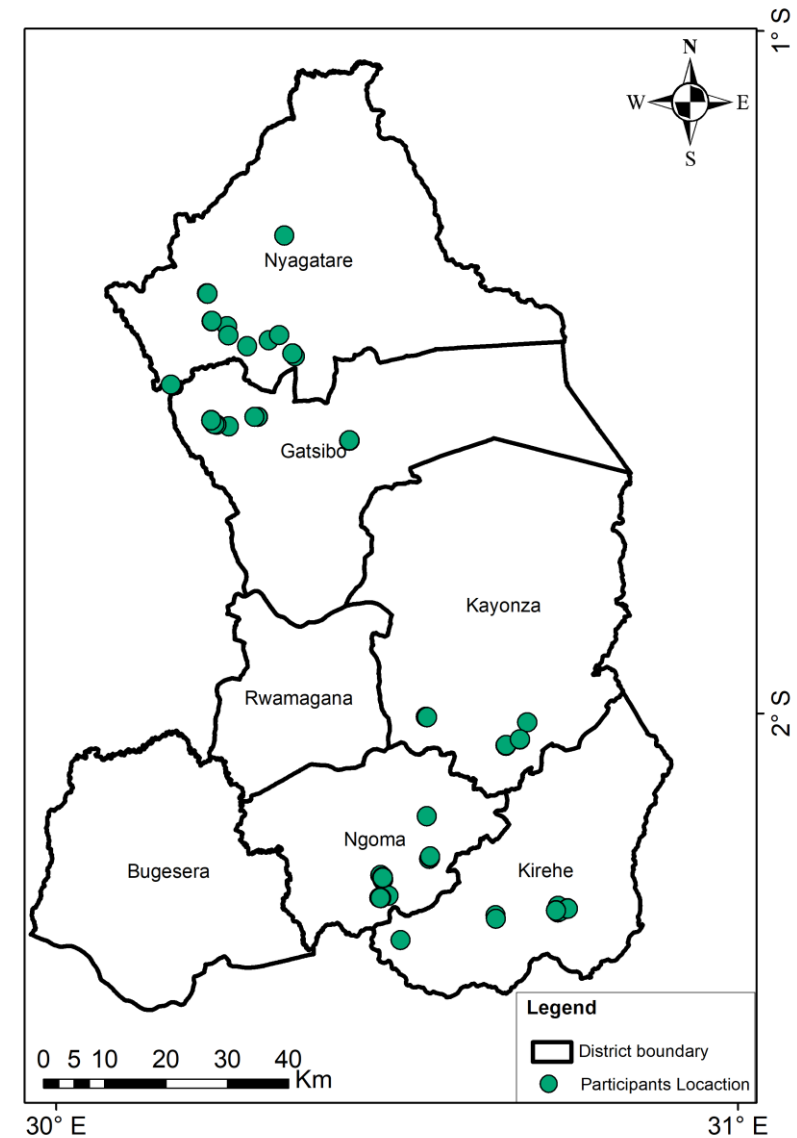
Methodology

Long-term meteorological data: Mathematical/ Statistical Methods

- ❖ Mann-Kendall test[11]
- ❖ Sen's Slope estimator
- ❖ Dynamic linear State-space model[12]
- ❖ Drought Index: SPI

Field surveys

- ❖ Farmers (204)
- ❖ Descriptive statistics
- ❖ Logistic regression



Key findings

Rainfall events: Seasonal changes at the regional level

Table: Slope value of identified trends for rainfall events at the Eastern regional scale.

1981-2021				
Season	Rainfall amount mm/day/year	Onset days/year	Cessation days/year	Season Duration days/year
MAM	-0.01	-0.21	0.00	0.21
SOND	0.00	-0.21*	0.00	0.23*

The * in the results indicates that significant regional trends are observed at a 95% confidence level.

Key findings

Temperature events: Seasonal changes at the regional level

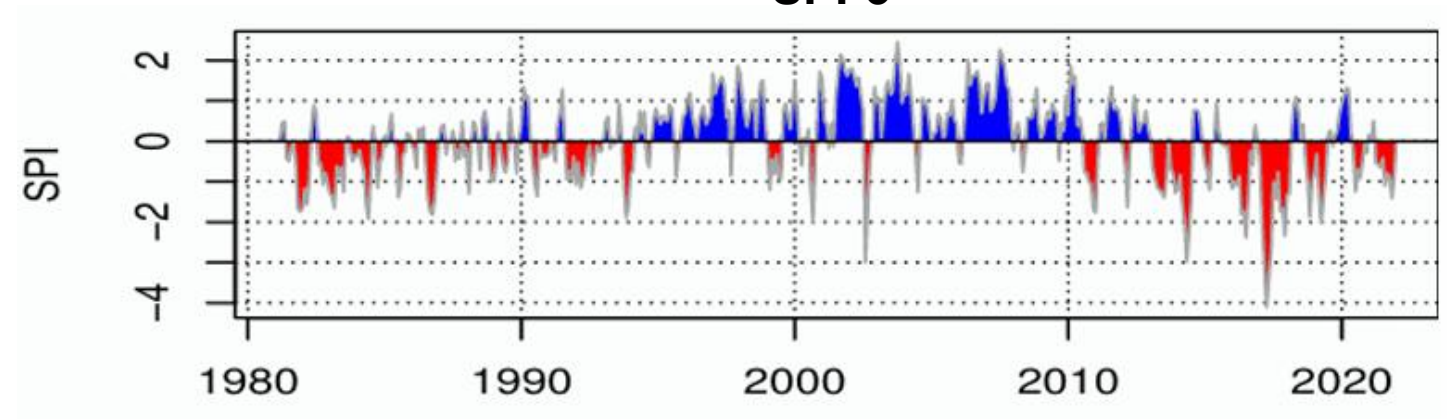
Table: Displays changes (in °C) with a 95% confidence interval in brackets [] for the averaged seasonal and annual means of Tx, Tn, and T in the Eastern Province of Rwanda from 1983 to 2021

1983-2021			
Season	Tx	Tn	T
JF	0.88 [-1.02-2.74]	1.71 [0.66-2.83]	1.47 [0.28-2.62]
MAM	0.16 [-1.60-2.00]	2.37 [1.07-3.68]	1.69 [0.22-2.93]
JJA	0.85 [-0.27-1.97]	3.37 [1.75-4.81]	2.37 [0.94-3.68]
SOND	-0.37 [-2.17-1.42]	2.72 [1.10-4.46]	1.17 [-0.18-2.47]
Annual	0.30 [-1.31-1.71]	2.95 [1.64-4.45]	1.87 [0.61-3.19]

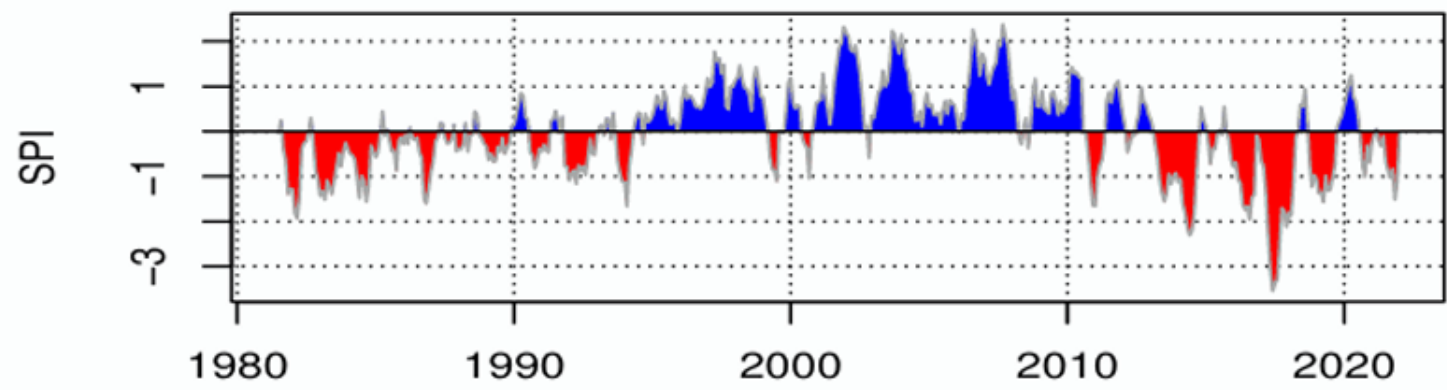
Key findings

Drought events: Temporal variability of drought index time series – Eastern Province

SPI-3



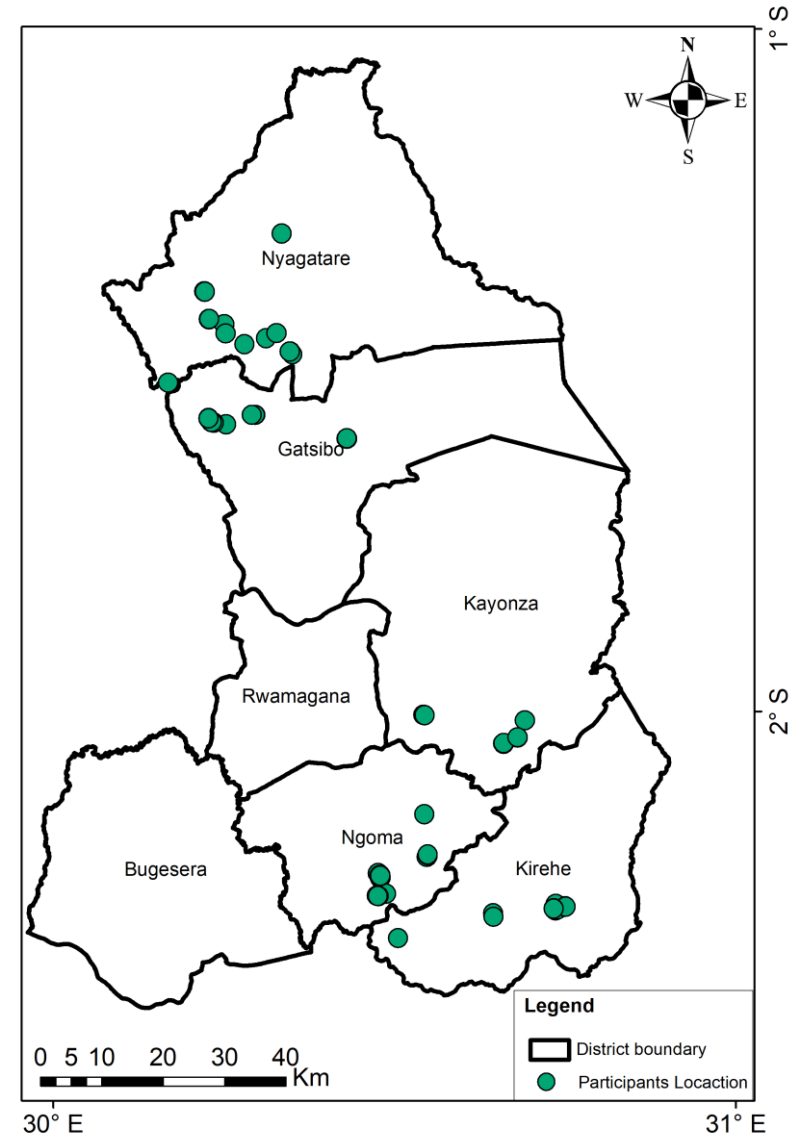
SPI-6



Key findings

Perceptions: socioeconomic characteristics and locations

Variables	Category	Frequency	Percentage (%)	Mean
Gender	Female	88	43	
	Male	116	57	
Age	20-34	48	24	43.66
	35-49	98	48	
	50-64	48	24	
	65-80	10	5	
Farming Experience (years)	1-20	96	47	22.18
	21-40	97	48	
	41-60	10	5	
Farm size (in hectares)	0-1	144	71	1.3
	1.1-2	40	20	
	> 2	20	10	
Farm ownership status	Owner	108	53	
	Tenant	34	17	
	Both	62	30	
Livestock ownership	Yes	131	64	
	No	73	36	
Group membership	Yes	76	37	
	No	128	63	
Exchanging info	Yes	161	79	
	No	43	21	
Access to weather info	Yes	99	49	
	No	105	51	
Access to bank service	Yes	119	58	
	No	85	42	

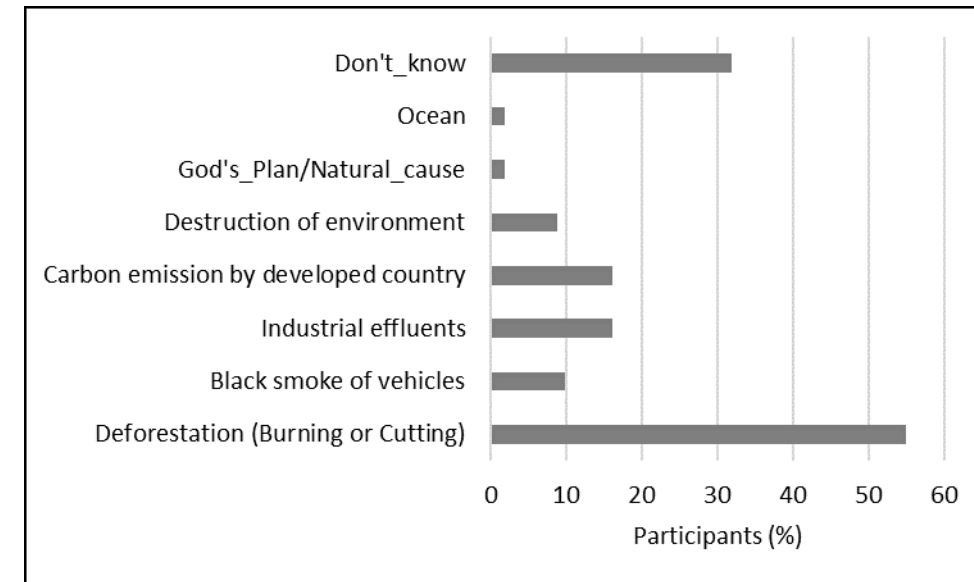


Key findings

Perceptions: Farmers' Knowledge

Table: Climate indicators associated with farmers' knowledge about rainy season onset and cessation (n=204)

	Onset skills			Cessation skills	
	Frequency	%		Frequency	%
Cloud	72	35	Rainfall distribution	93	46
Wind	38	19	Rainfall amount	36	18
Temperature	27	13	Rainfall duration	35	17
Lightning	12	6	Rainfall frequency	22	11
Do not know	32	16	Cloud	16	8
			Temperature	13	6
			Wind	4	2
			Do not know	25	12

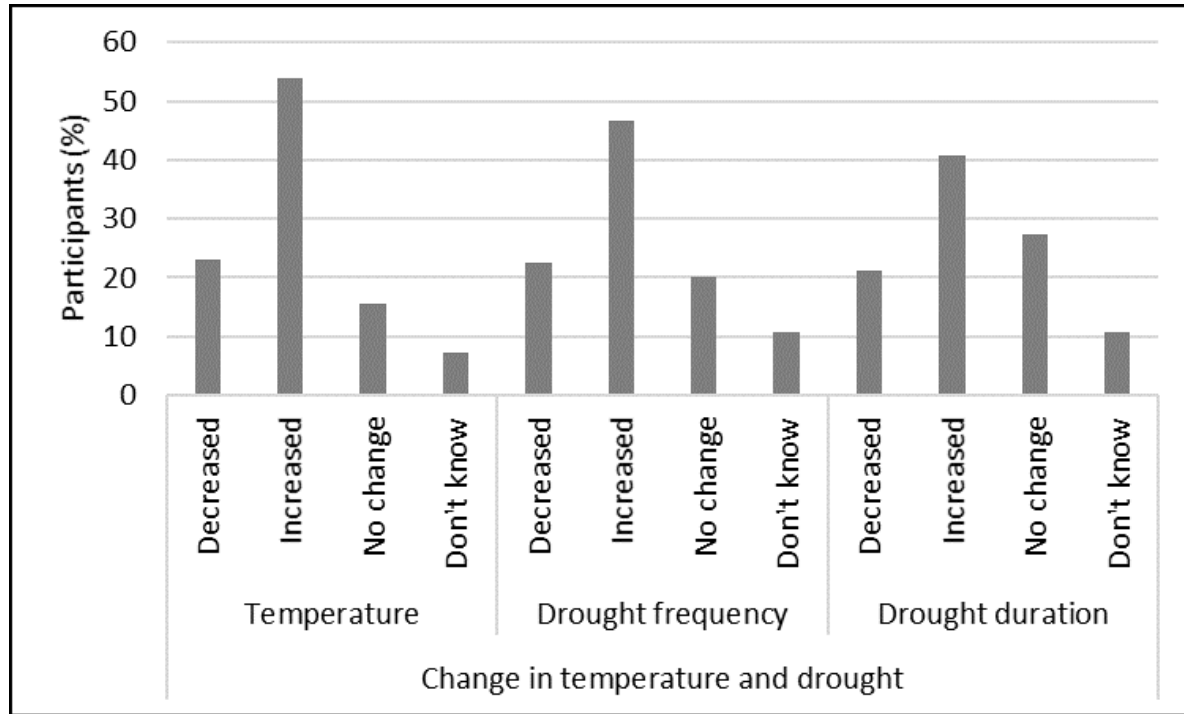


Farmers' responses regarding their awareness of the causes and factors contributing to climate change (n=204).

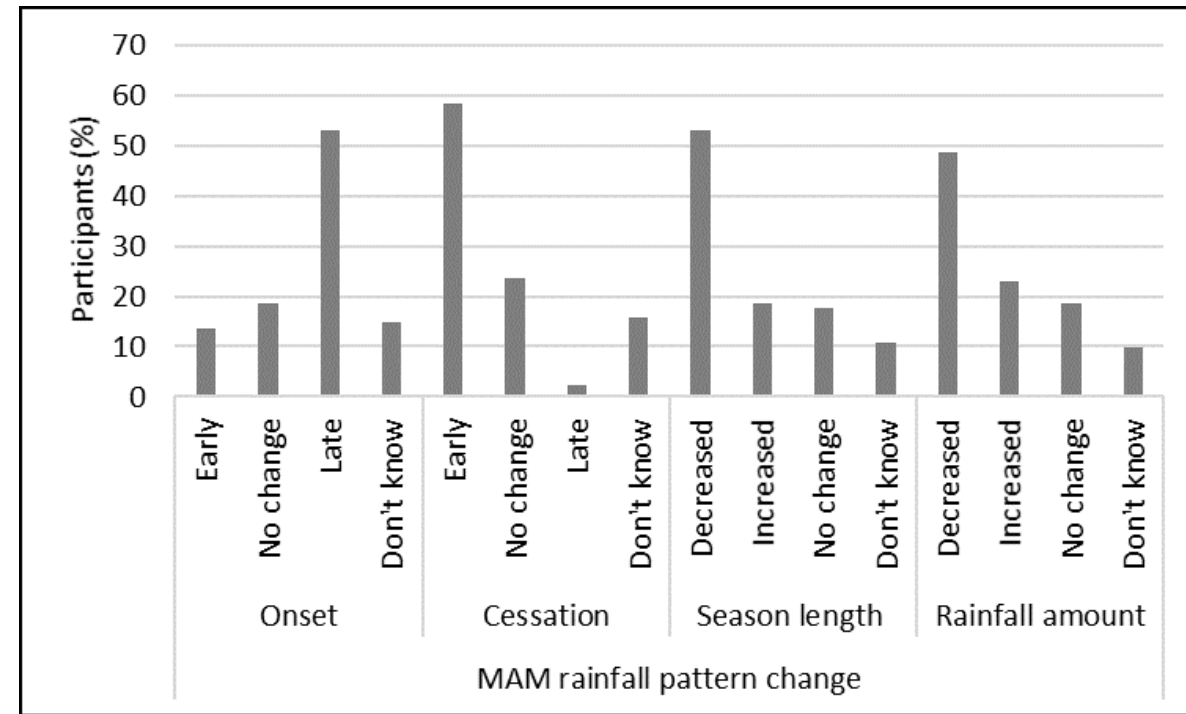
Key findings

Perceptions: Changes

Perception of change in temperature and drought pattern (n=204).



Perceptions of change in the MAM season rainfall Pattern (n=204).



Key findings

Perceptions: Impacts and development of adaptation strategies

Impacts

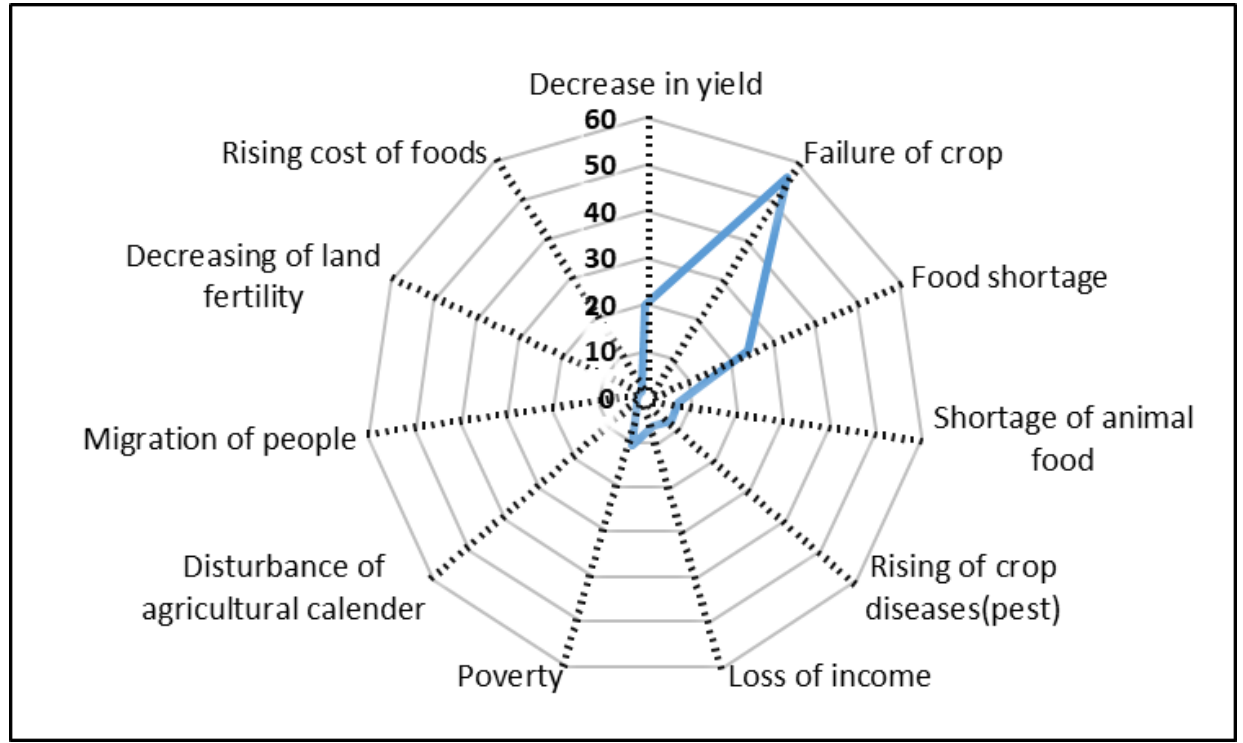


Table: Climate change adaptation strategies adopted by respondent farmers (n=204)

Adaptation Strategies	Frequ ency	Perce ntage
Agroforestry/Planting trees (PT)	81	40
Changing crop varieties (CCV)	47	23
Application of fertilizer (organic and inorganic) (AF)	47	23
Changing planting dates (CPD)	54	26
Soil conservation (SC)	50	25
Focus on wetland (FWL)	21	10
Use irrigation (UI)	43	21
Mulching (M)	9	4
Use of pesticides (UP)	15	7
Planting grass (PG)	11	5

Key findings

Socioeconomic factors influencing farmers' adaptation choices: odds ratios

Table: Logistic regression results: odds ratios and 95 % confidence interval showing socioeconomic factors influencing farmers' choice of selected adaptation strategies.

Variables	PT	CCV	AF
Gender	0.700 [0.345-1.418]	0.477* [0.205-1.109]	0.408** [0.167-1.000]
Age	0.965 [0.915-1.017]	0.963 [0.904-1.026]	1.009 [0.951-1.070]
Education level	1.037 [0.717-1.502]	0.963 [0.629-1.474]	1.013 [0.635-1.616]
Farmer experience(years)	1.019 [0.969-1.072]	1.036 [0.977-1.099]	1.002 [0.946-1.061]
Time spent/day (Hours)	1.007 [0.810-1.252]	0.843 [0.647-1.099]	0.751* [0.553-1.020]
Farm size (hectares)	0.885 [0.690-1.134]	1.013 [0.780-1.314]	0.773 [0.498-1.201]
Farm location	0.739 [0.513-1.064]	1.052 [0.697-1.587]	1.926** [1.225-3.028]
Land-holding status	1.158 [0.803-1.670]	1.324 [0.867-2.022]	1.008 [0.638-1.591]
Farming goal	1.668** [1.099-.531]	1.245 [0.745-2.083]	0.770 [0.460-1.288]
Livestock ownership	1.979* [0.965-4.060]	1.250 [0.530-2.948]	1.674 [0.679-4.128]
Farmer group membership	1.587 [0.776-3.245]	2.740** [1.206-6.226]	3.926** [1.556-9.906]
Exchanging info	2.024 [0.770-5.320]	3.167* [0.810-12.375]	1.118 [0.321-3.895]
Access to weather info (Radio)	1.234 [0.639-2.384]	1.272 [0.592-2.732]	2.271* [0.978-5.276]
Access to bank services	0.703 [0.344-1.437]	0.494* [0.216-1.127]	0.286** [0.116-0.706]
Household size (Individuals)	1.043 [0.893-1.218]	1.009 [0.846-1.205]	0.994 [0.818-1.208]
Constant		0.261	0.203
			0.403

* and ** show significant levels at 0.1 and 0.05, respectively.

SCIENTIFIC NOVELTY AND CONTRIBUTION

- ❖ **Understanding Local Perspectives for Adaptation:** This study examines farmers' perceptions of climate change, its impacts, and their current adaptation strategies in the Eastern Province, generating crucial insights to inform and enhance future adaptation interventions and policies.
- ❖ **Exploring Underexplored Factors for Resilience:** This analysis delves into previously underexplored variables that can significantly influence decision-making processes and ultimately enhance resilience to climate change impacts in the region.
- ❖ **Localized Climate Change Impacts:** This study provides a localized analysis of climate change effects within Rwanda's Eastern Province, highlighting the limitations of generalizing climate patterns across broader geographical areas and emphasizing the need for region-specific assessments.

Conclusion

- ❖ **Significant Warming & Intensified Drought:** The Eastern Province is experiencing a significant warming trend and increasingly severe drought events.
- ❖ **High Awareness, Information Gaps:** A significant majority of farmers are aware of climate change and accurately perceive increases in temperature and decreases in seasonal rainfall. However, a notable portion still lacks accurate information.
- ❖ **Climate Change Integrated into Decision-Making:** Farmers are considering the effects of climate change in their daily activities, enabling them to implement various adaptation strategies. However, barriers hinder the widespread and sustainable adoption of these practices.
- ❖ **Socioeconomic Factors Drive Adaptation:** Socioeconomic factors such as gender, farmer group membership, access to banking services, and livestock ownership significantly influence the types of adaptation strategies adopted by farmers.
- ❖ **Region-Specific Analysis for Enhanced Resilience:** This localized study in Eastern Rwanda underscores the importance of targeted climate analysis and the exploration of underexplored factors in farmer behavior to inform effective adaptation strategies and build greater resilience.

ACKNOWLEDGEMENTS

Data Availability Rainfall datasets were provided by the Rwanda Meteorology Agency (Meteo Rwanda). The data can be accessed through the online portal at <https://www.meteorwanda.gov.rw>.

Funds:

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- The Research Council of Finland (project numbers 353083, 353095, 321890).



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Thank you!



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RWANDA CLIMATE SCIENCE SYMPOSIUM 2025

Advancing Research And Networking

C2) Impacts of Climate Change and Risk Assessment

14 May 2025, 10:00 – 12:00 P.M.

Evaluating Land degradation for sustainable silvopastoralism in Savanna Region: A Case Study in Matimba and Rwimiyaga Sectors in Eastern Province of Rwanda

Author(s): David Ukwishaka^{1,2} Aime Tsinda², Emmanuel Muyombano², Josephine Malonza³, Esther Ndacyayisenga

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Background

1

- ❑ The savanna ecosystem is highly vulnerable to climate change, and this leads to other problems such as the land degradation due to drought
- ❑ Land degradation is a major global issue, threatening ecosystems, food security, and human well-being.
- ❑ Over 75% of Earth's land is degraded, affecting 3.2 billion people, and could reach 95% by 2050 (IPBES, 2018).
- ❑ Savanna ecosystems, including Rwanda's Eastern Province, are especially vulnerable to land degradation due to:
 - Prolonged dry seasons & limited rainfall (drought)
 - Overgrazing & deforestation
 - Unsustainable agriculture

Problem Statement

2

- ❑ Rwanda's savanna regions, particularly in Matimba and Rwimiyaga sectors of Nyagatare District, have experienced severe land degradation due to:
 - Deforestation for cattle ranching
 - Overgrazing and wind erosion
 - Drought-induced vegetation loss
 - Increase of built-up areas (settlement)
- ❑ Despite efforts by REMA (e.g. 915.3 ha restored using silvopastoral systems), limited research exists on:
 - ❑ The effectiveness of these practices in dry savanna drought prone areas to increase the resilience over drought
 - ❑ The extent and trends of degradation over time



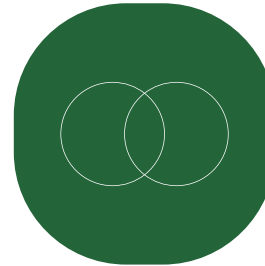
Objectives

3

The study seeks to provide insights into the effectiveness of these practices and their potential applicability in addressing land degradation induced by drought and other factors, and their potential to be applied in other areas. Specifically, this paper aims to:



Map and quantify land degradation (2000–2022)



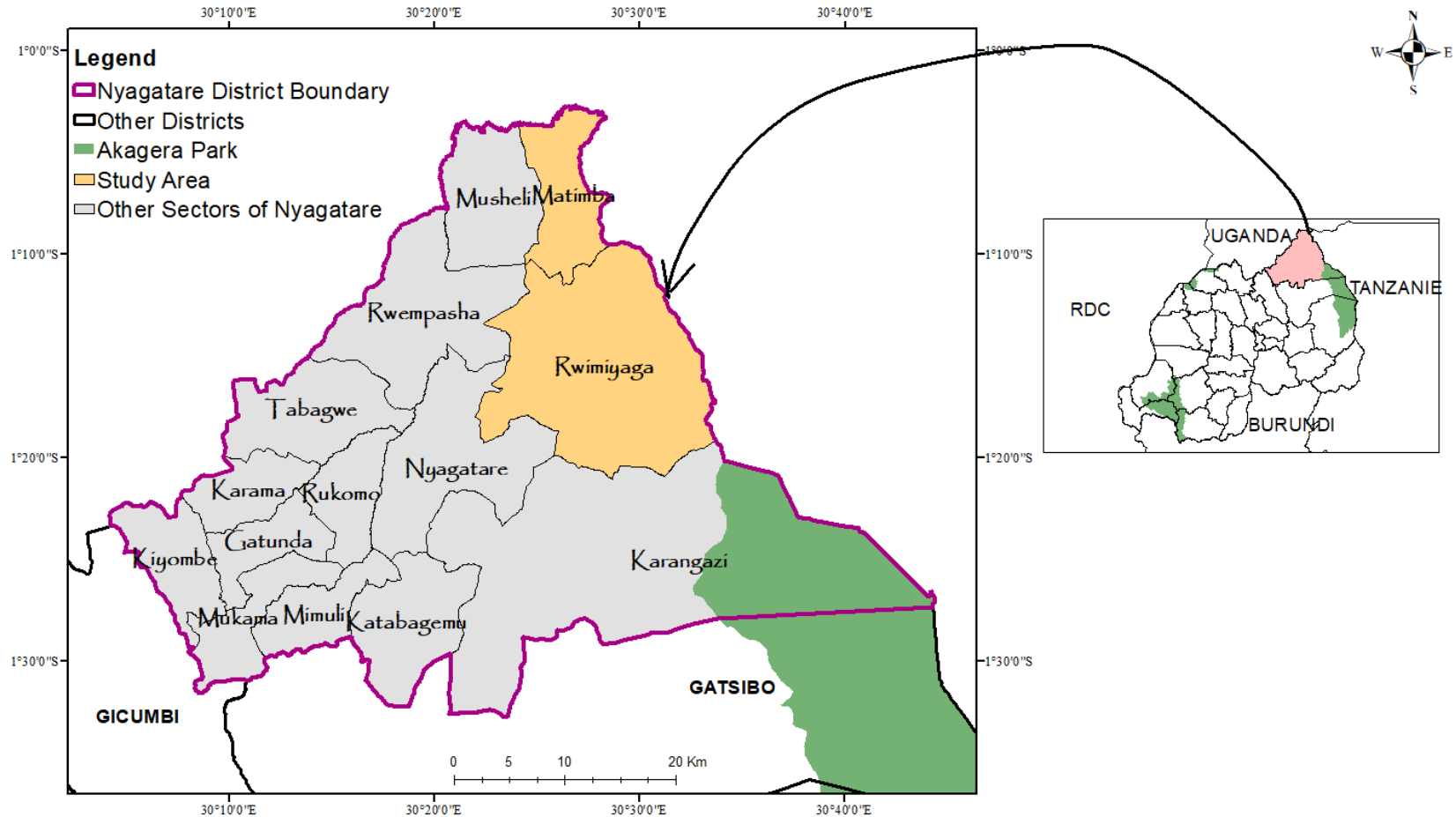
Compare degradation in areas with vs. without silvopastoralism



Assess silvopastoralism's impact on land restoration



Identify opportunities to scale up silvopastoral practices and Propose strategies for land resilience and sustainability



Study Area

- Location: Rwimiyaga & Matimba sectors, Nyagatare District, Eastern Rwanda
- Rationale: Area severely degraded by overgrazing, deforestation, and climate change impacts
- Intervention: Silvopastoralism implemented for land restoration

Material & Methods

5

This research used the **Good Practice Guidance (GPG) for SDG 15.3.1**, which is a standardized methodology developed by the UNCCD to help countries monitor and report on land degradation neutrality (LDN) using three core indicators

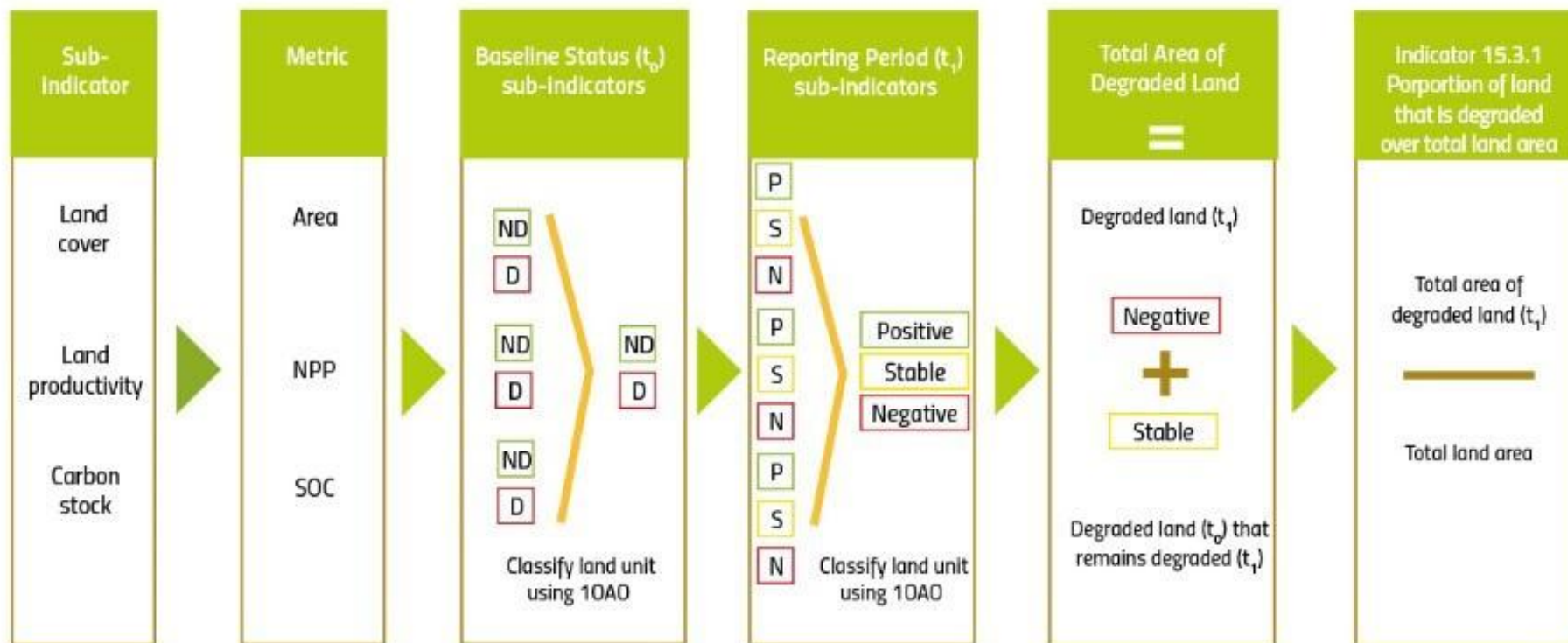
Assessment Approach

Land Cover Change: This sub-indicator tracks changes in the physical coverage of the land surface. Significant changes in land cover can indicate degradation, especially when natural ecosystems are replaced by human-made ones.

Land Productivity: This measures the net primary productivity (NPP) of vegetation using satellite data (MODIS). It indicates the biological capacity of land to produce biomass (e.g., crops, forage). Declines in productivity over time may suggest land degradation

Soil Organic Carbon (SOC): SOC reflects the amount of carbon stored in soil organic matter. It's a key indicator of soil health, fertility, and its ability to retain water and nutrients. A reduction in SOC typically indicates land degradation, erosion, or loss of soil quality

Material & Methods



Data Analysis Tools

ArcGIS/QGIS: Land cover mapping, final degradation maps

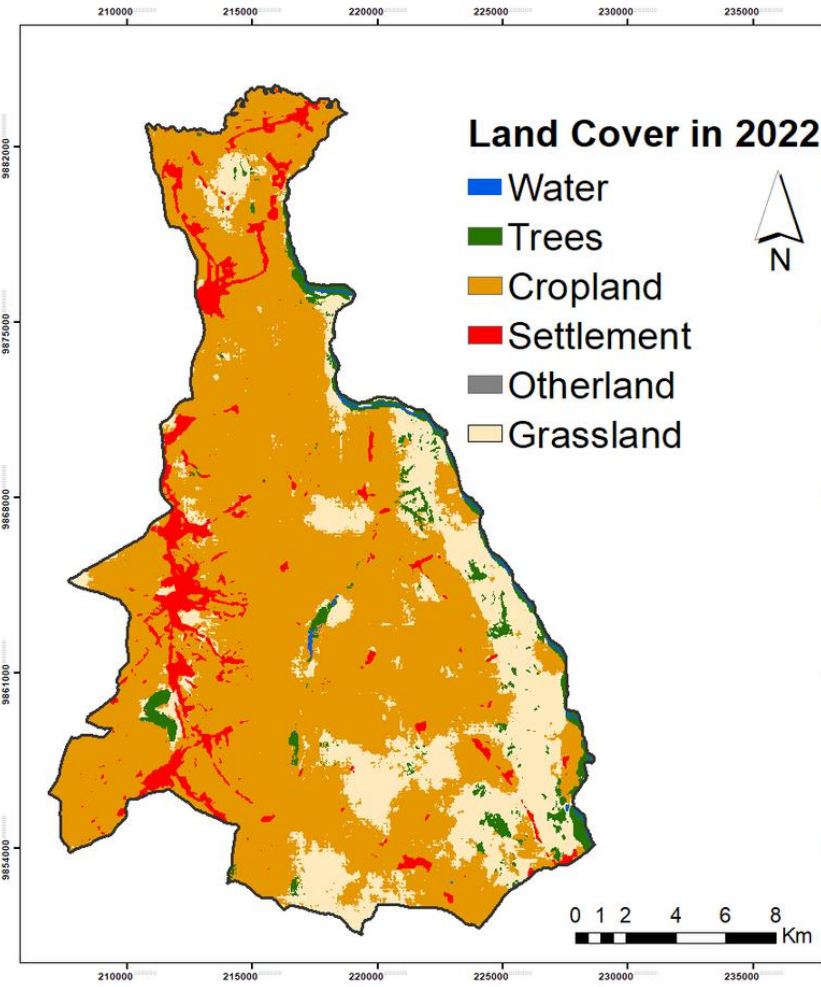
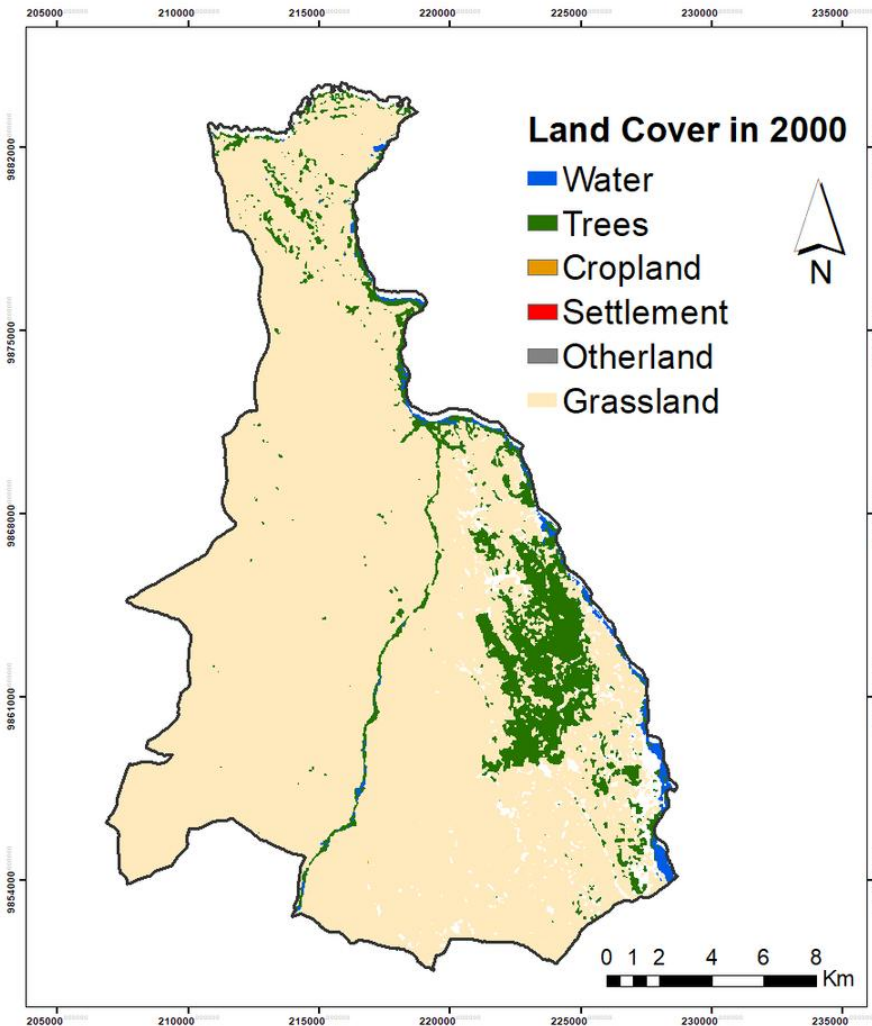
Trend.Earth: Soil Organic Carbon mapping

Google Earth Engine: Land productivity analysis (FAO approach)

Excel: Statistical analysis & graphing

Results

Land Cover Changes (2000–2022)

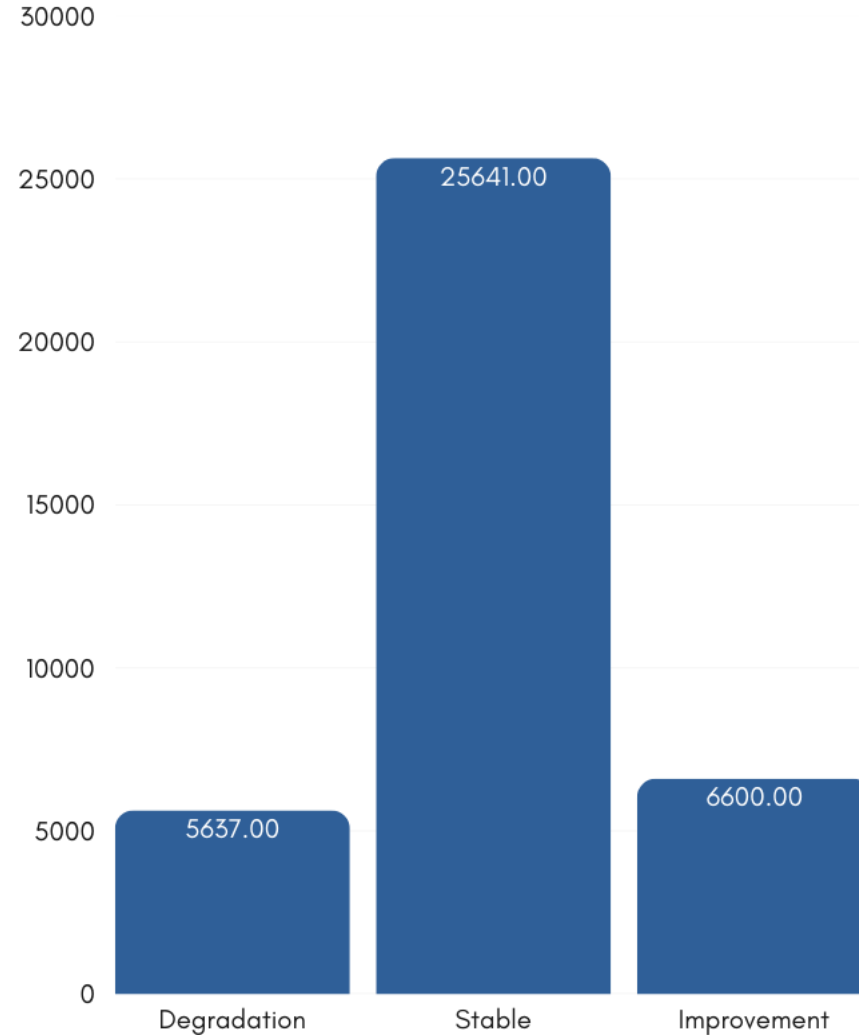
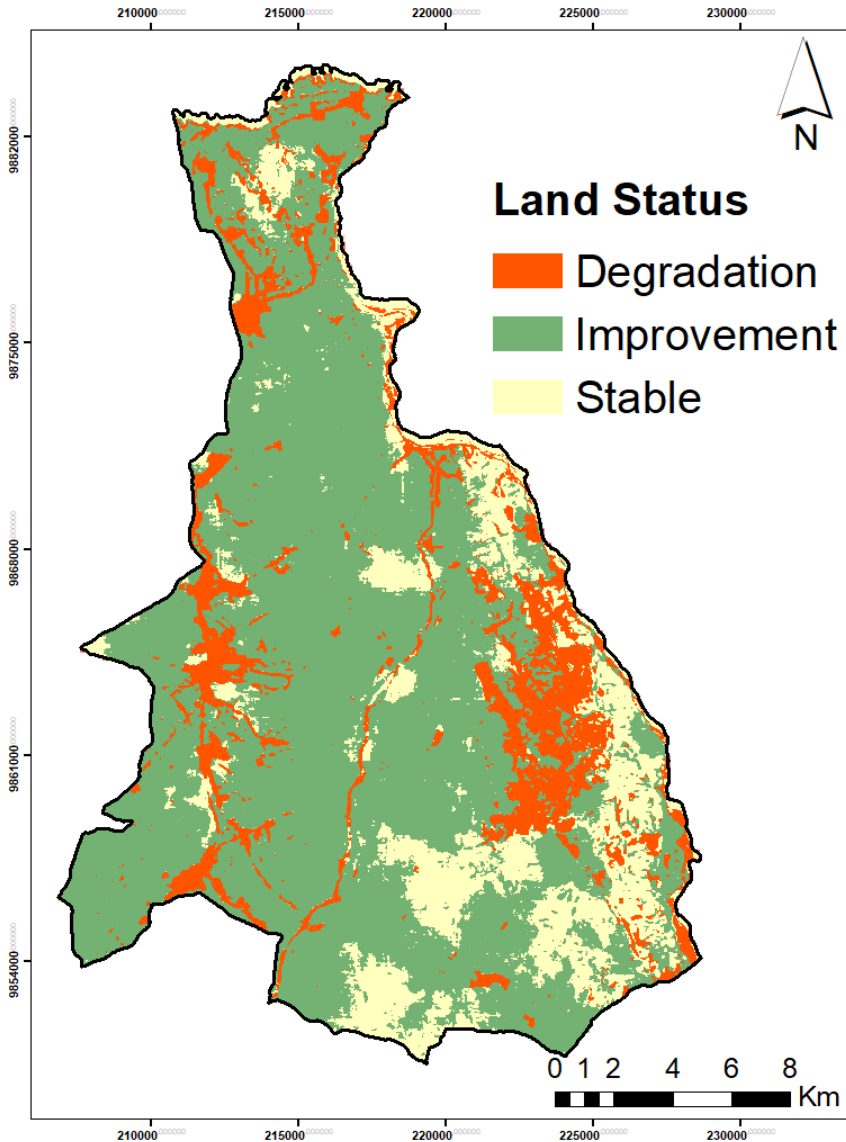


- Significant decline in natural vegetation.
- Increase in built-up areas and bare land.
- Deforestation and bush clearing for agriculture and settlements identified as major drivers

Results

8

Land Cover Changes (2000–2022)

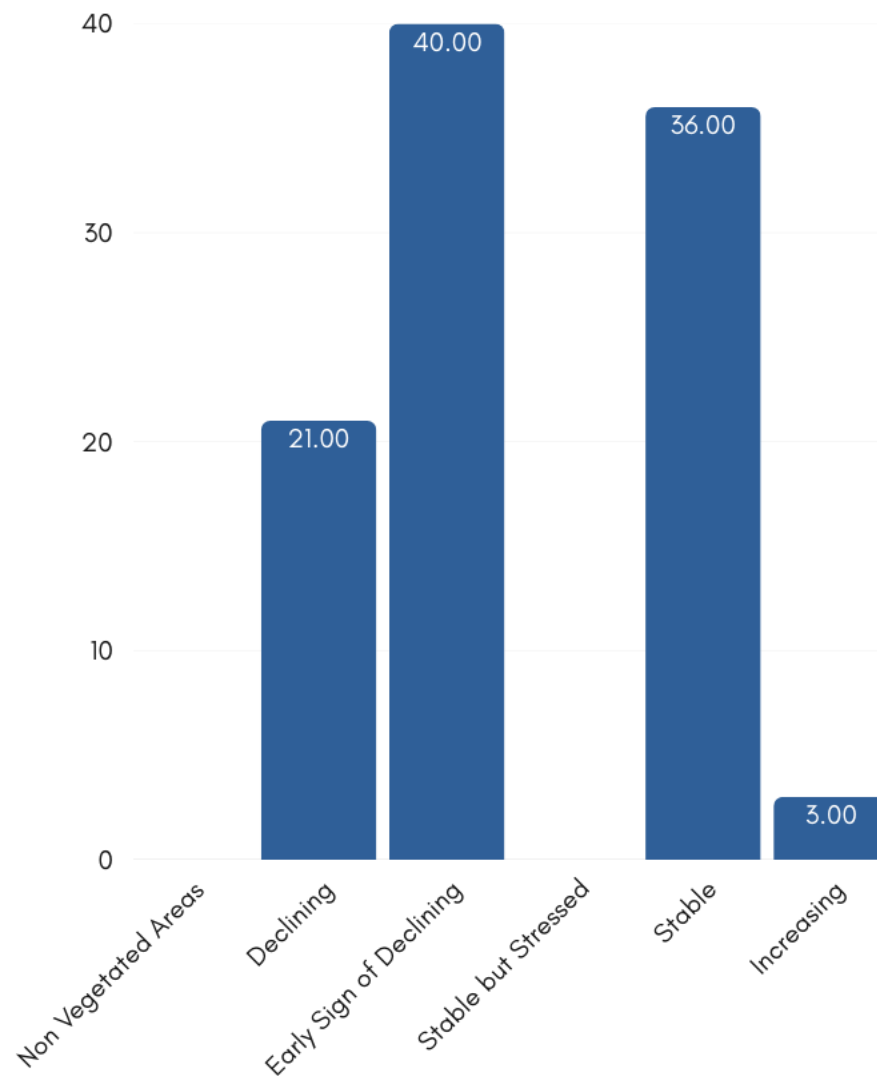
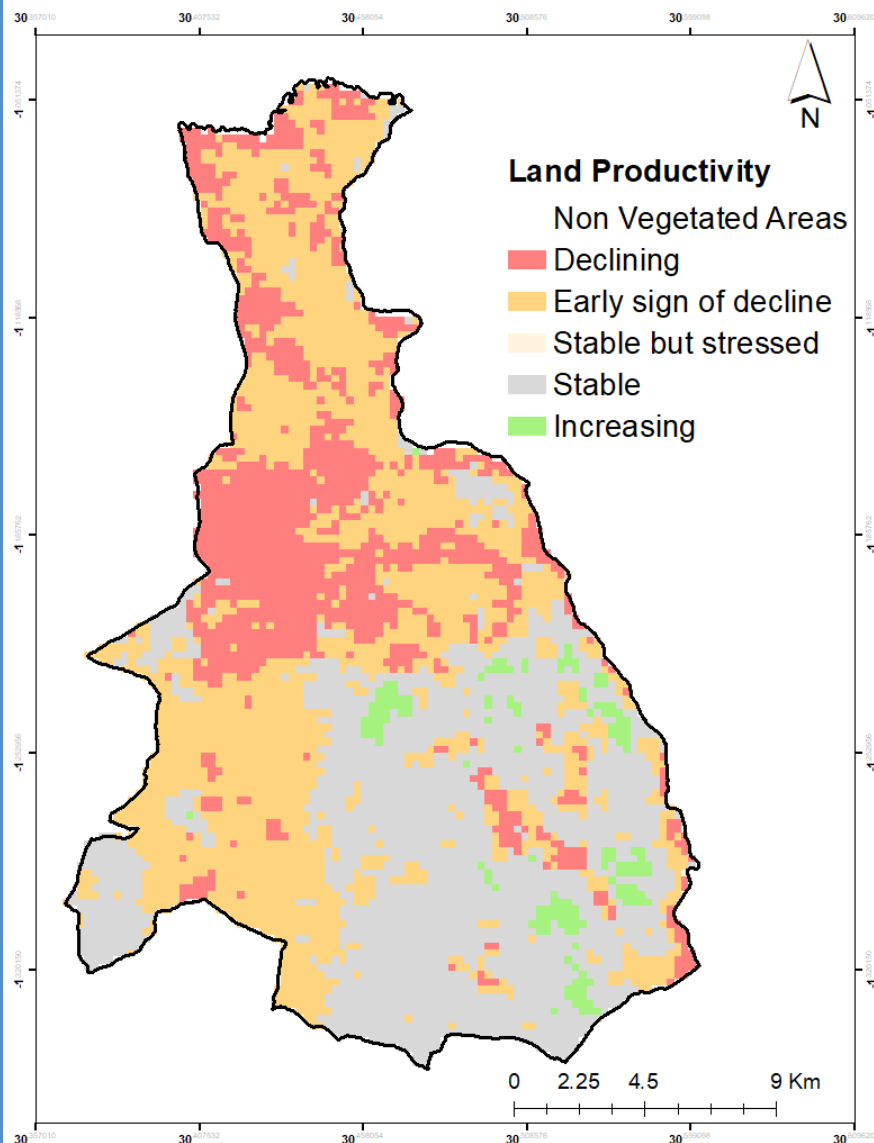


- According to the land status definition, 25,641 hectares showed improvement due to the expansion of cropland, resulting in increased land productivity.
- The study also found that 6,600 hectares remained stable, with no changes, mainly consisting of grassland still being used as rangeland

Results

9

Land Productivity (2000–2022)

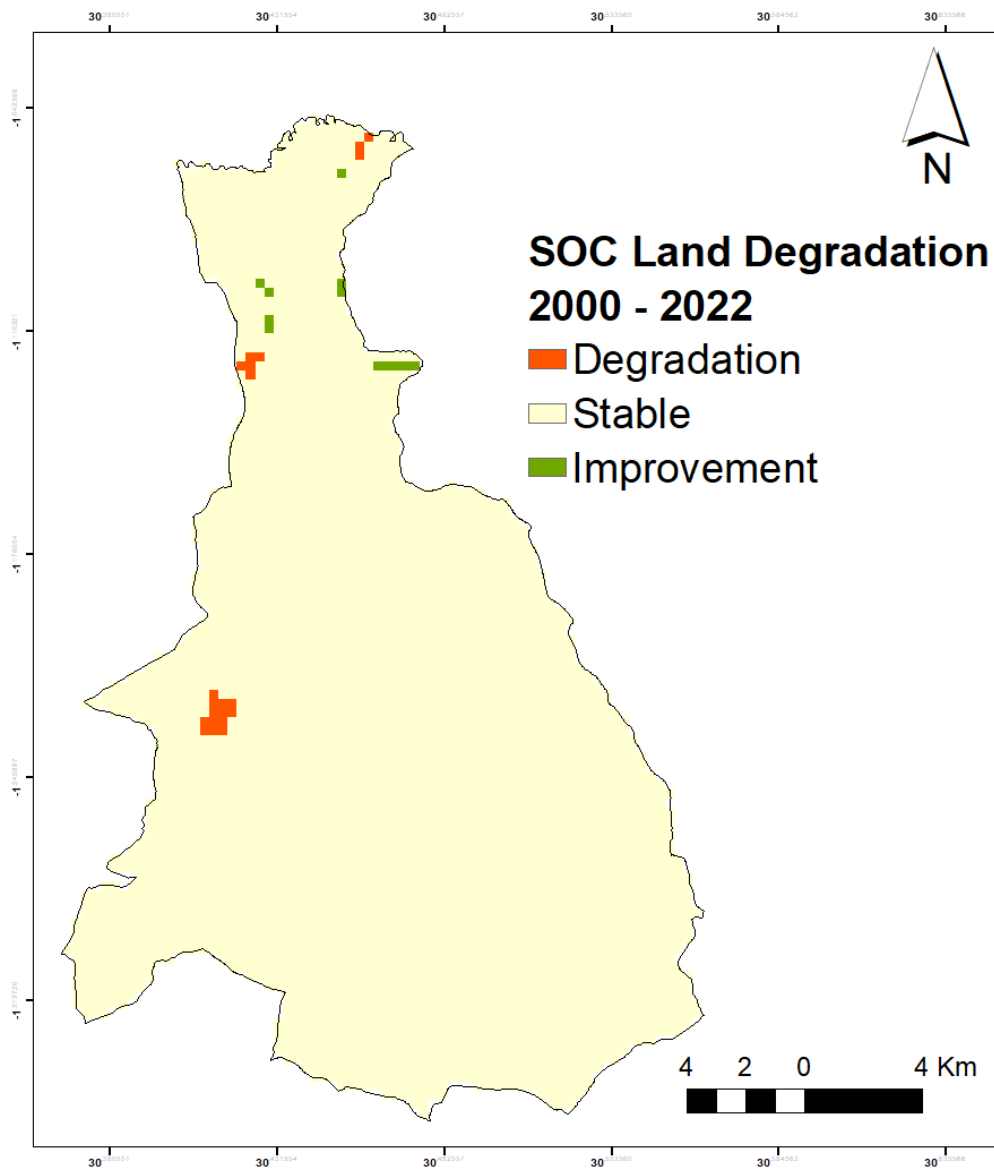


- The results indicated that in the study area, 40% of the land showed early signs of declining land productivity,
- While 48% demonstrated stable productivity, mainly in areas with persistent grassland.
- Signs of decline were prominent in areas with cropland. Further, 21% of land productivity has already declined, mostly in areas with settlements

Results

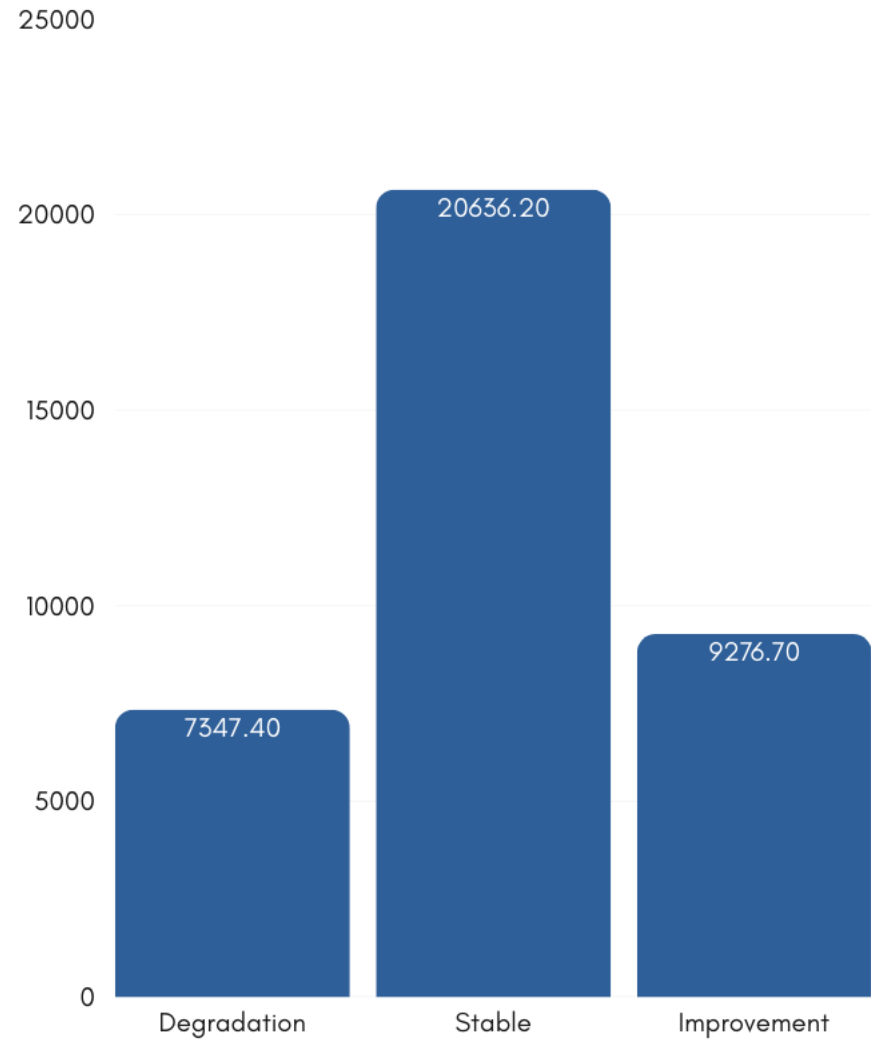
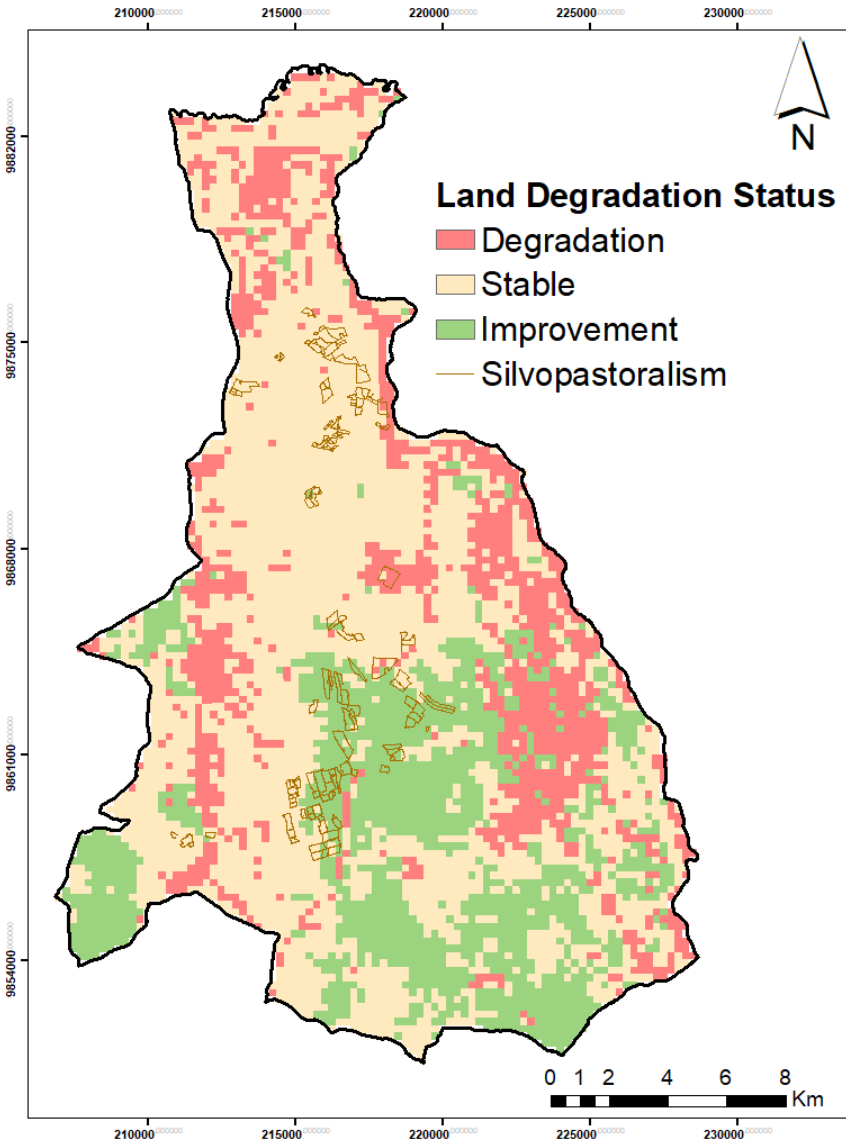
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Soil Organic Carbon (2000–2022)



- The Soil Organic Carbon (SOC) ranged from 15 to 165 tons per hectare. Between 2001 and 2022, SOC levels showed minimal variation overall.
- While some areas experienced localized degradation or improvement, most of the study area recorded no significant change in SOC stock

Overall land degradation (2000–2022)



- Overall, over 22 years (2000-2022), the Matimba and Rwimiyaga sectors have experienced land degradation of 7,347.4 hectares.
- The majority, 20,636.2 hectares, remained stable, with no significant changes in degradation or improvement.
- Areas totalling 9,276.7 hectares have shown improvement, indicating an increase in land quality.

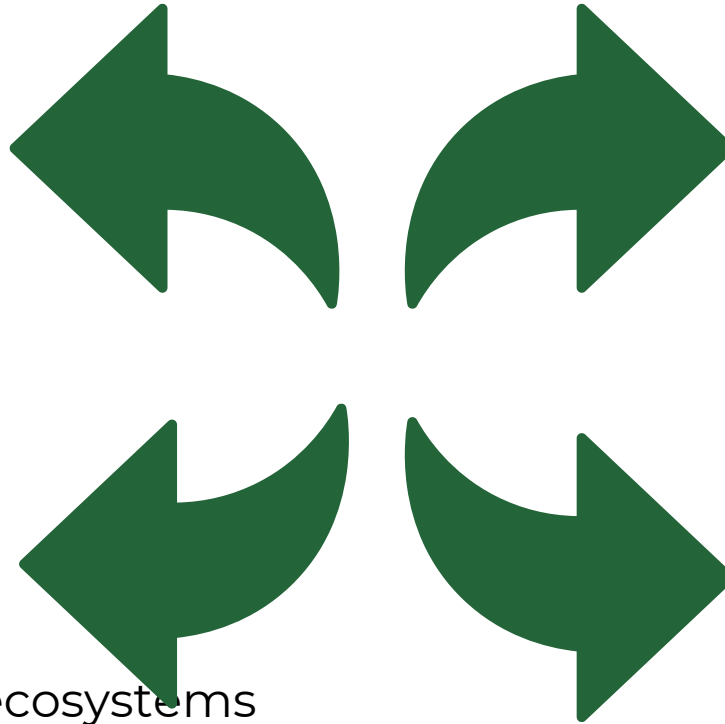
Land Degradation Trends

(2000–2022)

- ▣ Results shows 7,347.4 hectares degraded, driven mainly by:
 - 38% loss in tree cover
 - Expansion of cropland, livestock grazing, and settlements
 - Highlights strong pressure from population growth and

Ecological Consequences of Tree Cover Loss

- ▣ Trees are critical in savanna ecosystems for:
 - Biodiversity, water cycle, and nutrient cycling (Saha et al., 2023)
- ▣ Deforestation is accelerating landscape degradation



Drivers of Degradation

- Livestock overgrazing, agricultural expansion, and firewood dependence (REMA, 2022)
- Aligned with Laurance et al. (2023) and Rijal et al. (2022) on unsustainable land use

Silvopastoralism as a Solution

- ▣ Among paddocks practicing silvopastoralism:
 - 46.7% show land improvement
 - 48.9% remain stable
- ▣ Findings support this results from:
 - Murgueitio et al. (2011) – Improved soil and biodiversity

Land Degradation Status

The study confirms severe land degradation in Matimba and Rwimiyaga sectors, with 7,347.4 hectares degraded due to:

- Deforestation, overgrazing, and expansion of cropland and settlements

Impact from Land Use

Land cover change (2000–2022) reveals growing pressure from population-driven agriculture and urbanization

Silvopastoralism Effectiveness

Silvopastoralism shows promising results:

- 46.7% of paddocks in improving zones
- 48.9% in stable condition
- Only 4% in degraded areas

Recommendations

- Scale up silvopastoralism to improve land productivity and climate resilience
- Integrate into Rwanda's National Adaptation Plan (NAP) and land-use policies

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RWANDA CLIMATE SCIENCE SYMPOSIUM 2025

Advancing Research And Networking

C5) CLIMATE ACTION: ADAPTATION TO THE IMPACTS OF CLIMATE CHANGE

14 May 2025, 10:00 – 12:00 P.M.

EVALUATION OF THE ROLE OF GREEN INFRASTRUCTURE IN MITIGATING STORMWATER RUNOFF: A CASE STUDY OF KINAMBA CATCHMENT, KIGALI CITY

Ganza Musabyimana Aimee Dieze

UNILAK

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CONTENT

- Background of the study
- Problem statement
- Objectives
- Research methodology
- Results and discussion
- Conclusion
- Recommendations

BACKGROUND OF THE STUDY

- Rapid urbanization, concentrated economic activity, and climate change are driving environmental challenges like flooding, pollution, urban sprawl, and waste disposal (Uwera et al., 2020).
- Unplanned urban growth disrupts natural ecosystems, causing significant socio-environmental impacts in densely populated areas.
- Traditional “gray” infrastructure (storm sewers, tunnels) manages stormwater but struggles with intense rainfall, causing overflows, flooding, and water quality issues (Zimmerman et al., 2021).
- Green infrastructure (GI) offers a sustainable alternative, using systems like permeable pavements, rain gardens, and bioretention to reduce runoff and improve water quality (Li et al., 2019).
- Although GI is successfully integrated in countries like the USA, Australia, and China, it remains largely unexplored in rapidly urbanizing nations like Rwanda (Hou et al., 2019).

PROBLEM STATEMENT

- Rapid urbanization and climate change in Kinamba Catchment have increased impervious surfaces and intensified stormwater runoff, causing flooding, erosion, infrastructure damage, and water quality issues (MoE, 2018; Ndwueyzu et al., 2023).
- Conventional grey infrastructure often fails to manage growing runoff volumes, while Green Infrastructure (GI) offers sustainable, nature-based alternatives with added co-benefits (Bizimana et al., 2012; MoE, 2018).
- Although cities like Copenhagen and Bangkok have successfully integrated GI, Kigali faces barriers such as limited resources, technical knowledge gaps, and a lack of localized performance evidence (Hakuzimana et al., 2023).
- Initiatives like the Green City Kigali Project promote climate-resilient infrastructure, but the effectiveness of GI in flood-prone areas like Kinamba remains under-researched.
- This study aims to assess GI's impact on stormwater runoff mitigation in Kinamba Catchment, providing context-specific evidence to inform urban planning in Kigali and similar Rwandan cities.



Source: Newtimes, 2019

OBJECTIVES

Main Objective:

- To evaluate the role of green infrastructure in mitigating stormwater runoff, specifically assessing its potential to reduce runoff volume and overflow within the Kinamba Catchment, Kigali City.

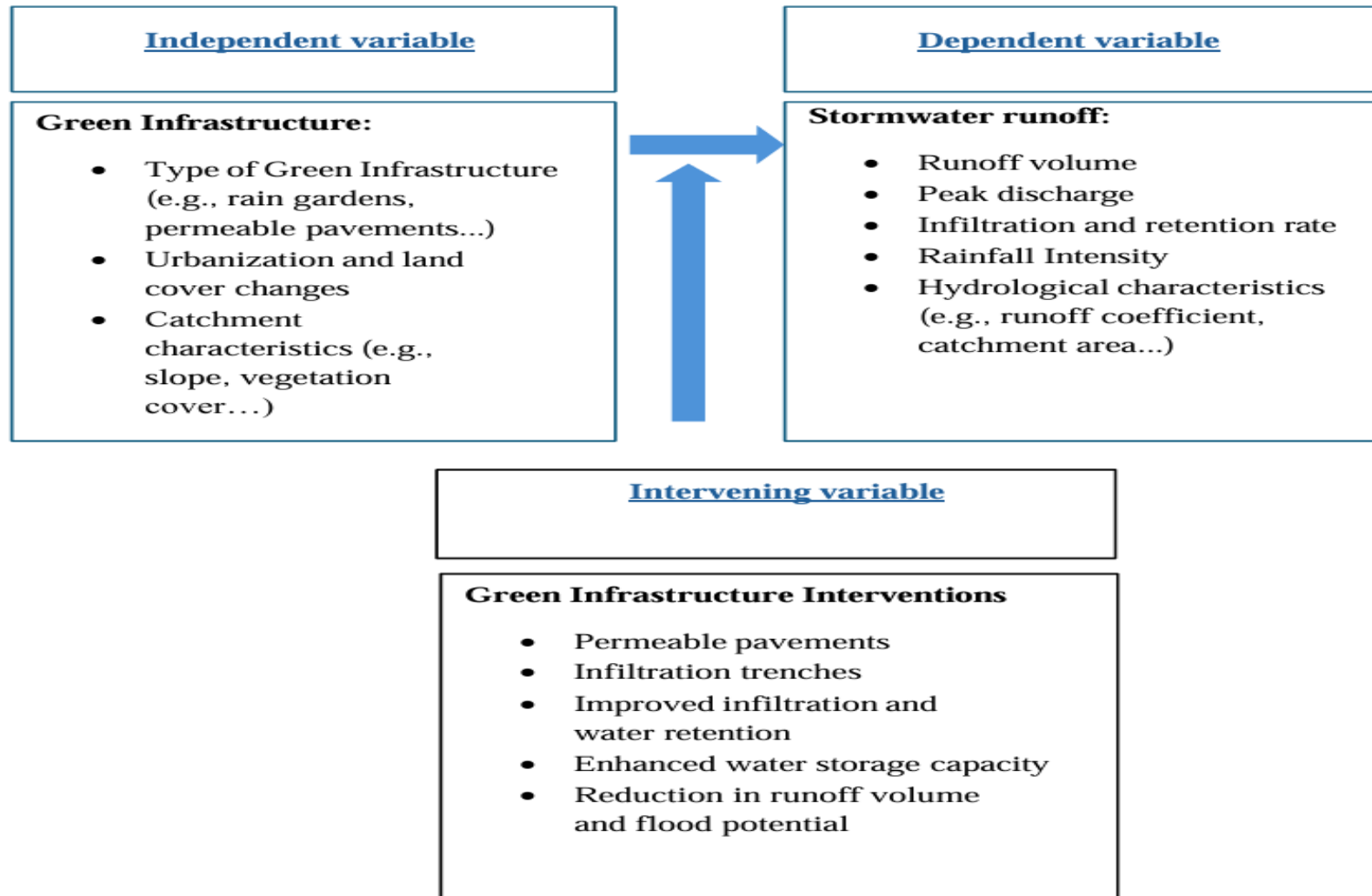
Specific Objectives:

- To assess the presence and coverage of green infrastructure within the Kinamba catchment.
- To assess the key factors contributing to stormwater runoff in the Kinamba catchment.
- To analyze the relationship between green infrastructure and stormwater runoff in Kinamba.

Research questions:

- What is the availability and geographical extent of Green Infrastructure in the Kinamba area?
- What are the main drivers contributing to stormwater runoff in Kinamba catchment?
- What is the relationship between the presence of green infrastructure and the pattern or severity of stormwater runoff in the Kinamba Catchment?

CONCEPTUAL FRAMEWORK

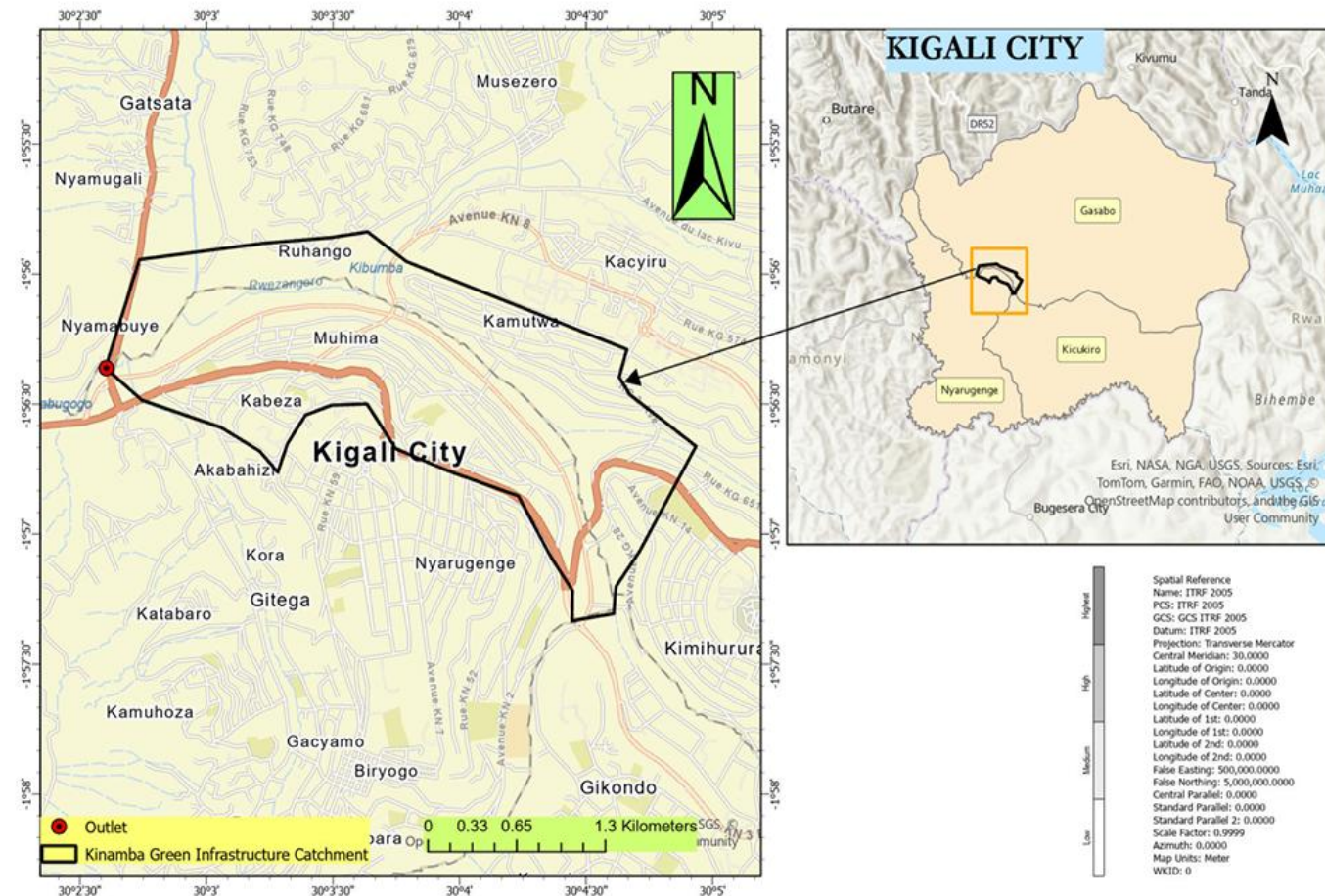


RESEARCH METHODOLOGY

Study area:

- The study focuses on the Kinamba Catchment, located across Nyarugenge, Gasabo, and Kicukiro Districts in Kigali City.
- Key flood hotspots, such as Gisozi and Kinamba, were selected as case study areas.
- High flood risk due to stormwater runoff, rapid urbanization, and inadequate drainage.
- Expanding impervious surfaces and land-use changes exacerbate flooding.

STUDY AREA



Source: Researcher, 2025

RESEARCH METHODOLOGY

Research Design:

- **Approach:** Mixed-methods (cross-sectional, descriptive, scenario-based modeling).
- **Cross-Sectional Design:** Spatial and hydrological data analysis (GIS mapping, rainfall-runoff monitoring).
- **Descriptive Component:** Assessment of GI implementation and coverage.
- **Scenario Modeling:** Exploring GI impact on runoff volume, peak discharge, and infiltration rates.
- **Quantitative Paradigm:** Hydrological modeling, GIS mapping, rainfall-runoff data validation, literature review.

RESEARCH METHODOLOGY

Data Collection Techniques:

- **Field Observation:** Site visits to flood-prone areas, drainage inspection, flood mark analysis, land-use assessment, GIS-supported mapping for priority GI areas.
- **Documentary Review:** Secondary data on rainfall (RMA), flood events (RWB), land use (LULC), topography, soils; supported runoff modeling and drainage analysis.
- **Rainfall & Runoff Data:** Historical rainfall records (various return periods), discharge and infiltration data from RMA & RWB used for hydrological modeling.
- **GIS Spatial Analysis:** Watershed delineation (DEMs), slope and drainage network mapping, LULC classification, hydrological soil group assessment for infiltration capacity.
- **Land Use Change Analysis:** Identified progressive green space loss (2000–2024), contributing to increased runoff and reduced infiltration rates.

VALIDITY, RELIABILITY AND DATA ANALYSIS

Validity & Reliability

- **Secondary Data from RWB & RMA:** Data sourced from reliable government and regulatory bodies, ensuring credibility.
- **Methodological Consistency:** Established methodologies from the RWB for stormwater runoff analysis, ensuring both validity and reliability.

Data Analysis

- **Land Use Patterns:** Analyzed land use changes from GIS data provided by RWB.
- **Hydrological Data Processing:** Used discharge data from RMA to assess stormwater runoff (m^3/s).
- **Impact Evaluation:** Comparative analysis of green infrastructure and existing drainage systems, based on RWB and RMA data.

RESULTS AND DISCUSSION

- i. **To assess the presence and coverage of green infrastructure within the Kinamba:**
- Limited GI Coverage: Field observations revealed insufficient and poorly functioning green infrastructure.
 - Types of GI Identified:
 - Degraded drainage channels
 - Few or absent rain gardens
 - Widespread impermeable pavements
 - Impact on Runoff: Low GI presence reduces water infiltration, increases runoff, and worsens flood risk and water quality issues.



Figure 3.1 Existing green infrastructure in Kinamba area: Source, Author 2025

RESULTS AND DISCUSSION

ii. To Key Factors Contributing to Stormwater Runoff in the Kinamba Catchment :

Runoff Volume

- High impervious surface area reduces infiltration, increases runoff
- Average runoff volume: 26.62 m³/s (range: 18.18–38.00 m³/s)
- Built-up area decreased (2017–2021): 78% → 64%
- Green space increased: 3% → 12%
- Need for improved stormwater management strategies

Table 3.2: Analysis of Runoff Volume in the Kinamba Catchment

Parameters	Value
Minimum Discharge	0 m ³ /s
Maximum Discharge	555.401 m ³ /s
Mean Discharge	9.961 m ³ /s
Average infiltration rate	0.39
Built-up Area (2017–2023)	64%
Green Space (2017–2023)	3% to 12%

Source: Rwanda Meteorological Agency (2025)

RESULTS AND DISCUSSION

Peak Discharge:

- Mean discharge: 9.96 m³/s (range: 2.35–18.15 m³/s)
- High variability in flow patterns = flood risk
- Causes: rainfall fluctuations, urbanization, inadequate GI
- GI improvements needed to stabilize discharge rates

Infiltration & Retention Rate:

- Mean infiltration: 7.89 m³/s (range: 7.12–9.18 m³/s)
- Low variability = consistently poor infiltration
- Causes: impervious surfaces, limited GI, intense rainfall
- Urgent need for catchment-wide GI interventions

Table 3.3: Discharge results of Kinamba Catchment

	N	Range	Min.	Max.	Mean	<u>Std.Dev</u>	Variance
Discharge	20352	555.401	0	555.401	9.96	19.34784	374.3391

Table 3.4: Infiltration results of Kinamba Catchment

	N	Range	Minimum	Maximum	Mean	Std. Deviation	Variance
Infiltration	51616	5.507	1.548	3.959	0.38831	0.001104	0.063

Source: Rwanda Meteorological Agency (2025)

RESULTS AND DISCUSSION

Rainfall Intensity

- Key driver of runoff generation
- Peak rainfall event: 102.2 mm/hr (25 Dec 2019)
- High-intensity storms overwhelm drainage & increase flood risk
- GI can mitigate by enhancing infiltration & slowing runoff

Hydrological Characteristics

- Built-up area decline (2017–2023): 78% → 64%
- Green space increase: 3% → 12%
- Impervious surfaces still dominate = management challenge
- Integrated planning & GI implementation crucial

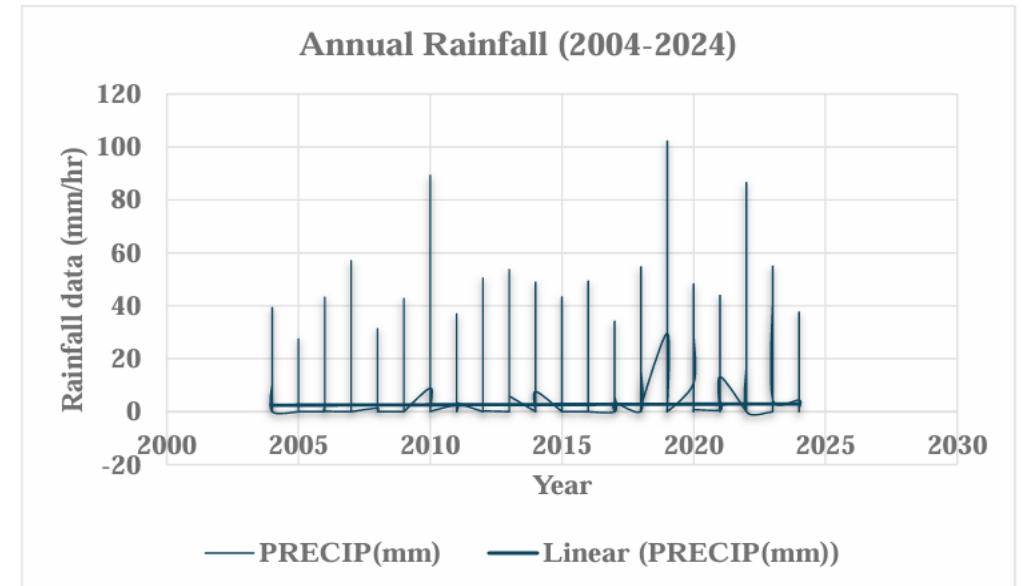


Table 3.1 Changes in Land Use and Land Cover in Kinamba Catchment (2017–2023)

Land Use Category	2017 (%)	2023 (%)
Built-up area	78	64
Tree cover	3	12
Grassland	15	10
Cropland	8	5
Water bodies	0.5	0.1

Source: Source: Author's analysis (2025)

RESULTS AND DISCUSSION

iii. To analyze the relationship between green infrastructure and stormwater runoff in Kinamba

- Green Infrastructure (GI) helps reduce flooding and improve water management
- Enhances infiltration, reduces runoff, improves water quality
- Current challenges in Kinamba:
 - Inadequate GI coverage
 - High runoff and low infiltration rates
- Key benefits of GI implementation:
 - Reduced runoff volumes
 - Increased infiltration rates
 - Stabilized peak flows

Table 3.5: Comparison of parameters with and without GI intervention

Parameter	Without GI	With GI
Runoff Volume (m ³)	High	Reduced
Peak Flow Rate (m ³ /s)	High	Lower
Infiltration Rate (mm/hr)	Low	Higher
Groundwater Recharge (%)	Minimal	Increased
Possibility of Flooding	High	Reduced
Water Quality (Pollutant Load: sediments, nutrients, contaminants)	Poor	Improved(natural filtration)

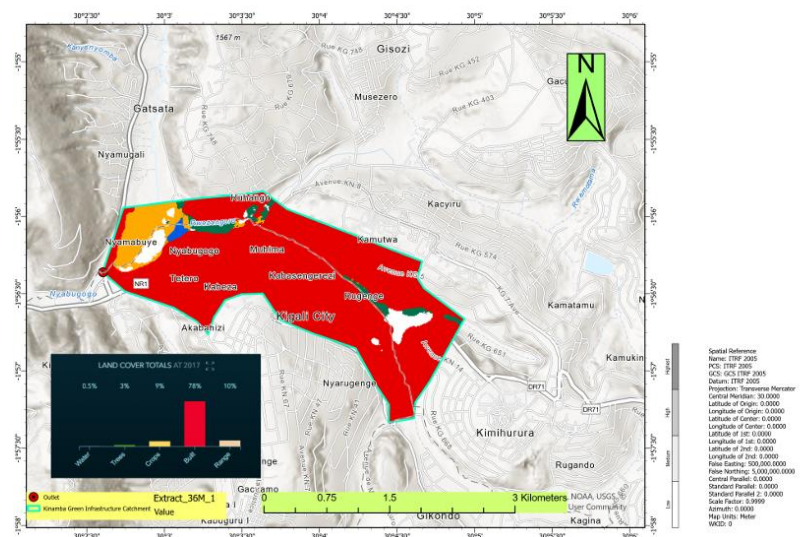
Source: Author's analysis (2025)

RESULTS AND DISCUSSION

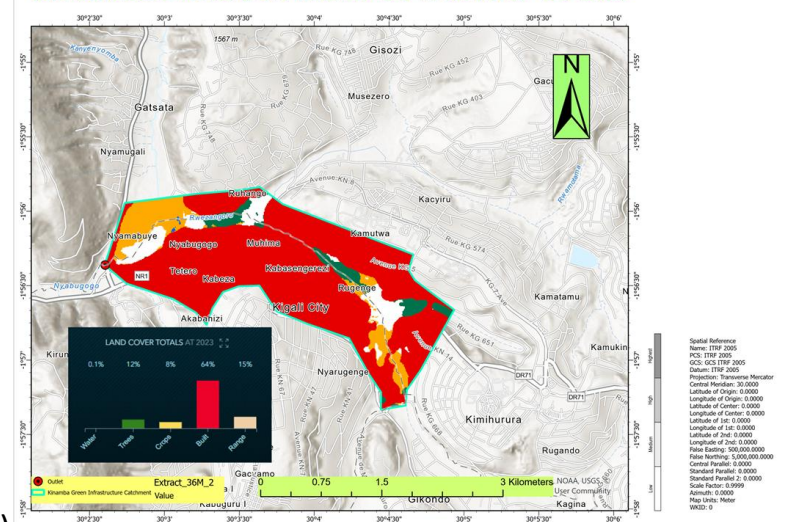
Land Cover Changes and Implications for Stormwater Management in Kinamba:

- Green infrastructure (GI) reduces flooding by enhancing natural water absorption, easing pressure on Kinamba's inadequate conventional drainage systems.
- According to this Figure (LULC 2017–2023), land cover changes include: ↓ water (0.5% → 0.1%), ↑ trees (3% → 12%), ↓ cropland (8% → 5%), ↓ built-up area (78% → 64%), ↓ grassland (15% → 10%).
- These shifts affect stormwater management and emphasize the need for strategic urban planning to optimize GI effectiveness.
- Discharge levels (mean: 9.961 m³/s, range: 555.401 m³/s) greatly exceed infiltration capacity (mean: 0.38831 mm/hr, range: 5.507 mm/hr), indicating poor water absorption.
- Findings highlight the urgent need for expanded and well-maintained GI to mitigate flooding risks and improve water management in Kinamba.

KINAMBA LANDUSE LAND COVER MAP OF 2017



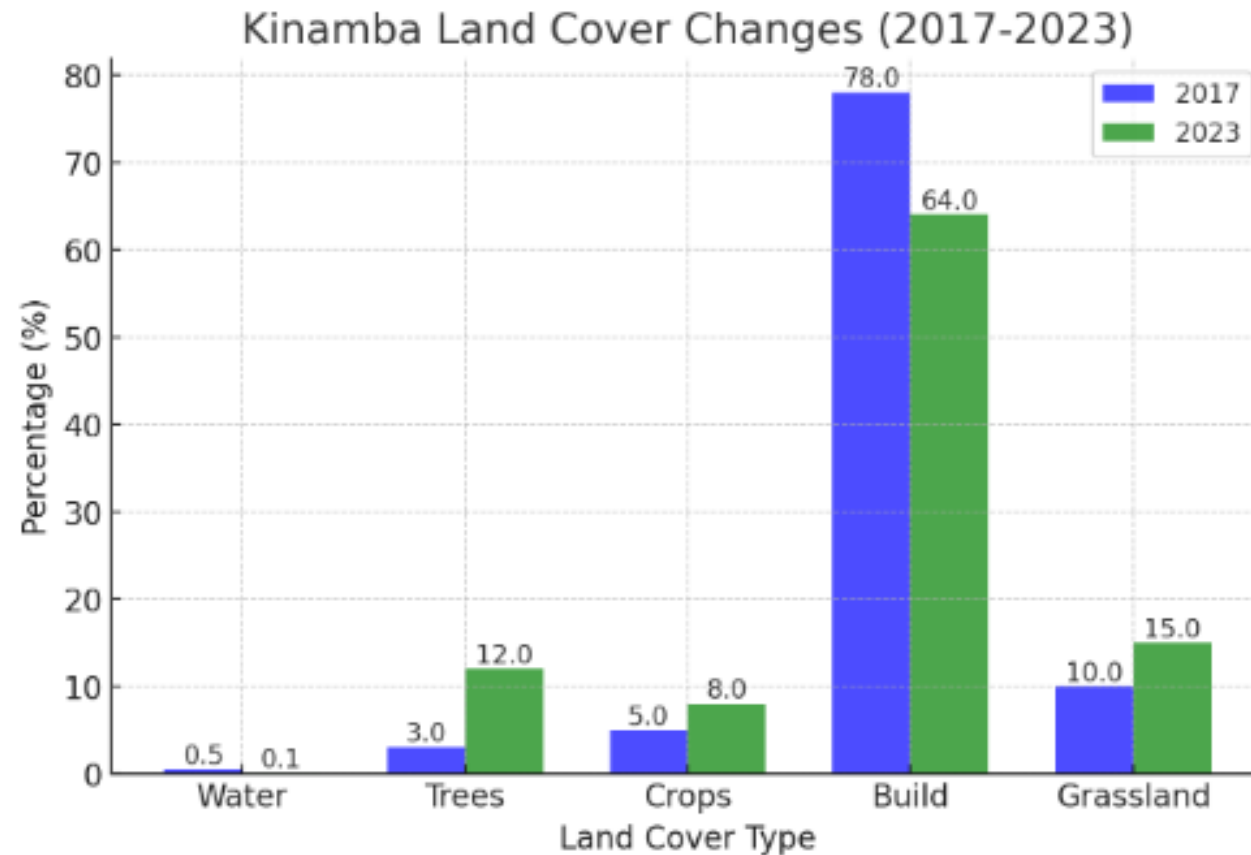
KINAMBA LANDUSE LAND COVER MAP OF 2023



Source: Author's analysis (2025)

RESULTS AND DISCUSSION

Graph of Kinamba Land cover changes during 2017-2023



Source: Author's analysis (2025)

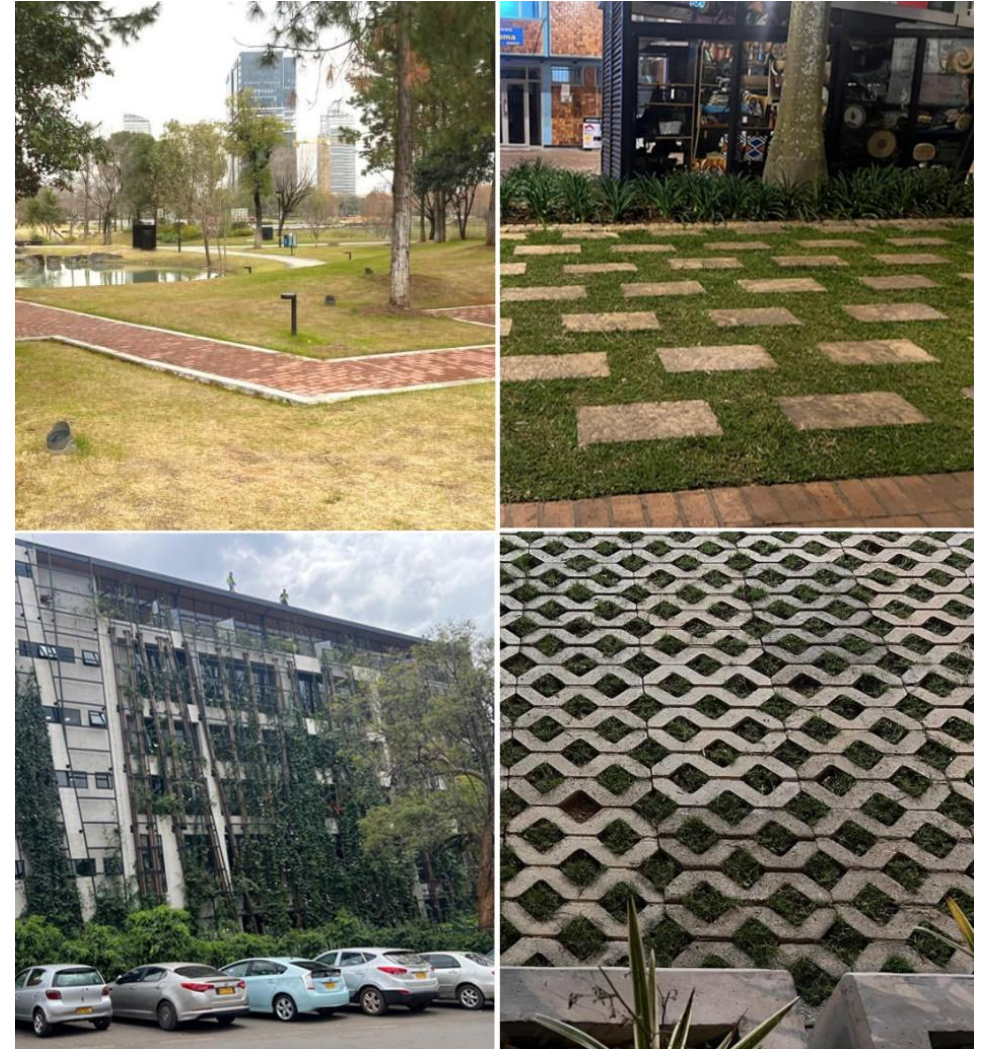
RESULTS AND DISCUSSION

Different type Green Infrastructure which can be introduced in Kinamba area:

Table 3.6: Green infrastructure practices and their applicability

Green Infrastructure Type	Function	Applicability to Kinamba
Green Roofs	Absorbs rainfall, reduces heat, and mitigates runoff.	Reduces the amount of runoff that rushes into a watershed all at once.
Permeable Pavements	Increases infiltration and reduces surface runoff.	Suitable for pathways and parking areas.
Rain Gardens & Planter Boxes	Captures runoff, filters pollutants	Ideal for residential and community spaces.
Bioswales	Slows runoff, filters sediments and contaminants.	Suitable for roadside drainage areas.
Urban Tree Canopy	Increases water retention and promotes infiltration.	Applicable in open public spaces.

Source: Author's analysis (2025)



Source, Author 2025

SUMMARY OF FINDINGS

- The study evaluated the impact of green infrastructure (GI) on stormwater runoff in Kinamba Catchment, revealing increased runoff, flooding, and water pollution due to urbanization and climate change.
- Infiltration and discharge data showed low infiltration rates and high discharge variability, indicating extreme runoff events and limitations of existing drainage systems.
- Land use analysis (2000–2024) revealed a significant loss of green spaces, contributing to increased runoff and reduced urban resilience.
- Key zones (residential, agricultural, commercial, industrial, and transport) lack adequate GI, with urban compaction, clayey soils, and heavy rainfall limiting GI effectiveness.
- Successful GI integration requires strong policy support, community engagement, and strategic planning to enhance infiltration, reduce peak discharge, and improve water quality.

CONCLUSION

- The Kinamba Catchment faces high runoff volumes due to low infiltration rates, extensive impervious surfaces, and soil compaction.
- Discharge data shows extreme variability, reflecting intense rainfall, limited GI coverage, and inadequate conventional drainage systems.
- Land use analysis (2000–2024) highlights a sharp loss of green spaces, increasing runoff, pollution, and reducing urban resilience.
- GI plays a crucial role in enhancing infiltration, reducing peak discharge, and improving water quality, but its effectiveness depends on maintenance, planning, and policy support.
- A holistic approach integrating GI with conventional drainage is essential for sustainable stormwater management and long-term catchment resilience.

RECOMMENDATIONS

Strategic GI Implementation:

- Prioritize GI in high runoff, impervious areas using land use maps and spatial analysis.
- Implement infiltration-focused GI (rain gardens, bioretention cells, permeable pavements).
- Design GI to manage peak discharge (retention basins, swales) and retrofit existing grey infrastructure.

Data-Driven Evaluation:

- Establish monitoring of infiltration, discharge, and rainfall (use Gitega station data).
- Apply hydrological models (SWMM, HEC-HMS) to assess GI impacts and support adaptive management.

Policy & Community Engagement:

- Integrate GI into Kigali's urban plans, enforce GI-friendly regulations, and launch public education campaigns.
- Provide incentives for private GI adoption and build capacity for planners and engineers.

Land Use & Sustainability Measures:

- Manage informal settlements, promote urban reforestation, and introduce agricultural buffers.
- Secure funding for GI projects and maintenance through government, aid, and partnerships.

Holistic Stormwater Strategy:

- Combine GI with existing drainage systems to reduce runoff, sewer overflow, and enhance catchment resilience.

LIMITATIONS & FUTURE RESEARCH

Limitations

- Limited availability of long-term, high-resolution rainfall and discharge data
- Incomplete spatial coverage of green infrastructure data within Kinamba Catchment
- Potential uncertainties in land use classification and hydrological model assumptions
- Constraints in assessing long-term GI maintenance and performance due to short study duration
- Limited stakeholder engagement and absence of socio-economic data in GI assessment

Future Research

- Conduct long-term monitoring of infiltration, discharge, and rainfall variability
- Explore the socio-economic impacts and community perceptions of GI interventions
- Refine hydrological models with more granular spatial and temporal data
- Assess the effectiveness of combined GI and grey infrastructure solutions
- Investigate the role of urban planning policies in enhancing GI adoption and sustainability

ACKNOWLEDGEMENTS

- Sincere gratitude to my supervisor, Dr. NSANZUMUKIZA Martin Vincent, for expert guidance, constructive feedback, and continuous support
- Heartfelt thanks to my family and friends for their constant encouragement, patience, and understanding throughout this journey
- Appreciation to my colleagues and friends for their unwavering support and assistance during the research
- Special thanks to Rwanda Meteorology Agency (RMA) and Rwanda Water Resources Board (RWB) for providing essential rainfall and hydrological data
- Acknowledgement of the staff and faculty of the Environmental Economics and Natural Resource Management program at UNILAK for their academic support and resources

Thank you for your attention and time

1st

RWANDA CLIMATE SCIENCE SYMPOSIUM 2025

Advancing Research And Networking

A5. Measurement and reduction of greenhouse gas emissions

13 May 2025, 14:00 – 16:00 P.M.

Rooftop Solar Potential in Rwanda: A Pathway to Achieve 2030 Greenhouse Gas Reduction Targets

Presented by: **NYINAWUMUNTU Olivine**

Affiliation: (**ISA Fellow**) at the Indian Institute of Technology Delhi (**IIT Delhi**)

Workplace: Rwanda Energy Group /EUCL Huye Branch (**Electrical Technician**)



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RESEARCH & INNOVATION





Introduction

This research investigates the societal and financial effects of implementing rooftop solar energy systems in both Rural and Urban areas of Rwanda, where restricted electricity access obstructs socio-economic progress.

By examining three household groups—low-income, middle-income, and high-income.

The research evaluates the capability of rooftop solar setups to produce energy, decrease CO₂ emissions, and generate economic advantages, including job creation and income from carbon credits.

Rwanda faces persistent energy challenges in rural areas due to:

- ❑ - Limited access to affordable and clean energy
- ❑ High reliance on polluting energy sources (biomass).
- ❑ Insufficient financing options and infrastructure for renewable energy

This study addresses these issues by exploring rooftop solar solutions and their socio-economic impacts.

Literature Review Highlights



- Some literature identifies obstacles, including cost and ignorance, while offering policy suggestions to increase rooftop solar system adoption in rural areas.
- Other literature highlights the difficulties in attaining energy equity in Rwanda's rural areas
- Rwanda government books highlight that hydropower is the highest source of electrical power source which has been adopted by MINIFRA solar has been adopted by MINIFRA; however, its potential needs to be defined, and biomass and wind potentials need to be defined



Research Gap

Limited Focus:

- Feasibility study on solar rooftop technology in Rwanda
- There is a lack of income-specific studies on Renewable adoption in Rwanda.



Objectives and Research Questions

• **General Objective:** Assess socio-economic impacts of rooftop solar in rural Rwanda

Specific Objectives:

- Estimate energy generation potential by household type.
- Analyze financial feasibility, including carbon credit revenues.
- Evaluate environmental and health benefits.
- Identify job creation opportunities.

Methodology



The methodology is designed to provide:

a. Family categories:

Poor, Middle-income, and Rich.

a. Rooftop sizes are based on household economic category for both Rural and Urban areas.

b. Solar energy potential based on rooftop areas and Rwanda's solar irradiance.

c. Estimating Rooftop capacity by considering the area and available daily radiation, let's take a DNI of 4.5 kWh/m²/day for rooftop capacity estimation.

Technical analysis

Rooftop energy capacity
= DNI × Rooftop Area available

- **Daily, probably power from rooftop capacity**

$$= \frac{\text{Total Rooftop energy available/day}}{\text{sunshine hour /day}}$$

- **Total power from each rooftop category**

= power available for 1 rooftop × number of rooftops in this category

- **Net annual energy delivery (NAED)**
= Total energy/day × days of the year

Methodology

Socio-Economic analysis



- **Levelized Cost of Electricity (LCOE)**

$$= \frac{CO \left(\frac{d(1+d)^n}{(1+d)^n - 1} \right) + ACOM}{NAED}$$

- **d** is the bank's interest rate, assumed to be \$9.5%
- The solar panel lifespan assumption is 25 years
- The **ACOM** Annual Cost of Operation and maintenance is **2%** of the investment

- **Investment needed**

= Total MW needed to be generated × cost of generating 1 MW in Rwanda

- **Job creation**

= Total MW to be generated from solar × number of jobs generated per 1 MW of generation

- **The amount of Carbon savings**

= energy generated × carbon saving factor

- Researchers show that for the generation of 1 kWh of electricity, the carbon saving factor for solar energy is 1.1 kg of CO₂

- **Revenue from carbon saving**

= carbon saved × price per 1kg of carbon saved

- The price estimation is \$ 0.03/per 1 kg of CO₂e

Summary of findings



Rwanda has a population of approximately 14 million people, with 70% living in rural areas and 30% in urban areas

Urban Area of Rwanda rooftop potential indication

- ✓ **Average Rooftop Size:** Poor households have 18 m² of rooftop space, Middle-income 35 m², and Rich households have 105 m² available for solar installations.
- ✓ **Solar Potential for Poor Households:** 9.93×10^9 kWh of energy can be generated, with a \$6.5 million investment, saving 1.1×10^{10} kg CO₂, and creating 205 jobs. LCOE is 0.000082 \$/kWh
- ✓ **Solar Potential for Middle-Income Households:** 4×10^{10} kWh can be generated with a \$19.5 million investment, saving 4.4×10^{10} kg CO₂, and creating 615 jobs. LCOE is 0.00042 \$/kWh
- ✓ **Solar Potential for Rich Households:** 3×10^{10} kWh can be generated with a \$16.2 million investment, saving 3.3×10^{10} kg CO₂, and creating 510 jobs. LCOE is 0.000068 \$/kWh.



Rural Areas of Rwanda Rooftop Potential Indication

- ✓ **Average Rooftop Size:** Poor households have an average rooftop area of 21 m², Middle-income 49 m², and Rich households 140 m², influencing solar energy potential.
- ✓ **Solar Potential for Poor Households:** 3.26×10^{10} kWh of solar energy can be generated, with a \$19.5 million investment, saving 4×10^{10} kg CO₂ and creating 615 jobs. LCOE is 0.0006 \$/kWh
- ✓ **Solar Potential for Middle-Income Households:** 6×10^{10} kWh of energy can be generated, requiring a \$35.1 million investment, saving 6.6×10^{10} kg CO₂, and creating 1,107 jobs. LCOE is 0.000074 \$/kWh
- ✓ **Solar Potential for Rich Households:** 7×10^{10} kWh can be generated, requiring a \$39 million investment, saving 7.7×10^{10} kg CO₂, and creating 1,230 jobs. LCOE is 0.00007 \$/kWh

New Observations / Novelty

- ✚ The majority of Rwanda's population resides in Rural Areas, where Rural households outnumber those in urban locations.
- ✚ Poor households are common in both rural and urban settings, while wealthy households account for the fewest.
- ✚ Furthermore, Rural households are typically larger than urban ones, which influences overall energy demand and the requirements for rooftop solar capacity.



Recommendations

Policy Suggestions:

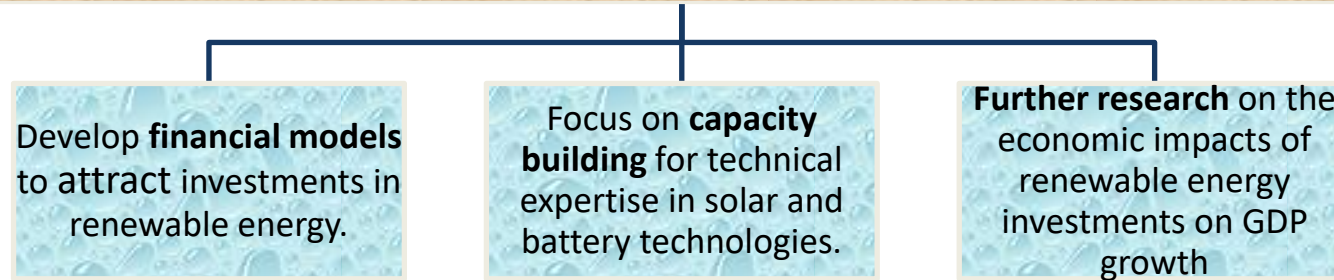
Introduce financial assistance/subsidies for low-income households.

- Develop hybrid solar programs to integrate solar energy solutions for both urban and rural areas.

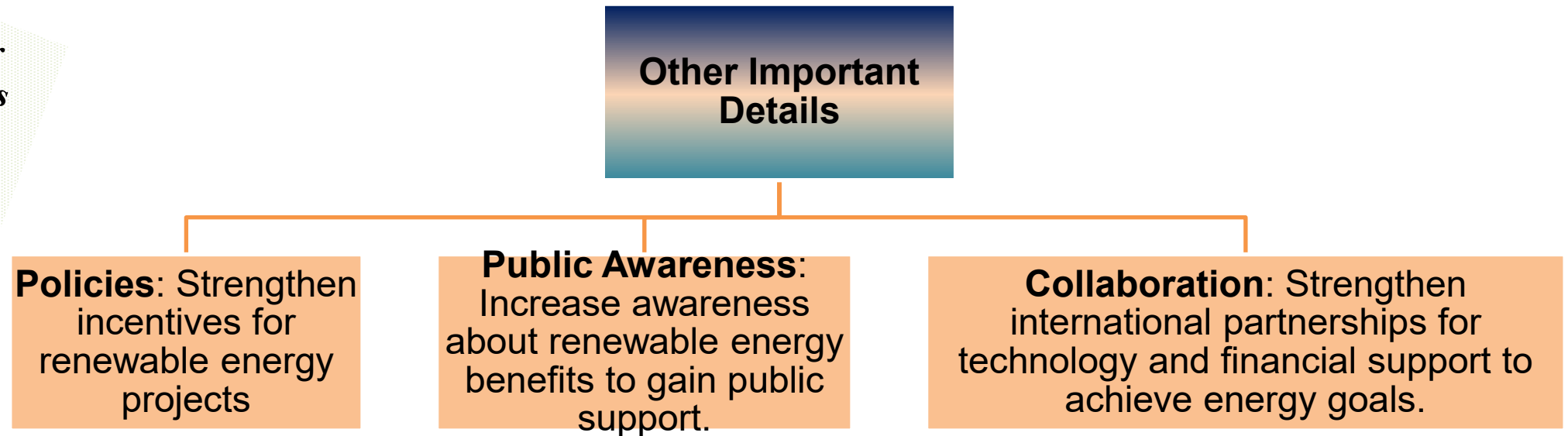
- Encourage partnerships between the private and public sectors to facilitate financing.

- Enhance training programs for jobs in the renewable energy sector.

Work to Be Done



• Further research is needed to evaluate the long-term sustainability of Rural solar rooftop projects





Presented by: Olivine Nyinawumuntu

INDIAN INSTITUTE OF TECHNOLOGY DELHI

**Department of Energy Science and
Engineering
(Renewable Energy Technologies and
Management)**

if there is any question, you feel free to ask.



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RWANDA CLIMATE SCIENCE SYMPOSIUM 2025

Advancing Research And Networking

D5) Climate action: Adaptation to and mitigating of climate change

14 May 2025, 10:00 – 12:00 PM, Plenary

Concluding Application of DISA: Weather guided potato production management reduces pesticide application

Mutangana D. Kabera*, Benson Kisinga, Elmar Schulte-Geldermann,
Matthias Trapp and Clemens B.A Wollny

Technical University Bingen, (Germany)
GIZ-BLP Project Rwanda - Rhineland-Palatinate

* Contact: Tel: +250 788 649 401
E-mail: peacelion10@gmail.com



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Zusammenarbeit (GIZ) GmbH



Rheinland-Pfalz
DIENSTLEISTUNGSZENTREN
LÄNDLICHER RAUM



esri Rwanda
THE SCIENCE OF WHERE™



Immediate Beneficiaries

Farmers and cooperatives, extension services/advisors

Project Duration

August 2023 – June 2025

Background

- Global warming results in significant **regional climatic changes** in the East and Central Africa region
- **Irish Potato** is a very important staple food crop in Rwanda.
- **Late Blight Disease (LBD)** caused by *Phytophthora infestans* is a growing challenge. Occurrence and spreading is highly triggered by temperature and air humidity-based indices.
- Currently, farmers apply fungicides weekly, not taking into account the actual risk of infection. This often leads to an **inadequate use of fungicides**, hence; high cost of production and environmental pollution.

Motivation

- **Forecast modelling for LBD** can provide a more precise use of pesticides (reducing amount and application frequency)
 - Modelling needs **regional, local and accurate weather data**
 - In Rwanda currently only a small part of the weather stations are fully automated
- ➔ **spatial and temporal densifying** of information capturing on a local scale

Methodology

Technological approaches

- Installing LoRaWAN-sensors in trial plots (temperature, relative air humidity) in real-time
- Smartphone Apps to capture rain events and diseases in the field in real-time
- Access to automated weather stations (API)
- Weather Forecast Data (i.e. Meteoblue)

DISA-Demo Viewer

DISA-Viewer

Navigation:

Introduction

DISA Weather Data Viewer

DISA Disease Data Survey

DISA Weather Data Survey

DISA Geodata Viewer

RW LoRa Kinigi LST25524477

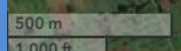
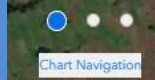
2. Oktober 2023 um 09:00

RH	74.9
TA	18.8

Zoomen auf < > 1 von 336

Gateway LoRaWAN Sensors

Weather station



A short introduction to our new DISA- Demo Viewer

„Landing Page“ (combining all data, apps and models in one platform)

- Hosted by ESRI Rwanda, will be moved to the RSA (Space Agency Rwanda)
- Direct access to our Lora-sensors and weather stations (Meteo Rwanda, planned as live data in near future)
- Combining apps to capture data in the field (pest events, rain events)
- Site-specific information combined with administrative borders

➔ **Localised Risk Maps based on LBD model** (in near future)

What is LoRaWAN?

LoRa and LoRaWAN: Long Range Wide Area Network, Low Power, Wide Area (LPWAN)

- Wireless network protocol specifically designed for transmitting small amounts of data over long distances
- Low-power and cost-effective solution for Internet of Things (IoT) applications
- Open standard for transmitting data over long distances with low power consumption, developed and maintained by the LoRa Alliance



Sensor



Gateway

Sensor



Thresholds:

Agronomic advice on a disease risk day is

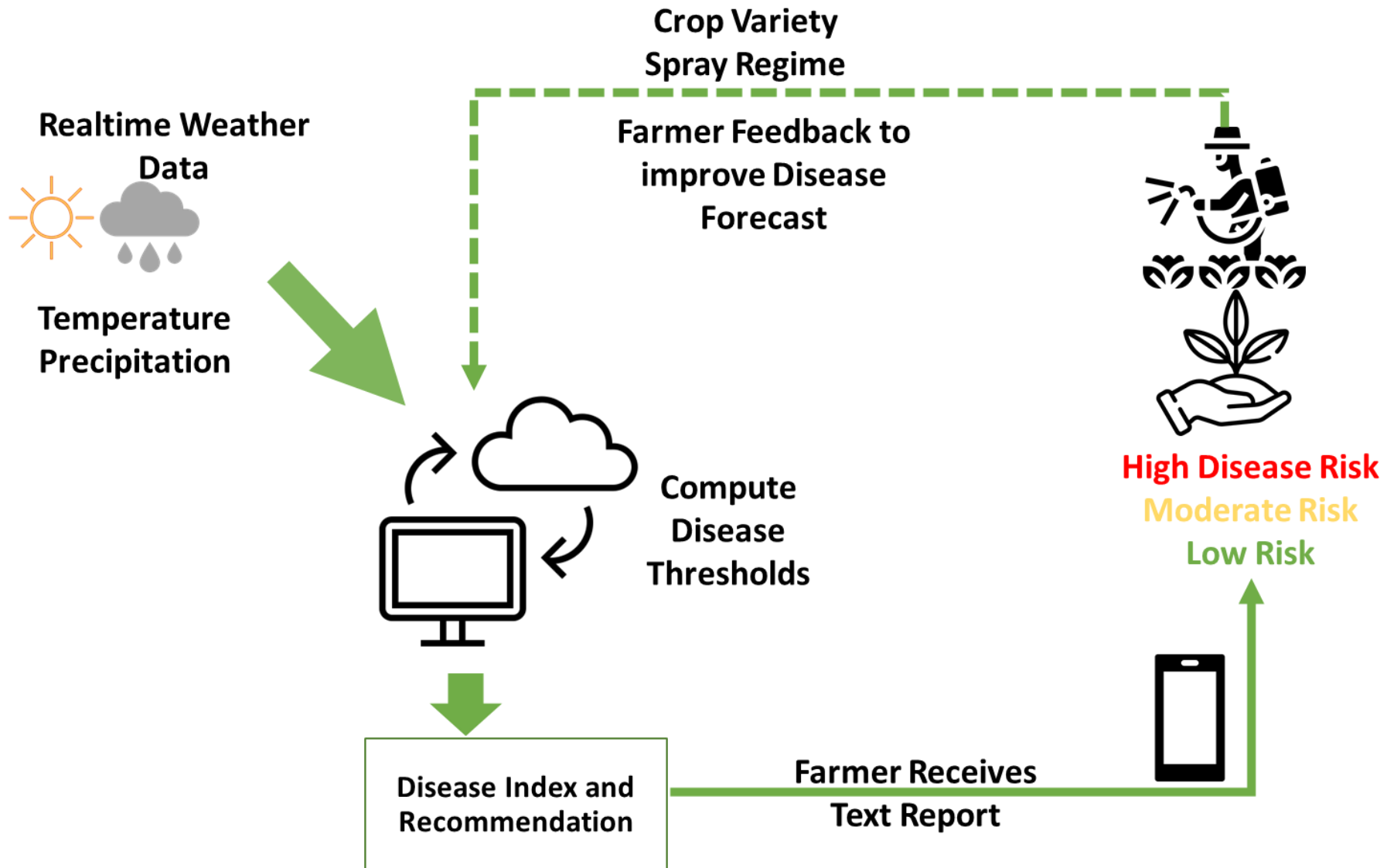
- RH > 80%
- Temperature between 15-25 °C

The risk index is then combined with the **V**ariety **R**esistance **I**ndex (VRI) and days after last application

- 14 days monitoring period for Resistant Variety
- 7 days monitoring period for Susceptible varieties

(meaning, more frequent monitoring for susceptible varieties)

Decision Support System on Lateblight Management:



Decision Support System on Lateblight Management Monitoring Model

Late Blight Monitor

*Region

Kinigi
 Rulindo

[↶](#) Zurück zum Anfang Ans Ende gehen



Late Blight Monitor

Select Available Varieties

Resistant Susceptible

*Days after Last Spray: Resistant Variety

[Zurück](#)

[↶](#) Zurück zum Anfang Ans Ende gehen



Late Blight Monitor

▼ **LB index Status: KINIGI**

Resistant Variety: [Moderate Risk, Spray Contact Fungicide](#)

Receive report via Text/Whatsapp

OK

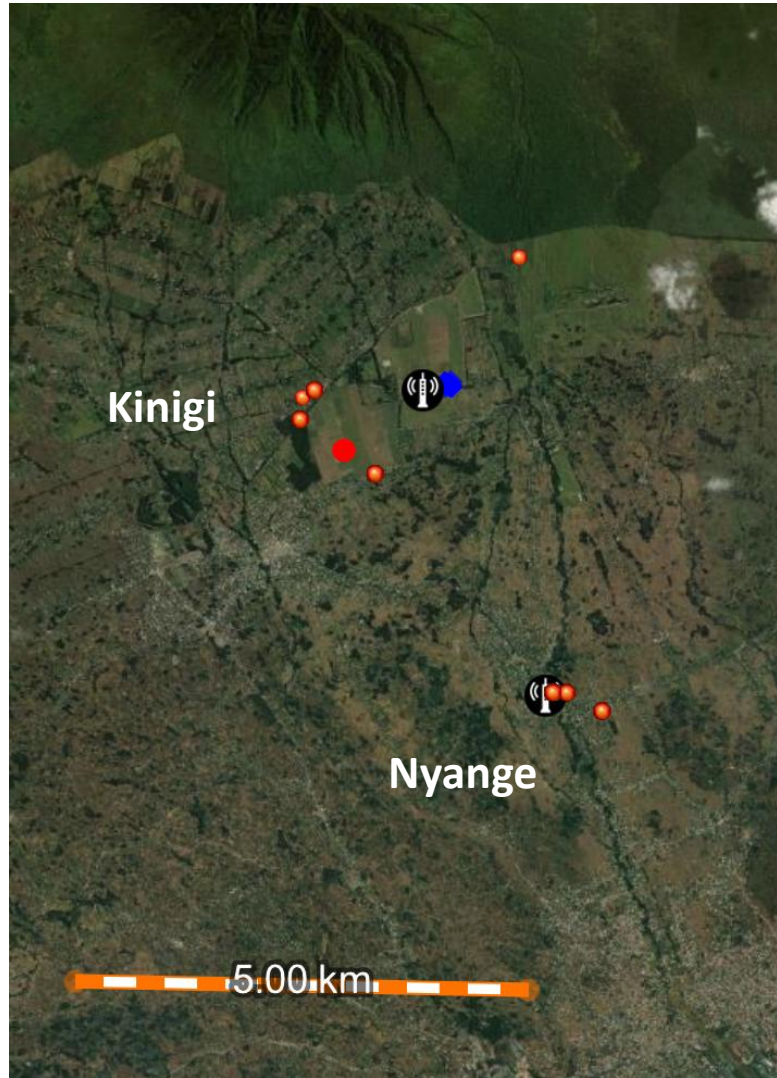
*Phone Number

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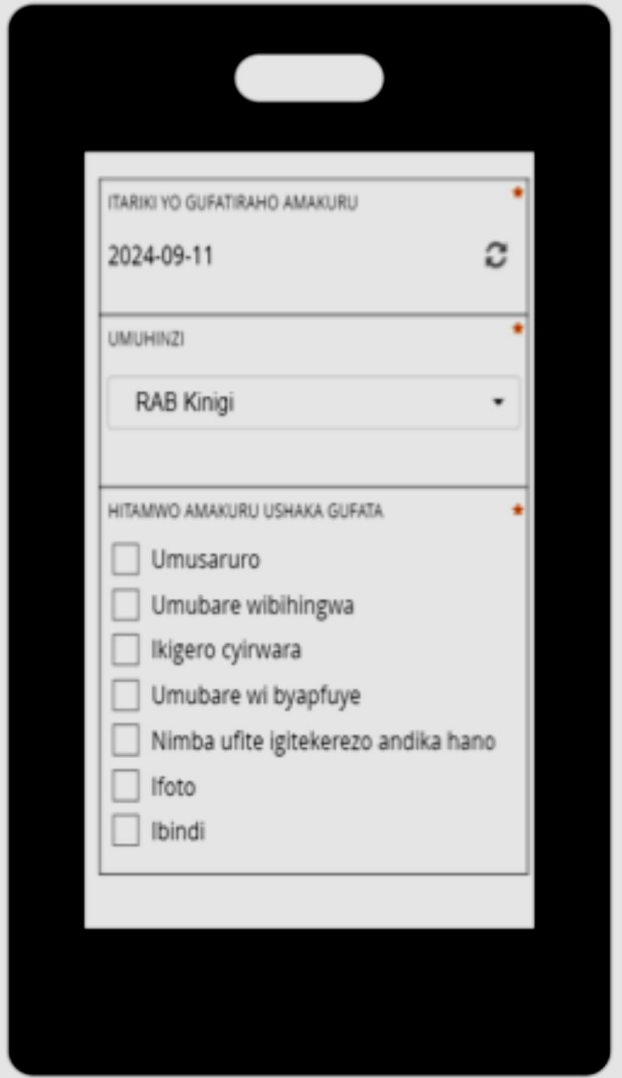
[Zurück](#)

[↶](#) Zurück zum Anfang Ans Ende gehen

Case: Kinigi-Nyange Pilot



DSS Monitoring + Data Collection and info spread



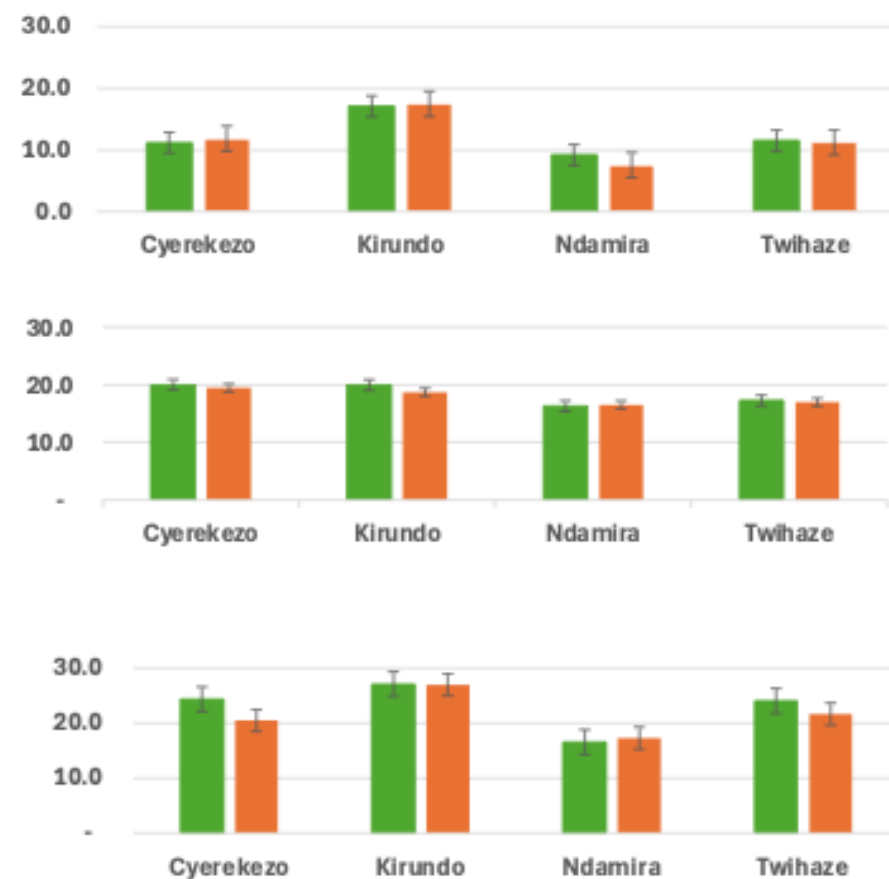
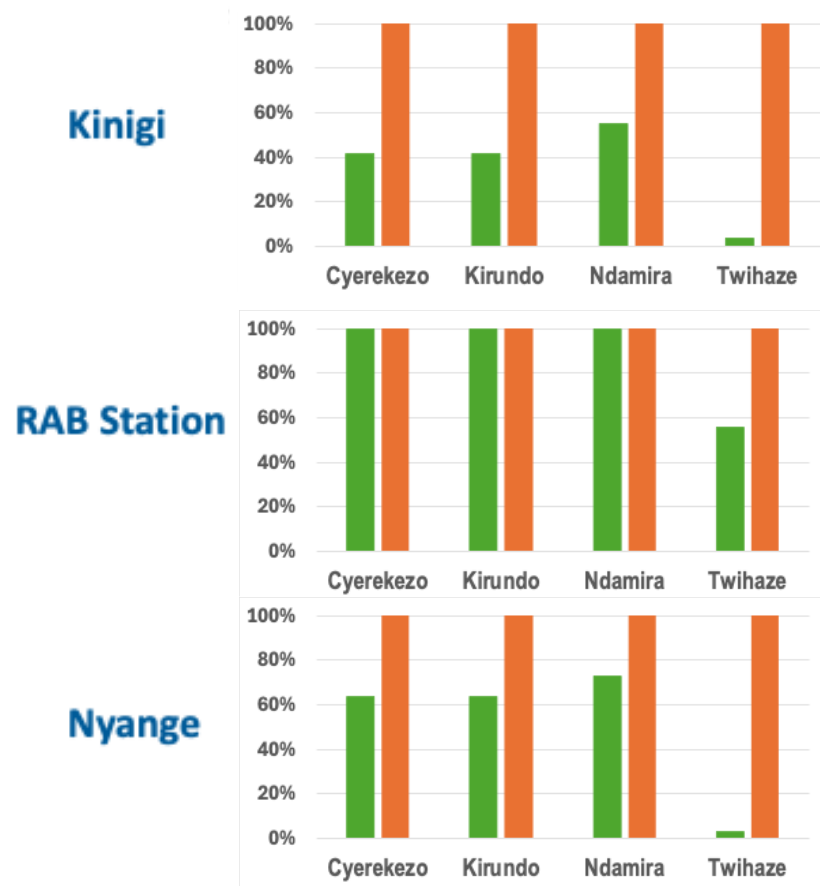
Results: Season B (2023/2024)

Number of Sprays

vs

Yield (T/ha)

■ Weather DST
■ Weekly



Results: Season A (2024/25)

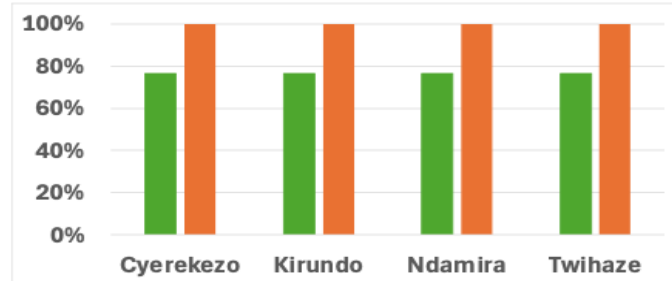
■ Weather DST
■ Weekly

Number of Sprays

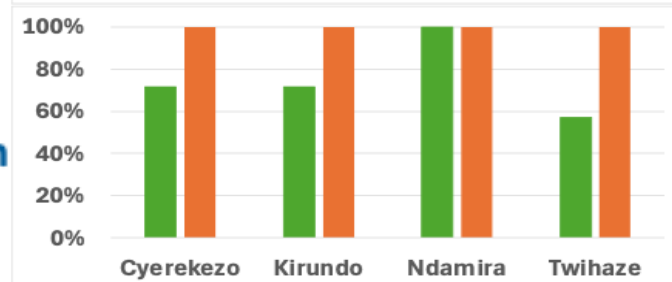
vs

Yield (T/ha)

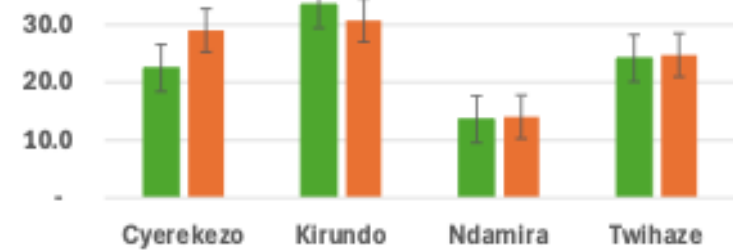
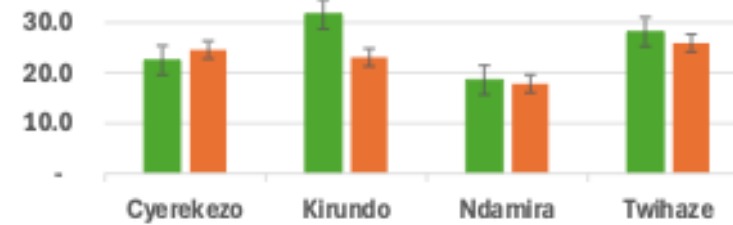
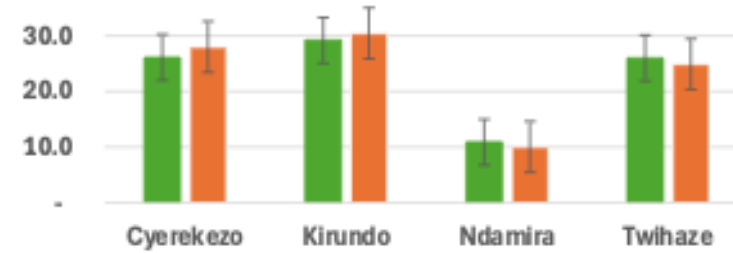
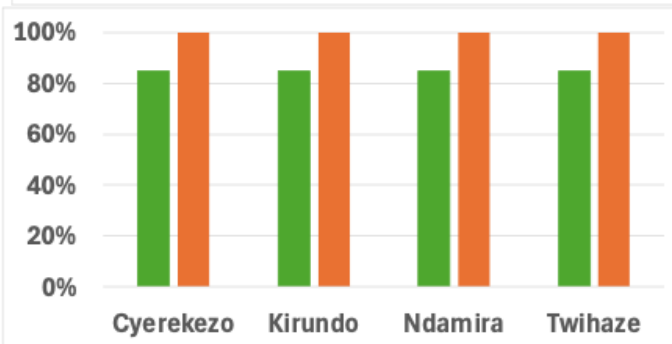
Kinigi



RAB Station



Nyange



Impact Analysis

01

Decision-Making

Farmers gained confidence in information-driven methods of farming

02

Sustainability

Reduced chemical usage aligns with sustainable practices

03

Economic

Cost savings improved farmers' incomes

Recommendations from Farmers

Trial Varieties

Replace susceptible varieties (Ndamira) with resilient options



Direct reach

Farmers need the information reach them immediately with no intermediary

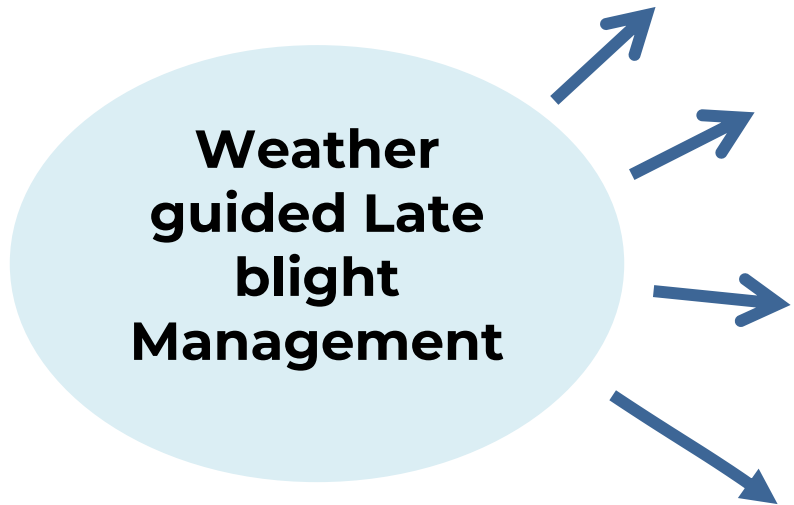
Beneficiary Base

Engage more farmers to maximize program impact

Scheduling

Offer highly accurate planting and harvesting schedules

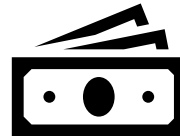
Lessons Learned



- **No difference in Yield with Reduced fungicide use**



- **Timely application**
- **Climate Friendly**



- **Reduce production Cost**

+ Decision to the use of Resistant Varieties

Danke Dziekuje Grazie
 Gracias הודות Thank you
 Obrigado ありがとう
 Спасибо Merci 谢谢
 Terima kasih Ngiyabonga
 Kiitos Teşekkürler
 شكراً عراً Ευχαριστώ
 ጸሐጸኞቻችን ጸሐጸኞቻችን
 감사합니다

Murakoze Cyane!



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RWANDA CLIMATE SCIENCE SYMPOSIUM 2025

Advancing Research And Networking

B3) OBSERVATION AND MODELLING OF CLIMATE CHANGE

13 May 2025, 14:00 – 14:15 P.M., Plenary

Complexity of Climate Variables Interdependence and their effects to Agricultural Sector in Rwanda

Athanase Hafashimana, ahafashimana@aimsric.org

Dr. Mouhamadou Bamba Sylla, msylla@aimsric.org

Dr. Philibert Nsengiyumva, p.nsengiyumva@ur.ac.rw

AIMS Research and Innovation Centre & The African Centre of Excellence in Data Science,
University of Rwanda



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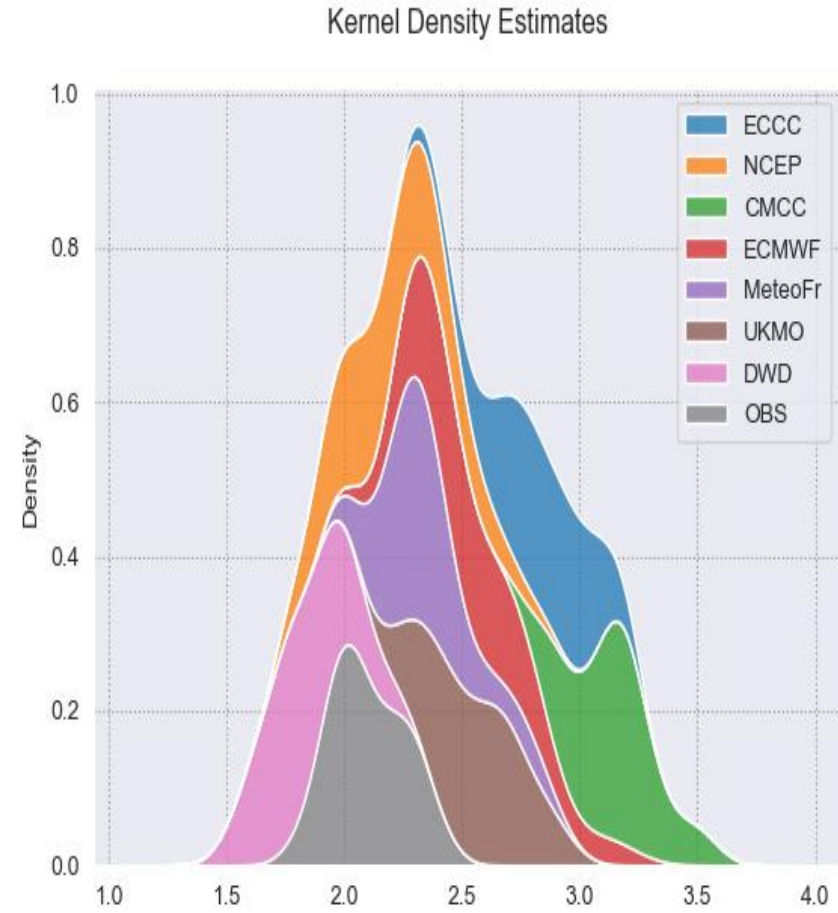
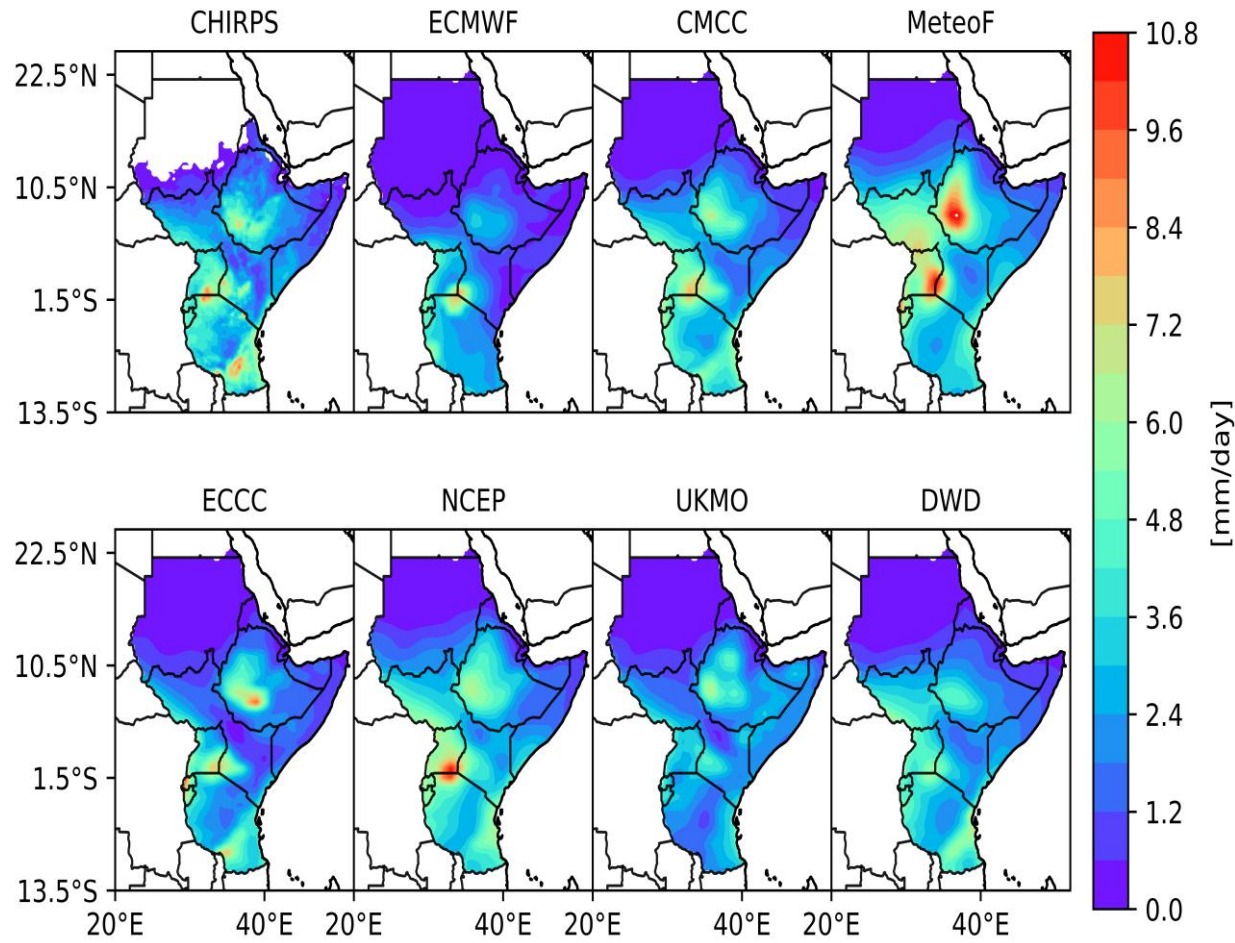
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Agriculture and Climate Variables

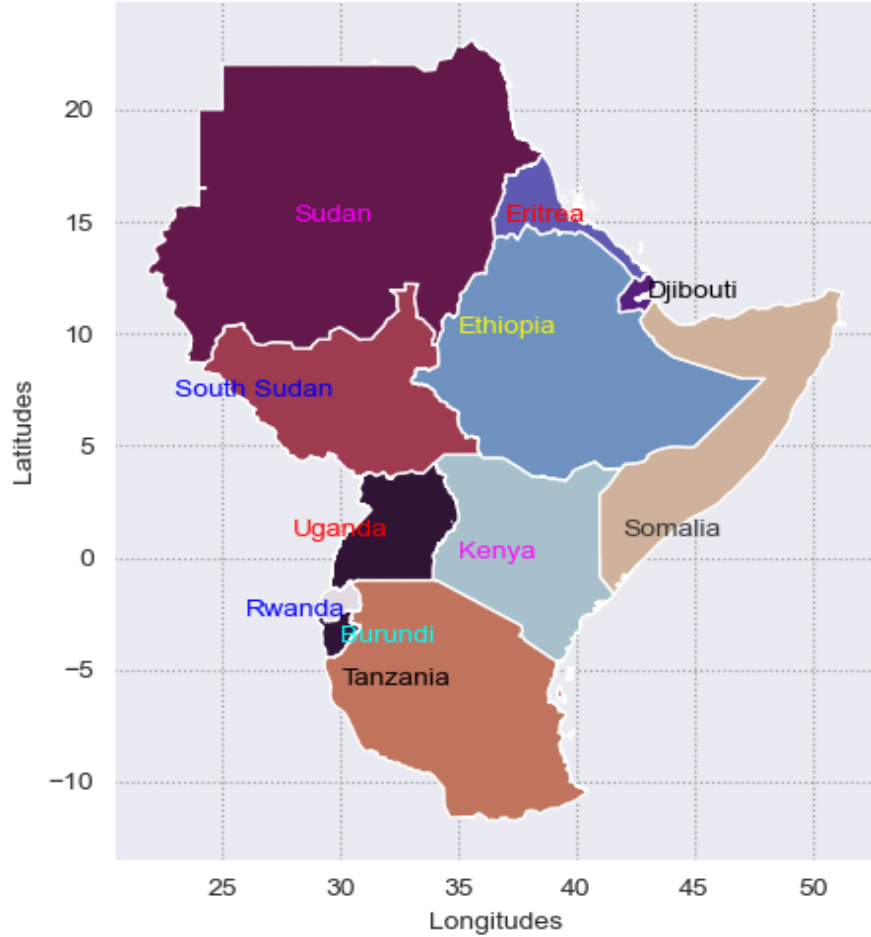
- ❑ Rwanda, like many other sub-Saharan countries (more than 95% of the croplands are rainfed [1]).
- ❑ More than 70% farmers relies on rainfed agriculture in sub-Saharan region for their income and sustenance [2].
- ❑ Precipitation is not a stand-alone variable in the climate system [Interdependence] [3].
- ❑ Global warming is about rising temperature in the climate ecosystem [4].
- ❑ Does global warming affect rainfall availability in Rwanda?
- ❑ What about the regional precipitation forecast bias in the Greater Horn of Africa?
- ❑ Which climate forcing is critical to the change of surface air temperature in Rwanda?
- ❑ What about precipitation amount and tea production in Rwanda? [5]

Rainfall data from GCMs and satellite Observations

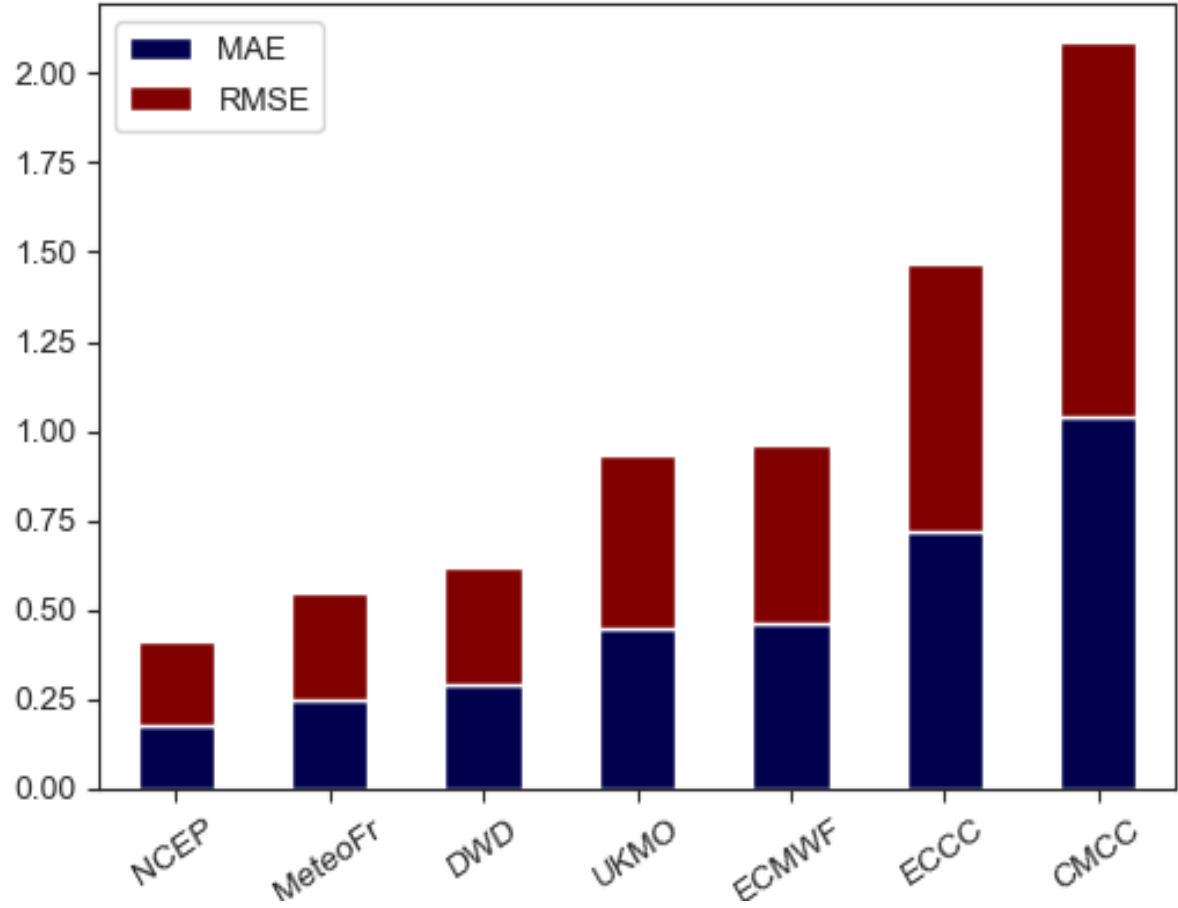


Regional Precipitation Seasonal Bias (GCMs) for MAM season

Great Horn of Africa (GHA)

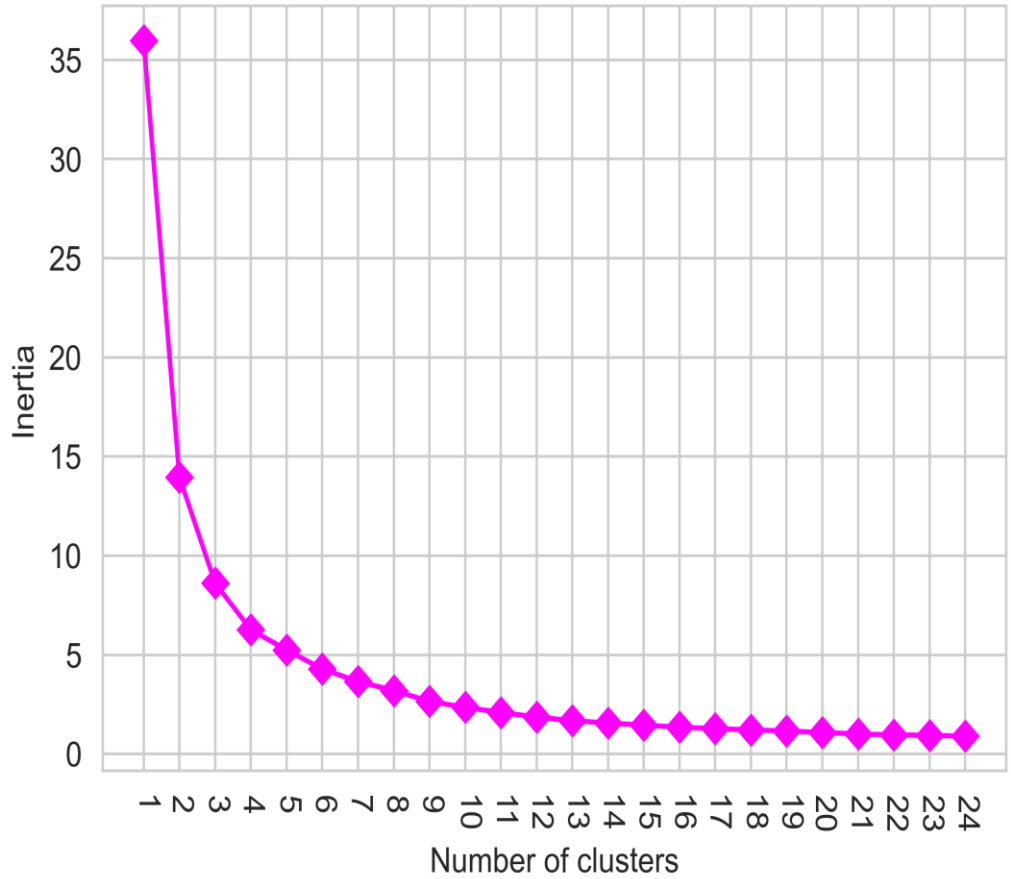


Bias in individual GCMs

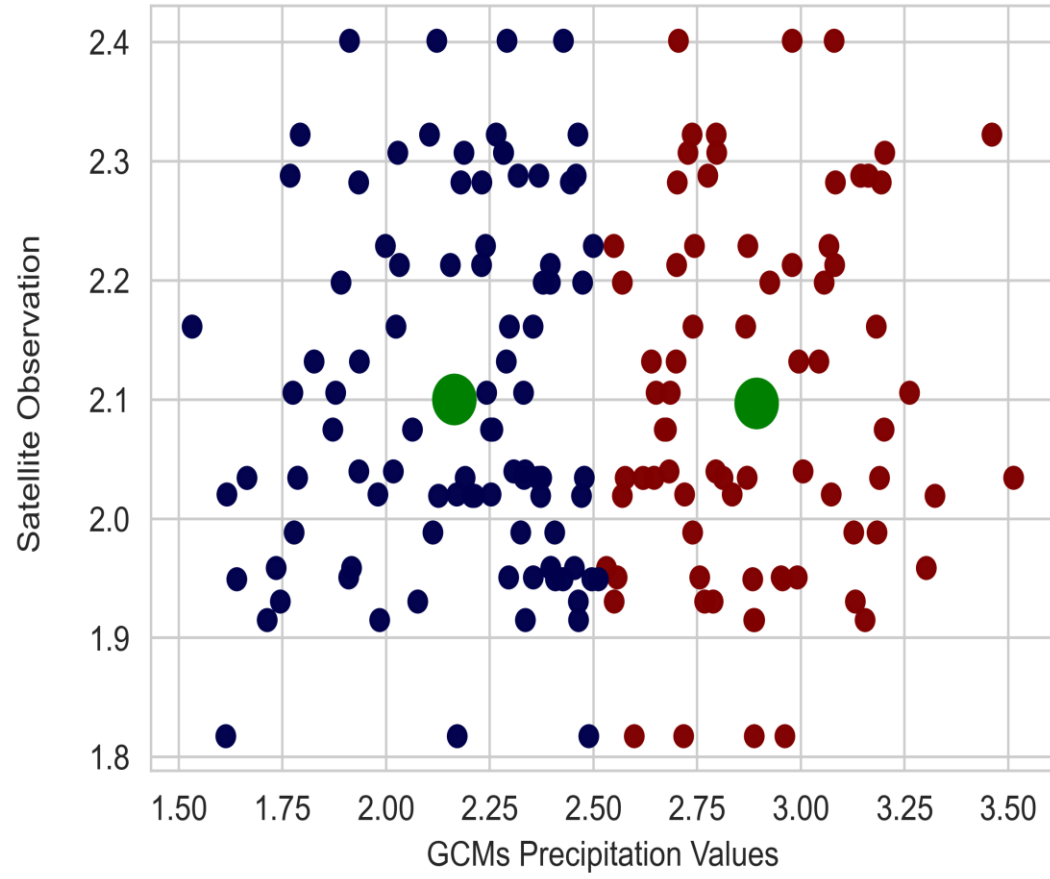


KMC in Identifying Possible Groups of GCMs

Elbow method



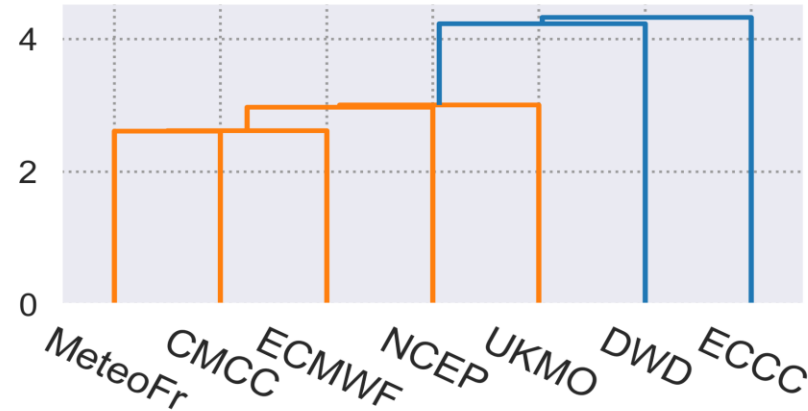
Maximum Clusters



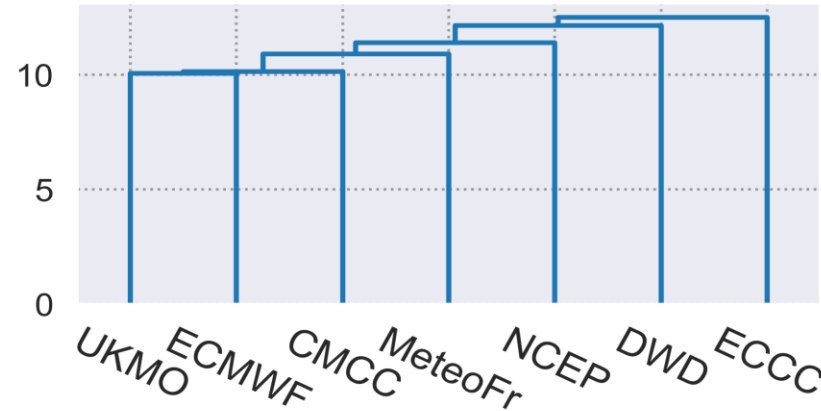
HCA in Forming an Ensemble of GCMs (1/3)

a) Single Linkage

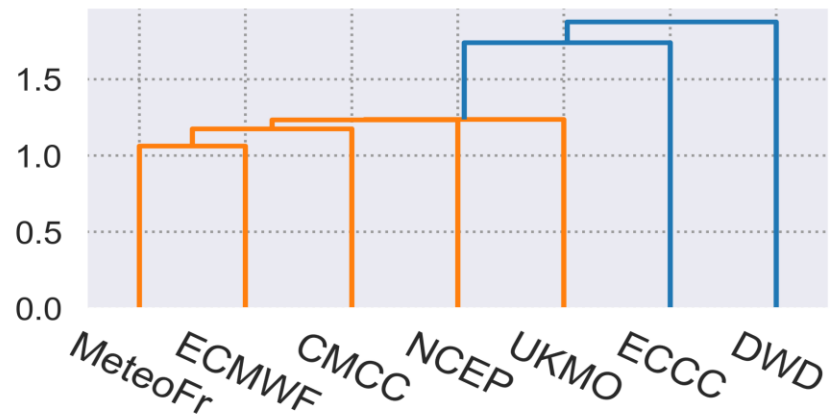
Euclidean



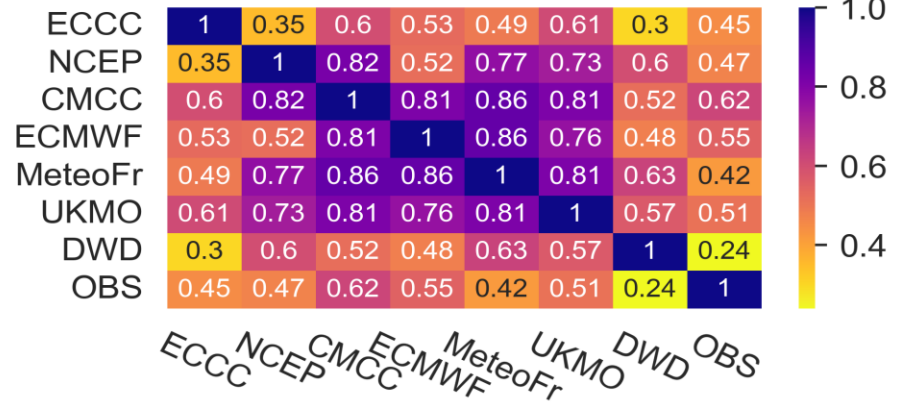
Canberra



Chebychev

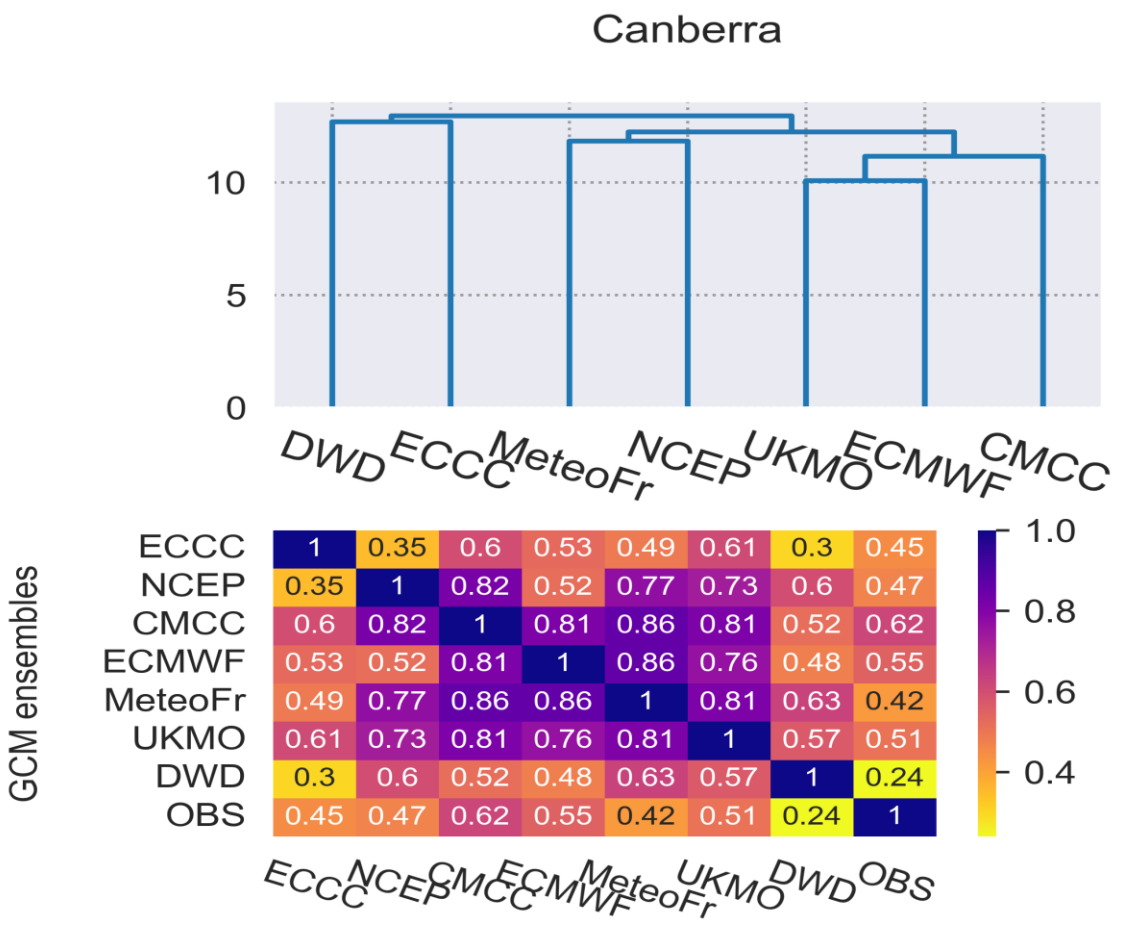
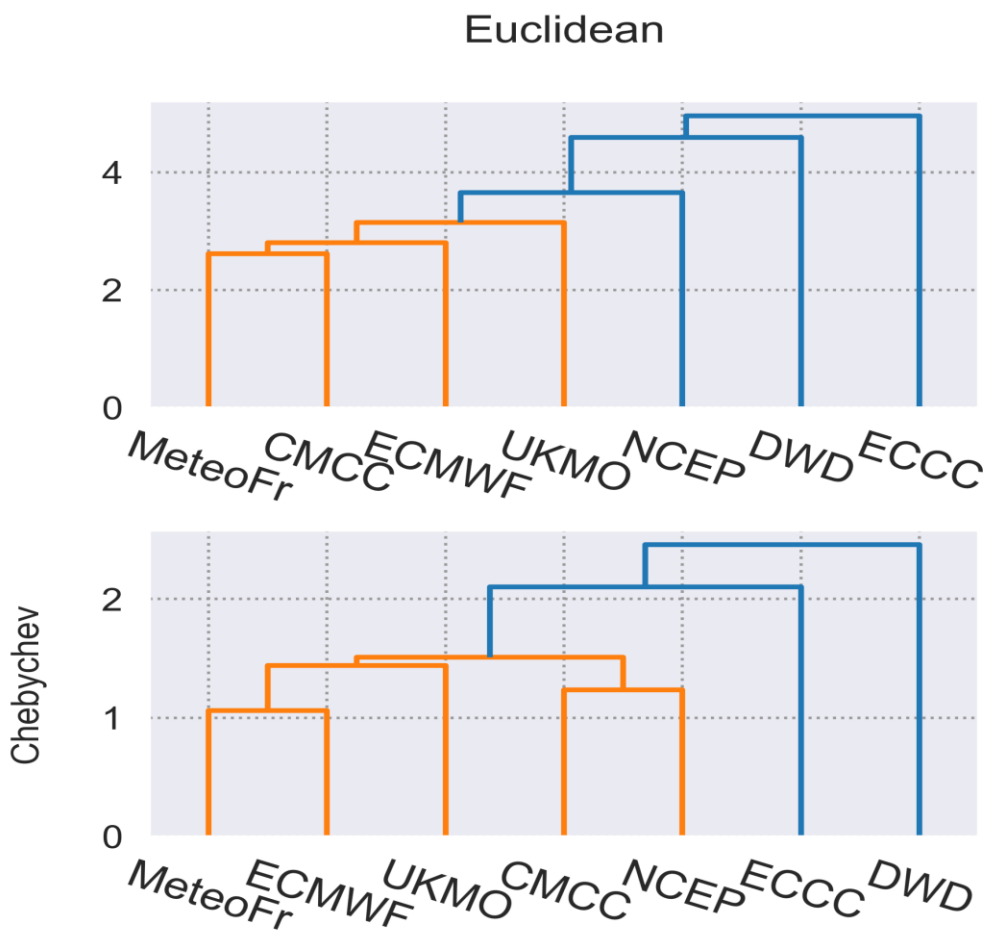


GCMs



HCA in Forming an Ensemble of GCMs (2/3)

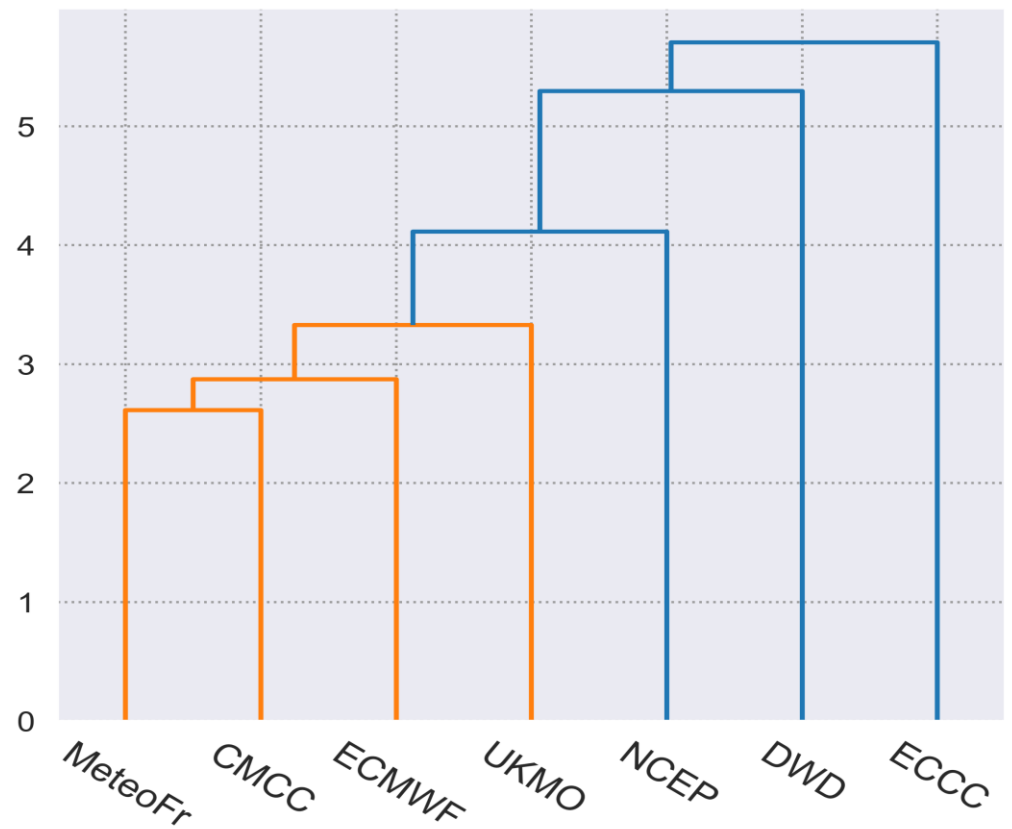
b) Average Linkage



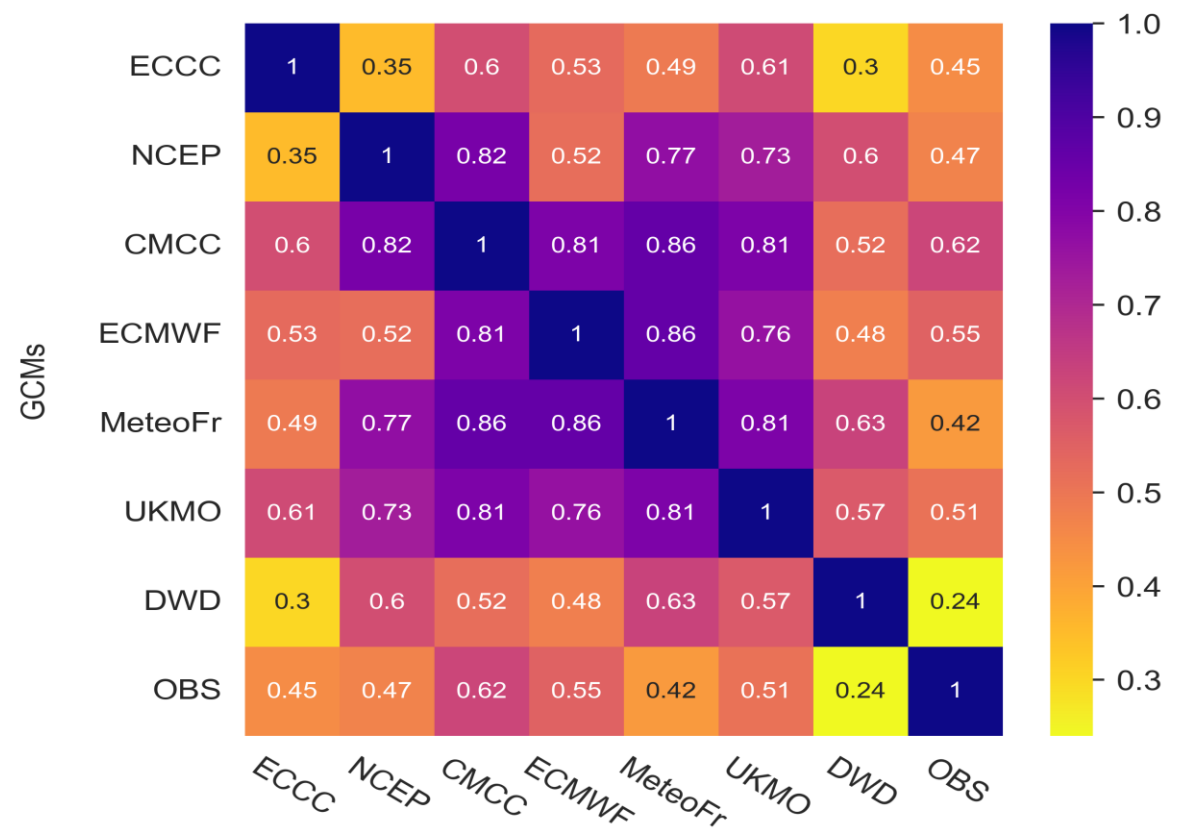
HCA in Forming an Ensemble of GCMs (3/3)

c) Ward's Method

Ward

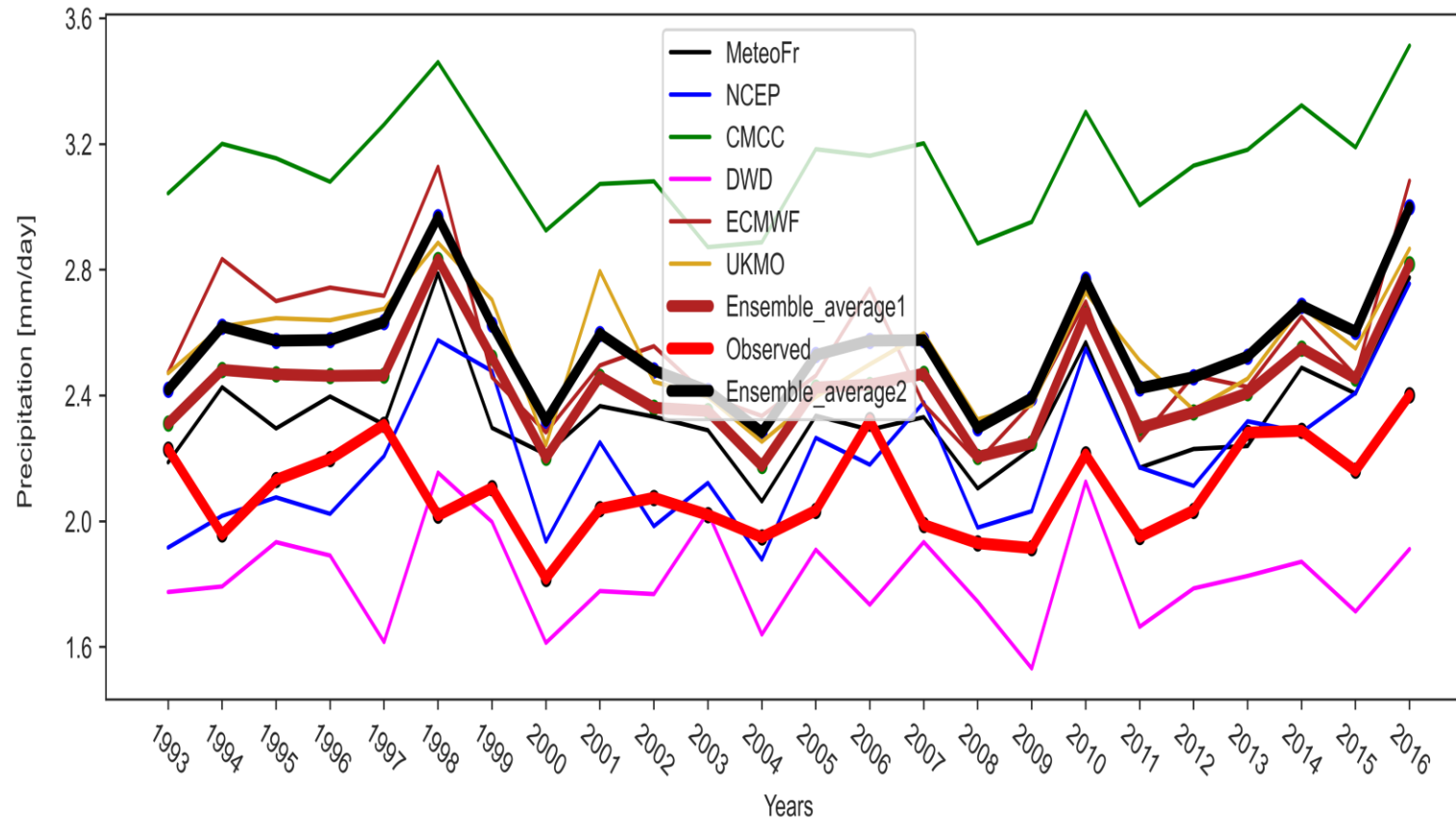


Correlation Heatmap

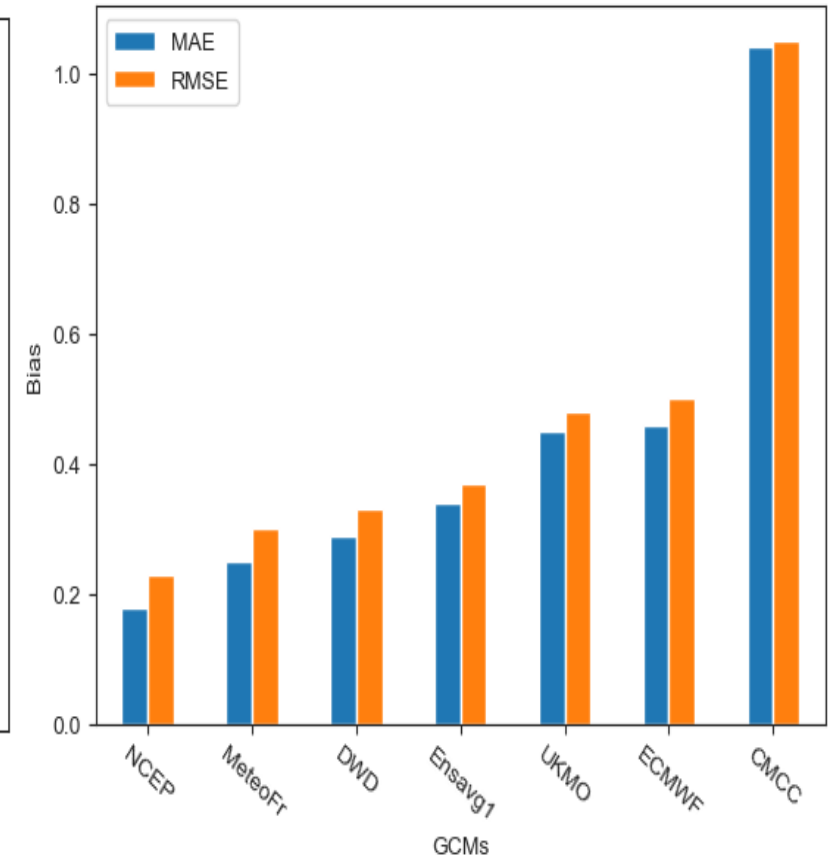


Potential of Multi-model Ensemble of GCMs in Simulating Satellite Observations [Temporal Res]

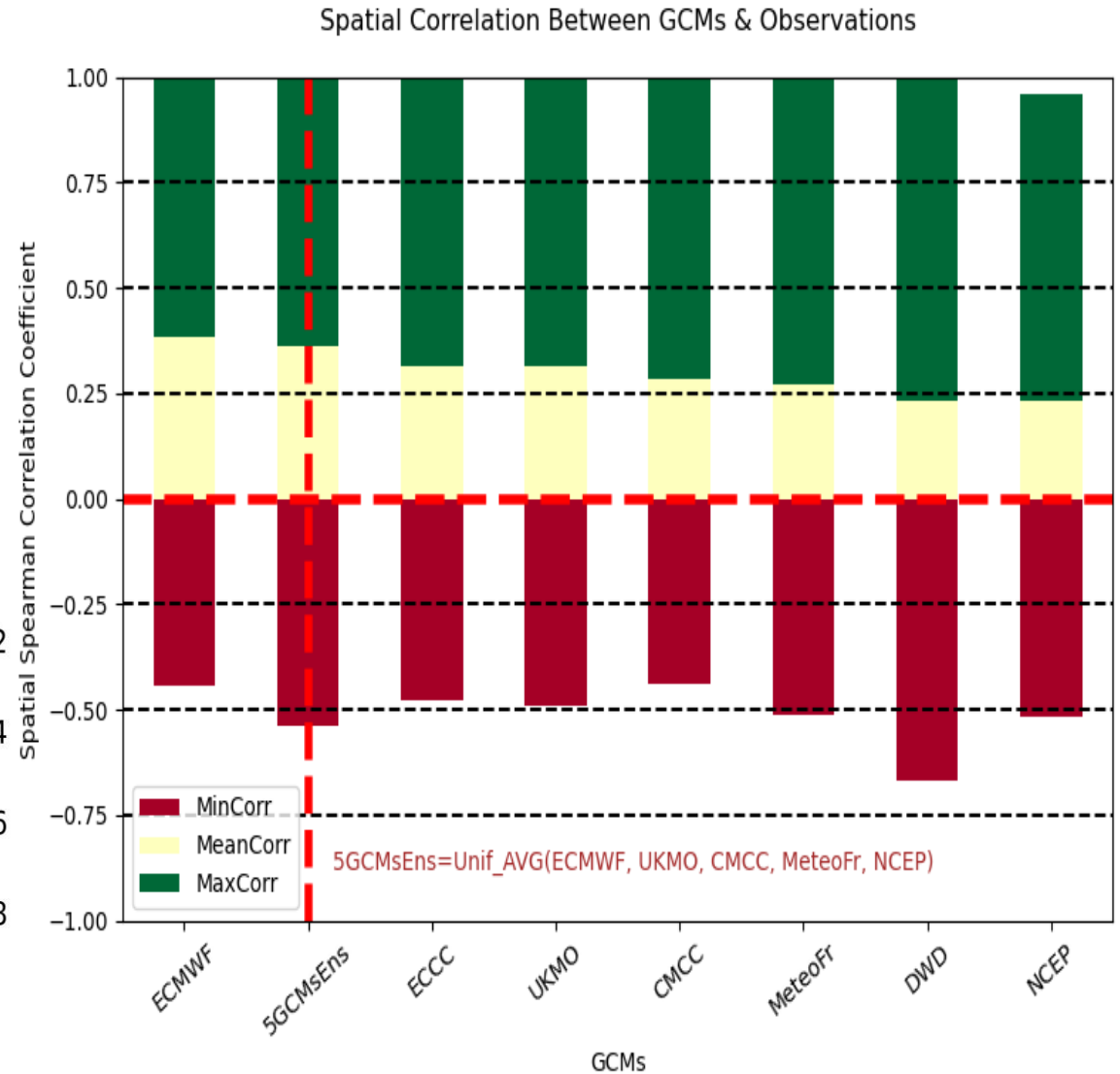
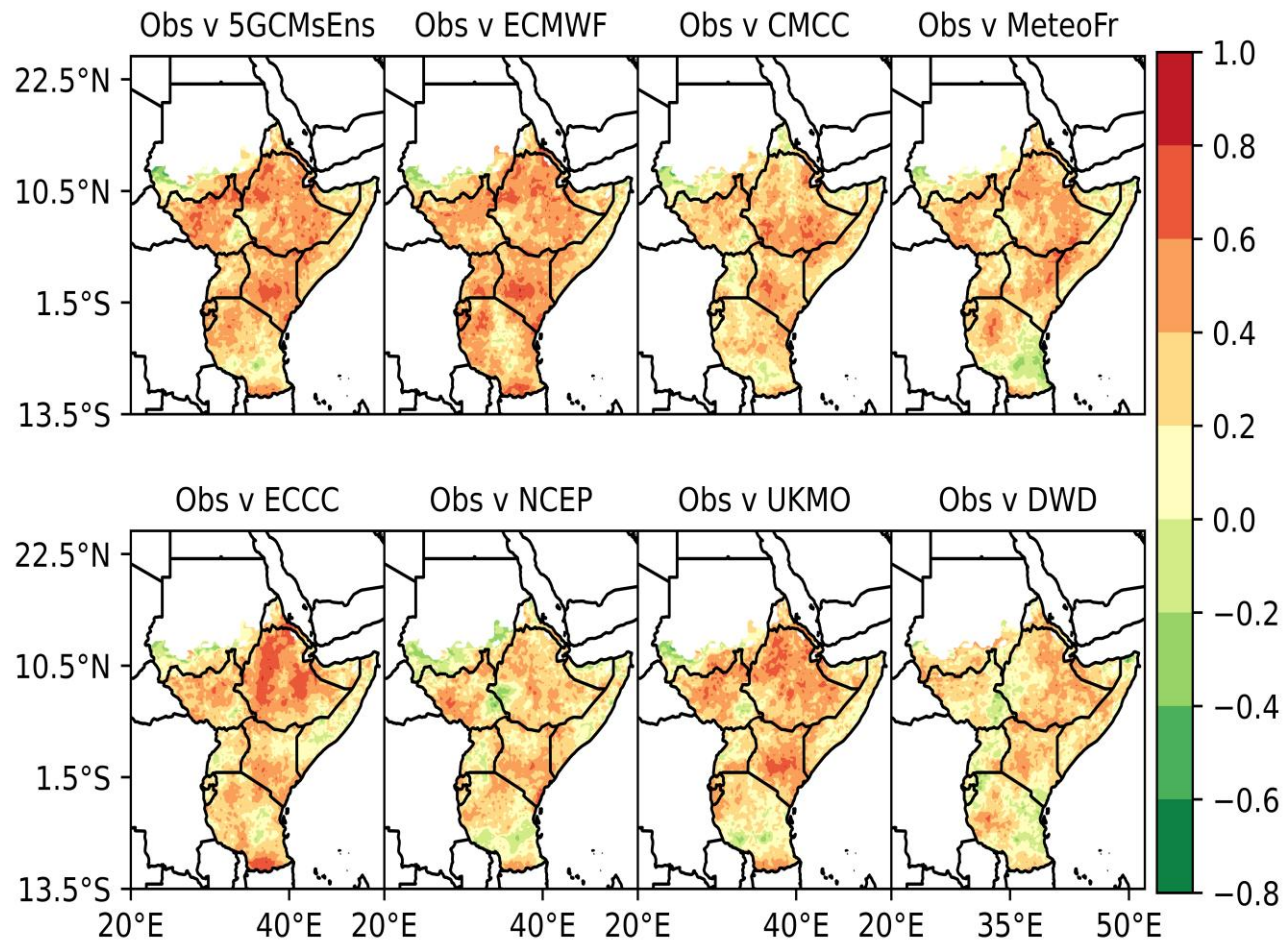
Ensemble averaging effects



Level of Bias in GCMs

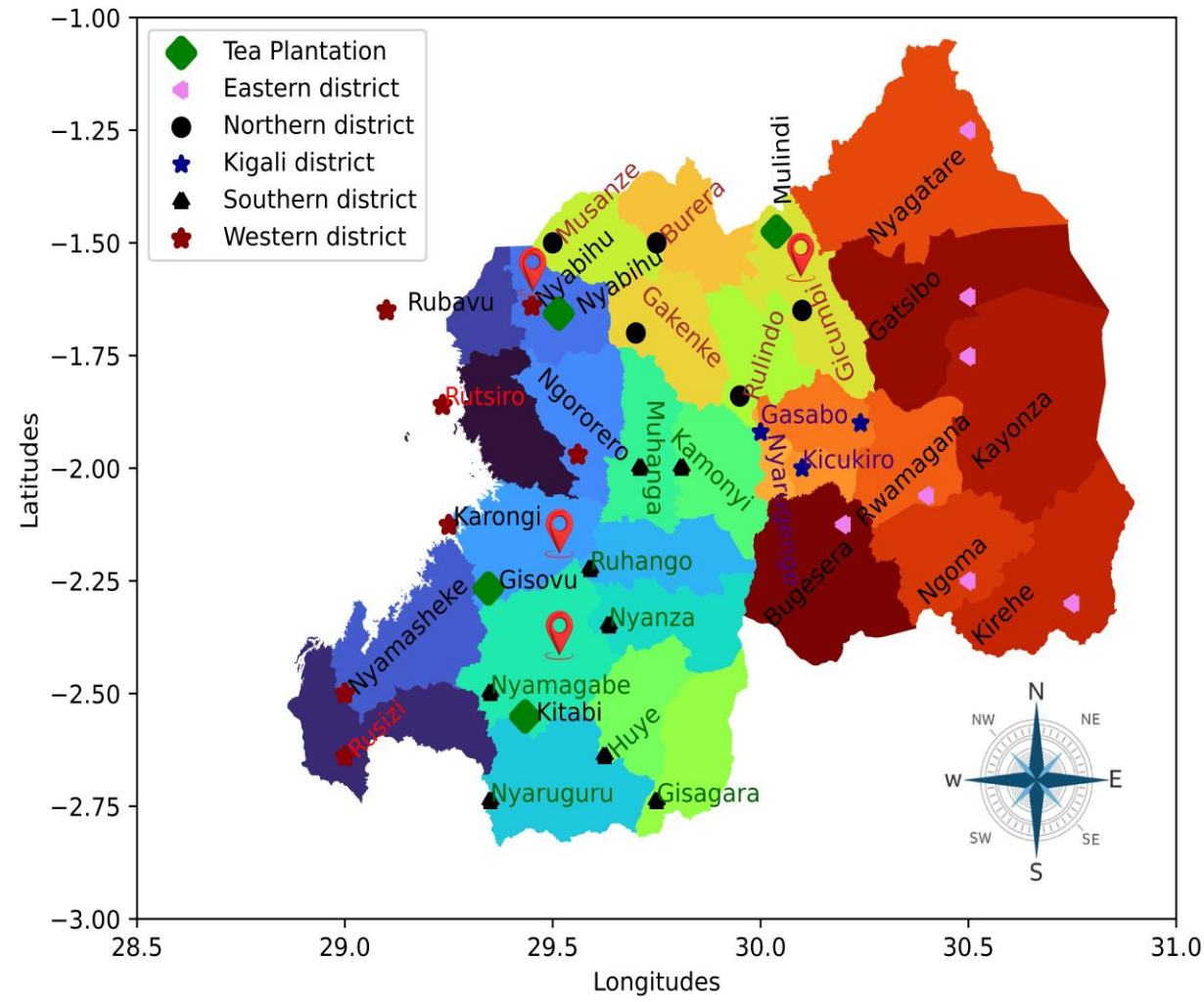


Potential of Multi-model Ensemble of GCMs in Simulating Satellite Observations [Spatial Res]



Rainfall and Tea Production in Rwanda

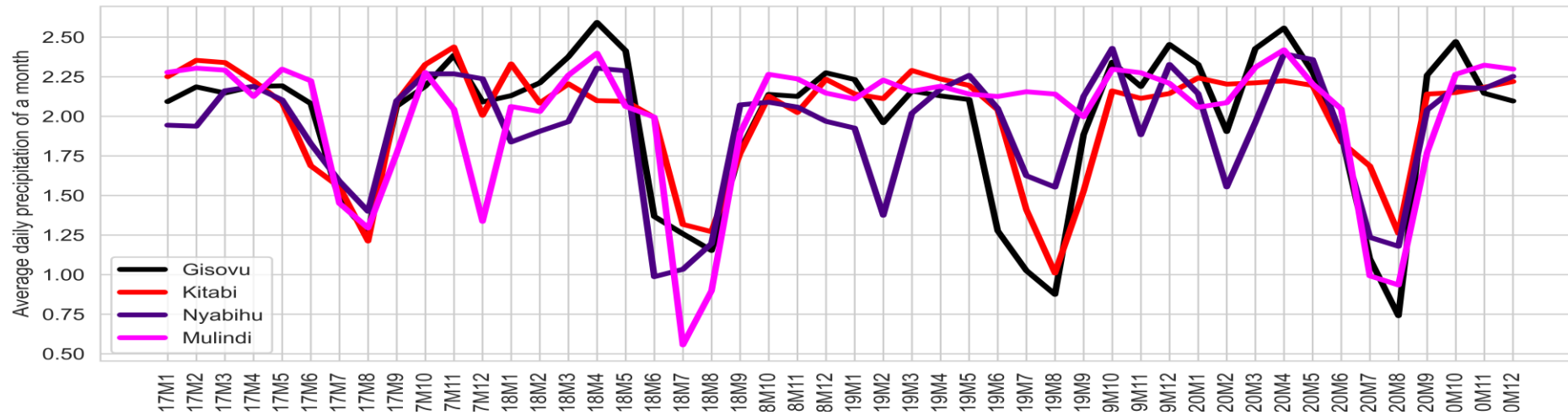
Districts of Tea Plantation in Rwanda



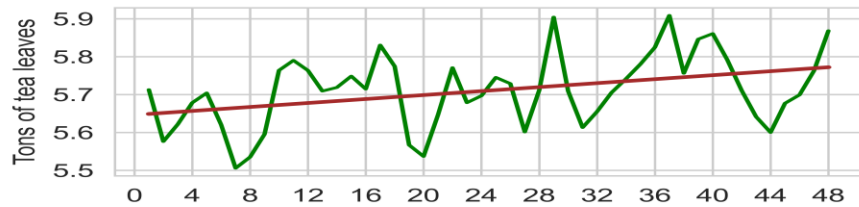
	Kitabi	Gisovu	Nyabihu	Mulindi
Year				
2017	70.5	71.3	67.9	73.1
2018	71.2	70.5	68.4	73.4
2019	71.4	70.5	68.7	73.3
2020	71.3	70.6	67.1	72.9

Rainfall Seasonal Variation and Short time Tred

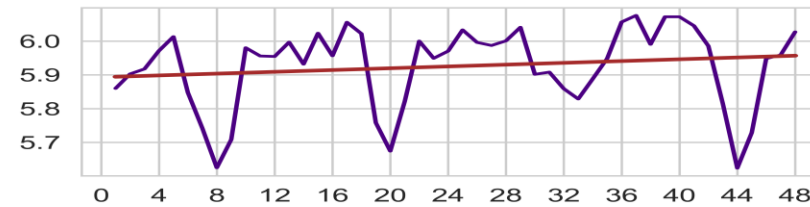
Time Series of Rainfall Received in Tea Factories Regions



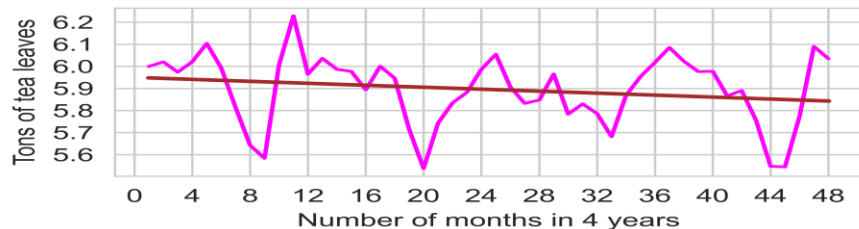
(a) Monthly Trend in Nyabihu



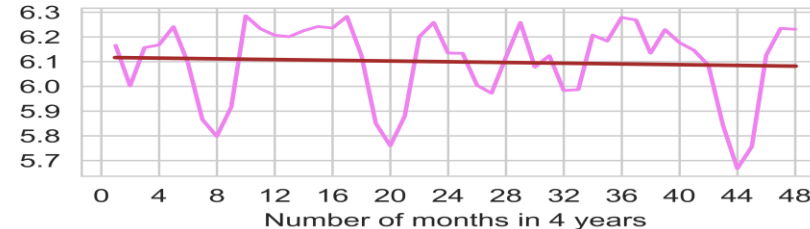
(b) Monthly Trend in Gisovu



(c) Monthly Trend in Kitabi



(d) Monthly Trend in Mulindi



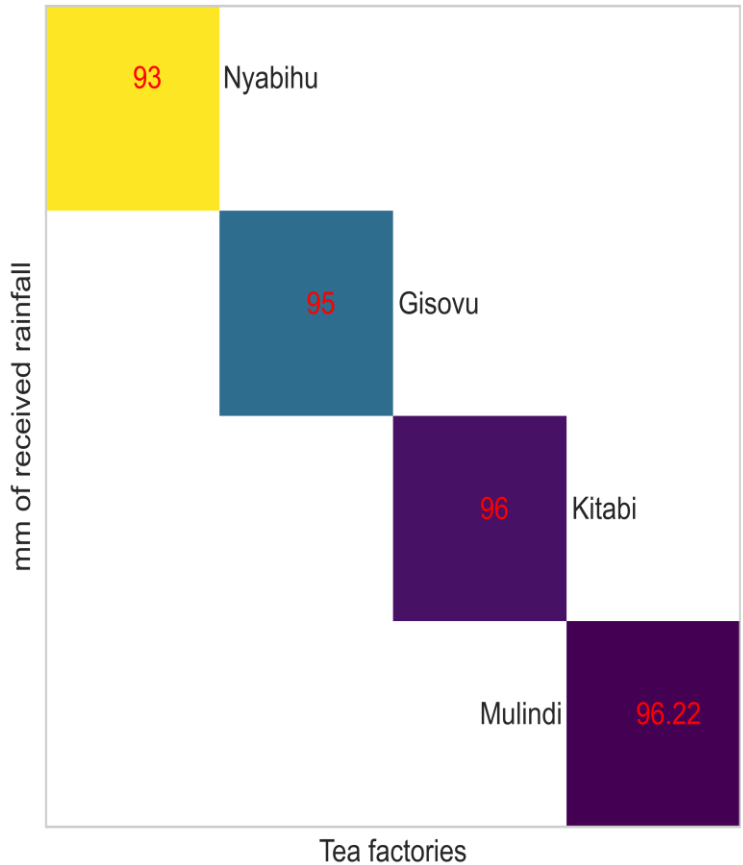
Significance of Rainfall on Tea Production

VARIABLES	FE Model1	FE Model 2	FE Model 3
LLand	0.019 (0.057)	0.020 (0.057)	0.031 (0.044)
LFertilizer	0.001 (0.013)	0.001 (0.013)	0.001 (0.012)
LTemp		-0.418 (0.972)	-0.371 (0.749)
LRainfall			0.215*** (0.019)
Constant	5.779*** (0.397)	5.875*** (0.457)	5.371*** (0.355)
Observations	192	192	192
R-squared	0.001	0.002	0.410
Number of Company	4	4	4

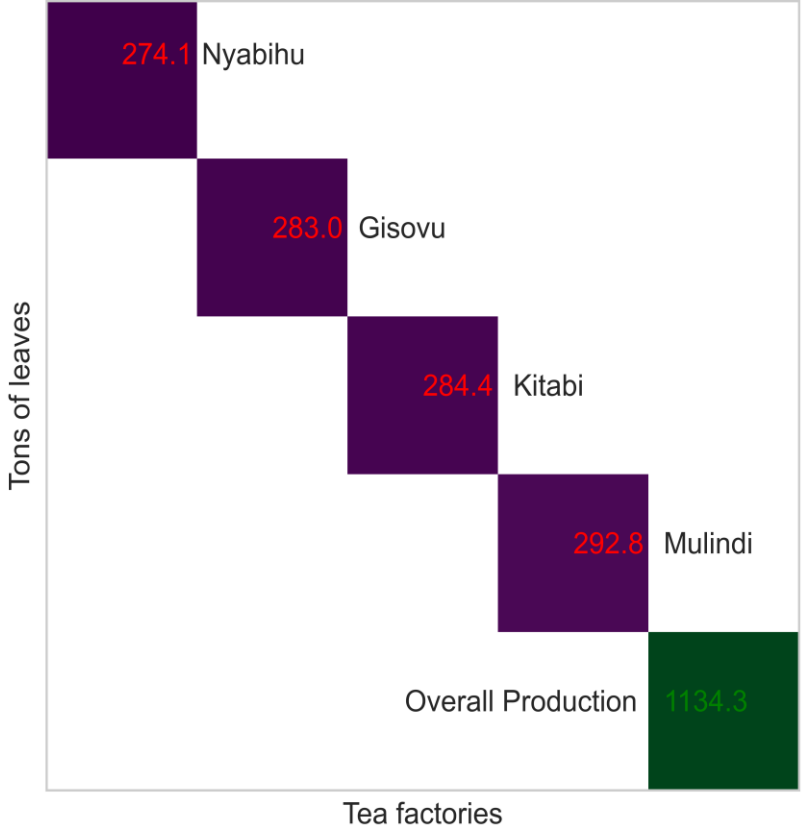
*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Rainfall Proportionality of Influence on Tea Production

(a) Ascending Total Rainfall Received

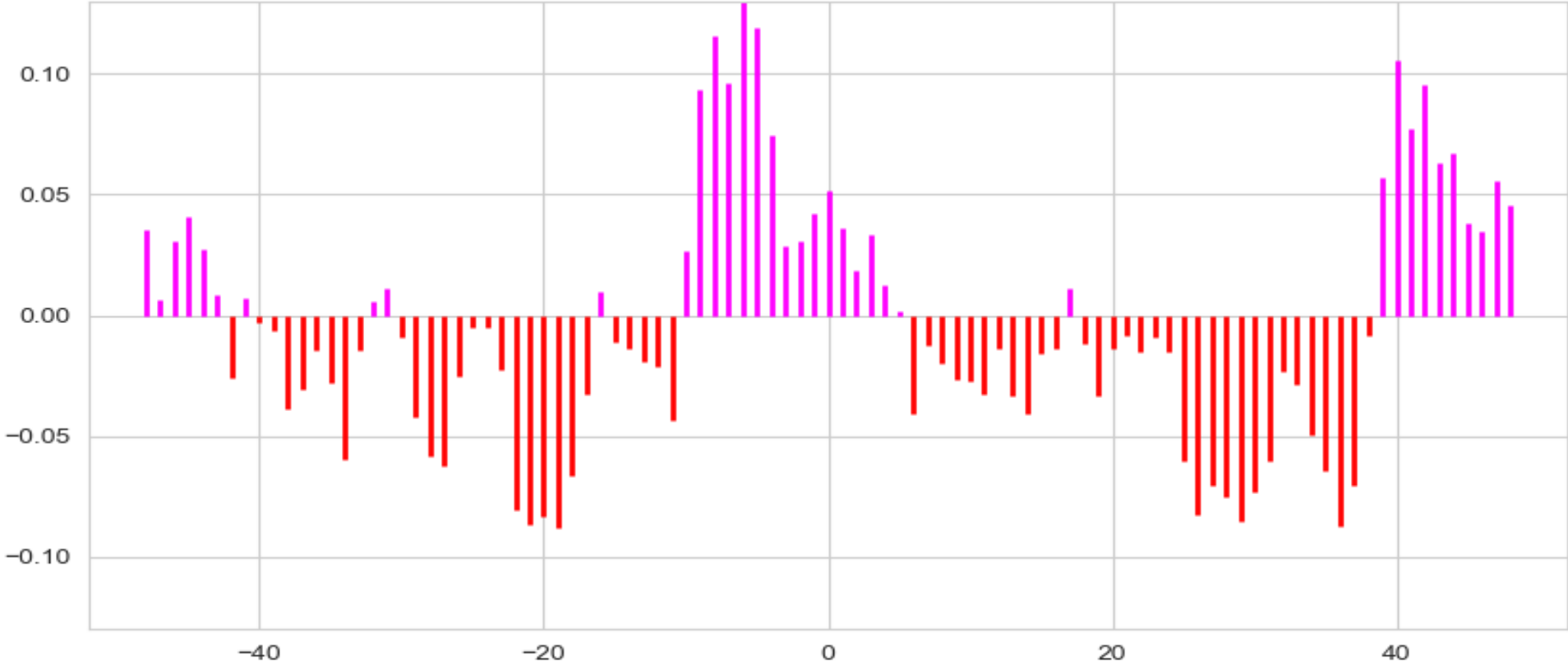


(b) Exact Value of Total Production



Climate Variables Interdependence

Cross Correlation Between Temperature and Rainfall (2017–2020)



Response of Surface air temperature in CMIP6 forcings

a) ACCESS-ESM

	Estimate	Std. Error	t value	Pr(> t)
(Intercept)	11.3800	9.8421	1.16	0.2567
aer	0.0560	0.2144	0.26	0.7956
GHG	0.4697	0.1950	2.41	0.0223
nat	-0.0606	0.3103	-0.20	0.8465

F-statistic = 2.091
P-value = 0.1224 > 0.05

b) MIROC

	Estimate	Std. Error	t value	Pr(> t)
(Intercept)	10.6578	9.9799	1.07	0.2941
GHG	0.0347	0.2644	0.13	0.8964
nat	0.3026	0.2107	1.44	0.1613
aer	0.2105	0.3983	0.53	0.6010

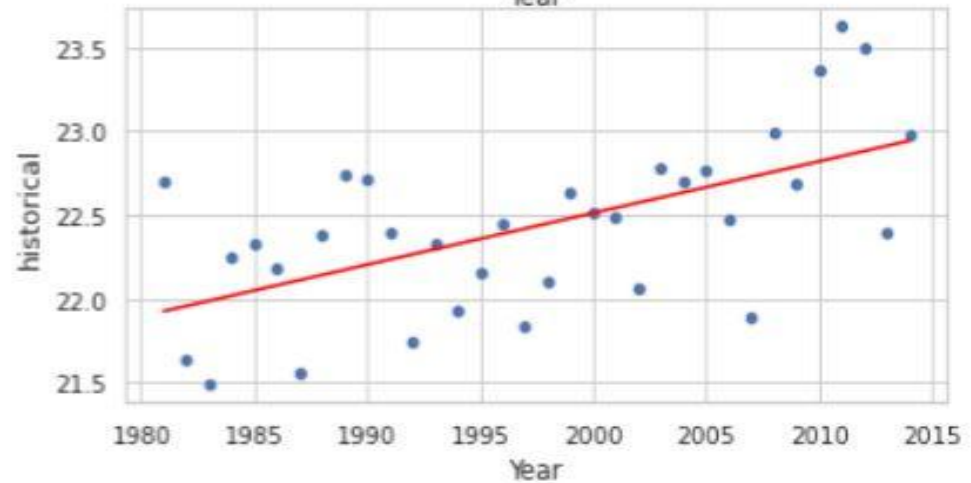
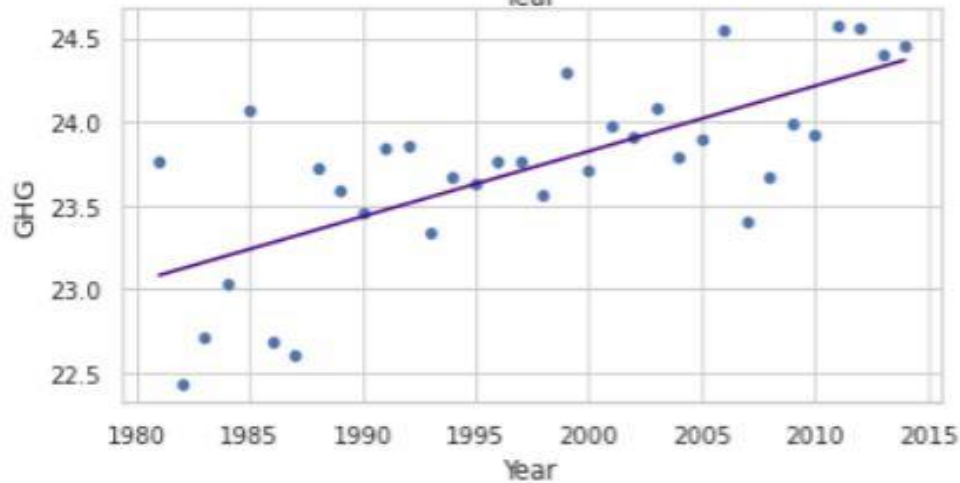
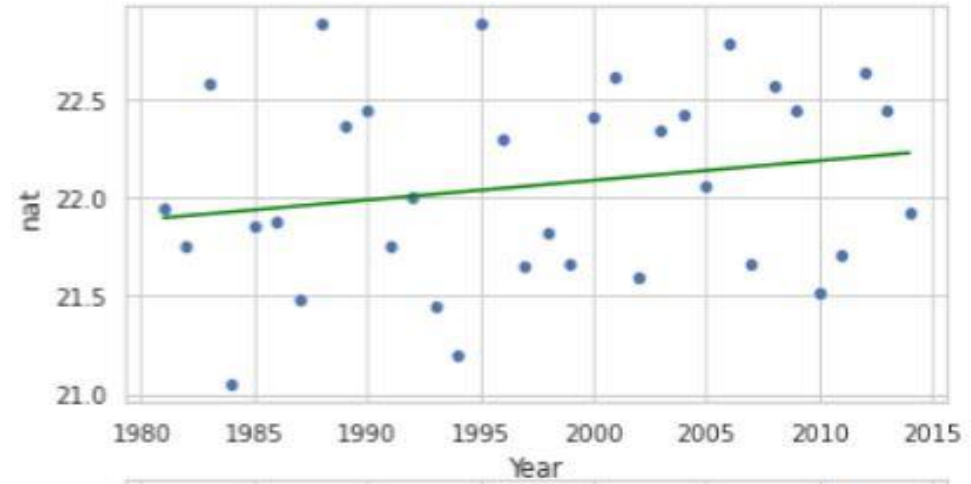
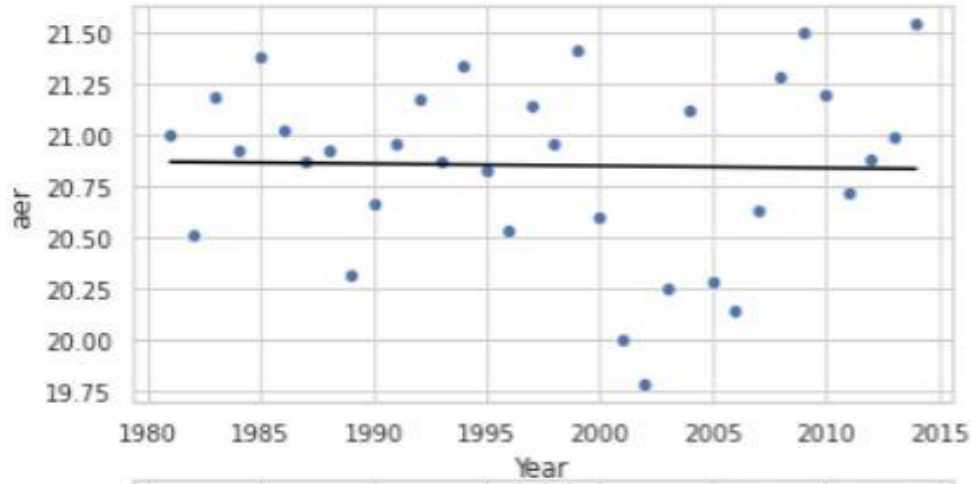
F-statistic = 0.9942
P-value = 0.4089 > 0.05

c) ACCESS-CM2

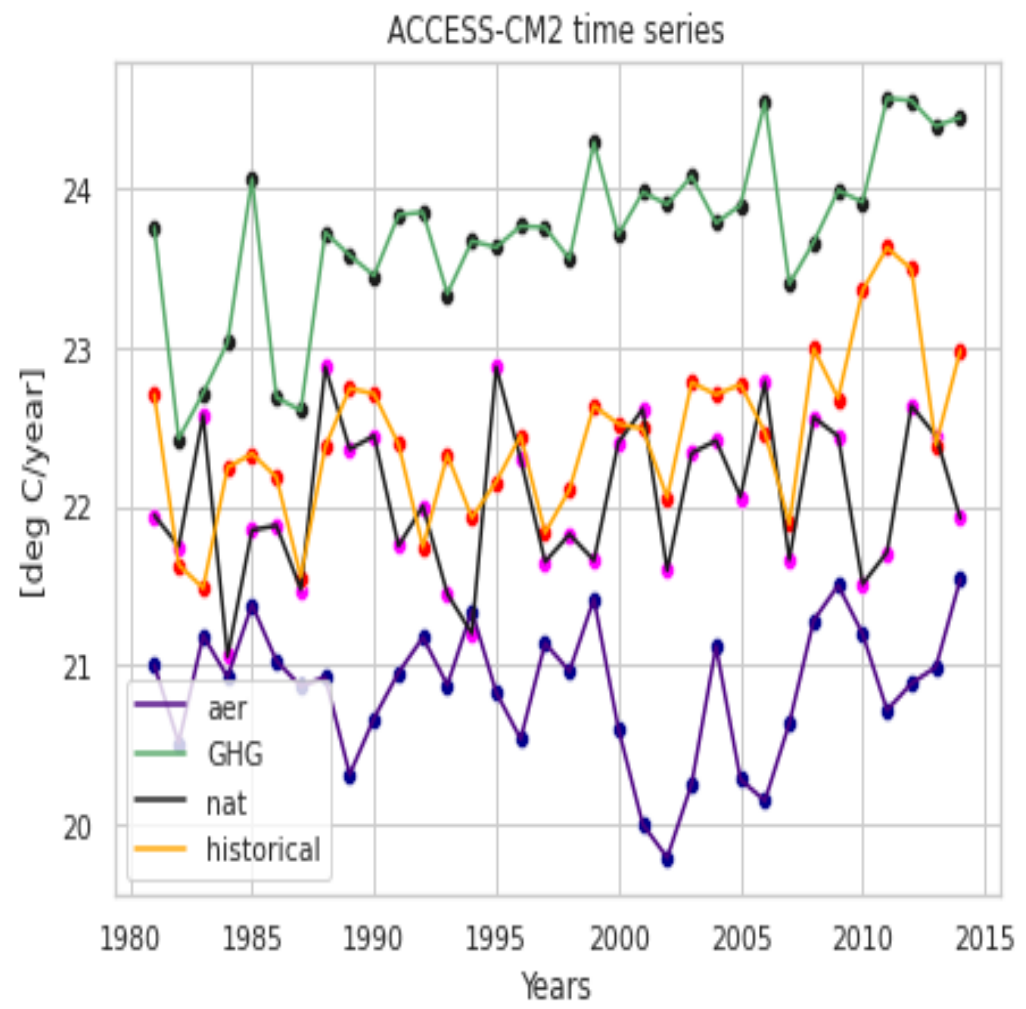
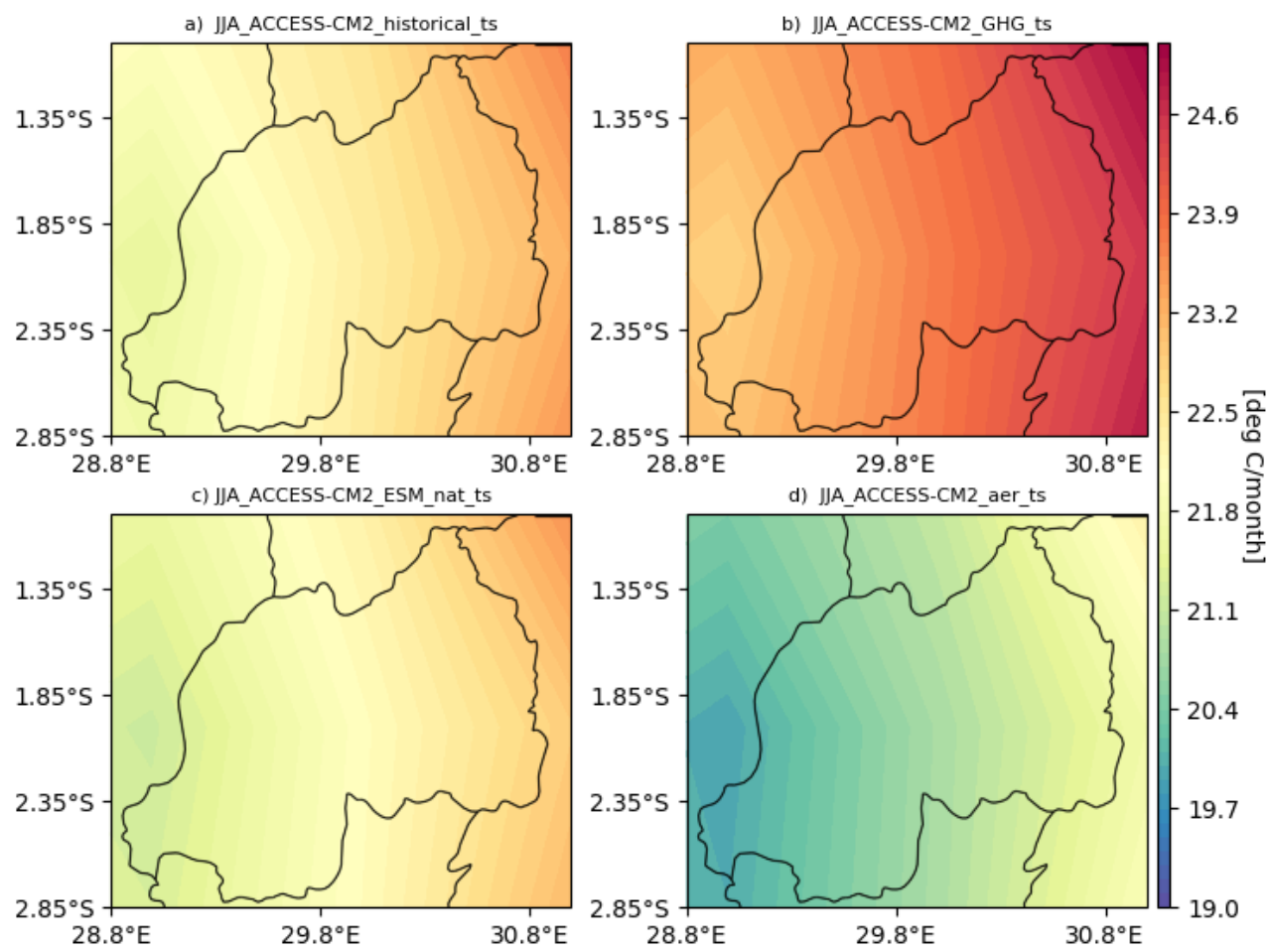
	Estimate	Std. Error	t value	Pr(> t)
(Intercept)	5.8022	5.5594	1.04	0.3050
aer	0.0364	0.1651	0.22	0.8271
GHG	0.6181	0.1343	4.60	0.0001
nat	0.0548	0.1529	0.36	0.7226

F-statistic = 8.024
P-value = 0.0004503 < 0.05

Anthropogenic Greenhouse Gas as a Statistically Significant Forcing for Surface Air Temperature



ACCESS-CM2 as a Statistically Significant model in Regressing Historical Surface Air Temperature



Take-home messages

- ✓ Rainfall is the key variable to rainfed Agriculture (Rwanda).
- ✓ Ensemble averaging may be useful to minimizing bias in seasonal rainfall forecast.
- ✓ Increasing Rainfall amount favorably increase tea production in Rwanda.
- ✓ Observed surface air temperature is varying due to anthropogenic greenhouse gases.
- ✓ Surface temperature and rainfall are interdependent.
- ✓ Modelling national climate change and variabilities should also consider teleconnections.

References

[1] L. Abrams. Unlocking the Potential of Enhanced Rainfed Agriculture. Report 39. Stockholm: SIWI, 2018.

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RWANDA CLIMATE SCIENCE SYMPOSIUM 2025

Advancing Research And Networking

B4) OBSERVATION AND MODELLING OF CLIMATE CHANGE

13 May 2025, 14:00 – 16:00 P.M., Plenary

ANALYZING POTENTIAL FLOOD OCCURANCE UNDER CLIMATE RELATED VARIABLE IN COASTAL AREAS OF KILIFI, KENYA

Author: **Eline Nyiransengiyumva**

Affiliation: University of Cape Coast

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Presentation outlines

- ❖ Introduction
- ❖ Materials and Method
- ❖ Results
- ❖ References

Introduction

- Climate change presents a significant threat to both present and future generations through its related impacts and hazards like floods.
- Floods have been significantly increasing in both intensity and spatial coverage globally, and is posing significant threats to human lives, livelihoods and properties (IPCC, 2023).

Introduction cont.

- Kenya like other part of the world, Low lying and coastal areas are more vulnerable to climate related flood hazards (Wing et al., 2022).
- Kilifi county, from 2009 to 2022, flood has affected more than 40,000 people, loss of hundreds lives and damages of millions of dollars (Njogu, 2022 and Kenya News Agency, 2023)
- In 2018 one flood incident causes displacement of over 500 families (Gari, 2018).

Problem statement

- Modeling flood occurrence in relation to climate related variables were done in different parts of the world (Alobid et al., 2024).
- But there is no work in region that studied on model of partners and trends on flood occurrence and climate change variables.

Materials and Method

Study area

- Kilifi located along the coast of Kenya
- Kilifi County is about 12,609 Km². According to Kenya National Bureau of Statistics (KNBS), it counts 1,453,787 people living in 298,472 households as per the 2019 census.
- It is characterized by a tropical climate and is vulnerable to climate-related hazards, particularly flooding, droughts, and coastal erosion

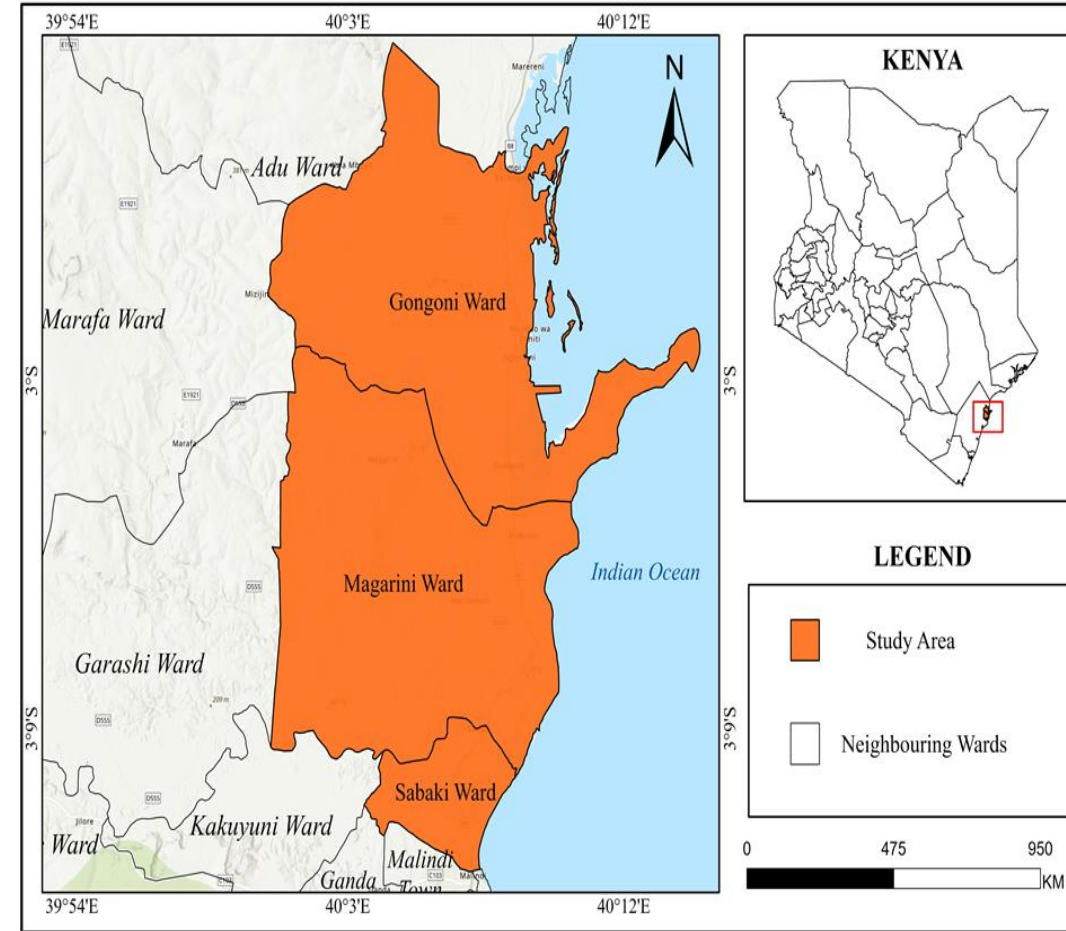


Figure1: Map of three coastal selected wards of Kilifi

Materials and Method cont.

Data types and sources

Study used climatic and hydrological secondary data from different institutions in Kenya and online database for 1990 to 2023.

- Precipitation and temperature data obtained from KMD
- River discharge data from the Global Runoff Data Centre, 30 minutes intervals
- Sea level rise data obtained from Permanent Service for Mean Sea Level .
- Flood frequency data was obtained from DRM

Materials and Method cont.

- **Data analysis**
- Time series models: ARIMA with nonseasonal Decomposition to analyze trends in flood occurrence, temperature, precipitation, sea level rise, and river discharge Trend and their Correlation.
- Software used SPSS

Results

Descriptive statistic

- The mean annual flood events were 197.94.
- Rainfall averaged 862.26 mm
- River discharge had a mean of 214.6 m³/s
- The temperature averaged 8.46 °C

Results cont.

Table 1: Correlation matrix for flood occurrence events, and climate related variables in Kilifi 1990-2023

	Flood occurrence	Annually Sea Level change	annually river discharge	Mean annually Precipitation	Mean annually temperature
Flood occurrence	1				
Annually Sea Level change	0.58	1			
Mean annually river discharge	0.732	0.347	1		
Mean annually Precipitation	0.914	0.43	0.617	1	
Mean annually temperature	0.635	0.659	0.348	0.470	1

Results

Table 2: Linear regression analysis of flood events and river discharge levels in Kilifi from 1990-2023

Variable	Coefficient (b)	Std. Error	t-Statistic	Prob. (p-value)
River Discharge	0.028	0.008	3.226	0.003
Sea Level Change	0.335	0.130	2.578	0.016
Precipitation	0.040	0.013	3.424	0.003
Constant (C)	-12.670	5.041	-2.513	0.019

Results cont.

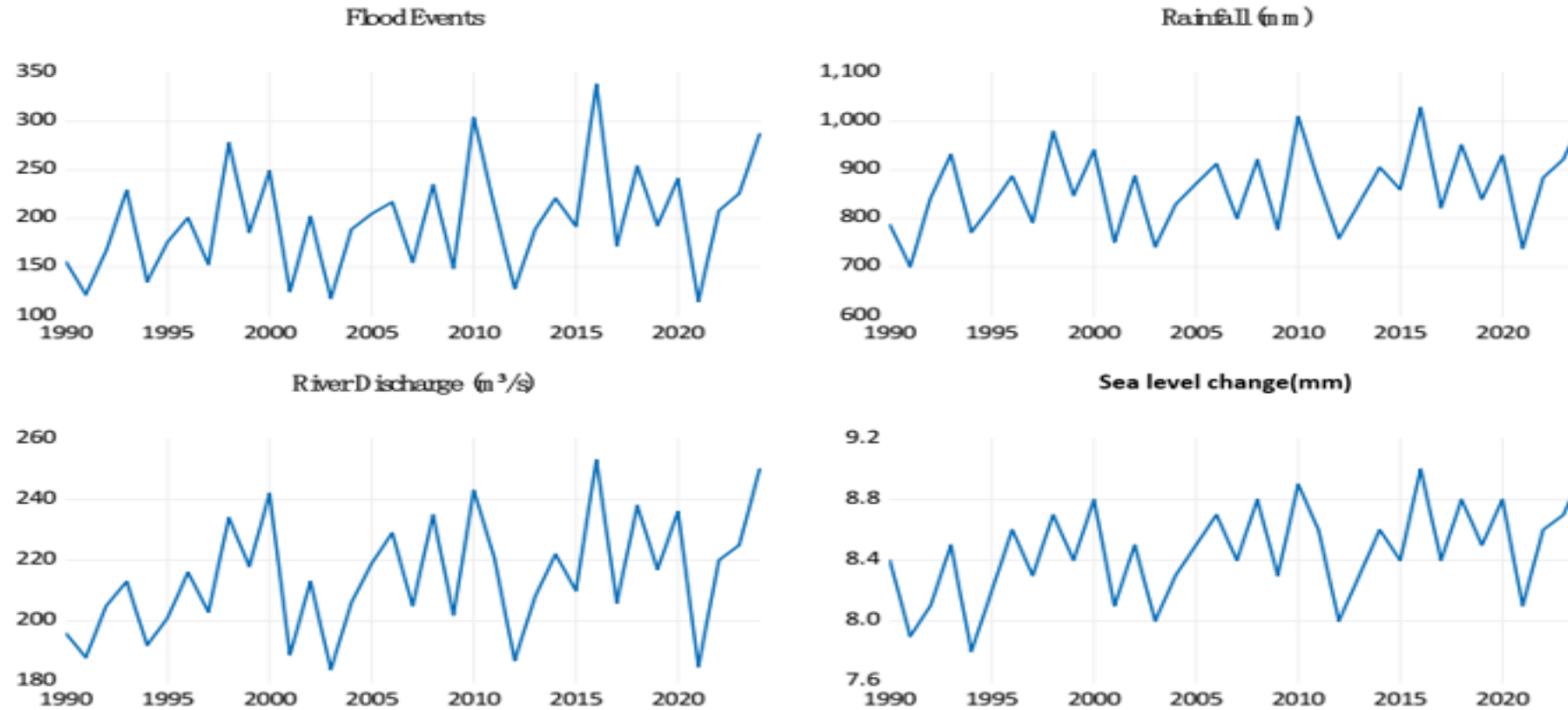


Figure 1. Time series plot of flood events, flood events, rainfall, river discharge, and sea level change in Kilifi for 1990-2023

Results cont.

The findings show that, flood frequency in Kilifi has been associated with climate and hydrological factors.

- Temperature
- Precipitation
- Sea level rise
- River discharge

Results cont.

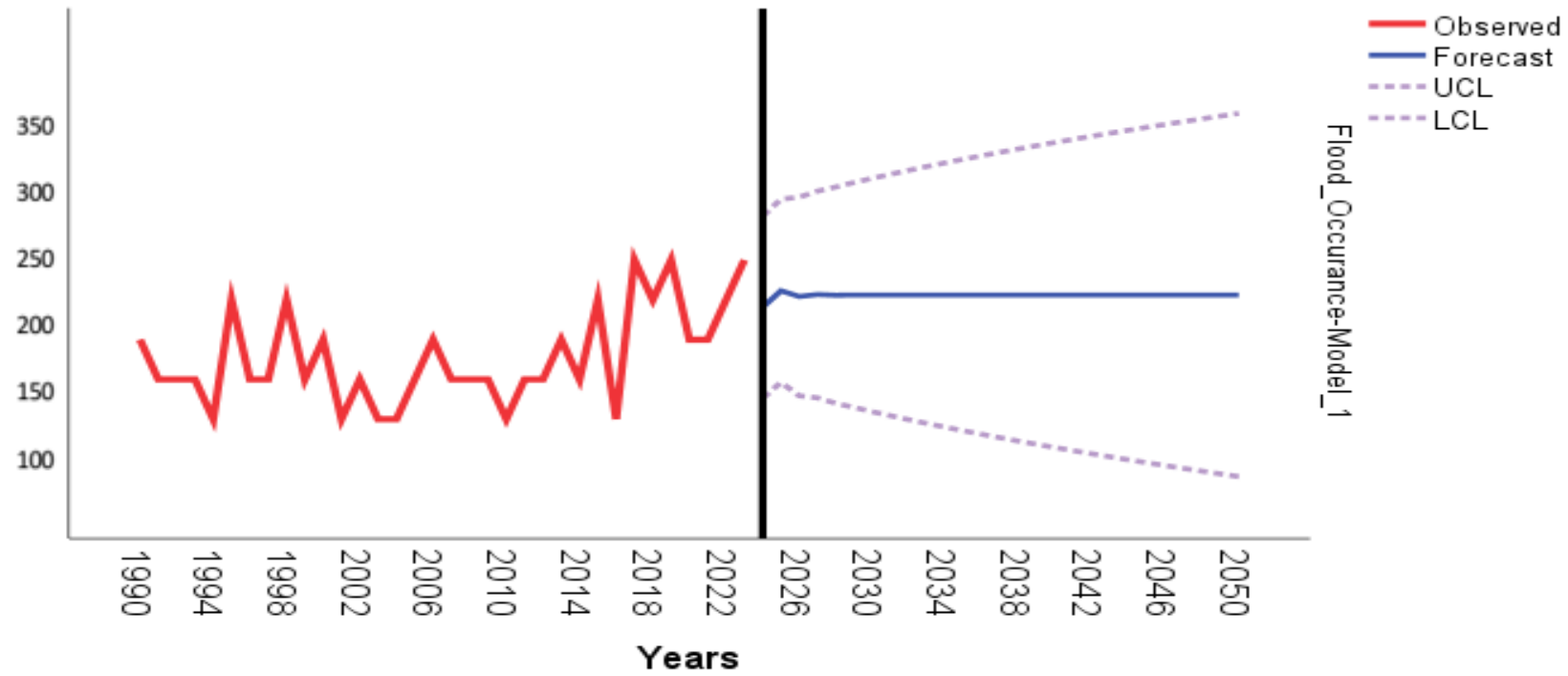


Figure 2: Forecast from ARIMA (1,1,1) of flood events

Results cont.

The Uncertainty of Future Projections

Trends of flood projection highlighted the uncertainties which are attributable to the complex interactions between climate change and flood drivers.

Although a positive association between temperature, precipitation, sea level change, river discharge and flood occurrence have been established, the precise prediction of future trends remains challenging.

It necessary to consider uncertainties in flood risk management and adaptation strategies

References.

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RWANDA CLIMATE SCIENCE SYMPOSIUM 2025

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B) OBSERVATION AND MODELLING OF CLIMATE CHANGE

13 May 2025, 14:00 – 16:00 P.M., Breakout room

Modeling of Water Loss and Demand Risk in Rwanda Eastern Irrigation Schemes

Jean Damascene HAKIZIMANA

PhD candidates at

University of Rwanda – College of Science and Technology

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PRESENTATION OUTLINE

01 **Background and Problem statement**

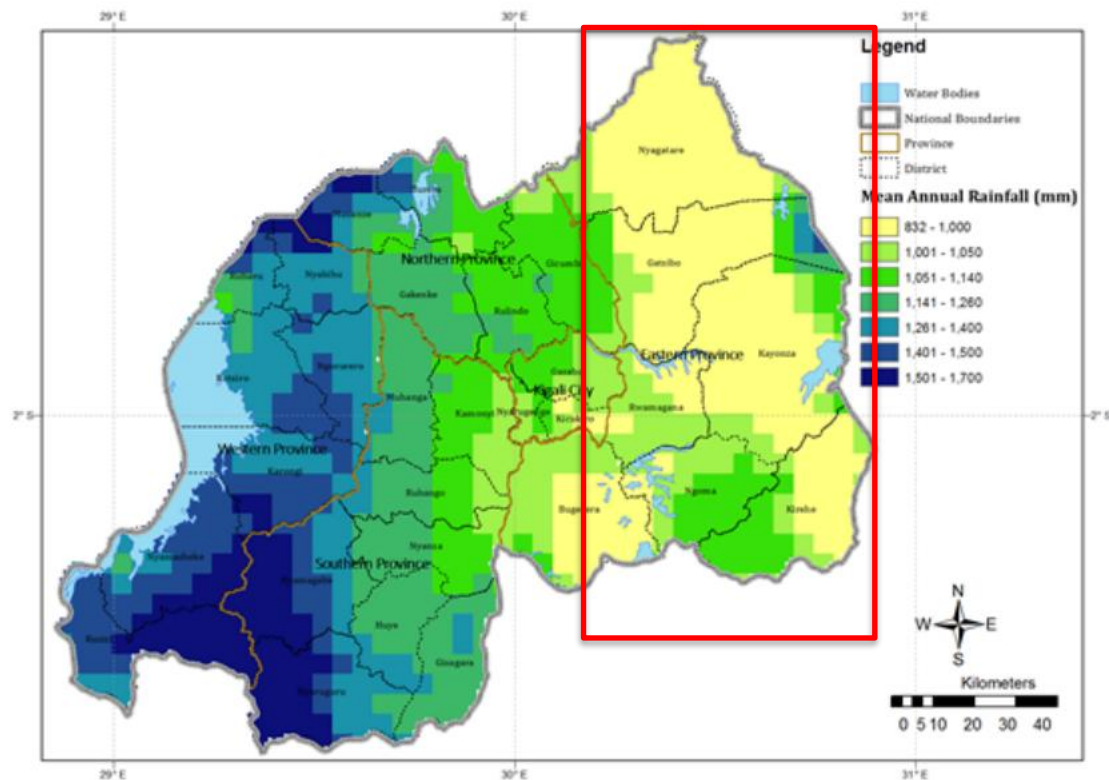
02 **Research Objectives**

03 **Research Methodology**

04 **Expected findings**

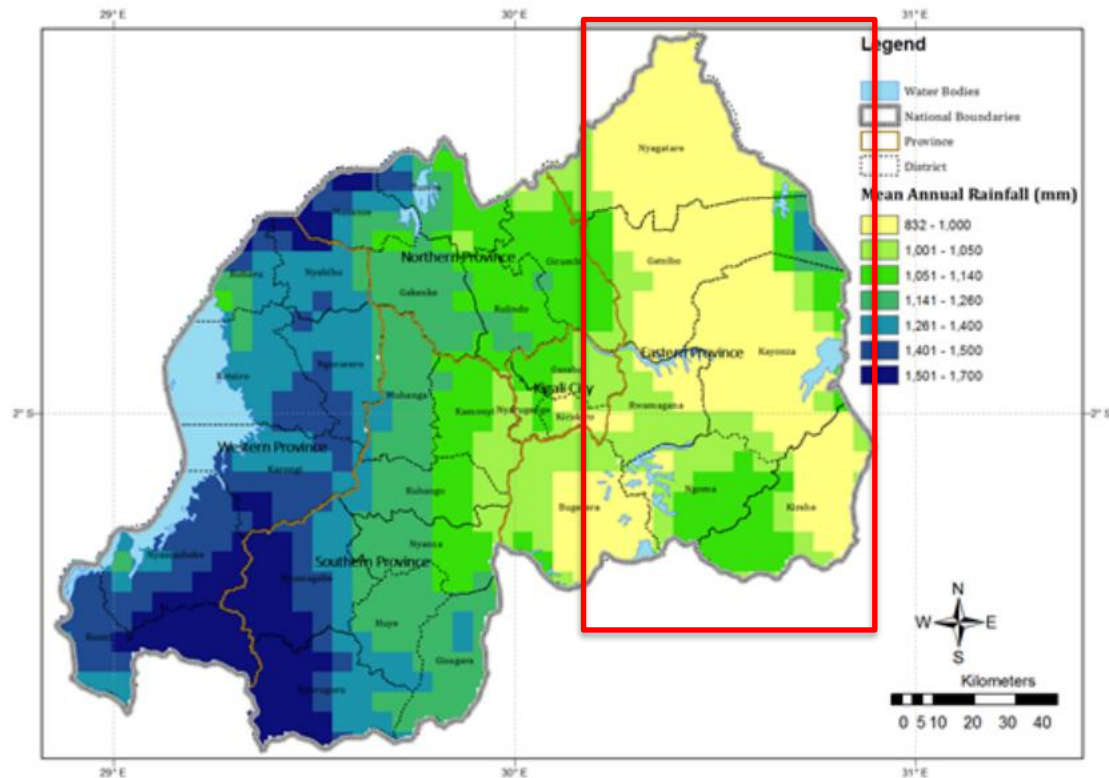
04 **Conclusion and Recommendation**

Background and Problem Statement



- Eastern province less watered (semi-arid)
- Repeated rain shortage events – drought
- Crops need to be supplemented in water or fully irrigated

Background and Problem statement...



- Irrigation as a must for Agriculture transformation
- making efficient water management crucial for productivity.

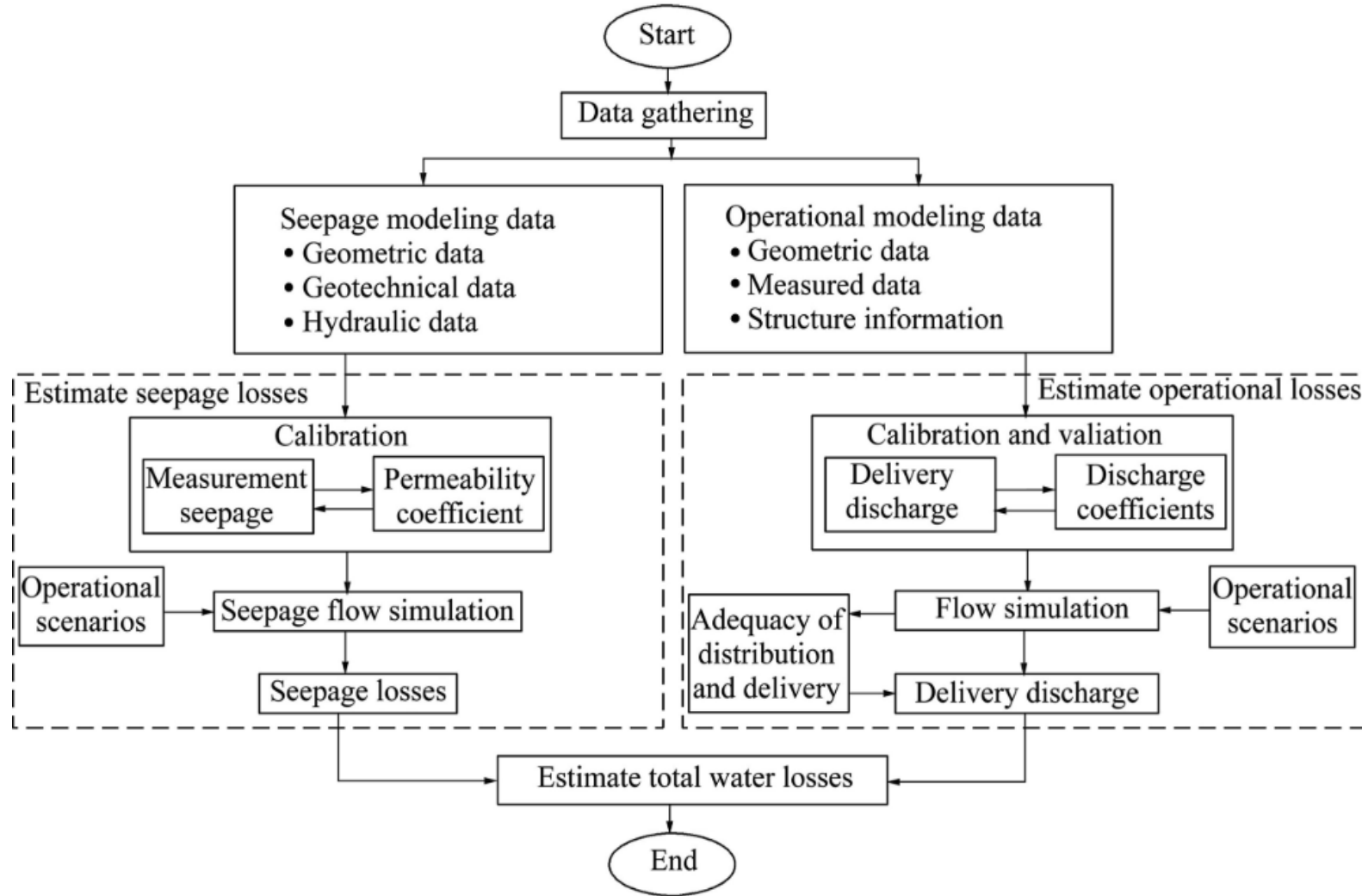
Research objectives



Analyzing Water Loss and Demand Effects on Agricultural Productivity in Eastern Rwanda's Irrigation Schemes

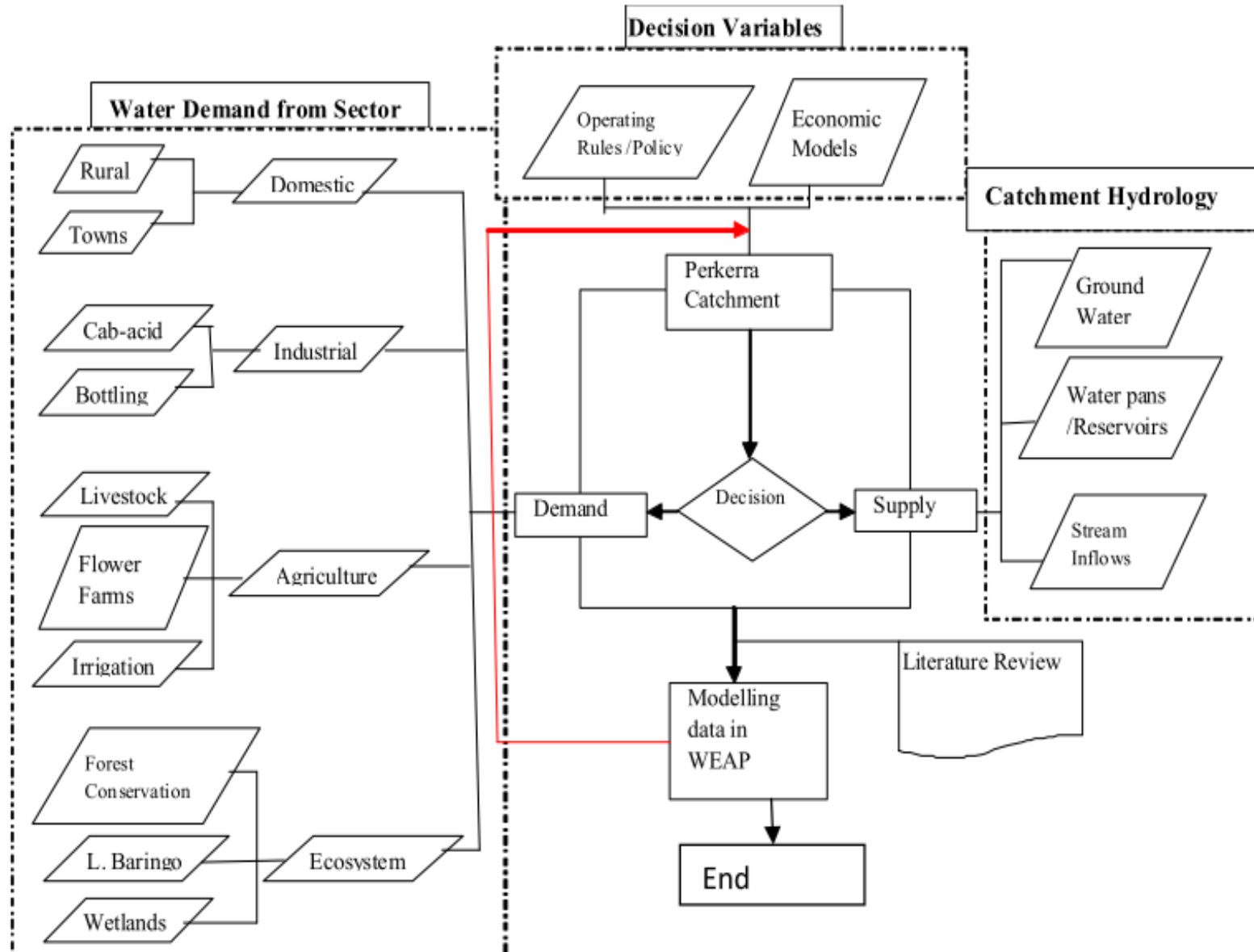


Research Methodology



- Water Losses Estimation using (HEC-RAS) [hydrodynamic model](#).
- utilizing Geographical Information System (GIS)
- Remote sensing data.
- Source : (Barkhordari & Hashemy Shahdany, 2022).

Research Methodology...



- **Modeling data in WEAP Model**
- **Water demand is modeled based on crop type, growth stages, and seasonal patterns**
- **Resource allocation.**
- **Data source: (MUGATSI, 2020)**

Expected results



- Climatic smart agriculture
- Integration policy
- Increase productivity
- Increase net return
- Improve input use efficiency
- reduce greenhouse gas emissions
- Increase resilience
- Increase gender social inclusions
- Smart Water Resource Management
- Significant water losses
- Enhanced irrigation management practices - higher yields

Conclusion and Recommendation



Conclusion

- Promoting food security and economic stability
- Improve the efficiency of water resources utilization
- Reduce agricultural water use

Recommendation

- providing recommendations for local farmers and policymakers to enhance agricultural resilience and productivity

Reference

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RWANDA CLIMATE SCIENCE SYMPOSIUM 2025

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C3) Impacts of Climate Change and Risk Assessment

14 May 2025, 10:00 – 12:00 P.M.

The consequences of Climate Change on mental health in Rwanda: A Narrative Review from Vulnerable communities.

Joie Sophia UMUHOZA^{1, 2*}, Yves Patrick NIYONIZERA¹, Romeo BANANEZA¹

¹University of Rwanda, College of Medicine and Health Sciences

²ECO-MAMA, Kigali City, Rwanda



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Introduction- Worldwide

- Climate change lead to long-term shifts in temperatures and weather patterns (According to UN).
- Climate Change on Health is increasingly having stronger and longer-lasting impacts on people, which can directly and indirectly affect their mental health and psychosocial well-being.
- WHO declare the shortage of Mental Health workers which leading to increase of case of Mental disorder, where 1 in 8 counted for Mental Disorder (WHO report, 2022)
- These different risks come together and lead to devastating events, which cause either **emotional trauma** or **psychological changes**.

Introduction- Africa

- Africa is among the top continents with highly alarming stories of Climate change due to its geographical location and its economic situation.
- In **Sub-Saharan Africa**, climate change contributes to **34%** of the **disability-adjusted life years (DALYs)** from mental health disorders. Mental health DALYs: **10,000,000**, Climate-related DALYs: **34% → 3,400,000**
 - PTSD increase during disasters: **14–34%**
 - Sample estimate: 10 million population

Research Rationale

- Mental health effects of climate change are under-researched
- Rwanda's unique challenges require local exploration
- Focus on vulnerable communities

Research Objectives

Primary objective:

To assess the consequences of climate change on Rwandan mental health, especially for the vulnerable Community.

General objectives:

- To explore the mental health challenges faced by the population in the Rural community, especially those dependent on agriculture.
- To identify the coping strategies used by those in climate-affected areas, particularly those with mental health disorders and a history of genocide.

Methodology

- **Literature Review**

Sources: **PubMed, Scopus, Google Scholar.**

- **Keywords Used**

'Climate Change', 'Mental Health', 'Rwanda Community', 'Global Warming', 'Rural Area', 'Food Security, 'Africa Metheology'.

- **Narrative Approach**

We exploring qualitative impacts on mental health, from different studies such as **Systematic Review, Meta Analysis Review, Case Studies,** and **Grey Literature.**

Methodology- Cont

Key Vulnerable Groups:

- Women and Children
- Youth
- Genocide survivors
- Farmers
- Residents in climate-prone areas

Key Findings

- ***Climate Anxiety: A Growing Mental Health Crisis Among Youth***

Sample Size: 10,000 youth (16–25 yrs, 10 countries)

84% worried → **8,400 youth**

45% daily life affected → **4,500 youth**

PTSD risk ↑ by **14–34%** (after extreme weather)

Suicide risk ↑ by **0.7–2.1%** (during heatwaves)

- **Rwanda Mental Health Gaps**

Affected population: **22%** → **3,190,000** people

Displaced with distress: **40%** → **80,000/year**

Mental health workers: **1.2 per 100,000**

Global average of mental health workers : **9 per 100,000**

Key Findings- Cont'd

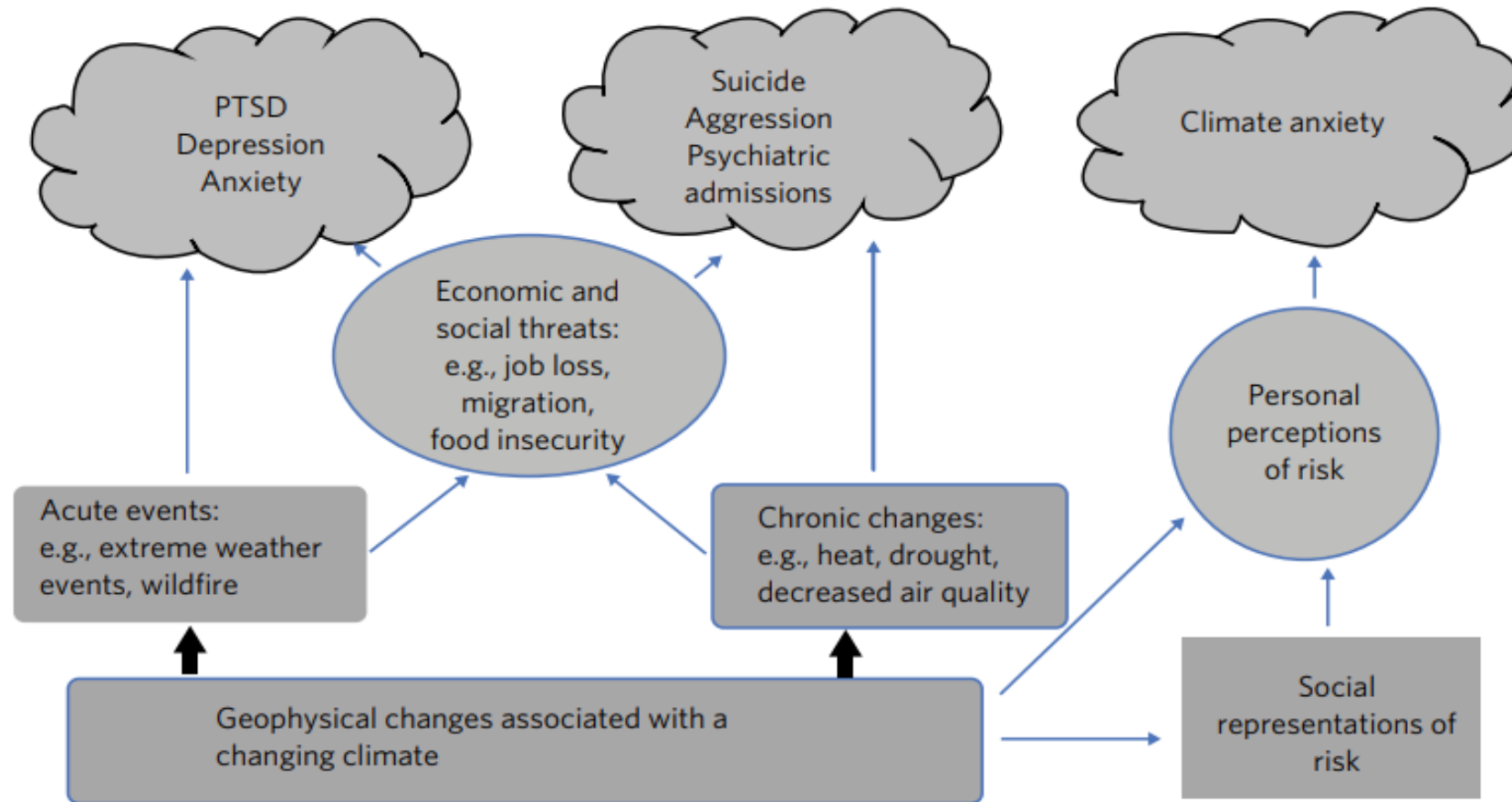


Fig.1 Image taken from Cambridge Un Press, Impact of Climate Change on the Mental Health. (Lukoye, 2022)

Recommendation

Include mental health in climate adaptation plans

- Prioritize support for vulnerable communities
- Expand mental health services and awareness
- Develop digital health interventions addressing the dual challenges
- Including the vulnerable groups at the front line care.
- Expand decentralized and tele-mental health services.
- Engage local leaders and reduce stigma.
- Launch public education campaigns.

Conclusion

Climate change has serious mental health consequence, Vulnerable groups are most at risk, and urgent policy and healthcare integration needed. Addressing this dual challenges requires integrated approaches that promote resilience, mental health supports, and integrate community based models

Q&A / Acknowledgments

Thank you for your attention

Questions?

Note: Our Narrative Review is still **ongoing**

References

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- [8] Marthoenis, “The January 2025 Southern California Wildfires: Public Mental Health Impacts and a Call to Action,” *Asian Journal of Public Health and Nursing*, vol. 1, no. 3, Jan. 2025, doi: 10.62377/fdtqx765.

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RWANDA CLIMATE SCIENCE SYMPOSIUM 2025

Advancing Research And Networking

C4.) Impact of Climate change and Risk Assessment

13 May 2025, 10:00-12:00P.M.

PLANNED RESEARCH

Impact of Climate Change on Female Participation and Employment Opportunities in the Agriculture Sector in Rwanda.

PLACIDIE MUKARUGWIRO, Lecturer of Mathematics at Rwanda Polytechnic Kigali College (RP-KIGALI-COLLEGE)
Email: mukarugwirop@gmail.com



giz



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INTRODUCTION

Agriculture contributes 30% of Rwandan GDP and employing 70% of the population, with women comprising 70-80 of the workforce (MINAGRI, 2024)

Climate change is increasingly threatening agricultural productivity especially in rural communities, rely heavily on rain-fed farming, (Christopher, 2024)



PROBLEM STATEMENT

Despite Rwanda's progressive policies, climate adaptation strategies often overlook gendered vulnerability.

Limited numbers of studies have assessed how climate variability affects female participation and employment opportunities in Rwanda's agricultural sector, creating a critical evidence gap.

OBJECTIVES

- 1 Assess climate variability impacts on female agricultural employment in Rwanda.
- 2 Identify gender-specific barriers to climate adaptation and resilience in the agriculture sector.
- 3 Propose gender-responsive strategies to enhance women's employment opportunities under climate change.

METHODS

Data

Climate data and agricultural employment statistics from NSIR

Semi-structured interviews (n=60) Focus group discussions (n=8) with female farmers in 4 agro-ecological zones of Rwanda

Review of policy documents

Sampling

Purposive sampling of women aged 18–65 from diverse socio-economic backgrounds

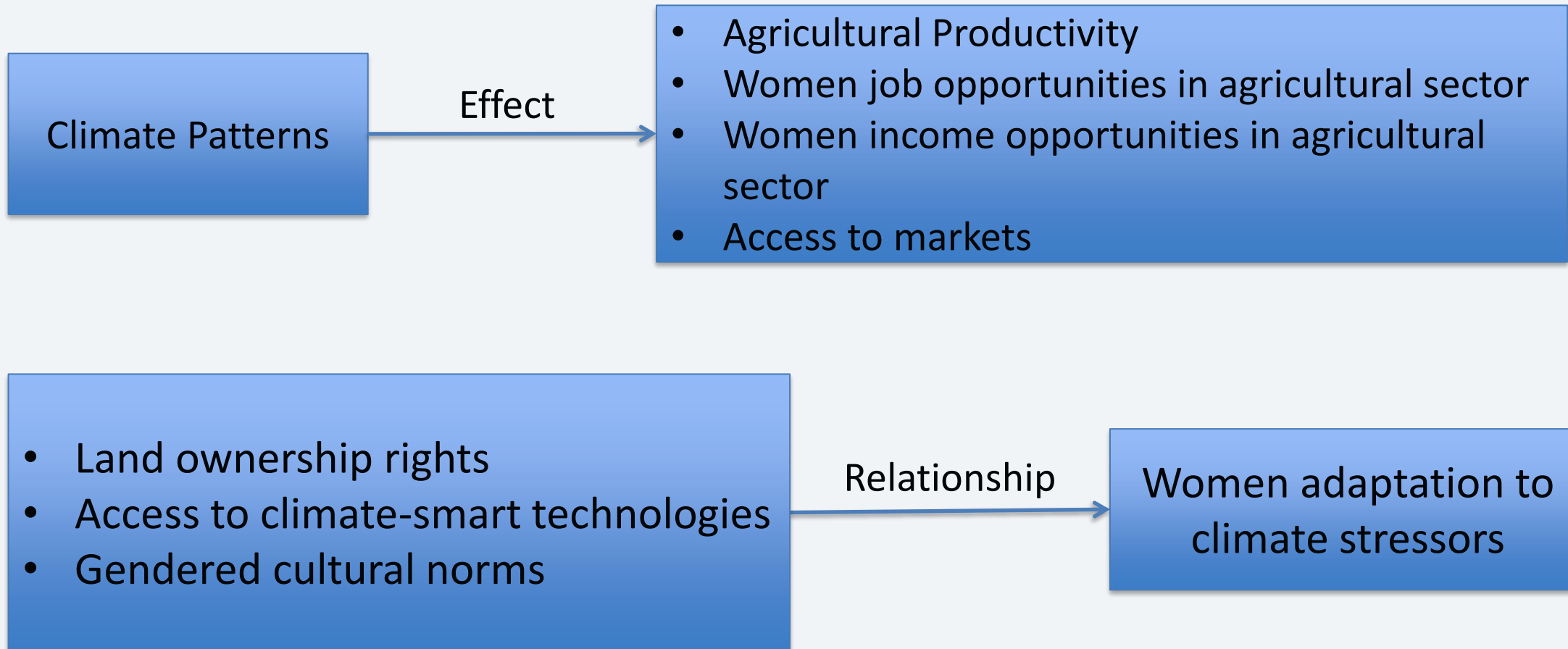
Secondary data from research centers databases

Analysis

Climate trends analysis using Python for time-series regression

R Studio for survey data analysis(Chi-square, t-test, Binary Regression)

Expected Results



CONCLUSIONS

- Understanding the **impact of climate change** on the **agriculture sector** in Rwanda, **particularly on women**, is essential for the development of common policies and a deep understanding of the matter.
- The results of this study will **support the inclusion of women's interests** in national climate change programs and agricultural development strategies in Rwanda, to achieve sustainable development goals in the agriculture sector.

*Thank
you!*

Some References

MINAGRI. (2024). RWANDA'S AGRICULTURE SECTOR TRANSFORMATION JOURNEY OVER THE LAST 29 YEARS.

Christopher. (2024). Climate change and variability in sub-Saharan Africa: A systematic review of trends and impacts on agriculture.

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RWANDA CLIMATE SCIENCE SYMPOSIUM 2025

Advancing Research And Networking

D4) CLIMATE ACTION: ADAPTATION TO AND MITIGATING OF CLIMATE CHANGE

14 May 2025, 10:00 – 12:00 P.M., Plenary

Project 'IKIRERE': Innovation and Knowledge Integration for Resilience in East Africa through climate Research and Education

Dr Cristina Ruiz Villena

National Centre for Earth Observation, University of Leicester

Co-authors: Rob Parker, Rose Meadows, Ankita Pant, Mouhamadou Bamba Sylla,
Emmanuel Sulungu, Vicky Kondi Akara, Molly Mutesi.



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CONTEXT OF THE PROJECT

Funded by the UK Science and Technology Facilities Council (STFC) under the **Africa-UK Physics Partnership (AUPP) Programme**, in collaboration with the Institute of Physics (IOP).

- The call is in response to analysis by IOP in 2019 that found that **only around 5% of research programmes** across **sub-Saharan Africa** involved **physics**.
- Three themes: energy, **climate** and capacity building. Some of the **aims** :
 - “**Build and sustain** a skilled and talented **cohort of early-career African physicists**”.
 - “Support **collaboration** and **capacity building** across the discipline of **physics** in eligible African countries”.
 - “Promote **gender inclusivity**, increasing the representation of women in physics”.
 - “Enhance existing and develop new sustainable, **equitable partnerships** between the **UK** and eligible **SSA** research partners”.

OVERVIEW OF THE PROJECT

Project Partners



- **2-year** collaborative project between NCEO – UoL (UK) and AIMS RIC (Rwanda), **£500k**. Feb-2025 – Feb-2027.
- Two main components:
 - Scientific **research** on **drought** and **heatwaves** in East Africa.
 - Using EO, model data, and ML.
 - Building blocks for future Digital Twin.
 - **Capacity building** and **gender equality**.
 - Three school visits per year.
 - Physics CAMP.
 - ECR workshop (climate, ML, etc).
 - African Women in STEM workshop.
 - Mentoring network.



Digital Earth
AFRICA



GEO GROUP ON
EARTH OBSERVATIONS

CEOS
Committee on Earth Observation Satellites



CAPACITY BUILDING

School Visits

- 3 x visits per year
- Physics-related activities
- Role models to inspire kids

Physics Camp

- Physics workshop for teenagers
- Lessons and hands-on activities
- Careers and role models

Early-Career Workshop

- Climate physics
- Machine learning
- Research skills
- Networking
- Careers

African Women in STEM Workshop

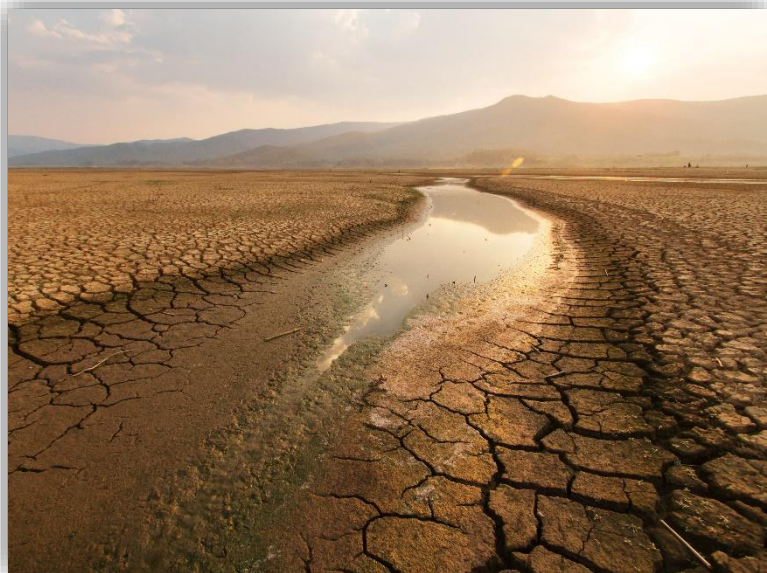
- Breaking barriers for women in STEM
- Soft skills training
- Networking, role models

Mentoring Network



SCIENTIFIC RESEARCH

- **MOTIVATION:** rain-fed **agriculture** is key for **food security** and **livelihoods** in many African countries, but droughts and heatwaves are set to intensify with climate change. We need better understanding of these extreme events to inform **adaptation** strategies.
- **AIM:** improve our understanding of the **physical drivers** of agricultural **drought** and **heatwaves** in East Africa, and their **future projections** under climate change.
 - **METHODS:** state-of-the-art **Earth Observation**, **reanalysis** and **model** datasets.



LAND SURFACE MODEL EMULATORS



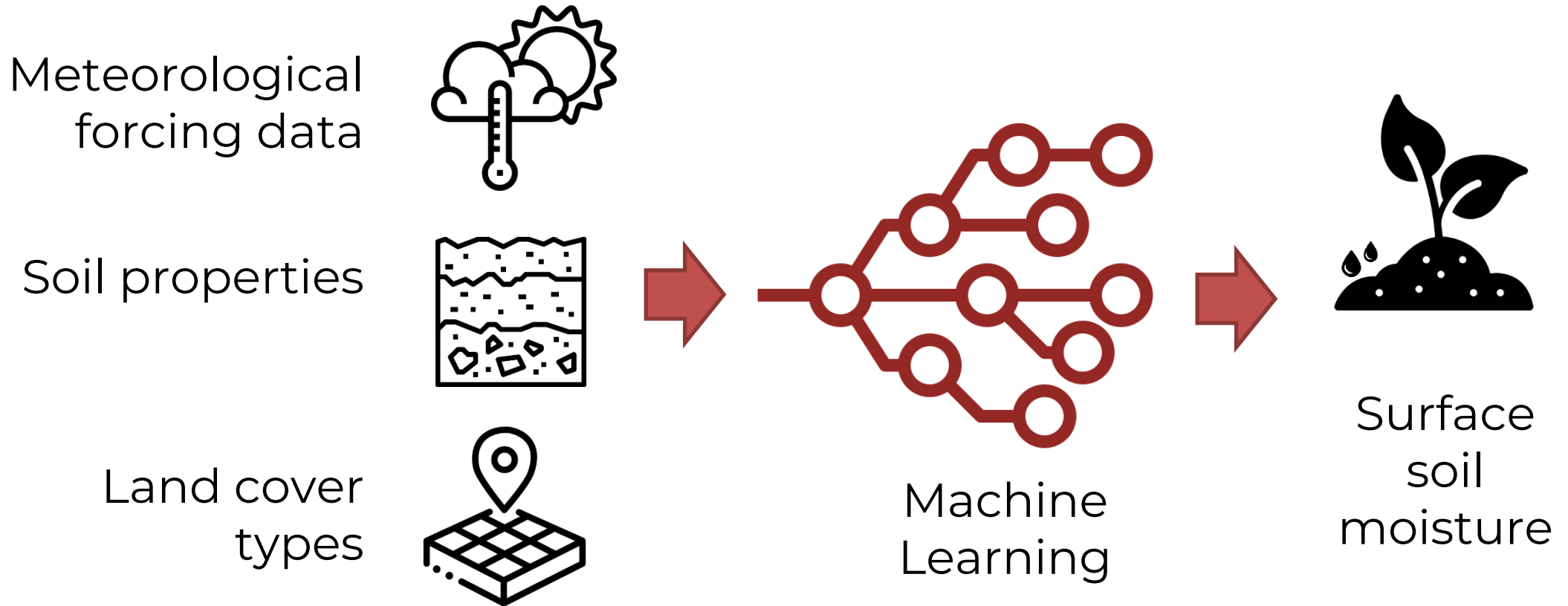
- **Community land surface model**, and terrestrial component of the UK Earth System Model.
- Widely used for many applications, including **assessments of climate impacts** on terrestrial systems.
- Very **complex** and **computationally expensive**, and operating it requires **expert knowledge**.

We have developed **machine-learning (ML) emulators** of parts of JULES.

Advantages of emulators

- ✓ We can run many simulations **very fast**
- ✓ **No need** for **expert** knowledge
- ✓ **No need** for expensive **supercomputers**
- ✓ We can derive useful **metrics** for users
- ✓ They can be deployed on **web platforms**
- ✓ They can **integrate** many types of data
- ✓ **Explainable AI**

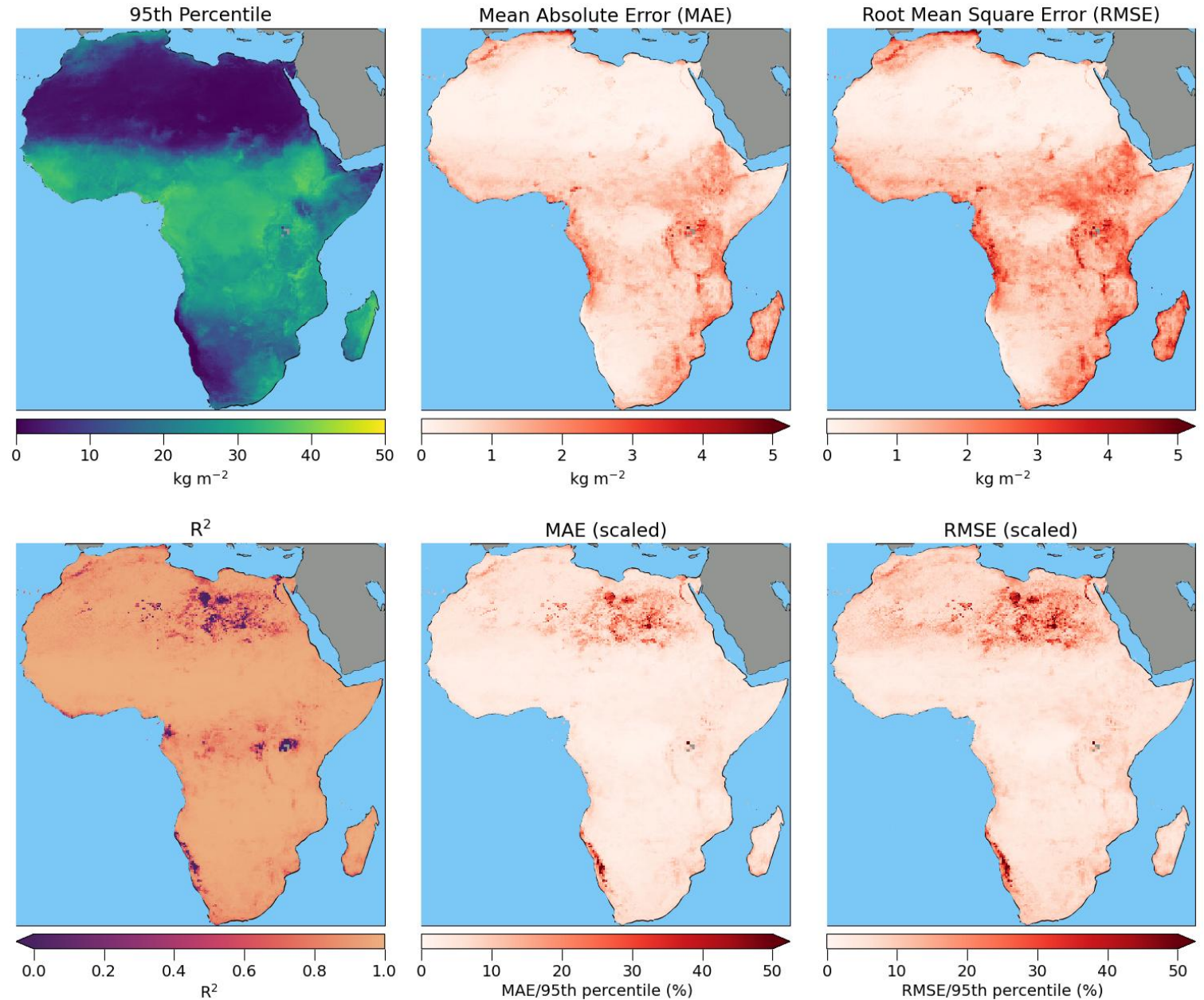
CASE STUDY: AFRICA SOIL MOISTURE EMULATOR



SOIL MOISTURE EMULATOR RESULTS (MAPS)

Our emulator can reproduce surface soil moisture from JULES with **excellent agreement** over Africa!

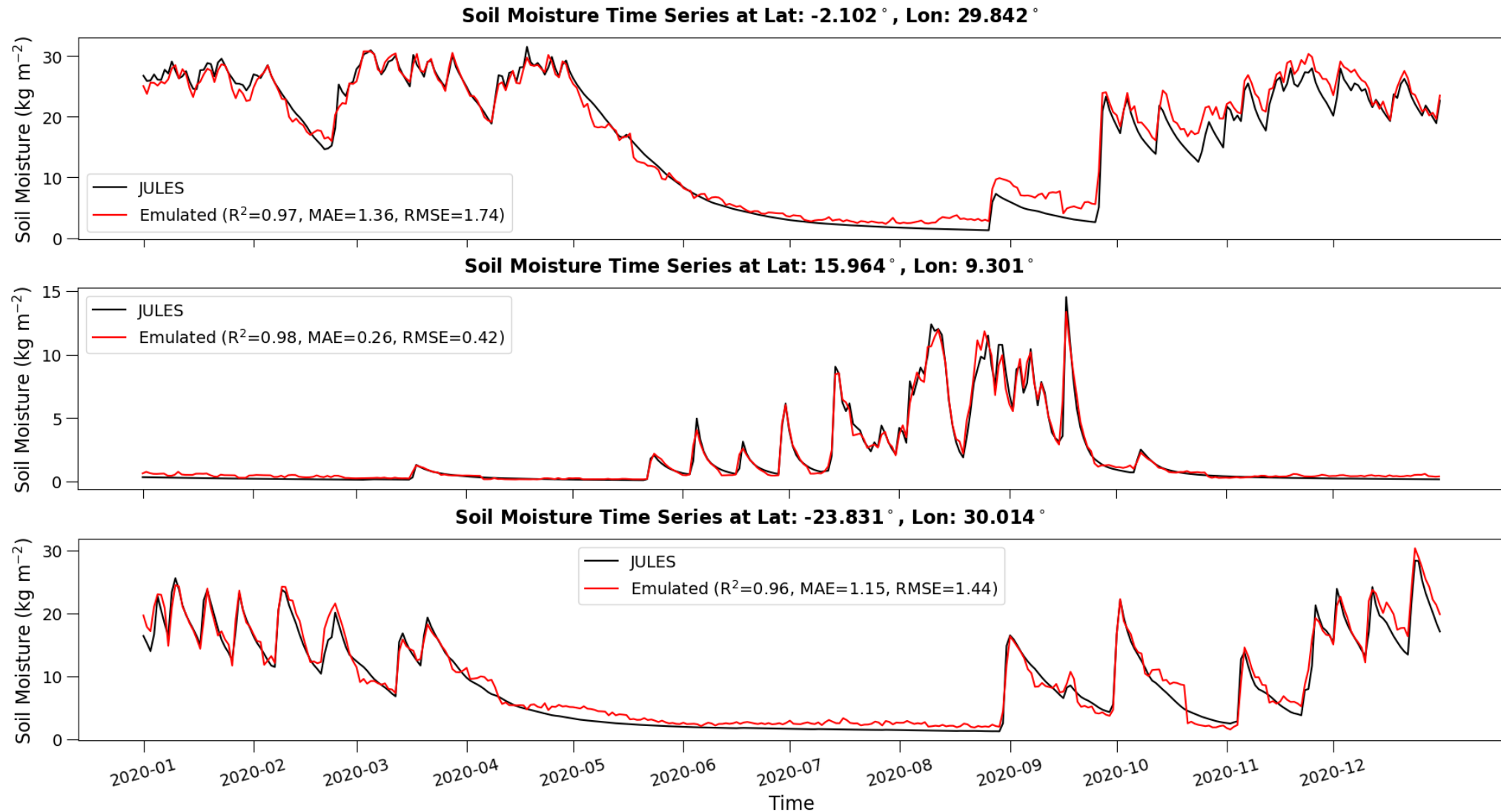
Soil moisture Statistics for Emulator Performance for Validation Period (2020)



National Centre for
Earth Observation

NATURAL ENVIRONMENT RESEARCH COUNCIL

SOIL MOISTURE EMULATOR RESULTS (TIME SERIES AT SAMPLE LOCATIONS)

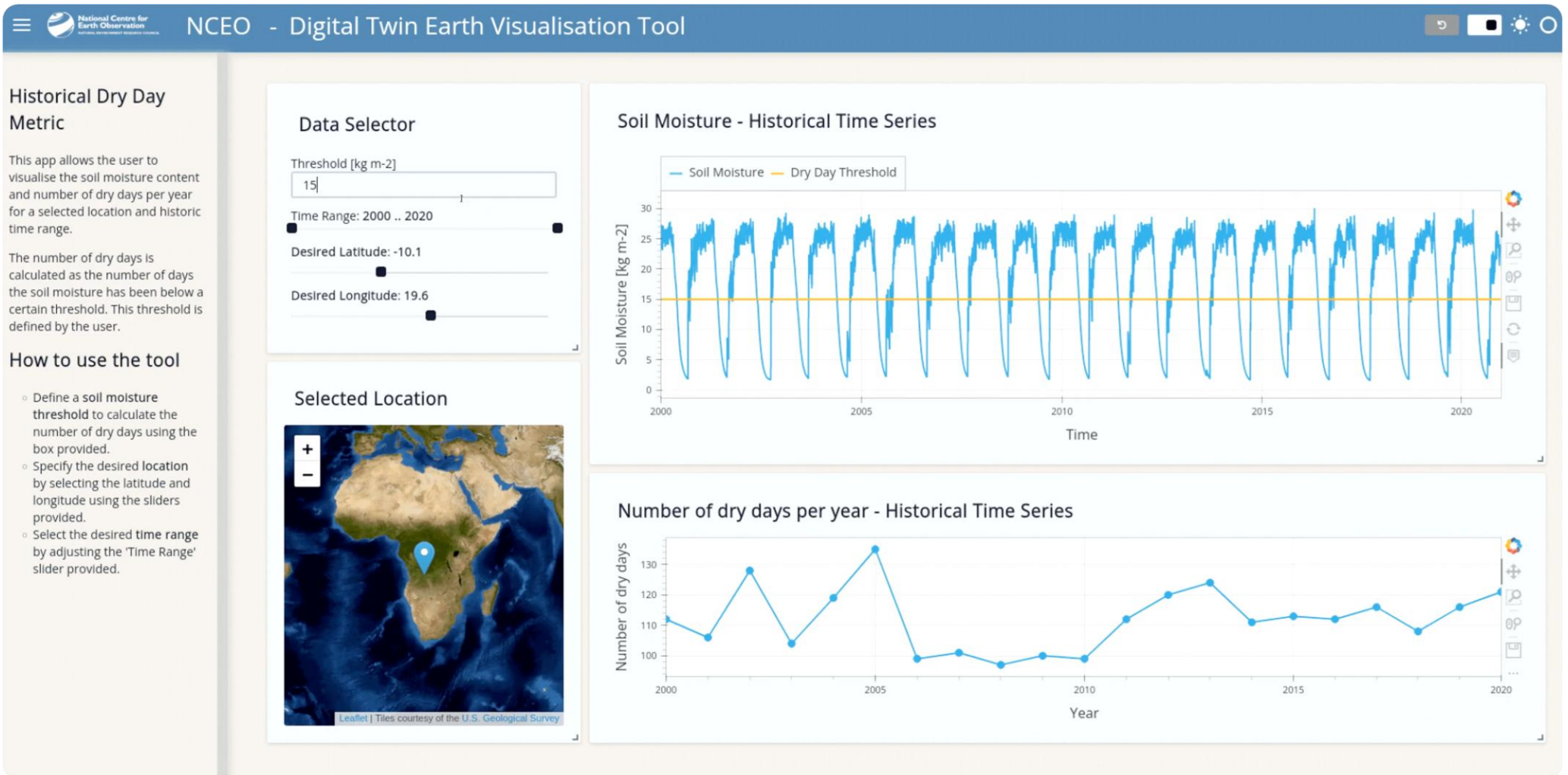


EMULATOR NEXT STEPS

- **Optimise** input features.
- Emulate **all soil layers**.
- Explore **explainable AI**.
- Combine with **EO data**.
- **Uncertainty** analysis.
- Plug into interactive **dashboard**.
- **Digital Twin**.



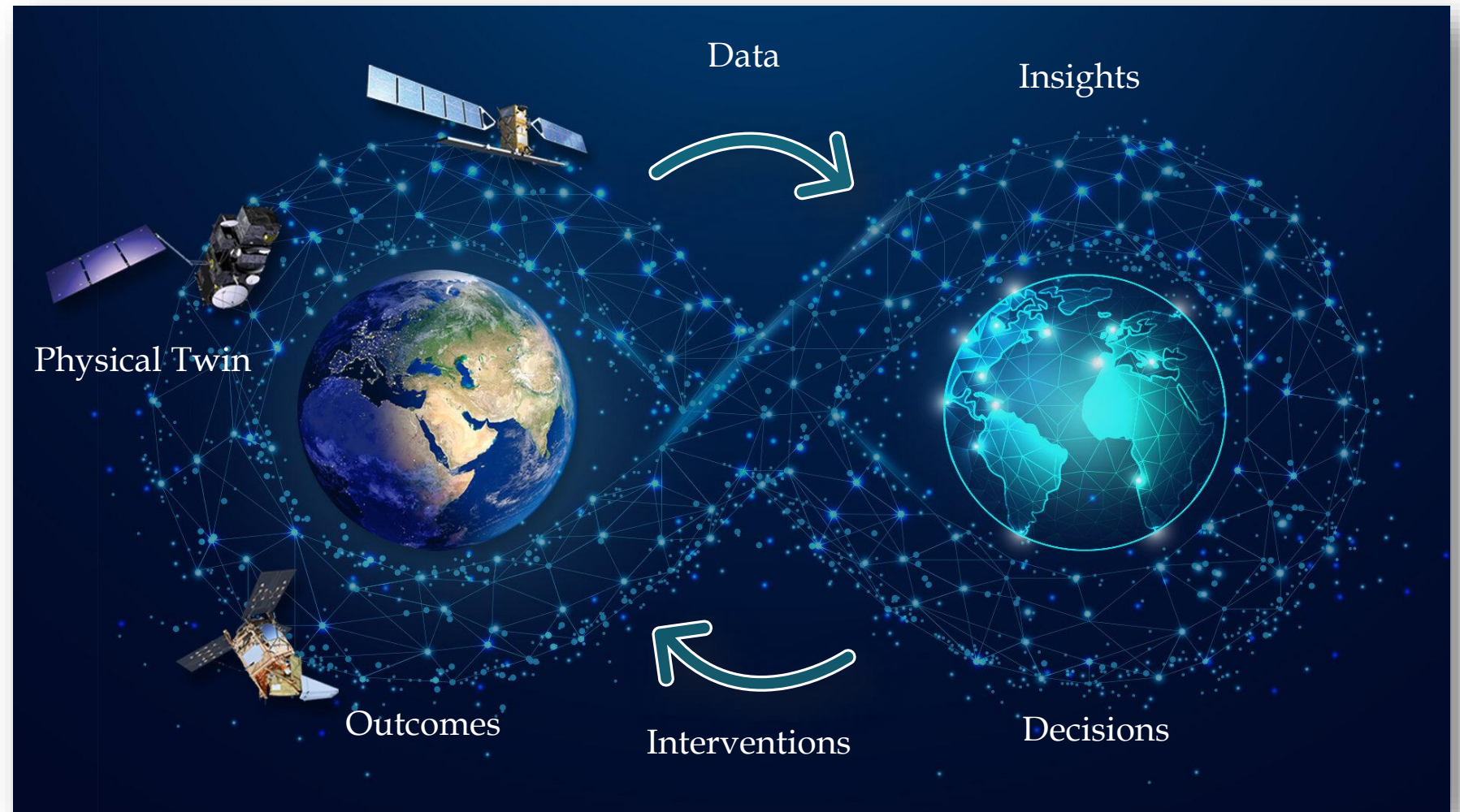
INTERACTIVE DASHBOARD EXAMPLE



ABOUT DIGITAL TWINS

Emulators can be building blocks of Digital Twins

Digital Twins can help us make environmental decisions



SUMMARY

- Ongoing Project **'IKIRERE'**: **I**nnovation and **K**nowledge **I**ntegration for **R**esilience in **E**ast Africa through climate **R**esearch and **E**ducation.
 - Research into **physical drivers of drought and heatwaves** in **East Africa** using state-of-the-art datasets.
 - **Capacity building** activities around climate physics for wide range of audiences.
- We have developed a **machine-learning emulator** of **soil moisture** from land surface model JULES over Africa with **excellent results**.
 - Potential to **democratise access** to climate data.
 - Building block for **Digital Twins**.

Thank you!

Contact:

Email:

crv2@leicester.ac.uk



www.linkedin.com/in/cristina-ruiz-villena



**National Centre for
Earth Observation**

NATURAL ENVIRONMENT RESEARCH COUNCIL

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RWANDA CLIMATE SCIENCE SYMPOSIUM 2025

Advancing Research And Networking

A2) Measurement and reduction of greenhouse gas emissions

13 May 2025, 14:00 – 16:00 PM

Refining Rwanda's Path to Climate Action: Measuring and Reducing Greenhouse Gas Emissions

Presented by:

Prof. Thompson Faraday Edigbonya

Department of Environmental Studies

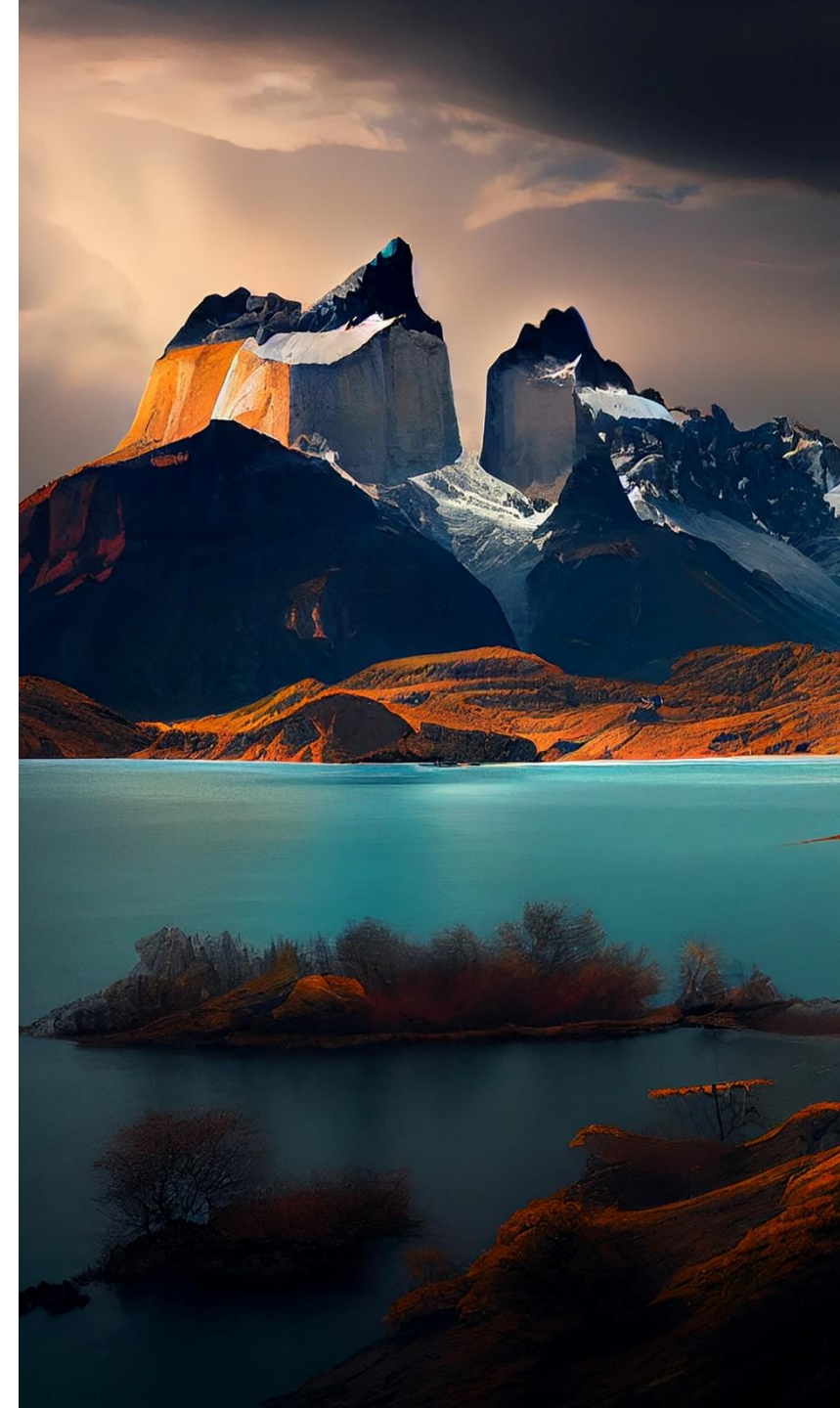
University of Lay Adventist Kigali, Rwanda

Date: May 13, 2025



Background and Motivation

- **Rwanda's Paradoxical Climate Position:** Although Rwanda contributes minimally to global GHG emissions, it is highly vulnerable to climate change impacts such as erratic rainfall, floods, and droughts that threaten livelihoods and ecosystems.
- **International Commitments:** Rwanda has ratified the Paris Agreement and submitted updated Nationally Determined Contributions (NDCs) with ambitious mitigation and adaptation targets.
- **Domestic Ambitions:** The Green Growth and Climate Resilience Strategy (GGCRS) and Vision 2050 underscore Rwanda's long-term commitment to a low-carbon development path.
- **Research Need:** Current efforts are hindered by limited capacity for real-time monitoring, sectoral inconsistencies in emissions data, and a lack of actionable integration between monitoring frameworks and national policy.



Research Objectives

- **Enhance Accuracy in GHG Accounting:** Develop innovative tools and methodologies for more precise measurement of emissions across key sectors such as agriculture, energy, and transport.
- **Strengthen Rwanda's MRV System:** Upgrade the Monitoring, Reporting, and Verification framework to align with the Enhanced Transparency Framework (ETF) under the UNFCCC, improving data integration and verification protocols.
- **Identify Practical Mitigation Pathways:** Evaluate viable mitigation strategies that not only reduce emissions but also offer socio-economic co-benefits, such as sustainable agriculture, clean energy, and forest-based solutions.
- **Support Climate-Informed Policymaking:** Provide evidence-based recommendations that enable policymakers to adopt climate-smart interventions at national and subnational levels.

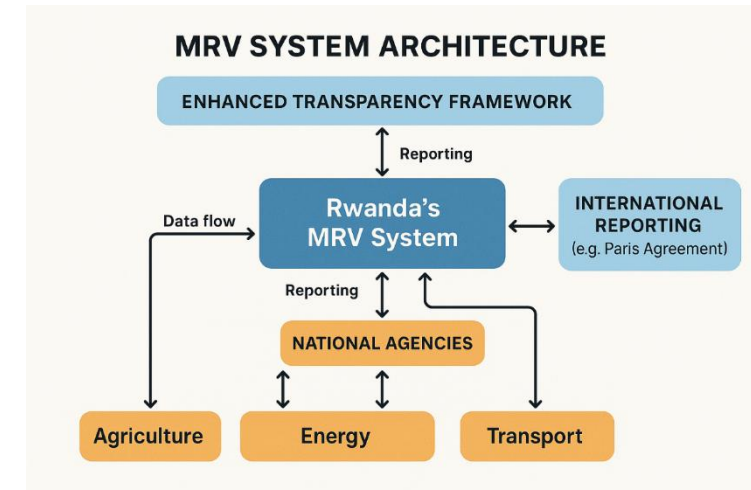
Methodology Overview



- **Mixed-Methods Approach:** Combines quantitative and qualitative techniques to address both technical and institutional dimensions of climate action.
 - **Remote Sensing and Satellite Imagery:** Used to monitor land-use changes, deforestation, and urban expansion affecting emissions.
 - **Ground-Based Sensors and Field Data:** Collected to calibrate and validate satellite data and to monitor emission hotspots.
 - **Sectoral Data Analysis:** Time-series emissions data analyzed to identify trends, anomalies, and sector-specific patterns.
 - **Stakeholder Consultations:** Interviews and focus groups with technical experts, policymakers, and community leaders ensure the research is grounded in local realities and institutional capacities.
- **Focus Sectors:** Energy, Agriculture, Transport, and Land Use sectors were prioritized due to their significant contribution to emissions and mitigation potential.

Rwanda's Climate Strategy and MRV System

- **Policy Alignment:** Rwanda's climate response is guided by multiple frameworks including Vision 2050, GGCRS, and NDCs, which together aim to transition the country toward green economic development.
- **Institutional Structure:** The Rwanda Environment Management Authority (REMA) coordinates MRV efforts, supported by sector ministries such as Agriculture, Infrastructure, and Energy.
- **MRV Gaps and Challenges:**
 - **Lack of Real-Time Data Sharing:** Ministries and agencies operate in silos with limited integration of emissions data.
 - **Inconsistent Reporting Across Sectors:** Agriculture and land use often lack standardized emission factors and reporting protocols.
 - **Limited Technical Capacity:** Human and technical resources for data analysis and verification remain scarce, especially at subnational levels.
- **Opportunity for Reform:** The study proposes an enhanced MRV system that is interoperable, transparent, and aligned with international reporting expectations.



An aerial photograph of a dense forest with a winding road. The trees are mostly green, with some showing autumnal colors. The road is a light-colored, paved path that curves through the forest. The overall scene is a natural, scenic landscape.

GHG Emission Trends and Sectoral Contributions

- **Agriculture Dominates Emissions:**

The agriculture sector accounts for approximately **52%** of Rwanda's total GHG emissions, largely from enteric fermentation, manure management, and crop residue burning.

- **Energy and Transport Are Rising:**

Energy contributes around **22%**, with emissions stemming from biomass combustion, inefficient cooking technologies, and fossil fuel usage in urban areas. Transport emissions (~15%) are growing due to urbanization and increased vehicle imports.

- **Other Sectors (11%) Include:**

Waste management (solid waste and wastewater treatment) and industrial processes contribute a smaller but non-negligible share of emissions.

- **Temporal Trends:**

Over the past decade, total emissions have steadily increased, particularly in energy and transport sectors, reflecting Rwanda's economic growth.

- **Data Limitations:**

- Incomplete activity data in rural sectors
- Use of default emission factors rather than country-specific metrics
- Fragmentation of sectoral data across institutions

Mitigation Strategies

- **Energy Sector Mitigation:**
 - Deployment of **solar mini-grids** in rural areas to replace diesel generators
 - Expansion of **clean cooking** solutions (e.g., biogas, improved cookstoves)
 - Implementation of **energy efficiency standards** for appliances and buildings
- **Agriculture Sector Mitigation:**
 - Promotion of **climate-smart agriculture**, including conservation tillage and integrated soil fertility management
 - Support for **agroforestry**, combining tree crops with food production for dual climate and food security benefits
 - Improved livestock management to reduce methane emissions
- **Transport Sector Interventions:**
 - **Electrification of public transport**, including e-buses and motorcycles
 - Incentives for **modal shifts** to cycling and public transit
 - Fuel economy standards and vehicle import regulations
- **Co-benefits:**

These mitigation strategies not only reduce emissions but also promote **energy security, public health, rural livelihoods, and gender equity.**

Strengthening Carbon Sinks

- **Natural Climate Solutions:**

Nature-based mitigation is vital for Rwanda due to its hilly terrain and dependence on biomass. Key practices include:

- **Afforestation and Reforestation:** Expansion of forest cover in degraded landscapes, especially in western and northern provinces
- **Agroforestry:** Integration of trees on farms to enhance carbon storage, soil fertility, and biodiversity
- **Forest Protection:** Strengthening community forest management and enforcement against illegal logging

- **Policy Integration:**

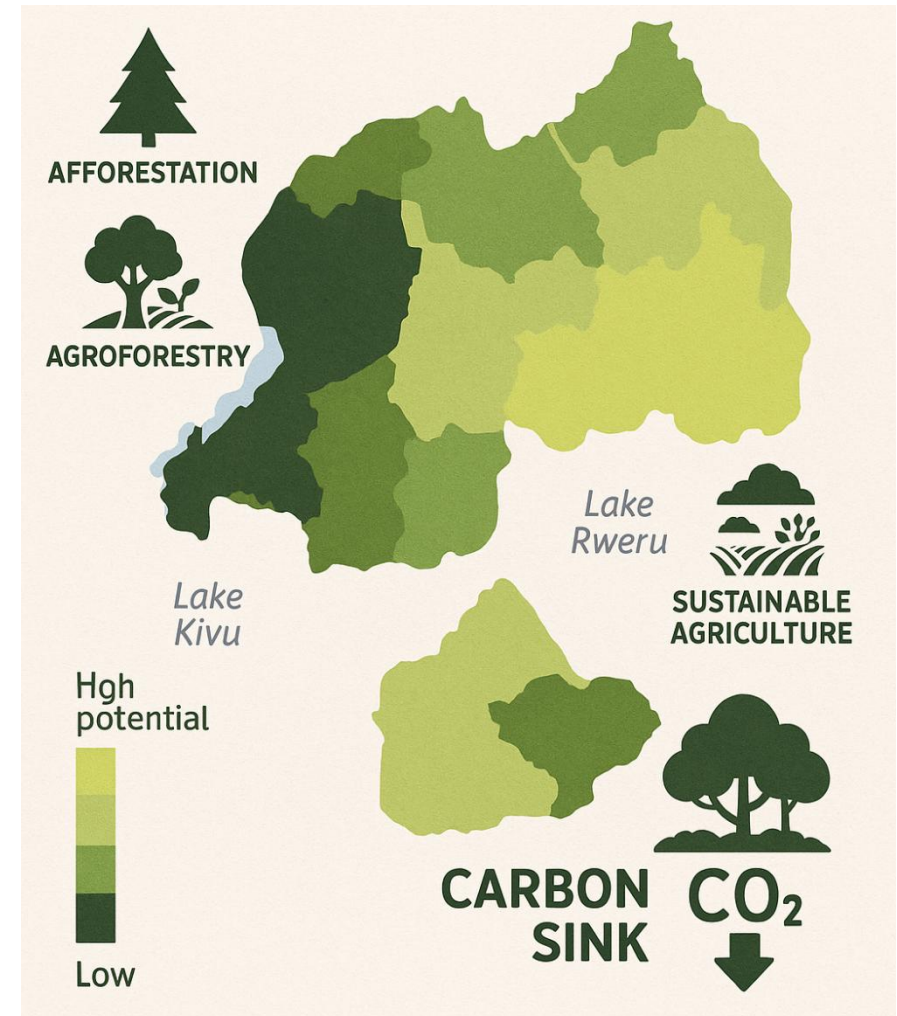
Carbon sink strategies are embedded in Rwanda's **Forest Landscape Restoration (FLR)** goals and **NDC commitments**, aiming to restore over 2 million hectares of degraded land.

- **Carbon Stock Enhancement Tools:**

- Use of **LiDAR and drone technology** for measuring forest biomass
- National forest inventory improvements for MRV reporting

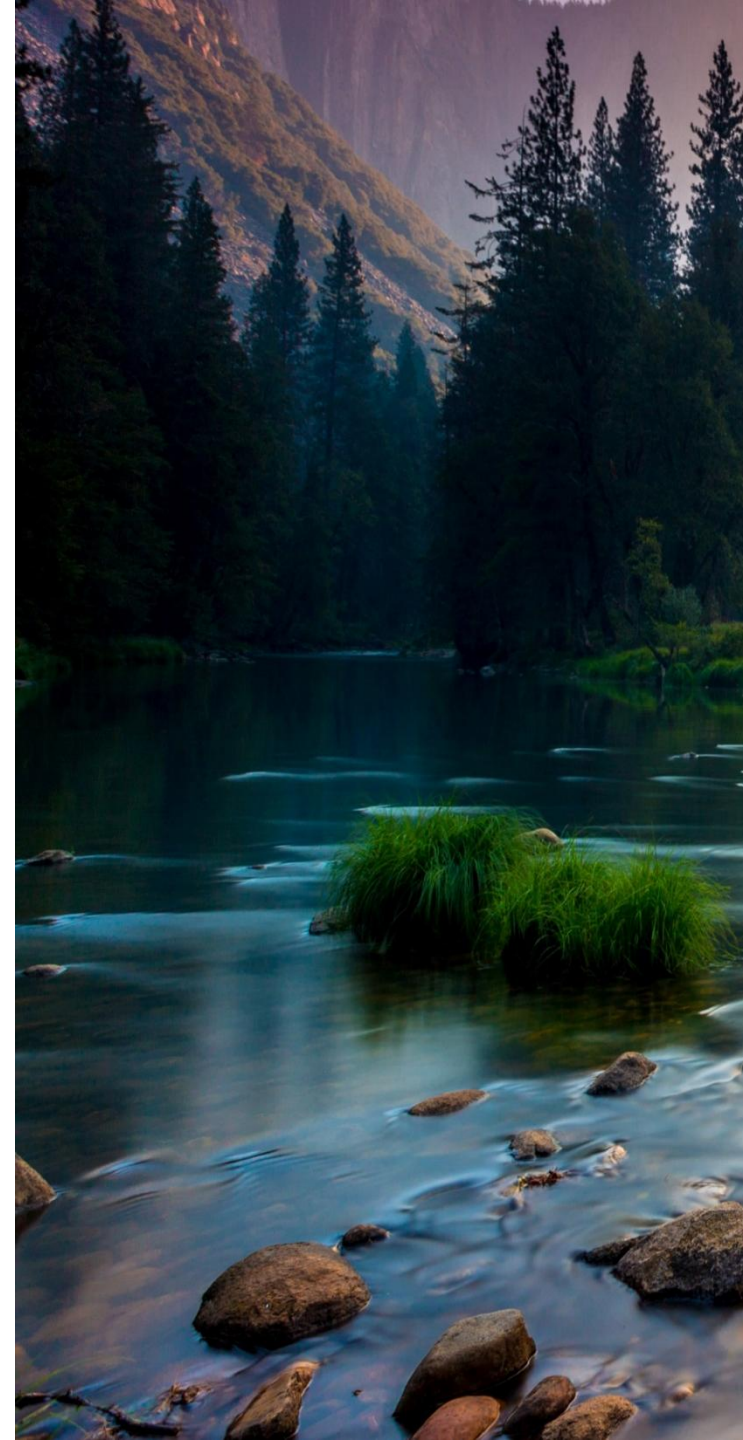
- **REDD+ Synergies:**

Rwanda is exploring engagement in REDD+ mechanisms, providing access to results-based finance for verified emissions reductions from deforestation and forest degradation.



Key Findings & Policy Implications

- **MRV System Enhancements:**
Improved digital infrastructure and harmonized data collection across ministries can boost transparency and accountability in climate reporting.
- **Sector-Specific Insights:**
 - Energy sector holds significant short-term potential via renewable energy scaling.
 - Agriculture requires long-term investments in extension services and research.
 - Transport will benefit from coordinated urban planning and infrastructure investment.
- **Cost-Effectiveness of Nature-Based Solutions:**
Land-use based mitigation (afforestation, agroforestry) offers a **low-cost, high-impact** pathway for Rwanda to meet its climate goals.
- **Institutional Needs:**
 - Build technical capacity within ministries
 - Enable decentralized MRV at the district level
 - Encourage private sector innovation in climate tech
- **Global Relevance:**
Rwanda's integrated approach offers valuable lessons for **Least Developed Countries (LDCs)** balancing development and climate resilience.



Conclusions and Recommendations

- **Conclusions:**
 - Rwanda has made notable progress in building a national MRV framework.
 - Emissions remain concentrated in agriculture, but all sectors show mitigation opportunities.
 - Stakeholder engagement is essential for sustainable implementation of climate strategies.
- **Recommendations:**
 1. **Digitize MRV Systems:** Develop real-time, interoperable MRV tools connected to national planning systems.
 2. **Scale Up Renewable Energy & Sustainable Agriculture:** Focus investment in high-impact mitigation projects with co-benefits.
 3. **Leverage International Finance:** Tap into the Green Climate Fund (GCF), Global Environment Facility (GEF), and carbon markets.
 4. **Policy Integration:** Ensure that MRV and mitigation targets are embedded into Rwanda's broader development plans.
 5. **Foster South-South Collaboration:** Share Rwanda's innovations with other African nations through regional platforms.
- **Future Research:**
 - Development of Rwanda-specific emission factors
 - Application of AI for emissions forecasting
 - Impact evaluation of mitigation policies at the household level



Thank you

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Climate Adaptation Knowledge Brokering in Rwanda

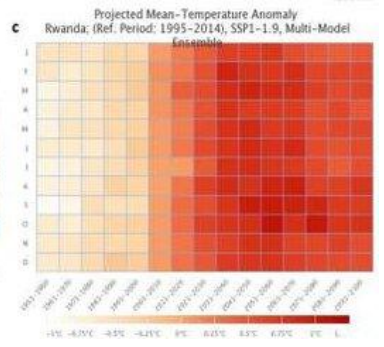
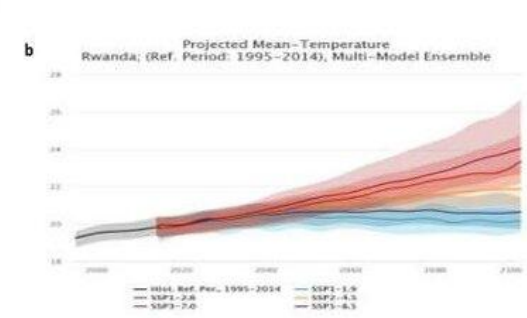
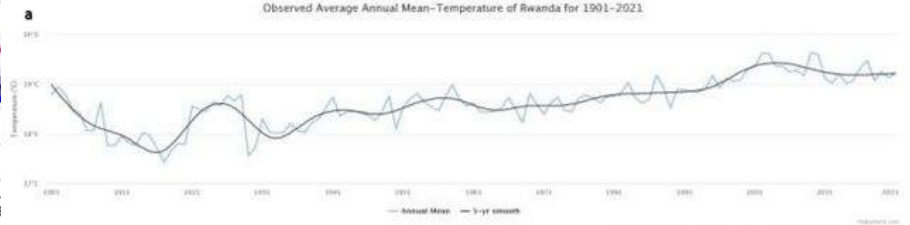
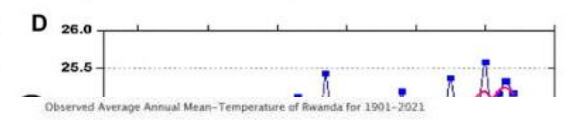
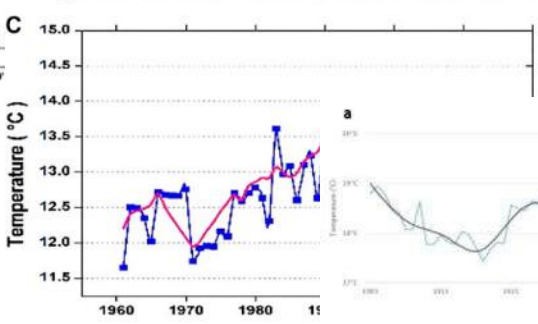
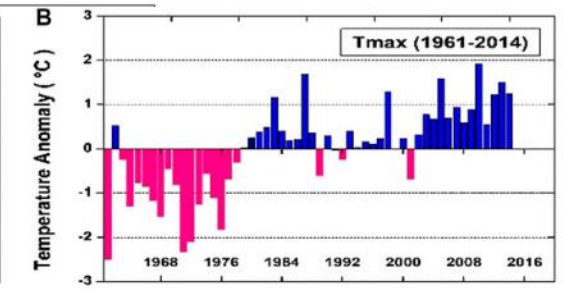
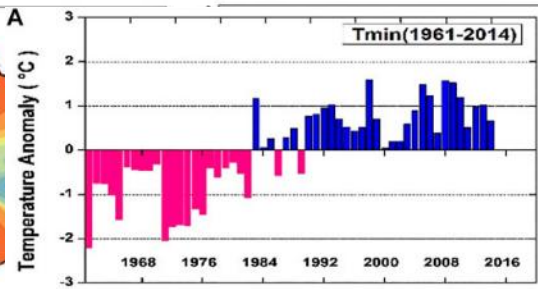
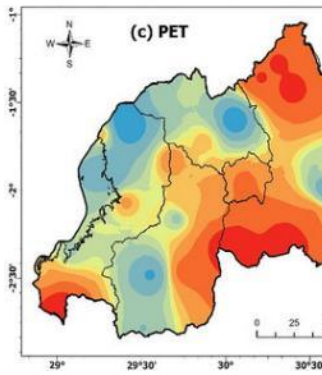
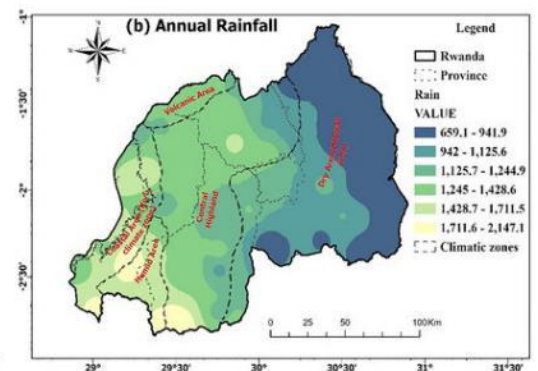
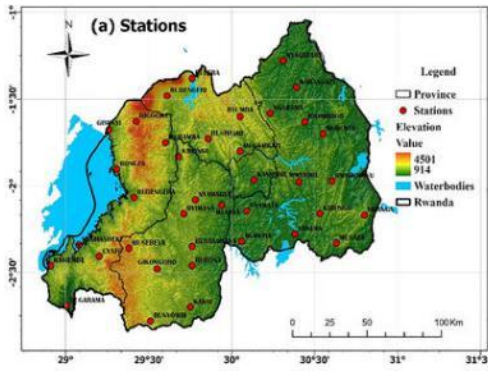
What Does it Take to
Contextualise, Make Sense of,
Visualise or Prepare Climate
Information for Usage?

Martin Rokitzki
Christian Muragijimana
Swarna Selvarajhan



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Climate Risks and Impacts ...

respond transfer be(come) resilient cope with minimise

adapt avert accept

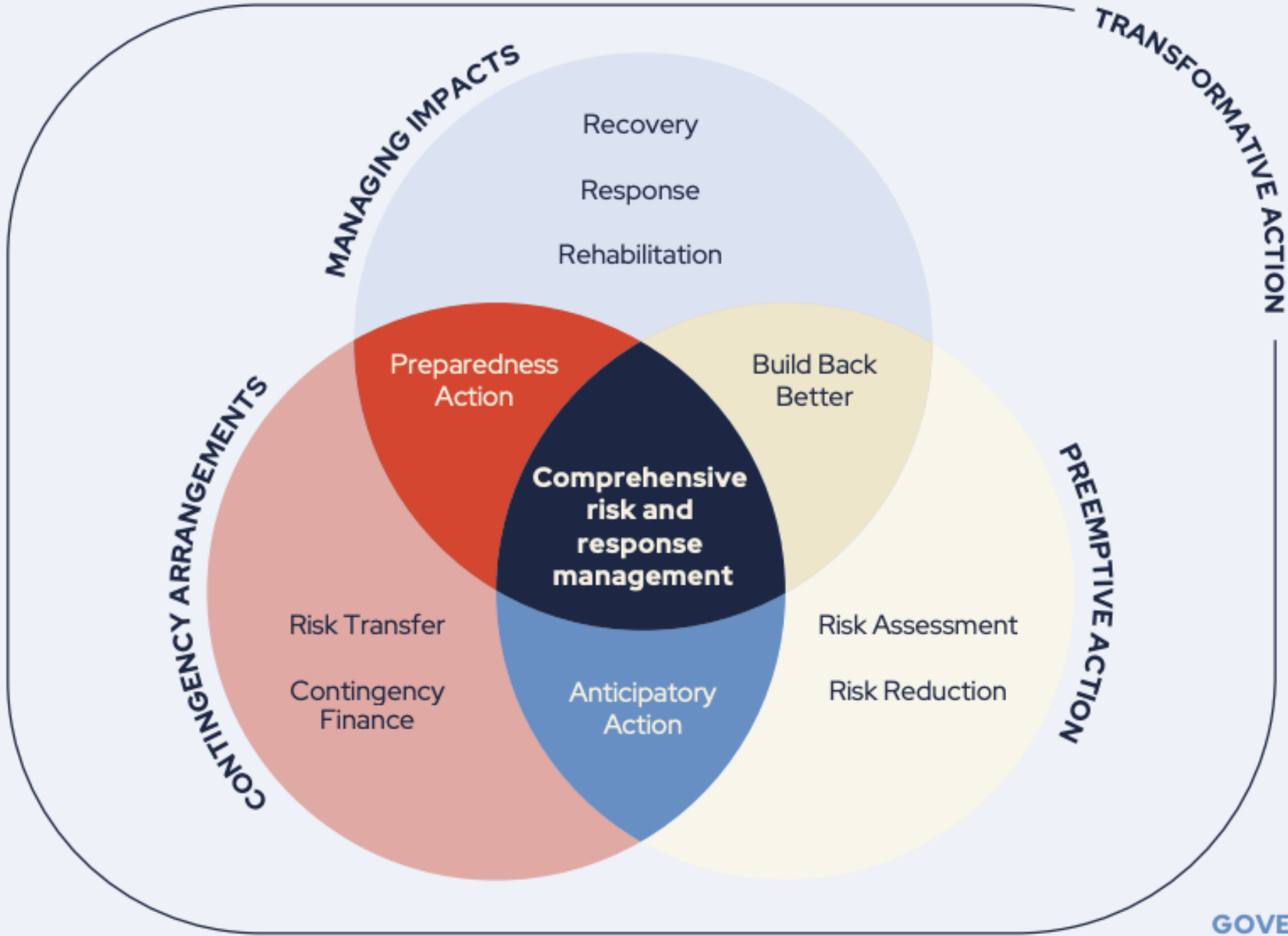
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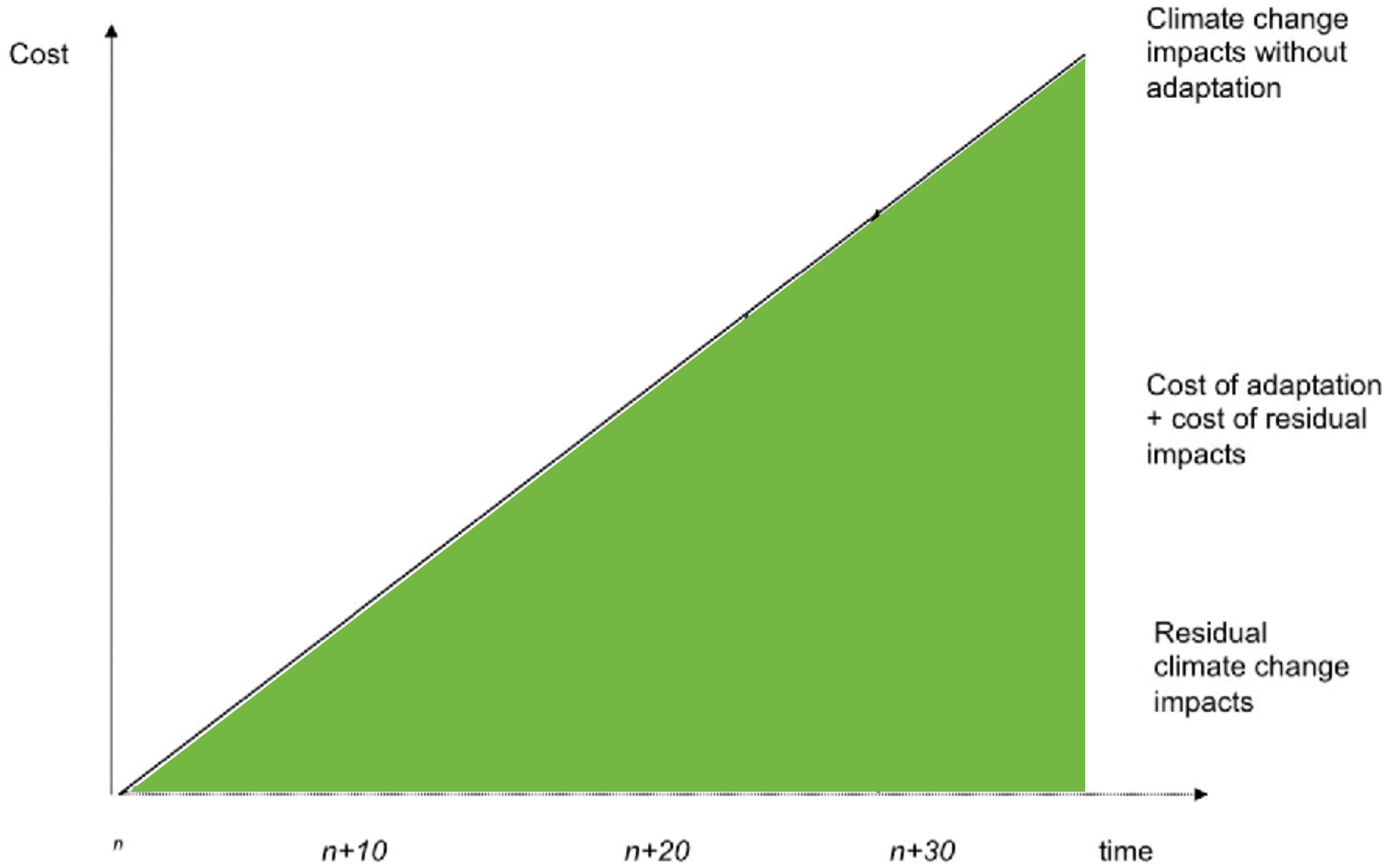
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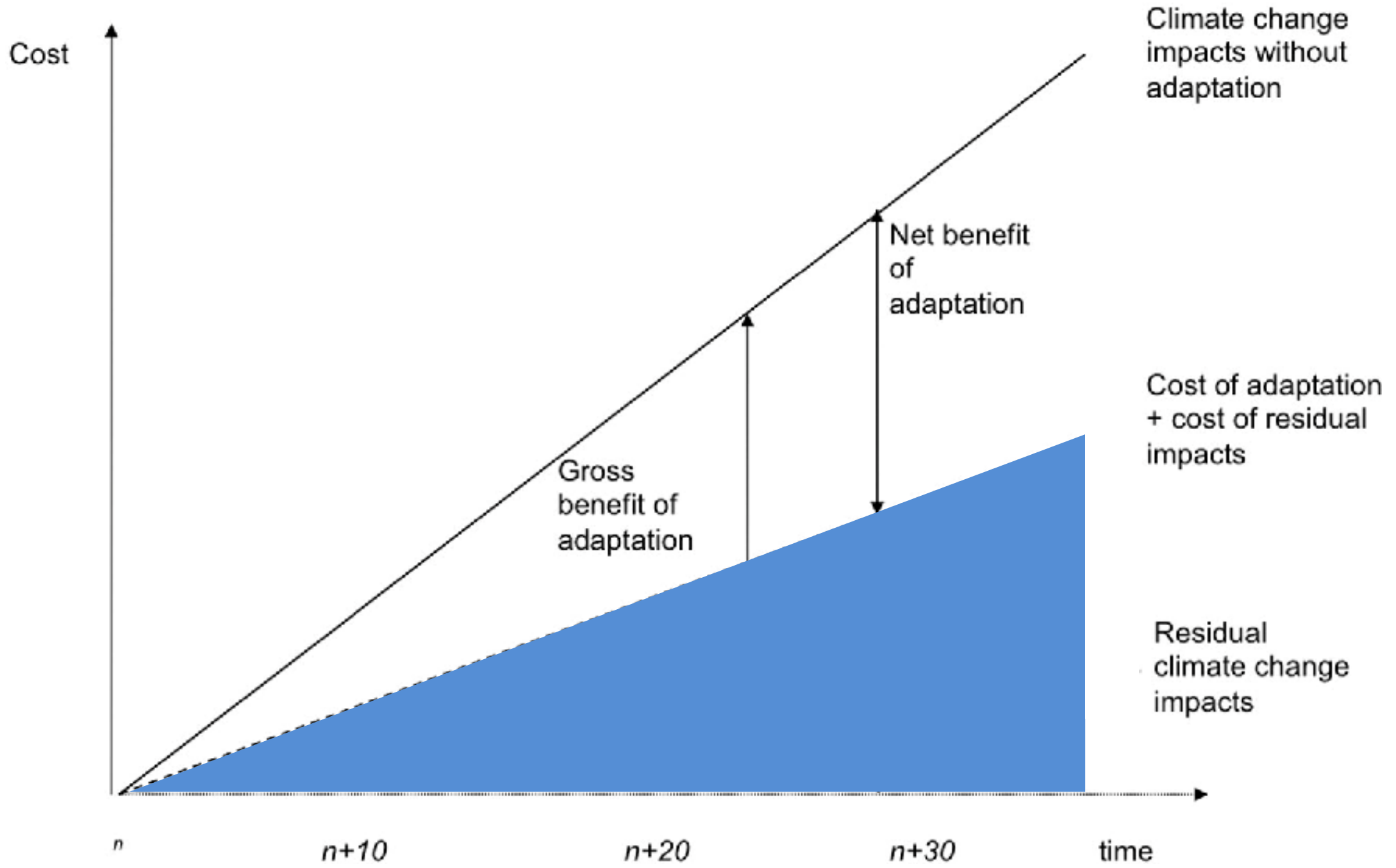
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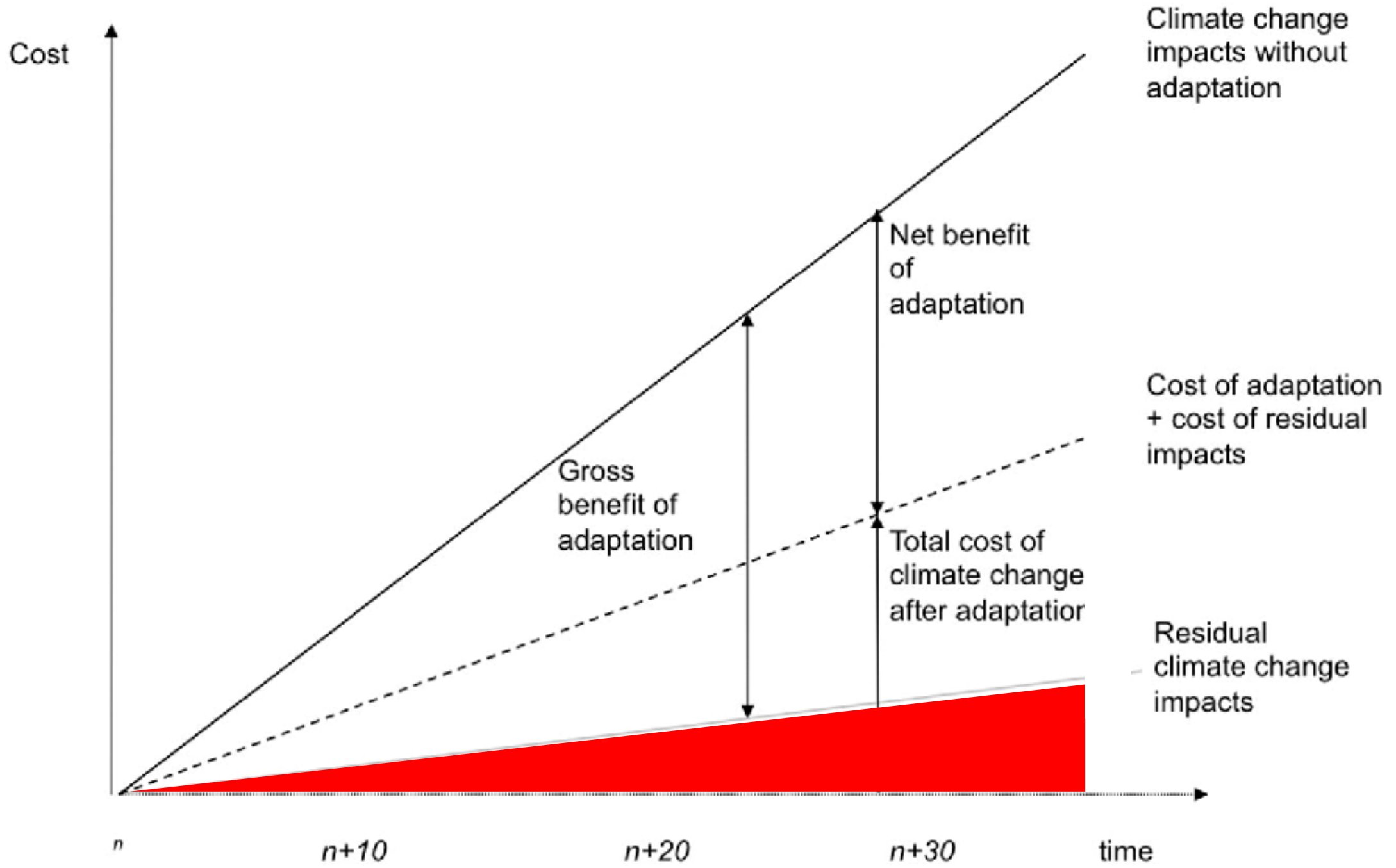
reduce manage assess











Adaptation Benefits

Economic Benefits:

- avoid Losses:
- minimize damage to infrastructure, assets, and livelihoods, leading to substantial economic savings.

Enhanced Productivity:

- maintain or increase their productivity.

Innovation and Growth:

- spur innovation and create new economic opportunities.

Local Economic Benefits:

- improve local economies by creating jobs, supporting businesses, and boosting local investment.

Adaptation Benefits

Social Benefits/ Improved Well-being :

- protect vulnerable populations from the impacts of climate change, such as extreme heat, droughts, and floods.
- improve the quality of life for individuals and communities.

Increased Resilience:

- develop the capacity to anticipate and respond to climate change effectively, strengthening their resilience.

Enhanced Public Health:

- improved air quality, access to clean water, and reduced vulnerability to heat waves can lead to significant improvements in public health.

Adaptation Benefits

Environmental Benefits:

- reduced environmental damage, i.e. minimize the impact of climate change on ecosystems and biodiversity.

Improved Ecosystem Services:

- enhance the vital services ecosystems provide, such as clean water, air, and soil.

What 'Adaptation' Questions Does Climate Information Help to Answer?

Which crop variety/ seeds to use/ select?

When to plant/ sow/ harvest?

How to avoid rain-induced soil erosion?

Transitioning to a new cultivar?



What 'Adaptation' Questions Does Climate Information Help to Answer?

To what extent will climate change impact food safety, for example through changes in exposure to aflatoxins?

How significantly may flooding affect the incidence of waterborne disease through decreases in water quality (e.g., via sewer overflows)?

To what extent will health monitoring, surveillance, and data collection activities be affected by extreme weather events?



What 'Adaptation' Questions Does Climate Information Help to Answer?

Is flooding likely to inundate sanitation facilities?

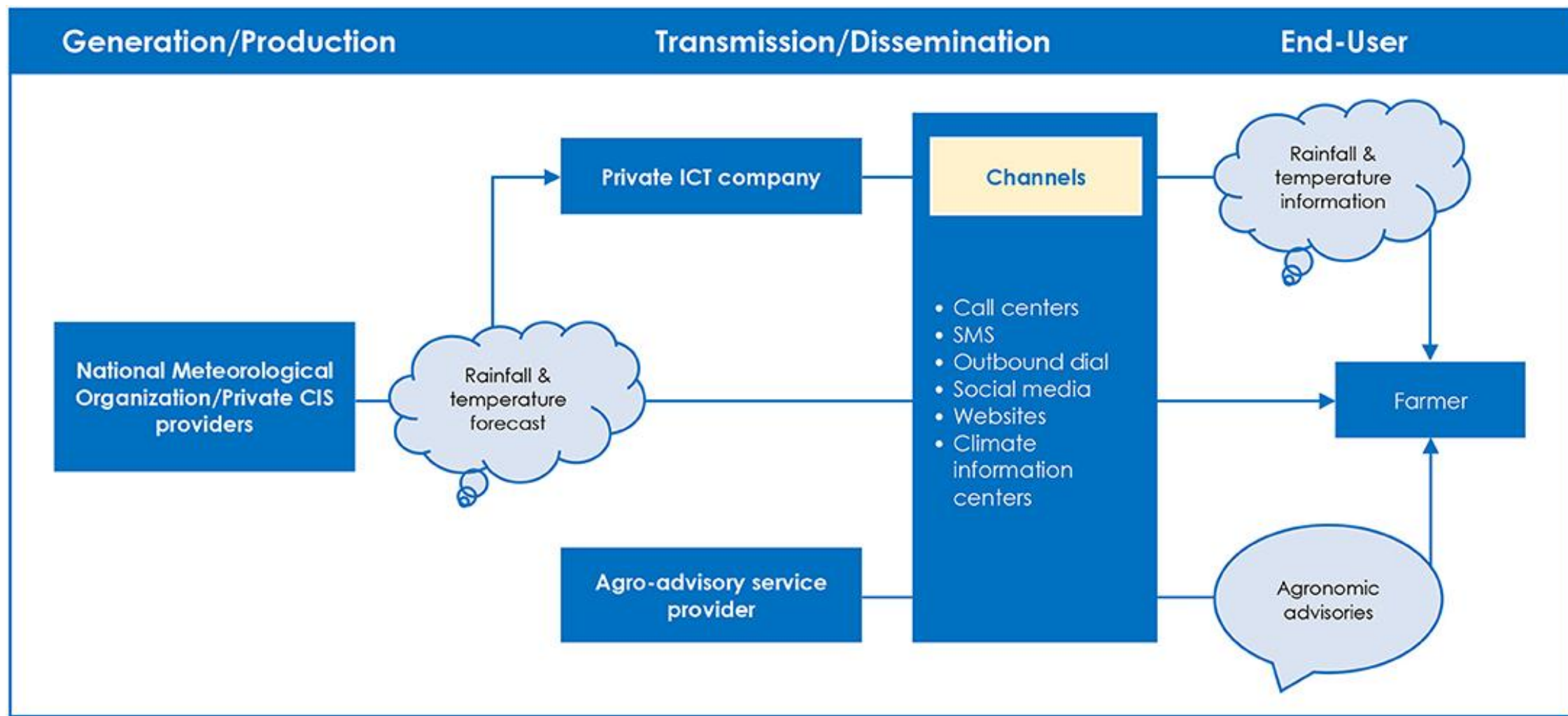
Are higher temperatures likely to increase the risk of hazardous algal blooms?

Is prolonged drought likely to increase water treatment costs?



Climate Adaptation Knowledge Brokering in Rwanda

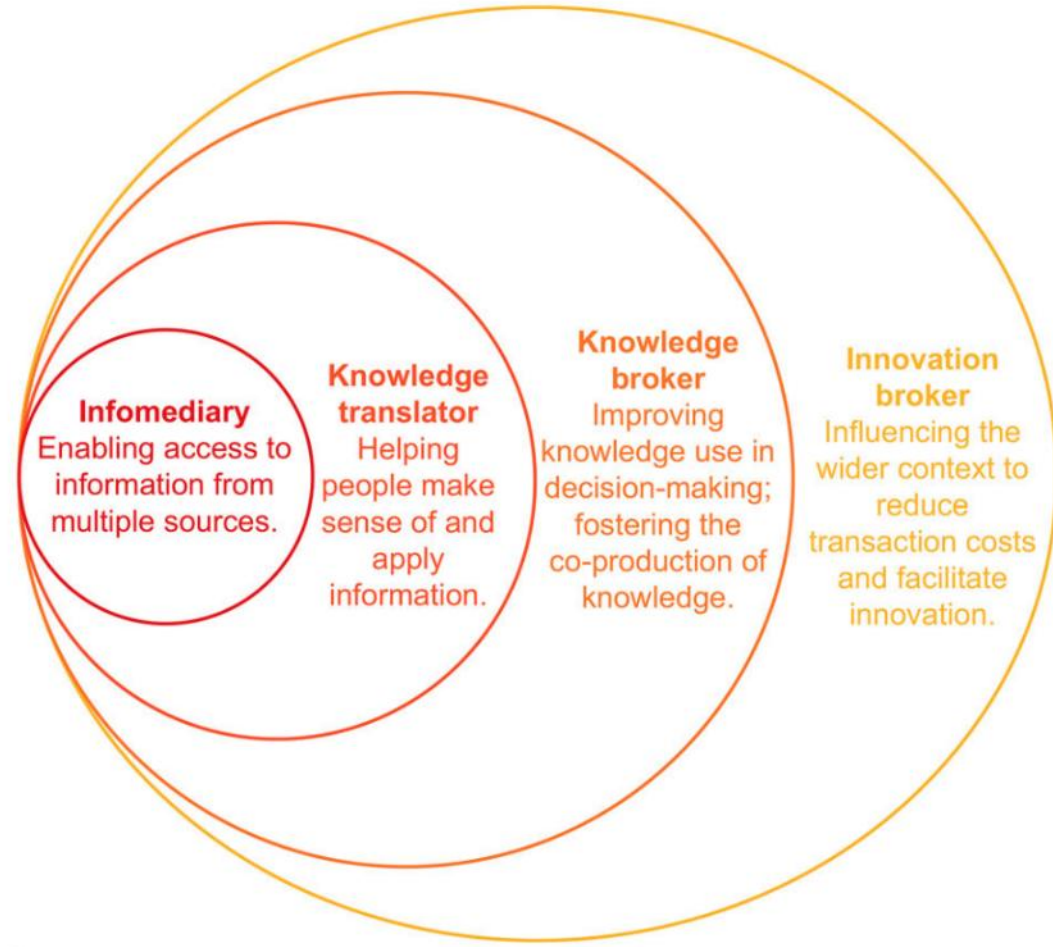
What Does it Take to Contextualise, Make Sense of, Visualise or Prepare Climate Information for Usage?



Existing linear model of CIS production in Ghana

Knowledge Brokering Spectrum

Informational Relational Systems

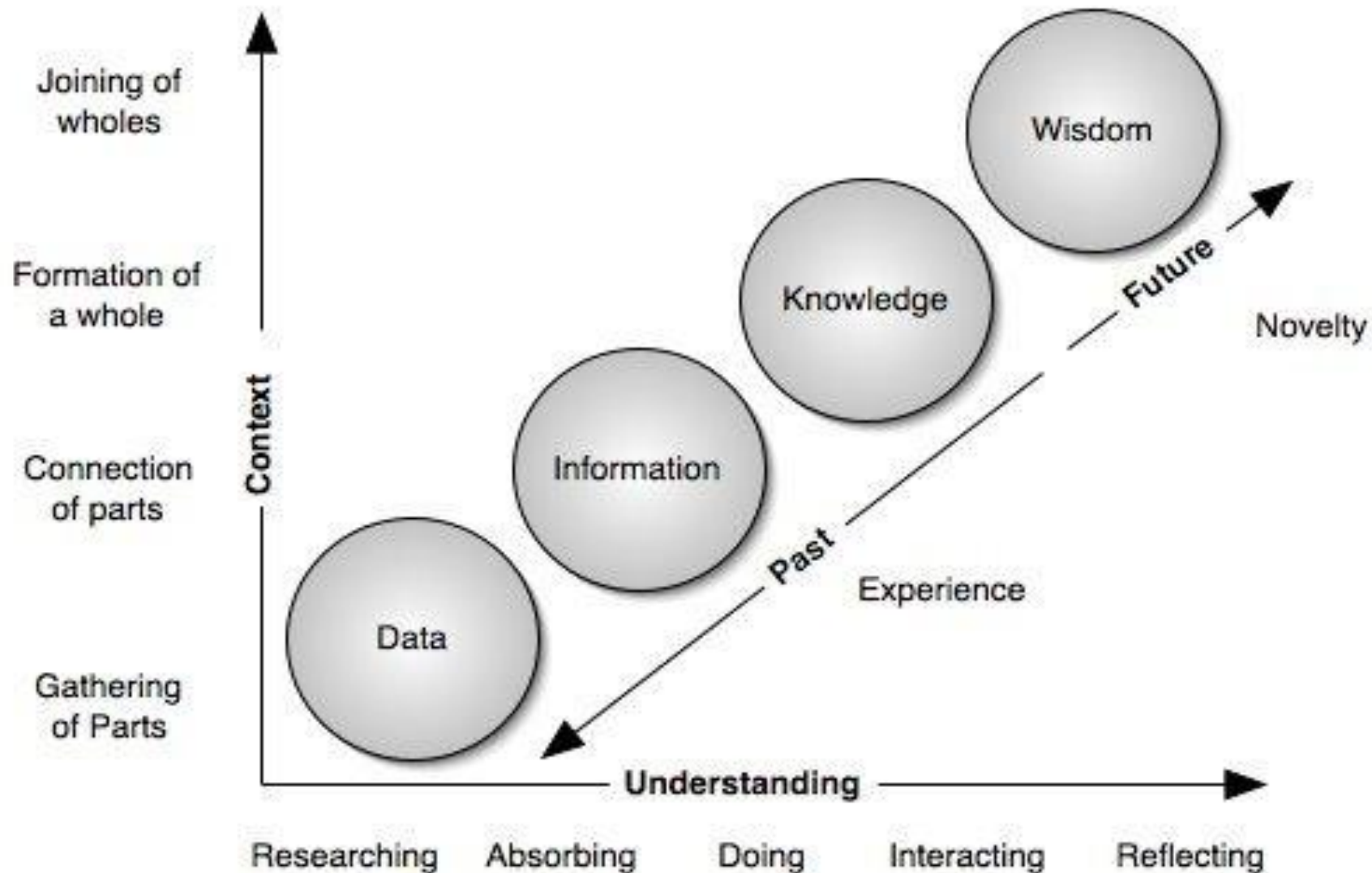


Linear dissemination of knowledge from producer to user

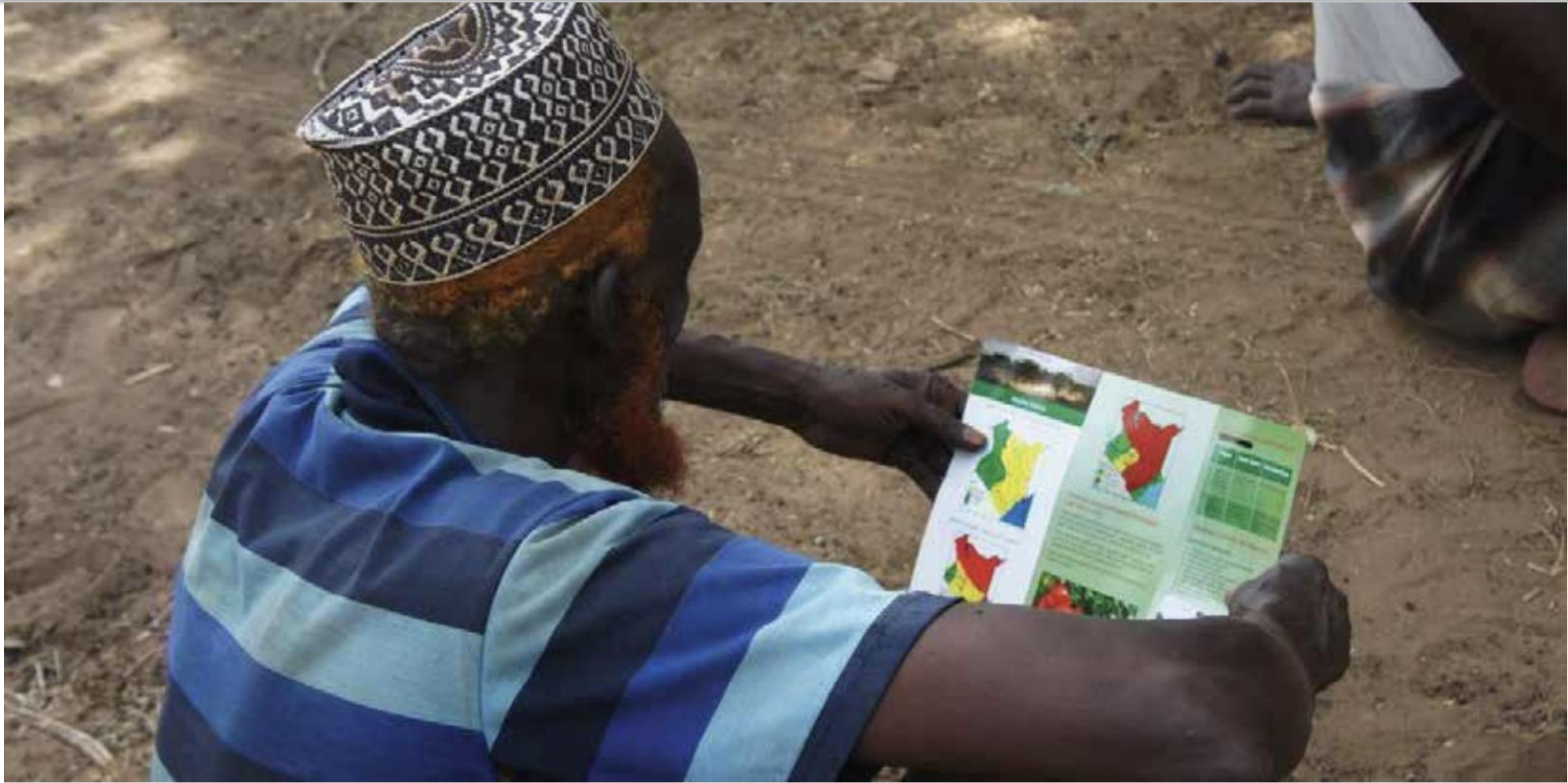


Co-production of knowledge, social learning and innovation

Making sense of... climate data & information



Making sense of... climate information



**Participatory Scenario Planning for co producing
user based climate services**

Interpreting... climate information

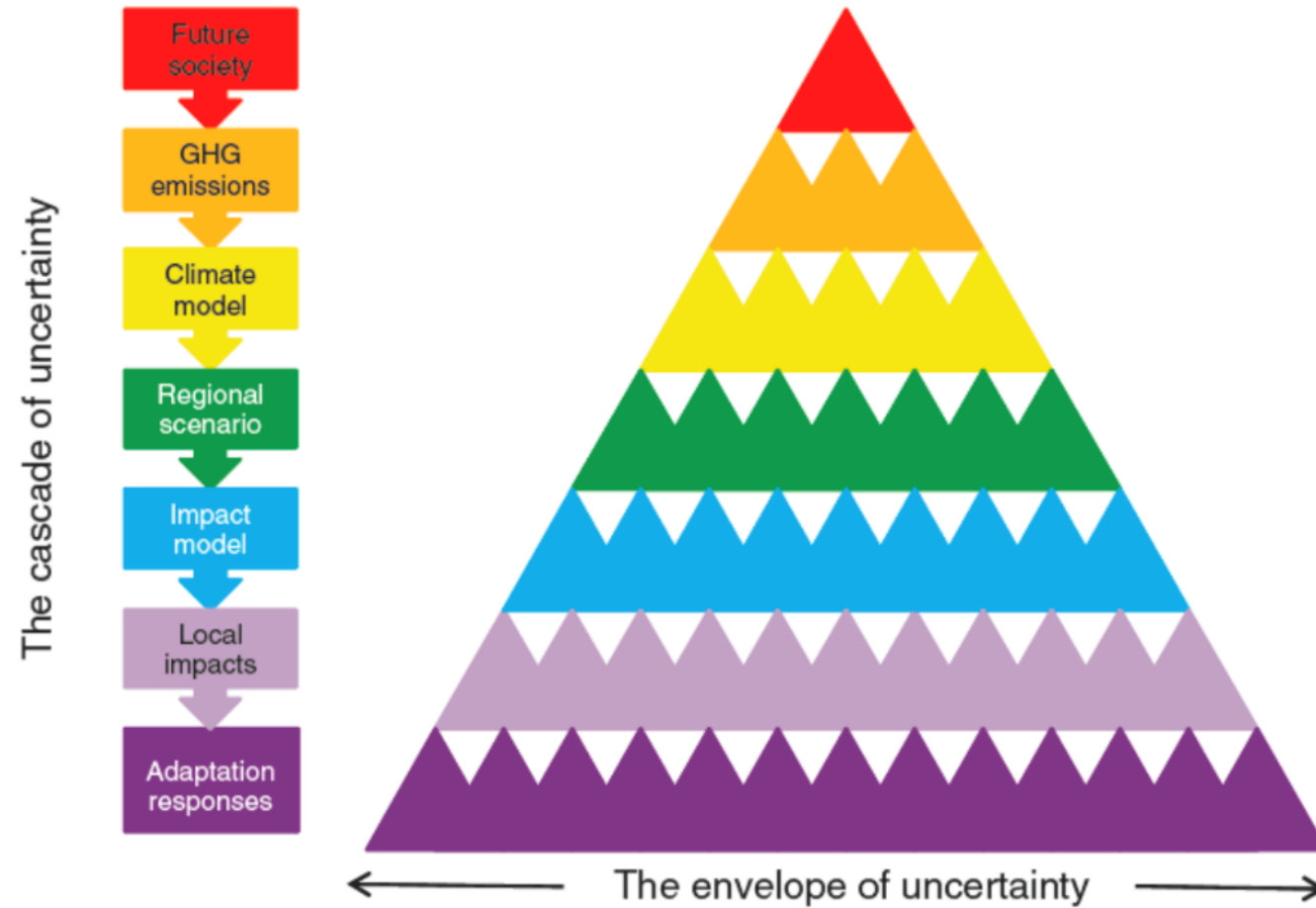
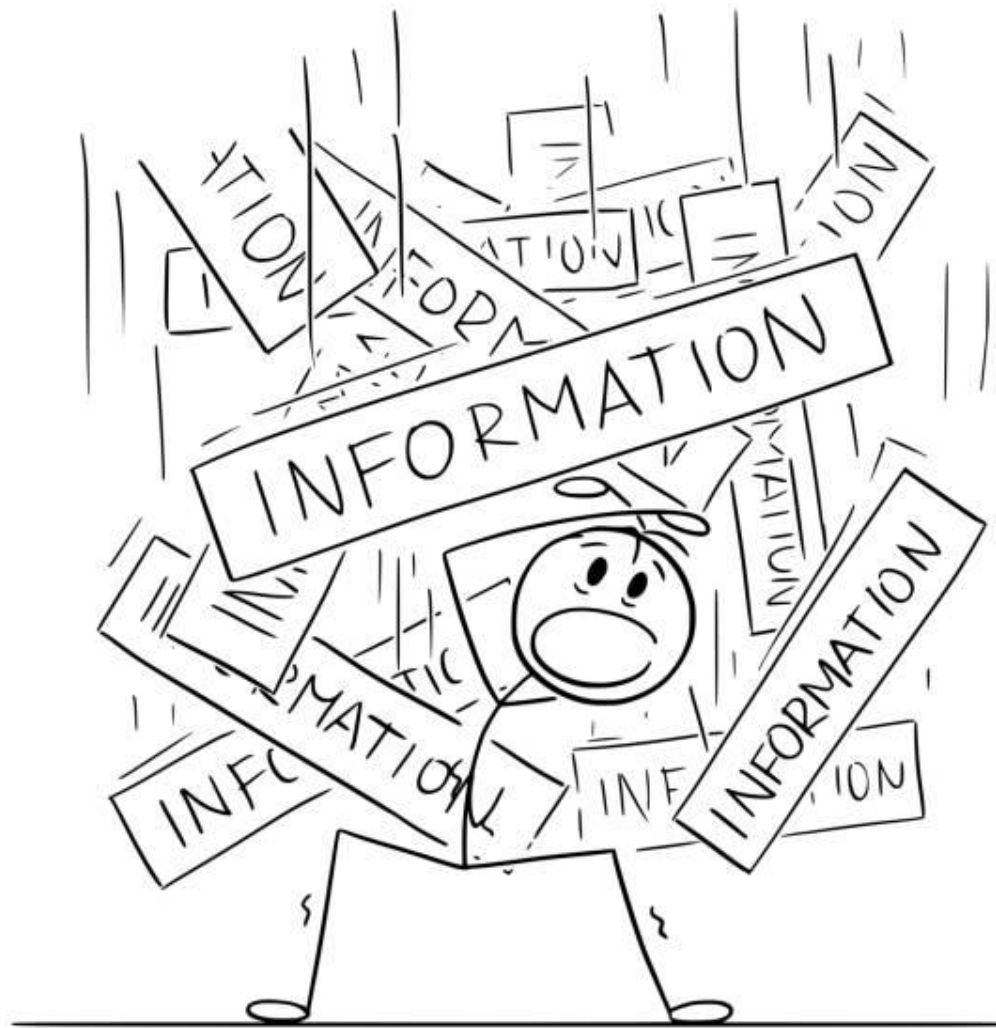


Figure 1: The cascade of uncertainty from *Wilby & Dessai (2010, Weather)*, illustrating the growth of the envelope of uncertainty from various sources going from future society to adaptation response.

Selecting ... climate information



Synthesising ... climate information




Filtering ... climate information

Interactive Map

Move the mouse over a point of interest and discover more about our data in action.

This map shows past and current uses of climate change data in practical applications. Together with industry we are applying our knowledge to help businesses, governments and citizens to adapt to climate change. This map will be updated on a regular basis.



Climate Change Service
climate.copernicus.eu

Filter:

Search
Start
Stop

Copernicus Climate Change Service (C3S) Case Studies


Climate Toolbox
APPLICATIONS ▾
TOOLS ▾
DATA ▾
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The Climate Toolbox


A collection of web tools for visualizing past and projected climate and hydrology of the contiguous United States.

Applications


A collection of tools for addressing questions relating to Agriculture, Climate, Fire Conditions, and Water.




AGRICULTURE



CLIMATE



FIRE




WATER

Tools

FIND YOUR VARIABLE


Variable Lookup
Find which tools in the Climate Toolbox have a certain variable [i](#)

Launch Tool




Climate Mapper
Maps of historical and future climate information across multiple sectors [i](#)

Launch Tool



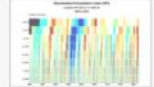
Historical Water Watcher
Maps of real-time water monitoring over the contiguous US [i](#)

Launch Tool




Historical Climate Tracker
Graphs and trend lines of historical climate variability for a location [i](#)

Launch Tool



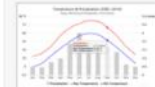
Historical Drought Stripes
Stripes of past short and long term droughts as a timeseries for a location [i](#)

Launch Tool




Historical Climate Scatter
Scatterplot graphs of two climate variables for a location [i](#)

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Historical Climograph
Climographs of monthly average climate for a location [i](#)

Launch Tool




Historical Seasonal Progression
Graphs of daily weather and forecasts for a location [i](#)

Launch Tool



Historical Climate Dashboard
Dashboard of real-time climate for a location [i](#)

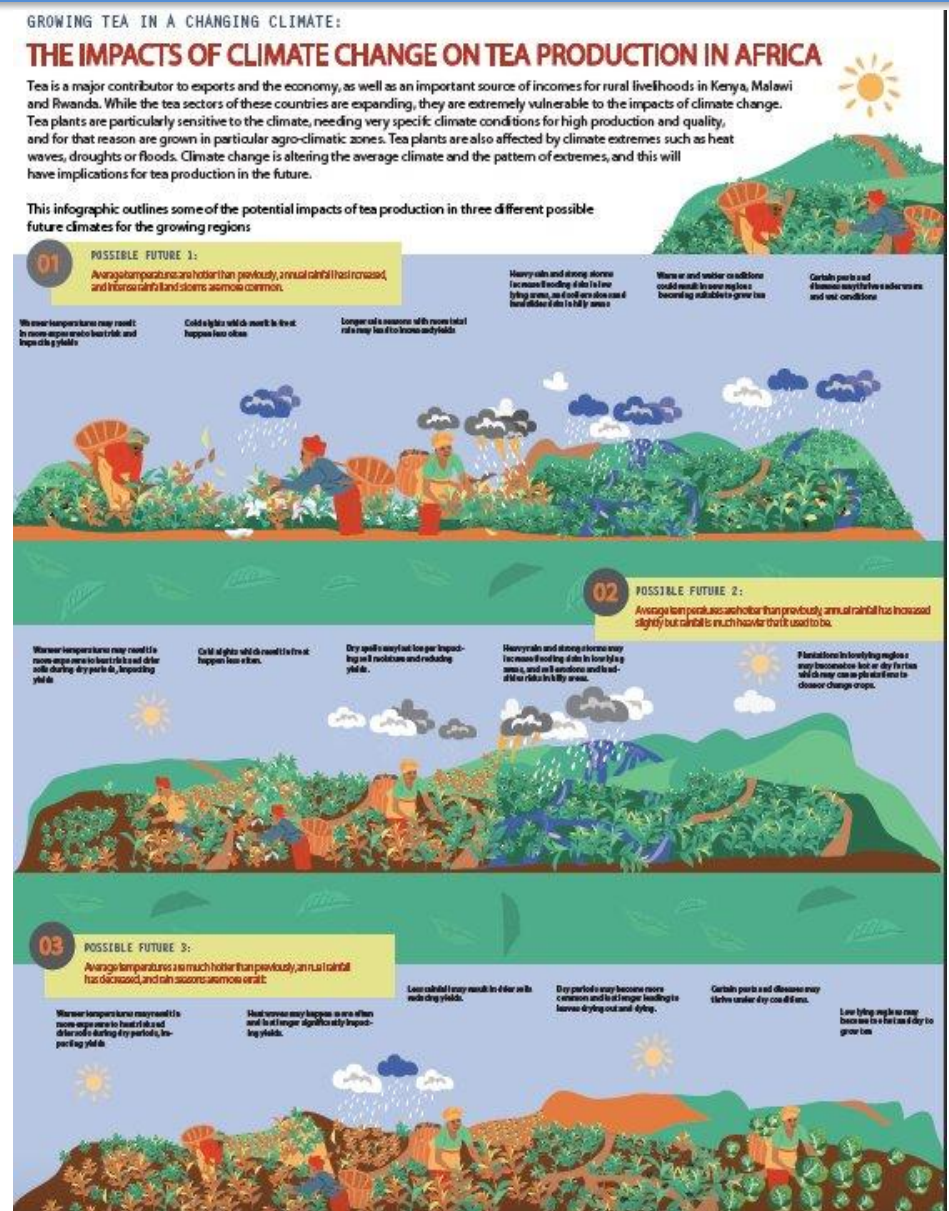
Launch Tool



Seasonal Forecast Graphs
Graphs of seasonal climate forecasts and statistics for a location [i](#)

Launch Tool

Visualising ... climate information



Infographic:

The Impacts Of Climate Change On Tea Production In Africa (FCFA)

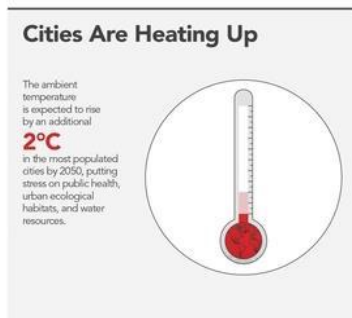
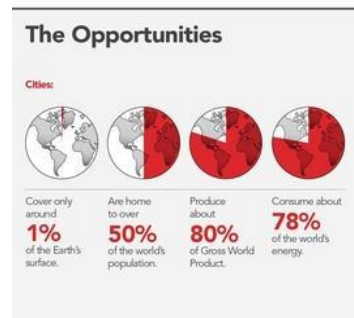
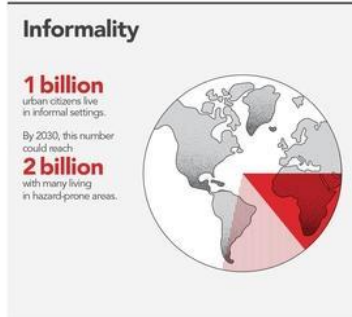
Simplify → annotate → visualise ... climate information



Climate Change and Cities

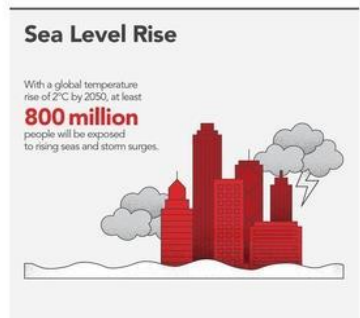
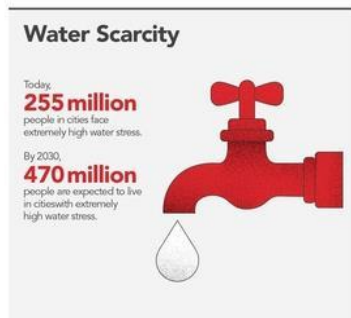
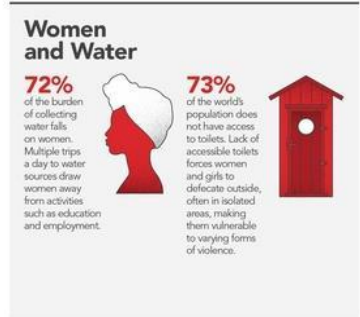
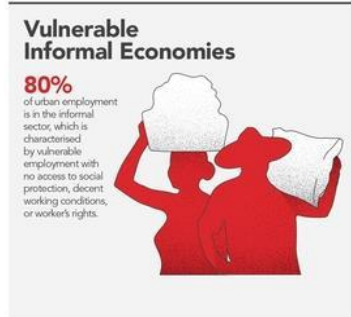
Cities Alliance
Cities Without Slums

Hosted by: UNOPS

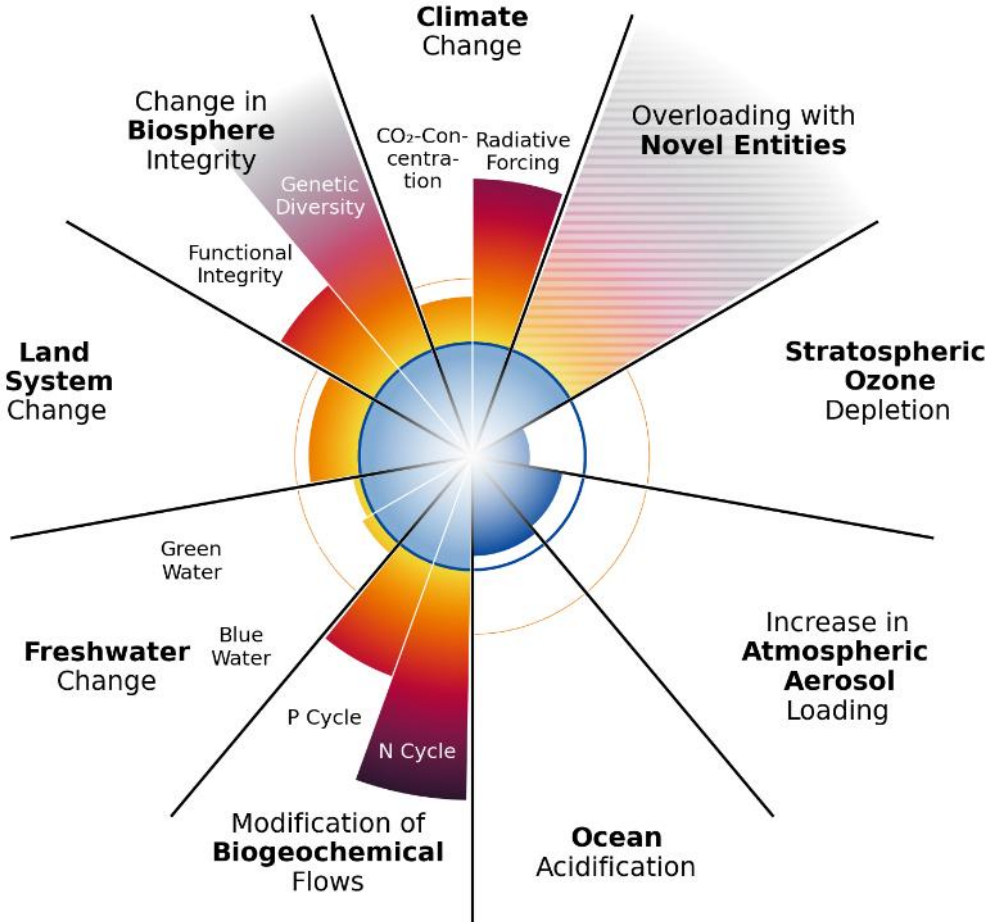


Cities and Resilience

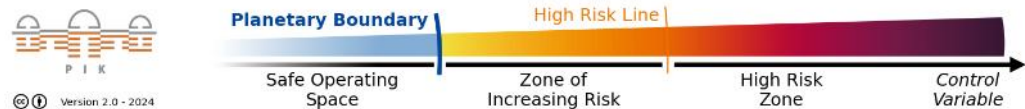
Together, we need to build sustainable cities by strengthening urban ecosystems, promoting investment in local resilience efforts, and advocating for people-centred approaches.



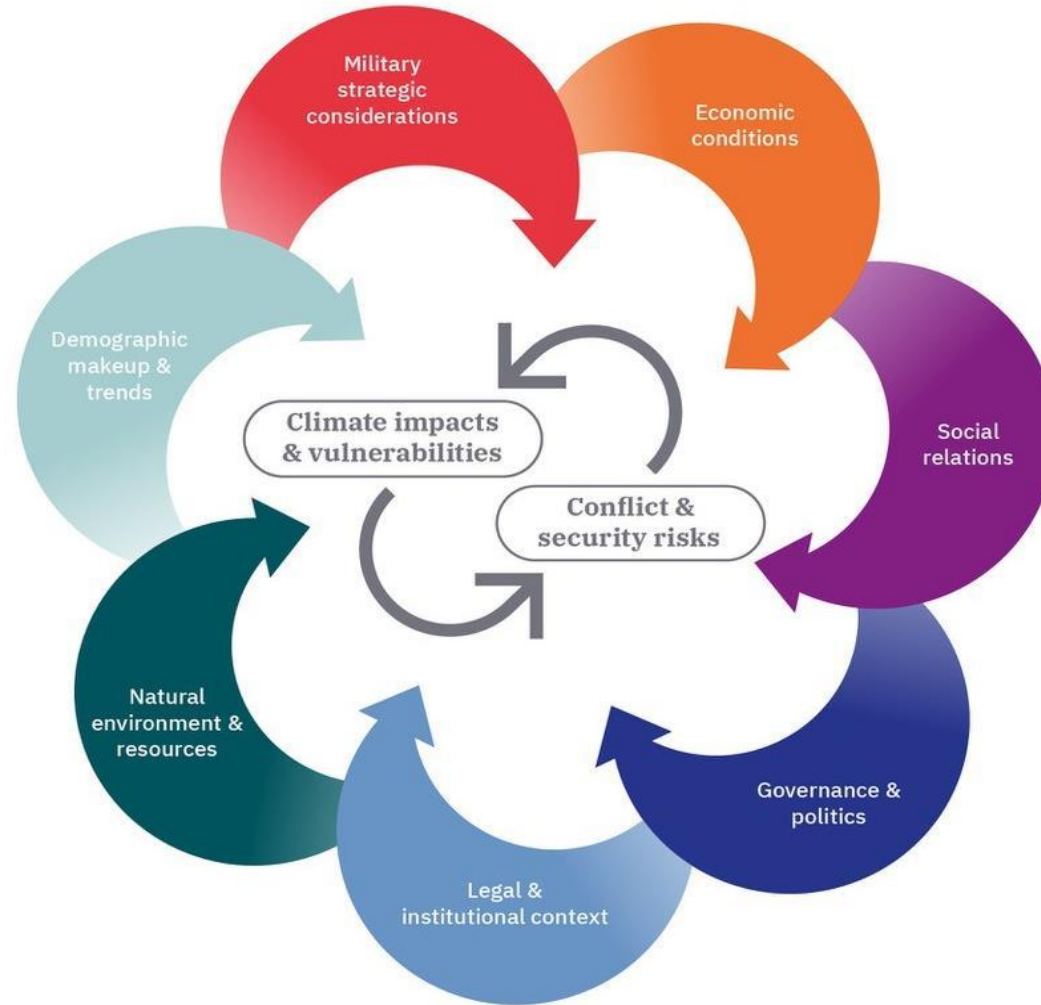
Simplify → annotate → visualise ... climate information



Colourblind-friendly visualization

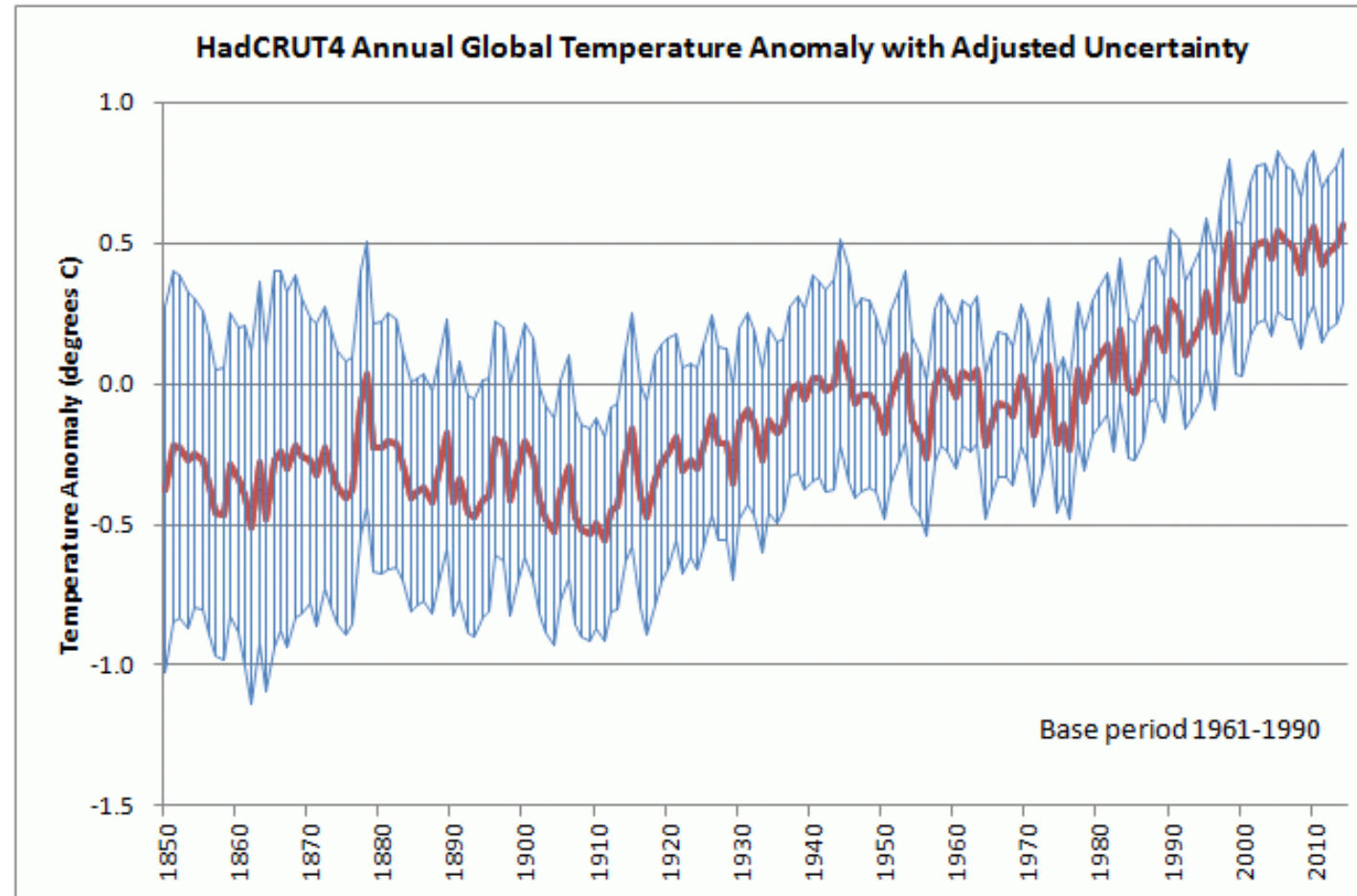


Contextualizing ... climate information



Context factors shape climate-security dynamics (Detges and Foong, 2023)

Communicating ... climate information



uncertainty or confidence intervals



Shaping Rwanda's Next Generation of Climate Adaptation Professionals and Climate Risk Managers

Climate Adaptation Research & Consulting Rwanda
a PlanAdapt Affiliate

Our Expertise



Framing the Decision Context, Engaging Stakeholders



Assessing, Valuating and Making Sense of Climate Risk



Shaping Planning and Business Processes



Monitoring, Evaluating and Learning From Adaptation Action



Knowledge Brokering, Bridging between Theory and Practice



Researching New Frontiers for Effective Implementation



Training, Building Capacity, Shaping Mindsets



Assessing Financing Options and Mobilising Resources



Designing and Delivering Impactful Climate Services

Climate Risk Can Be Managed!

Homegrown solutions by Rwandan climate adaptation knowledge brokers for Rwandans that struggle with the negative impacts of climate change and climate injustice

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Building and sustaining climate adaptation capacity and competencies in Rwanda!

1st

RWANDA CLIMATE SCIENCE SYMPOSIUM 2025

Advancing Research And Networking

A2) Measurement and reduction of greenhouse gas emissions

13 May 2025, 14:00 – 16:00 PM

STRENGTHENING RWANDA'S MRV SYSTEM IN THE ENERGY, AGRICULTURE, AND WASTE SECTORS: **Advancing Greenhouse Gas Measurement and Reduction through Actionable Climate Science**

Dr. KONDI AKARA Ghafi
Resident Researcher in
Climate Change Sciences
at AIMS RIC

gkondi@aimsric.org



AIMS

African Institute for
Mathematical Sciences
RESEARCH & INNOVATION

11/02/2026



Measure

Set baselines and track progress



Report

Monitor and report on progress and impacts



Verify

Provide transparent verification



Session Outline

- 1** Rwanda's Climate Vision and Commitments;
- 2** Importance of the MRV Framework in Rwanda;
- 3** Why Strengthening Rwanda's MRV Framework is Crucial;
- 4** Current state of the MRV system in Rwanda ;
- 5** Sector-specific analysis (Energy, Agriculture, Waste);
- 6** General Recommendations for Strengthening Rwanda's MRV System.

Rwanda's Climate Vision and Commitments

- ❑ **Vision:** Rwanda envisions becoming a climate-resilient, low-carbon economy by 2050. This ambition is aligned with its long-term development goals outlined in the Vision 2050, the Green Growth and Climate Resilience Strategy (GGCRS);
- ❑ **Key National Commitments:**
 - ❑ **Nationally Determined Contributions (NDC):** Rwanda submitted its updated NDC in 2020. Rwanda aims to reduce GHG emissions by up to 38% by 2030 (4.6 million tCO₂e), including 16% unconditionally (1.9 MtCO₂e) and an additional 22% conditionally with international support (2.7 MtCO₂e).
 - ❑ **Sectoral Focus:** Agriculture (55% of emissions), Energy (31%), and Waste (12%) are the top contributors to national GHG emissions..
 - ❑ **Climate Action Implementation:** Rwanda integrates climate actions into its National Strategy for Transformation (NST1) and sectoral policies.

Importance of the MRV Framework in Rwanda

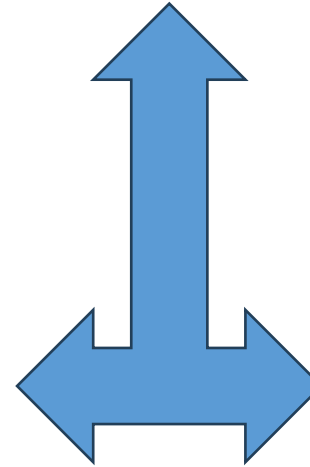
1- MRV Framework

Measurement

- Emissions & Removals (CO₂, CH₄, N₂O...)
- Mitigation & Adaptation actions
- Support needed & received (finance, technology, capacity-building)

Verification

- Technical reviews
- Audits
- International Consultation and Analysis (ICA)



Reporting

- GHG Inventories
- National Communications
- Nationally Determined Contributions (NDCs)
- Biennial Update Reports / Biennial Transparency Reports

Importance of the MRV Framework in Rwanda

2- the Importance

❑ **Tracking NDC Progress:**

Enables Rwanda to monitor its climate actions and assess progress toward its NDC targets; essential for reporting under the Paris Agreement.

❑ **Informing Policy:**

Provides robust data to guide policy decisions and climate investments.

❑ **Attracting Climate Finance:**

Builds international trust and supports access to funds like the Green Climate Fund (GCF).

❑ **Strengthening Institutions:**

Encourages knowledge sharing, technical skills, and development of sector-specific MRV systems.

❑ **Supporting Adaptation:**

Facilitates evaluation of resilience-building actions and supports community-based climate monitoring.

Why Strengthening Rwanda's MRV Framework is Crucial

Despite progress, Rwanda's MRV system faces challenges such as:

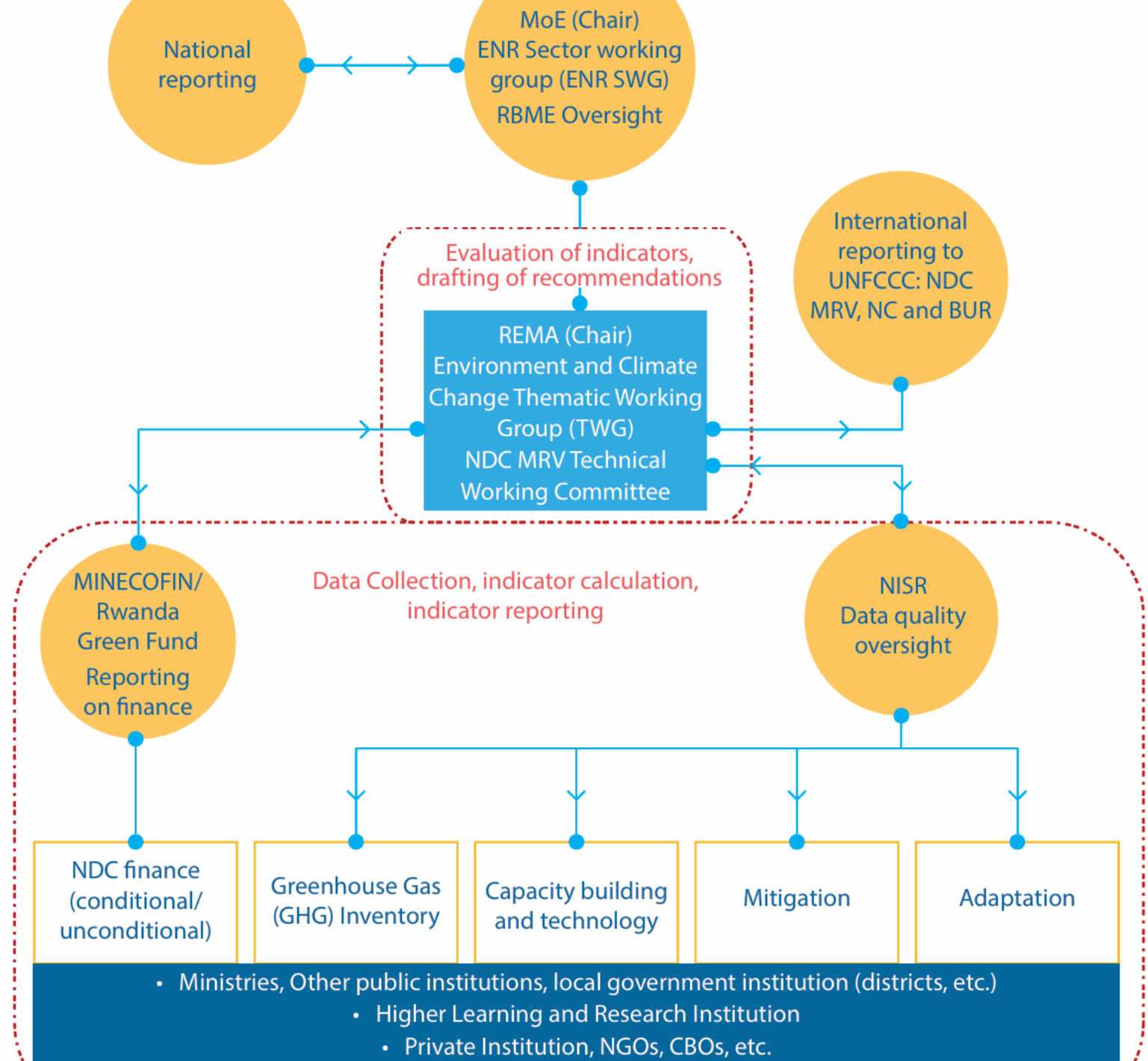
- Limited data availability and quality.
- Weak sectoral coordination.
- Capacity gaps at sub-national levels.
- Insufficient digital tools and automation.

Strengthening Rwanda's MRV system is key to ensuring credible and transparent emission reporting. It enables effective tracking of NDC progress, fulfillment of international commitments under the UNFCCC and Paris Agreement and supports climate policies grounded in scientific evidence.



Current state of the MRV system in Rwanda

1- NDC-MRV Structure and Related Policy Processes



Current state of the MRV system in Rwanda

2- Elements of an NDC MRV system which remain to be defined

- ❑ **Data collection responsibilities:**
Clarify who collects what (e.g. how MININFRA gathers solid waste landfill data), in what form, and how often.
- ❑ **Indicator evaluation procedures:**
Define the roles and workflows of REMA and the NDC MRV Technical Working Committee in assessing reported indicators.
- ❑ **GHG inventory compilation:**
Establish a clear and systematic approach for compiling the national GHG inventory as a core MRV data source.
- ❑ **Data quality assurance by NISR:**
Detail how the National Institute of Statistics of Rwanda (NISR) ensures oversight and validation of climate-related data.
- ❑ **Methodological alignment:**
Define standards and harmonized methodologies for calculating GHG mitigation impacts.

Sector Focus – Agriculture



- ❑ 55% of national GHG emissions [\(Updated_NDC_May_2020, p24\)](#)
- ❑ Major sources: enteric fermentation, manure, rice cultivation
- ❑ Gaps: smallholder data, agroforestry estimation
- ❑ Recommendation:
 - Adopt IPCC Tier 2 methods
 - Integrate farm-level data collection
 - Improve collaboration with CGIAR (Consultative Group on International Agricultural Research)

Sector Focus – Agriculture

Mitigation Measure : Soil and water conservation through continuous crop rotation (600,000 ha targeted)

(Updated_NDC_May_2020, p39)

Measurement (M):

- Data Collection:** Land area under crop rotation, frequency, crop types, soil erosion levels, CO₂/N₂O baseline emissions
- Calculation Indicators:** GHG emissions avoided (CO₂, N₂O), volume of carbon sequestered, erosion reduction rates
- Policies & Standards:** IPCC guidelines Tier 2, Rwanda's Green Growth Strategy

Reporting (R):

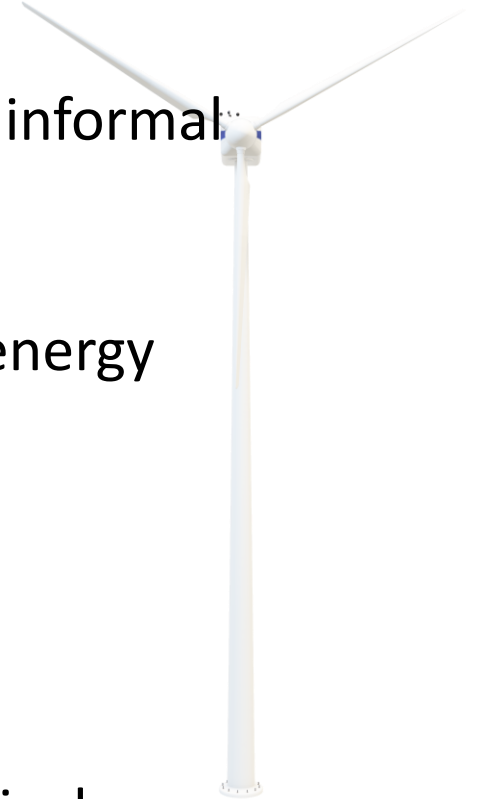
- Integrate into GHG Inventory & Biennial Transparency Reports
- Contribute to NDC tracking updates and National Communications

Verification (V):

- Field audits, technical reviews of submitted data
- Cross-checking with satellite imagery and local agricultural records
- External verification where feasible

Sector Focus – Energy

- ❑ 31% of national GHG emissions ([Updated_NDC_May_2020, p24](#))
- ❑ Sources: fossil fuels, biomass, electricity generation
- ❑ Gaps: lack of centralized database, informal energy use
- ❑ Strength: institutional memory of energy statistics
- ❑ Recommendations:
 - Centralize energy data
 - Use confidential statistics effectively
 - Build stronger data sharing protocols



Sector Focus – Energy

Mitigation Measure :
Development of 156 MW
hydroelectric capacity (large,
mini, and regional projects)

(Updated_NDC_May_2020, p36)

Measurement (M):

- Data Collection:** Installed capacity, operational hours, fuel baseline (peat, diesel), GHG intensity of replaced sources Calculation
- Indicators:** GHGs avoided (tCO₂e), electricity produced (MWh), fossil fuel use displaced
- Policies & Standards:** National Energy Policy, Clean Development Mechanism (CDM) methodologies

Reporting (R):

- Integrate into Energy Balance Sheets and GHG Inventories
- Contribute to tracking under National Energy Plans and the NDC

Verification (V):

- Independent performance audits
- Use of smart meters and automated monitoring tools
- Reporting cross-checked with IPP power generation data

Sector Focus

– Waste



- ❑ 12% of national GHG emissions (Updated_NDC_May_2020, p24)
- ❑ Sources: Emissions from landfills, wastewater, incineration
- ❑ Gaps: limited measurement of methane, few verification tools
- ❑ Recommendations:
 - Expand waste sector surveys
 - Implement direct measurement protocols
 - Train local governments in waste MRV

Sector Focus – Waste

Mitigation Measure :
Investment in wastewater
treatment and reuse
technologies

(Updated_NDC_May_2020, p41)

Measurement (M):

- Data Collection:** Volume of wastewater treated, type of treatment technology, baseline methane emissions, digestate output
- Calculation Indicators:** CH₄ and CO₂ emissions reduced, energy recovered, nutrient value of digestate
- Policies & Standards:** National Sanitation Policy, IPCC Waste Sector Guidelines

Reporting (R):

- Include in Biennial Transparency Reports and NDC progress updates
- Regional reporting on sanitation and climate co-benefits

Verification (V):

- Site visits, engineering reviews
- Third-party validation of emission reductions
- Data comparison with national wastewater records

General Recommendations for Strengthening Rwanda's MRV System

- ❑ **Legal and Institutional Frameworks:** Finalize and enforce MRV-related legal instruments ; clarify roles and responsibilities of institutions
 - ❑ **Data Systems and Digitalization:** Establish a centralized national MRV database; promote automated data flows between sectors
 - ❑ **Capacity Building:** Continuous training programs for national and sectoral experts; institutional memory retention strategies
-
- ❑ **Standardization and Guidelines:** Adopt internationally recognized MRV methodologies (IPCC, ETF); harmonize sectoral templates and protocols
 - ❑ **Stakeholder Engagement:** Engage local governments, civil society, academia, and the private sector in MRV processes
 - ❑ **Integration with National Planning:** Embed MRV in policy frameworks such as the NST1, Vision 2050, and sectoral development plans

Conclusion

Rwanda is on the right path to building a strong, credible MRV system

Strengthening MRV will:

- Ensure more accurate, complete, and timely data
- Enable Rwanda to meet international reporting obligations effectively
- Improve policy formulation and evidence-based planning
- Enhance accountability and transparency in climate action
- Support resource mobilization through credible reporting
- Empower local actors in data collection and monitoring

Let's continue building a science-based, inclusive, and data-driven system !

References

1. Republic of Rwanda. (2020). **Updated Nationally Determined Contribution (NDC)**. Submitted to the UNFCCC May 2020.
2. Elisée Gashugi, Sina Wartmann, Peter Katanisa, Michael Hammond, Alex Mulisa, and Pablo Benitez. (June 2021). **Final Report: Monitoring, Reporting and Verification Framework for Rwanda's Updated Nationally Determined Contribution**.
3. Aimé Tsinda, Brenda Ntaganda, and Beatrice Cyiza. (March 2023). **Rwanda's Climate Adaptation Monitoring, Evaluation, and Learning System in the Agriculture Sector: Institutional Arrangements**. Briefing Note 3.
4. Republic of Rwanda. **National Greenhouse Gas Inventory (2006–2018)**. Report to the United Nations Framework Convention on Climate Change (UNFCCC).



Thank You For Your Kind Attention!



1st

RWANDA CLIMATE SCIENCE SYMPOSIUM 2025

Advancing Research And Networking

Impacts of CLIMATE CHANGE AND RISK ASSESMENT

14 May 2025, 10:00 – 12:00 P.M., Plenary

Economic Impacts of Climate Change

Getaw Tadesse (PhD)

AKADEMIYA2063

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Motivation

- Despite plenty of discussions and documentation, the full cost of climate change is not yet well captured
- Some pitfalls or challenges
 - Mixing the impacts of **temperature rise** and **extreme weather events** : *no strong evidence showing the correlation between the two*
 - The complex effects (environment, social and economic) and victims (households, communities, nations) of climate change are not considered
 - *Some damages and losses are difficult to measure, monetize and attribute*
 - *The mixing of costs of actions and inactions*
- *The objective of this presentation is to delve*
 - *Concepts on typology of impacts (damages and losses),*
 - *Empirics on climate risk, vulnerability and macroeconomic impacts*

Typology of impacts (damages and losses) of climate change

Environmental damages

- Loss of arable lands
- Biodiversity loss
- Forest degradation and wildfires
- Fresh water shortage
- Rising sea levels

Social damages

- Loss of lives and health
- School dropouts due to heat stress and loss of income
- Migration :both internal and external ; a study in Ethiopia

Economic damages

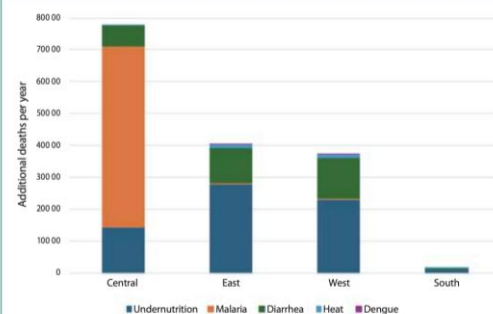
Microeconomic

- Reduction in ag productivity
- Reduction in labor productivity
- Income loss
- Rising household expenditure
- Entrepreneurship and informal sector

Macroeconomic

- Price rise /inflation
- Growth /GDP
- Employment
- inequality /poverty

FIGURE 5.9—EFFECTS OF CLIMATE CHANGE ON SELECTED CAUSES OF DEATH IN AFRICA SOUTH OF THE SAHARA, 2020–2030



Source: Authors, adapted from WHO (2014).

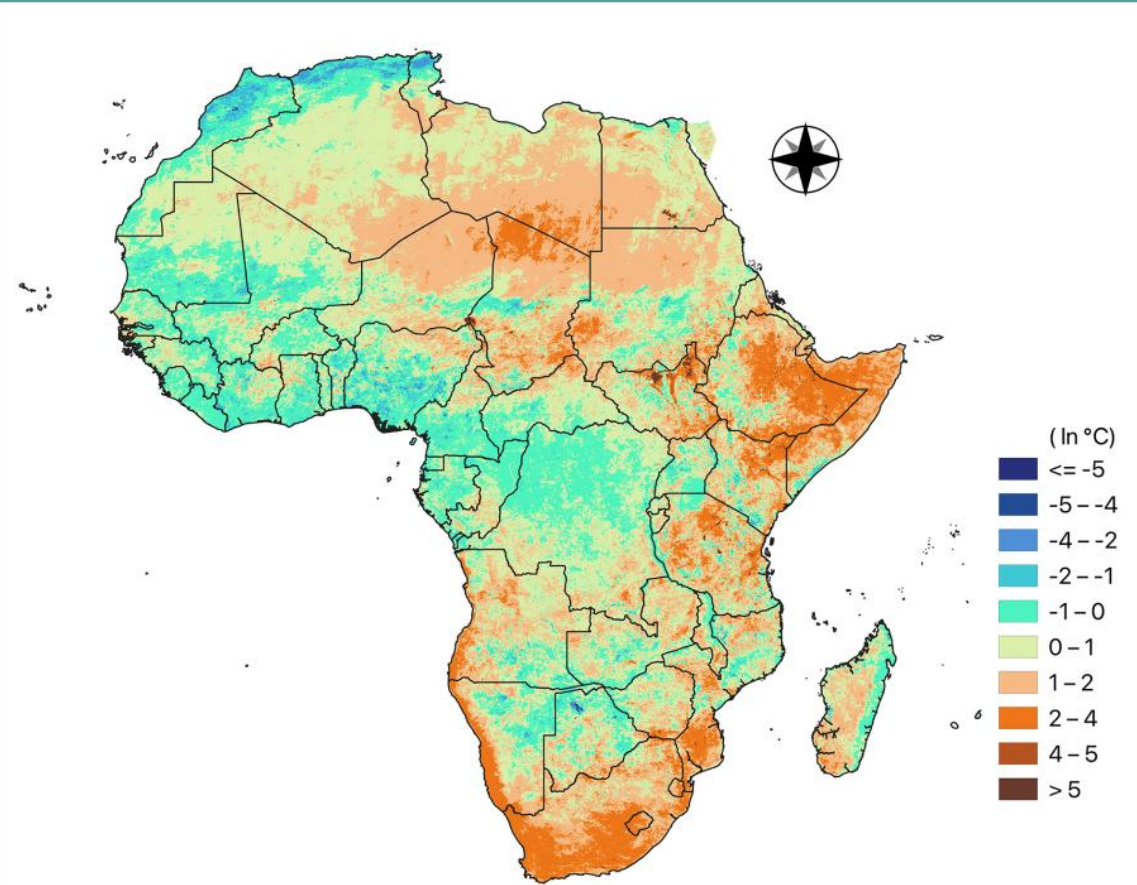
Factors affecting economic impacts

According to IPCC, the damages, losses or vulnerabilities depend on

- Exposure : climate change vs extreme events
- Sensitivity : elasticity to damage
- Adaptative capacity: broadly defined as the ability to absorb, adjust and transform

Exposure: Temperature is rising but climate risks are not

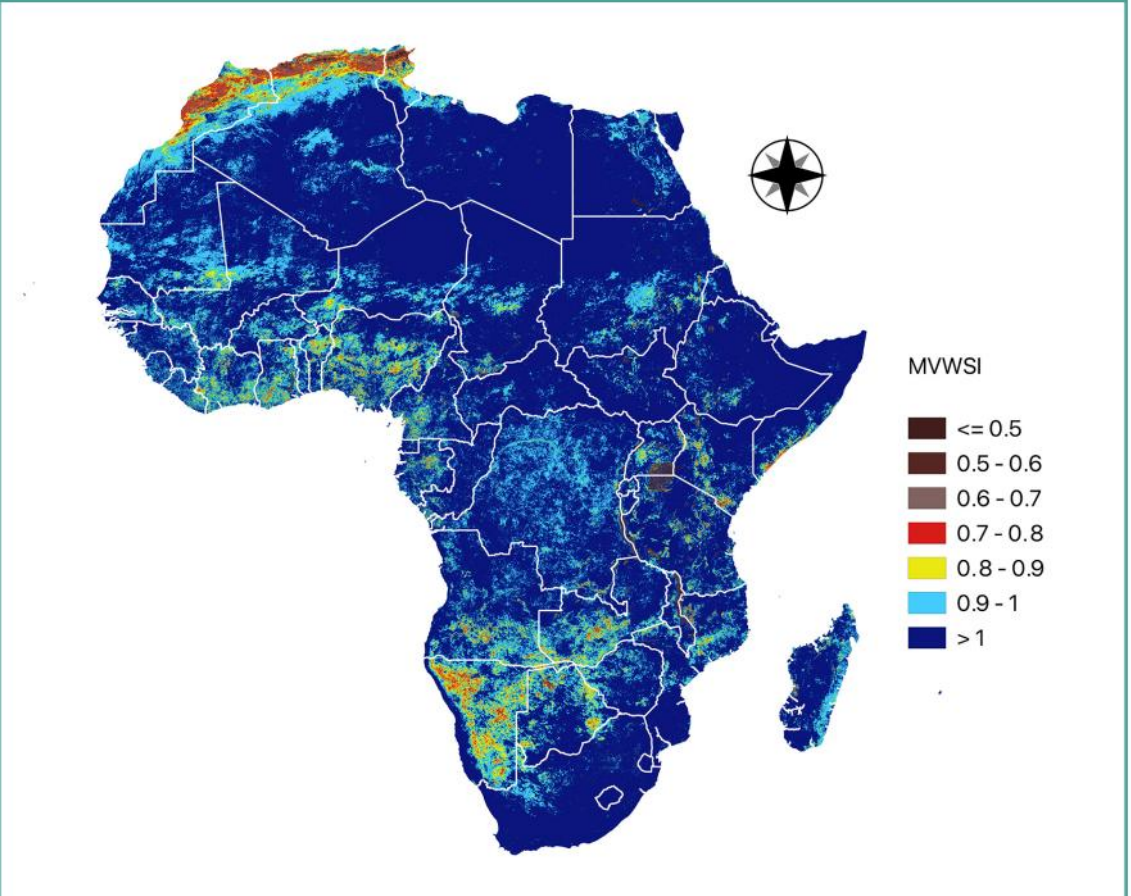
FIGURE 5.3—AFRICA 2023 LAND SURFACE TEMPERATURE DIFFERENCE FROM THE AVERAGE OF THE LAST 20 YEARS



Source: Data processing and map by authors, based on MODIS data.

DISCLAIMER: The designations employed and the presentation of material on this map do not imply the expression of any opinion whatsoever on the part of AKADEMIYA2063, the editors, and the authors.

FIGURE 5.6—AFRICA 2023 MODIFIED VEGETATION WATER SUPPLY INDEX

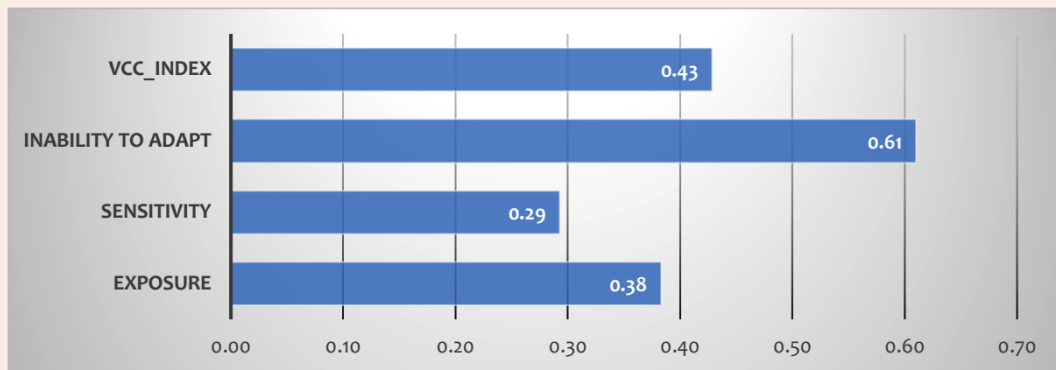


Source: Data processing and map by authors, based on MODIS datasets.

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Vulnerability to Climate Change (VCC)

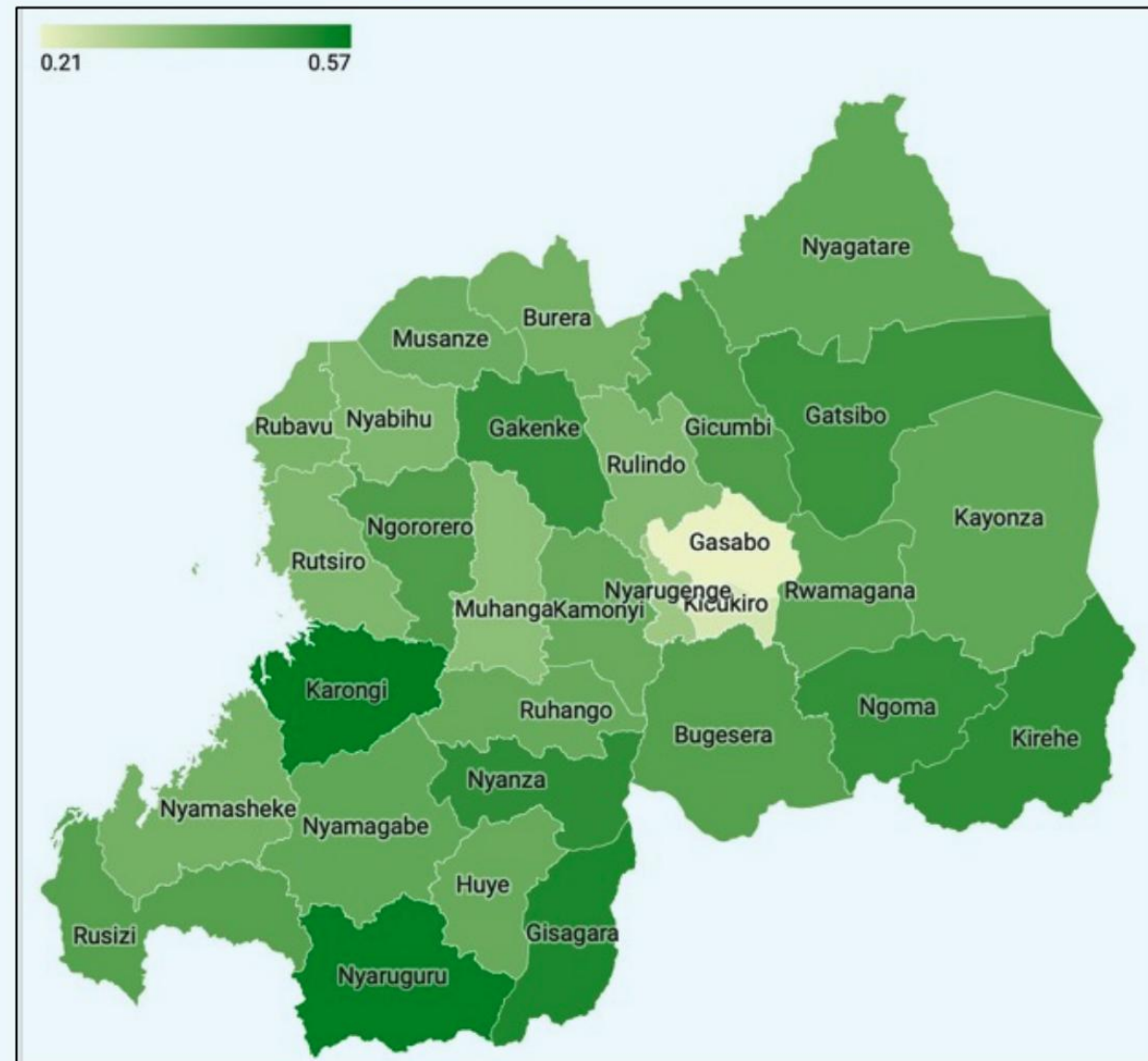
Figure 1: Vulnerability to Climate Change (VCC) Index score by component in 2021



Source: Authors' calculations using the 2021 CFSVA data (NISR 2023)

Province	Changes in VCC from 2018 to 2021
National	-0.05
Kigali	-0.16
Southern	-0.07
Western	-0.07
Northern	-0.03
Eastern	-0.03

Map 1: Household climate change vulnerability by district in Rwanda



Source: Authors' calculations using the 2021 CFSVA data (NISR 2023)

Impacts on agricultural productivity in Africa (by 2050 compared to 2005)

- Most affected: wheat, potatoes
- Less affected: maize, sorghum,
- No effect: Rice, Groundnuts, soyabeans,

TABLE 6.2 — PERCENTAGE CHANGE IN RAINFED YIELDS DUE TO CLIMATE CHANGE, 2005–2050, RCP8.5

Country/region	Median	Range		Includes CO ₂
		Min	Max	
Groundnuts				
World	9.3	6.1	15.0	20.2
Africa	6.8	-3.6	8.8	20.9
Eastern Africa	12.4	-11.0	15.8	21.0
Central Africa	9.3	2.7	14.3	22.4
Northern Africa	4.1	-23.4	37.7	22.1
Southern Africa	5.3	-9.4	15.0	18.8
Western Africa	3.0	-5.7	8.0	20.5
Maize				
World	-12.5	-36.2	-8.1	3.8
Africa	-11.0	-14.8	-5.6	-0.1
Eastern Africa	-3.0	-17.1	2.2	-0.2
Central Africa	-11.3	-18.9	-7.6	-0.2
Northern Africa	-26.4	-38.5	-7.8	0.0
Southern Africa	-9.4	-18.0	-1.4	-0.1
Western Africa	-17.7	-18.8	-13.0	-0.2
Potatoes				
World	0.9	-14.0	11.0	17.0
Africa	-16.4	-32.4	-3.4	12.0
Eastern Africa	-6.0	-19.0	1.0	11.8
Central Africa	-29.8	-59.2	0.3	8.3
Northern Africa	11.0	-17.2	31.9	29.0
Southern Africa	-28.0	-51.5	-6.6	13.3
Western Africa	-57.0	-81.4	-32.9	5.4
Rice				
World	8.2	3.7	14.7	15.0
Africa	2.9	-4.4	4.0	11.0
Eastern Africa	-4.5	-18.8	10.0	9.6
Central Africa	2.0	-7.0	3.6	11.2
Northern Africa	29.5	6.7	52.9	15.4
Southern Africa	6.6	1.3	12.5	8.8
Western Africa	3.4	-3.3	5.8	12.1
Sorghum				
World	-2.4	-5.9	-0.2	2.2
Africa	-1.1	-13.2	0.6	1.2
Eastern Africa	9.3	-7.9	11.2	0.8
Central Africa	-0.8	-5.8	3.8	0.8
Northern Africa	5.7	-23.2	8.8	1.8
Southern Africa	2.9	-7.4	4.6	0.9
Western Africa	-5.2	-11.8	-1.8	0.8
Soybeans				
World	6.9	-1.7	19.1	22.1
Africa	13.0	8.7	16.4	22.6
Eastern Africa	21.9	2.5	34.3	26.5
Central Africa	12.6	8.5	16.8	23.5
Northern Africa	28.7	20.8	62.6	22.1
Southern Africa	11.0	0.3	27.5	21.2
Western Africa	12.2	4.1	17.9	22.4
Wheat				
World	21.1	17.1	24.3	14.4
Africa	-31.3	-37.0	-22.0	6.9
Eastern Africa	1.1	-1.0	3.1	12.8
Central Africa	-5.0	-11.3	3.1	11.6
Northern Africa	-42.5	-50.9	-31.7	4.9
Southern Africa	-4.9	-22.6	1.6	10.7
Western Africa	-21.2	-34.2	48.0	8.5

Source: DSSAT crop model results based on five RCP8.5 climate models from ISIMIP3b.
 Note: RCP8.5 = representative concentration pathway 8.5 (highest-emissions scenario). The model assumes no adaptation measures such as changing crop mixes or cultivars in any given location. It also assumes no land expansion.

Impacts on agricultural productivity in Rwanda (by 2030 compared to 2020)



Table 4. Simulated changes in agricultural productivity of some major crops in Rwanda

	Business-as-Usual		Climate change		
	Mean	SD	Mean	SD	Variation (mean)
Agriculture	4.83	0.46	-7.17	0.21	-12
Maize	4.50	0.18	-11.68	0.04	-16.18
Rice	-1.53	0.35	4.76	0.26	6.29
Other cereals	1.71	0.85	-27.79	0.25	-29.5
Pulses	1.69	0.11	-2.32	0.04	-4.01
Oilseeds	-2.37	0.20	3.78	0.09	6.15
Roots	18.23	0.71	-15.00	0.21	-33.23
Vegetables	3.87	0.15	-22.34	0.12	-26.21
Fruits and nuts	5.48	0.27	0.88	0.15	-4.6
Coffee, tea, and cocoa	10.08	1.24	-15.31	0.70	-25.39
Other crops	6.60	0.53	13.35	0.19	6.75

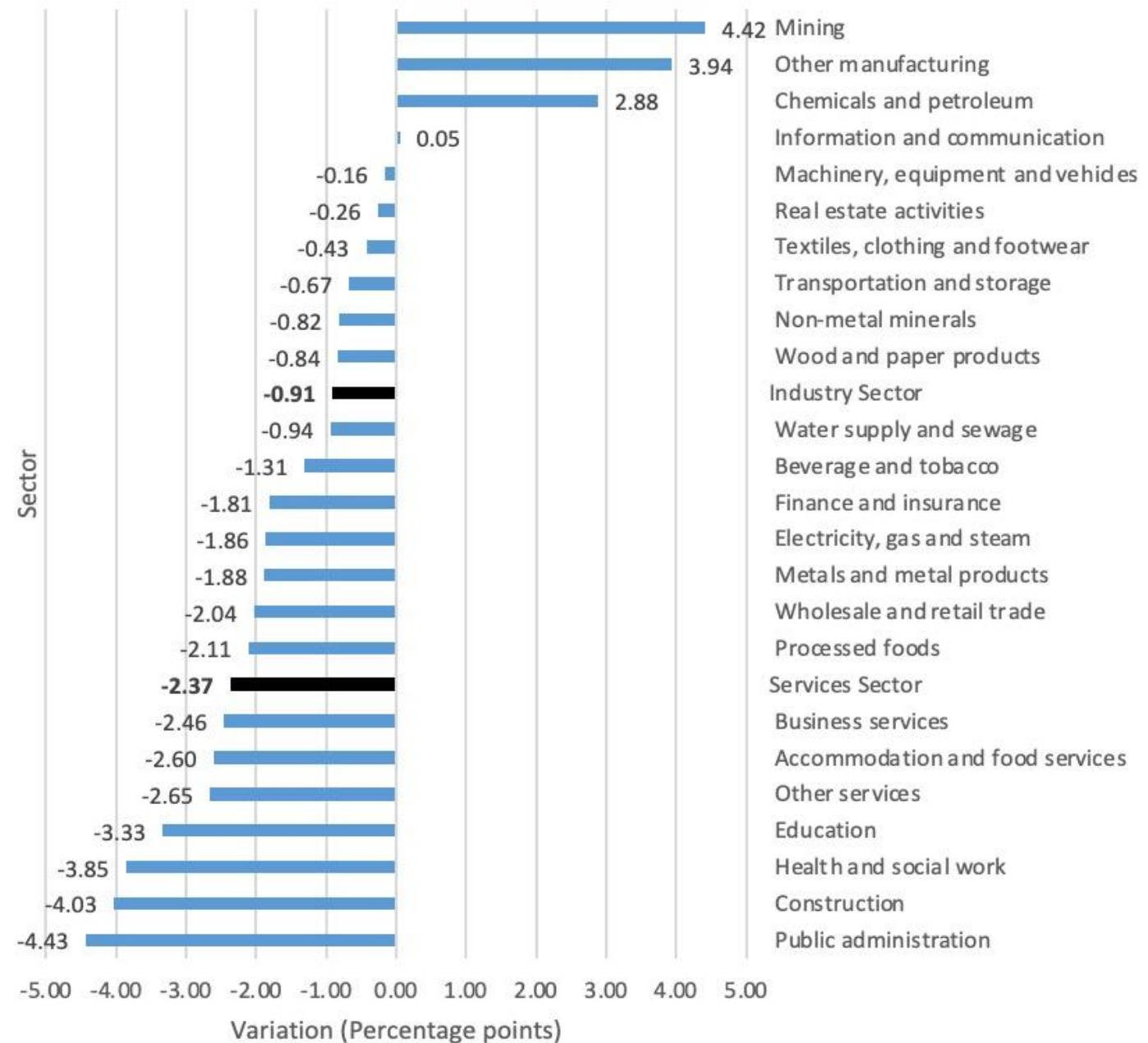
Source: Compilation from simulation results (2024).

- Most affected: Maize, roots, and vegetables, coffee and tea
- Less affected: fruits and nuts,
- No effect: Rice and oilseeds

Impacts on Non-farm sectors' value addition (compared to BAU-without CC)

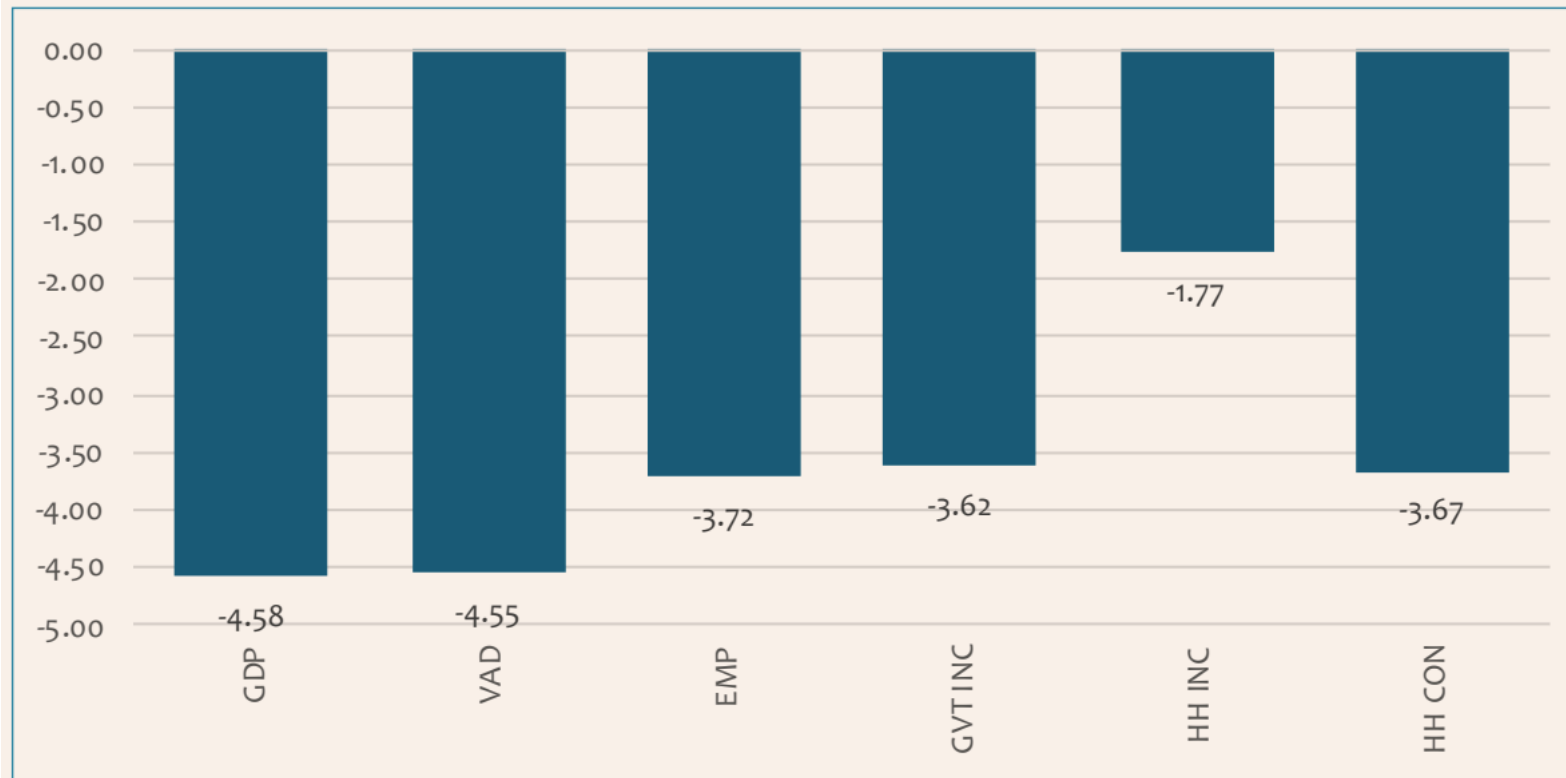
- The impact of climate change on agricultural productivity trickles down to other sectors
- Only few sectors such as mining, manufacturing sectors are immune
- The service will be reduced by 2.4 percentage points

Figure 1: Climate Change Impacts on Non-Agriculture Sectors



Macroeconomic Impacts: (Compared to BAU)

Figure 3: Macro-economic Impacts of Climate Change in Rwanda, Percentage Variation



Source: Authors' calculations.

GDP = gross domestic product, VAD = value-added, EMP = employment, GVT INC = government income, HH INC = household income, HH CON = household consumption.

Cost of Action

The cost of actions are of two types

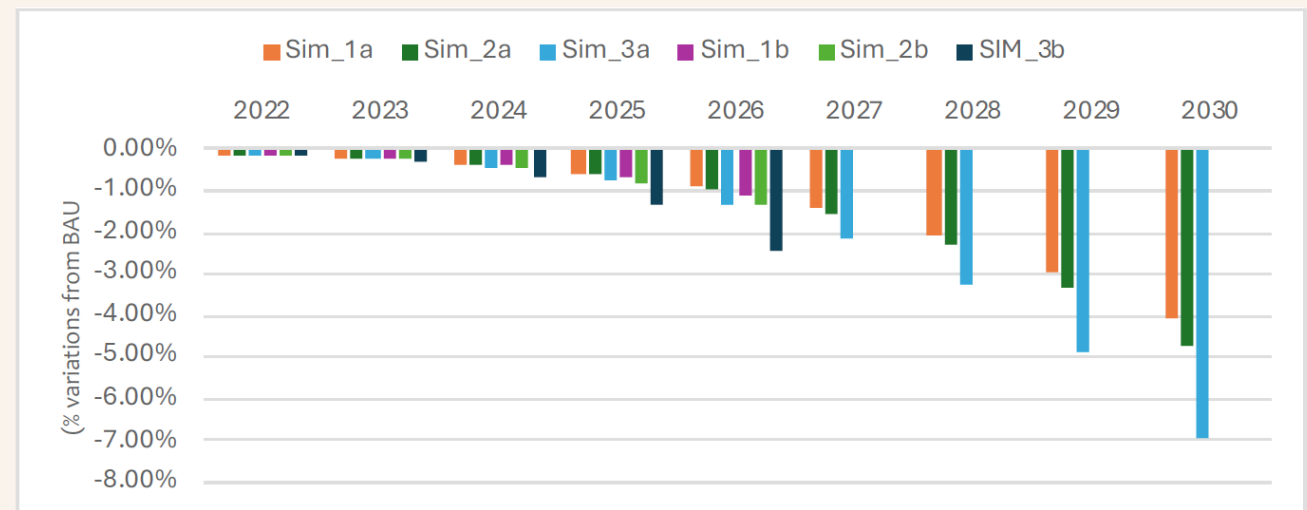
1. Investments needed to reverse impacts of climate change

- According to the AfDB, Africa requires \$277 billion annually to adapt and mitigate climate change

2. Abatement cost : the cost of reducing GHG emissions

- The direct abatement cost: investment in clean technology
- Indirect cost : the forgone ber

Figure 3b: Emissions Reduction Impacts on RGDP (% variations from BaU)



Source: Authors' calculations.

Conclusion

- Exploring the impacts of climate change is essential for several reasons
- However, we must understand the complexity and multiplicity of the damages and losses and their dependency on exposure, sensitivity and adaptive capacity
- In Africa, including Rwanda, the impact is pronounced not by widespread exposure but because of sensitivity and lack of capacity to cope with the shocks and stresses
- Because of the structure of the economies, a small reduction in crop and livestock productivity induces significant impacts on non-farm sectors and macroeconomies
- Therefore, Africa shouldn't retreat from climate actions and sustainable development