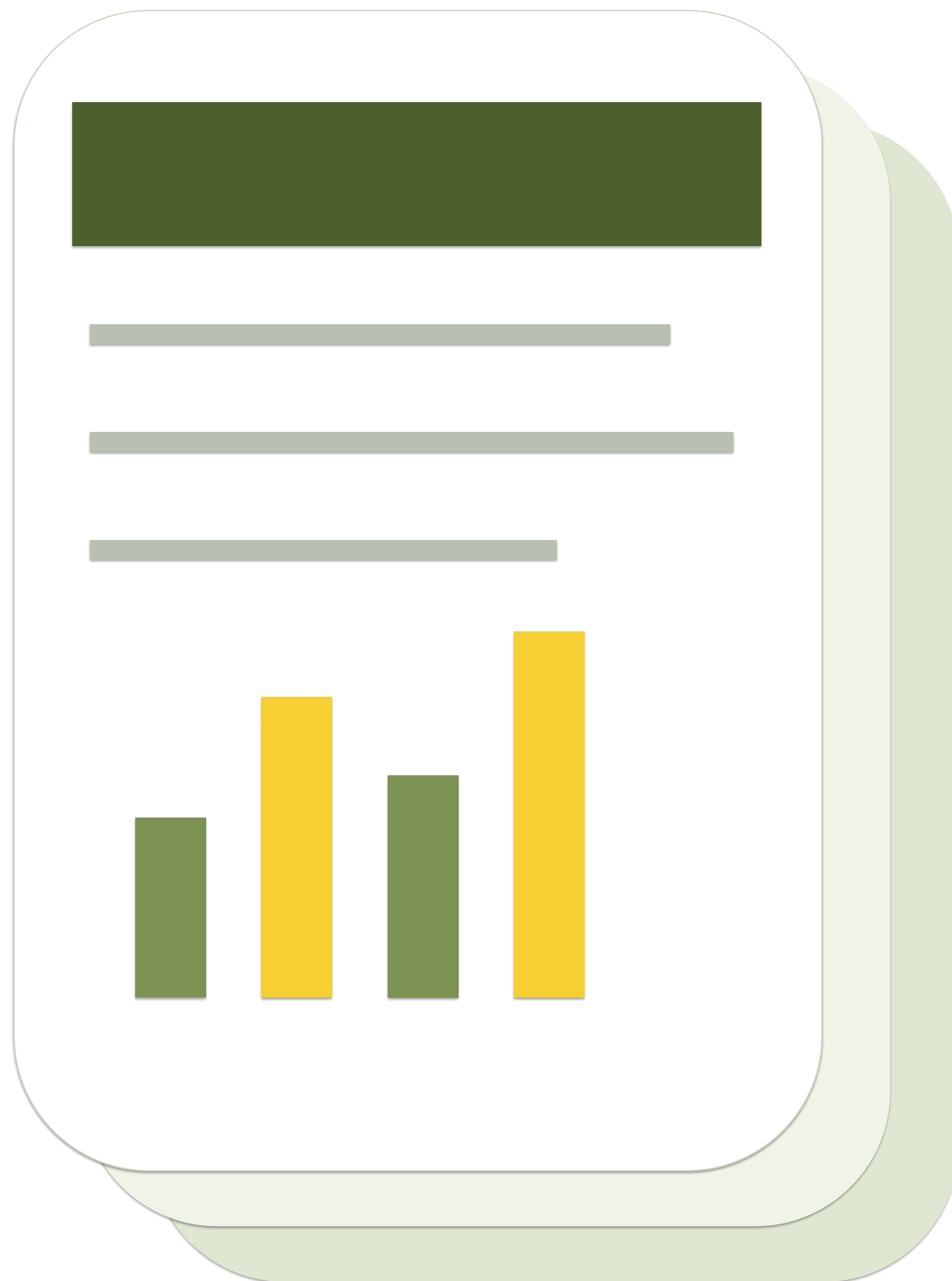


POSTER PRESENTATIONS

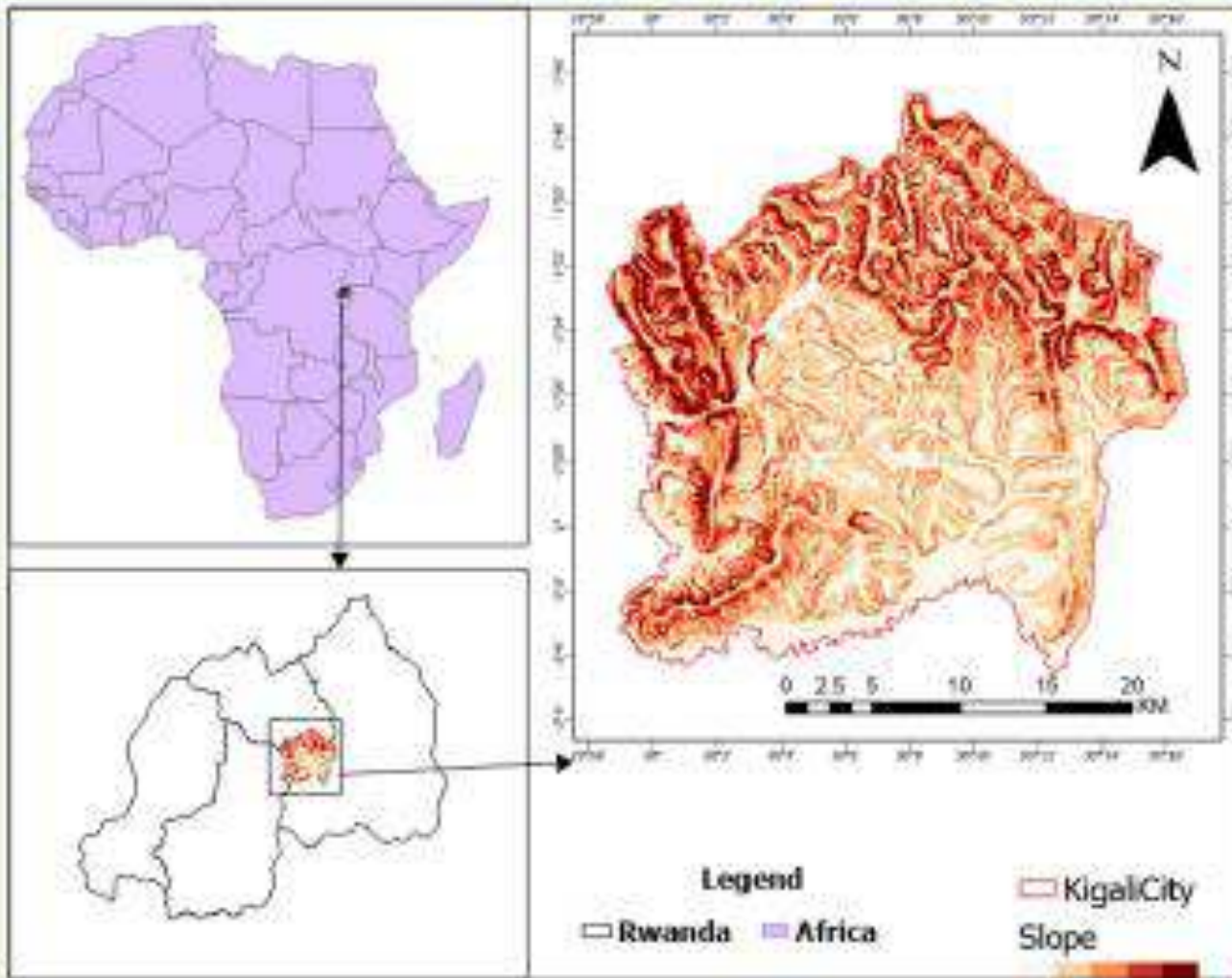
A collection of research posters presented at the
2nd Rwanda Climate Science Symposium.



1.Introduction

Rapid urbanization in Kigali City is transforming land-cover patterns through the expansion of impervious surfaces and the reduction and fragmentation of vegetated and wetland areas. These changes can intensify Urban Heat Island (UHI) effects and increase surface thermal stress. Nature-Based Solutions (NBS), including urban forests, parks, wetlands, and riparian vegetation, offer potential ecosystem-based approaches for mitigating urban heat. This study examines spatiotemporal changes in Land Surface Temperature (LST) and UHI intensity and evaluates the cooling potential of NBS across Kigali City(2005-2025).

2.Study area and data

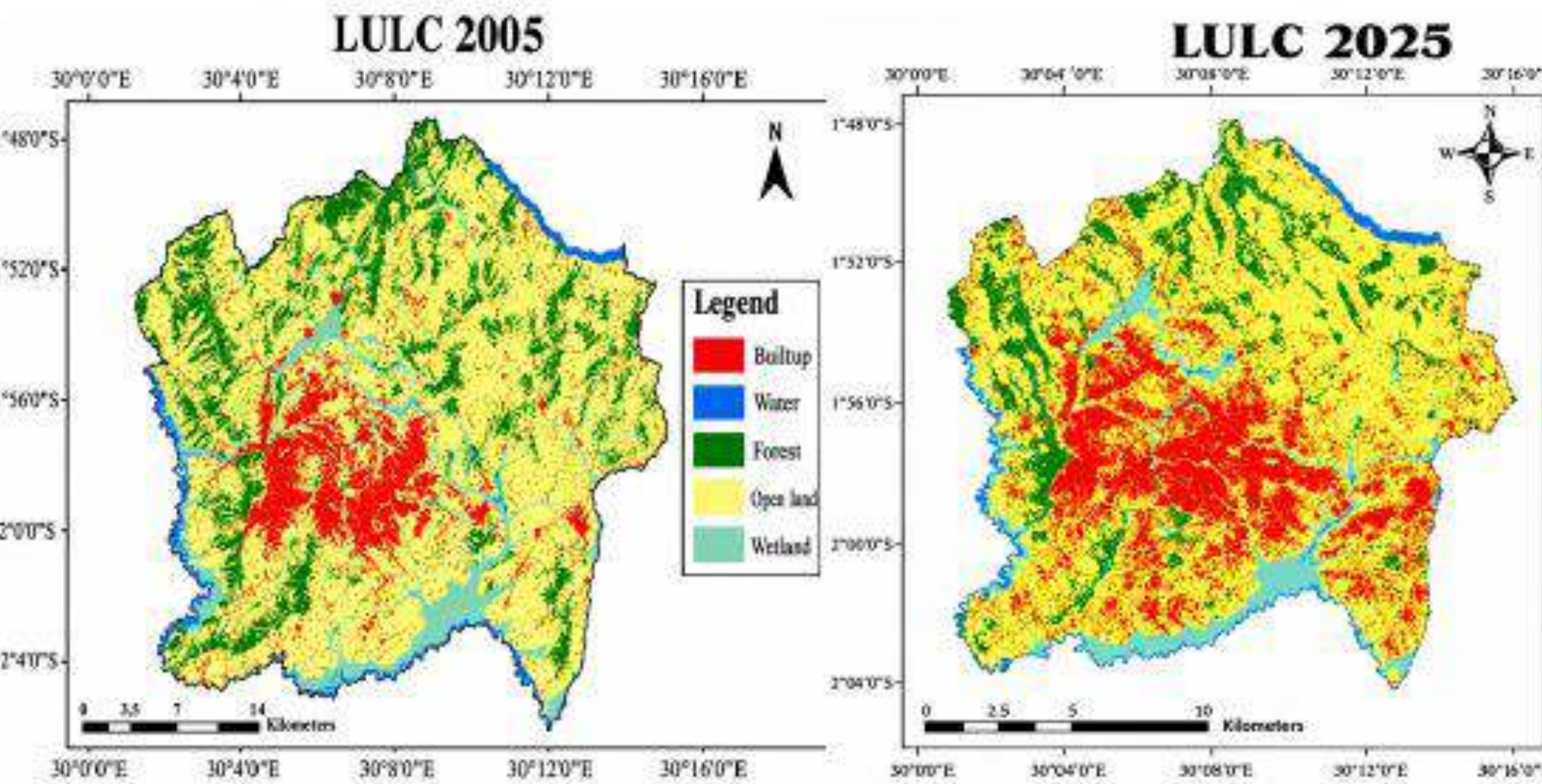


- Kigali boundary: user-provided GEE asset.
- Landsat 5 TM: 2005 and 2010.
- Landsat 8/9 OLI/TIRS: 2015 LST.
- Sentinel-2: 2025 high-resolution land-cover/NBS mapping.
- Derived variables: NDVI, NDBI, MNDWI and LST.

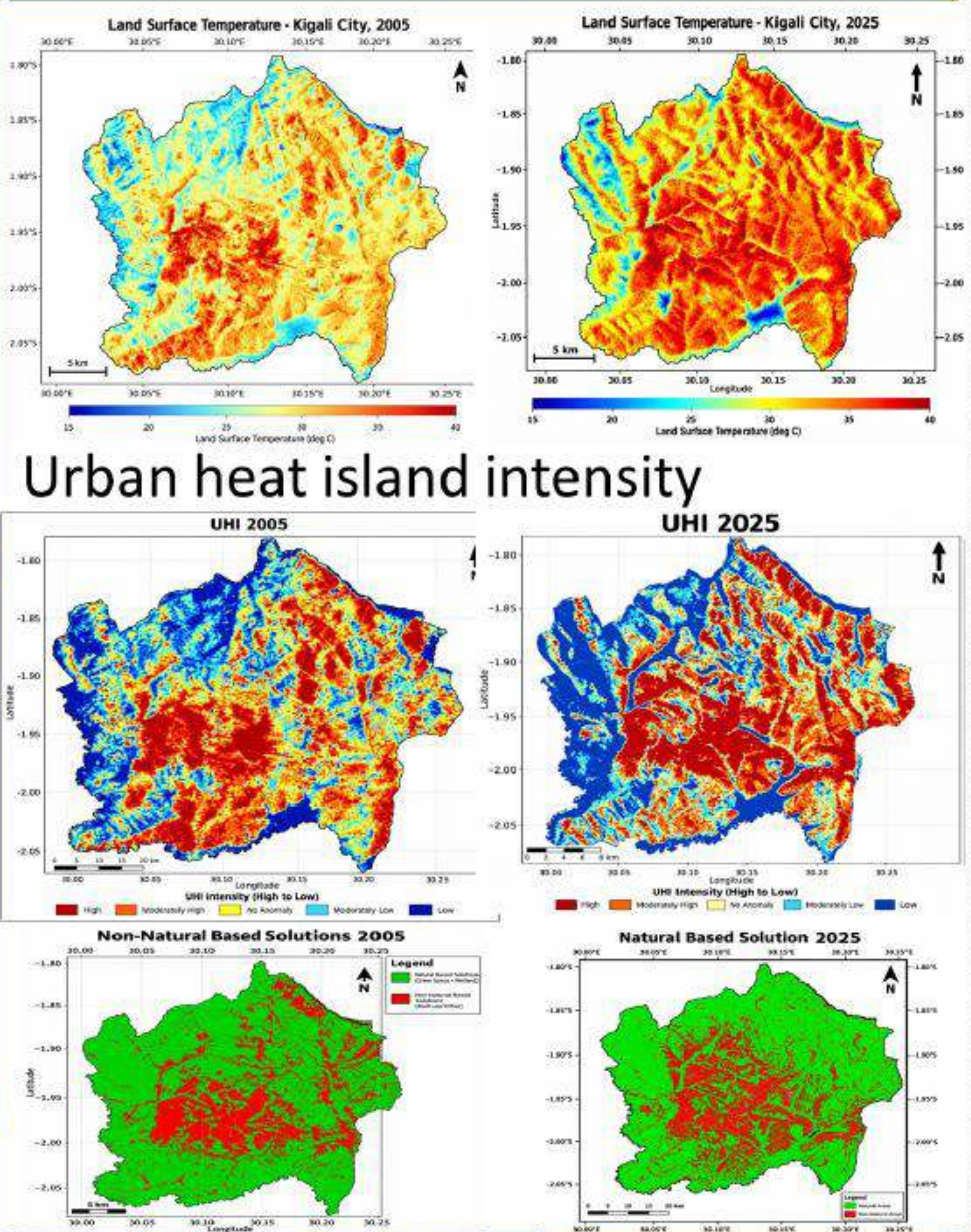
3.Methodology



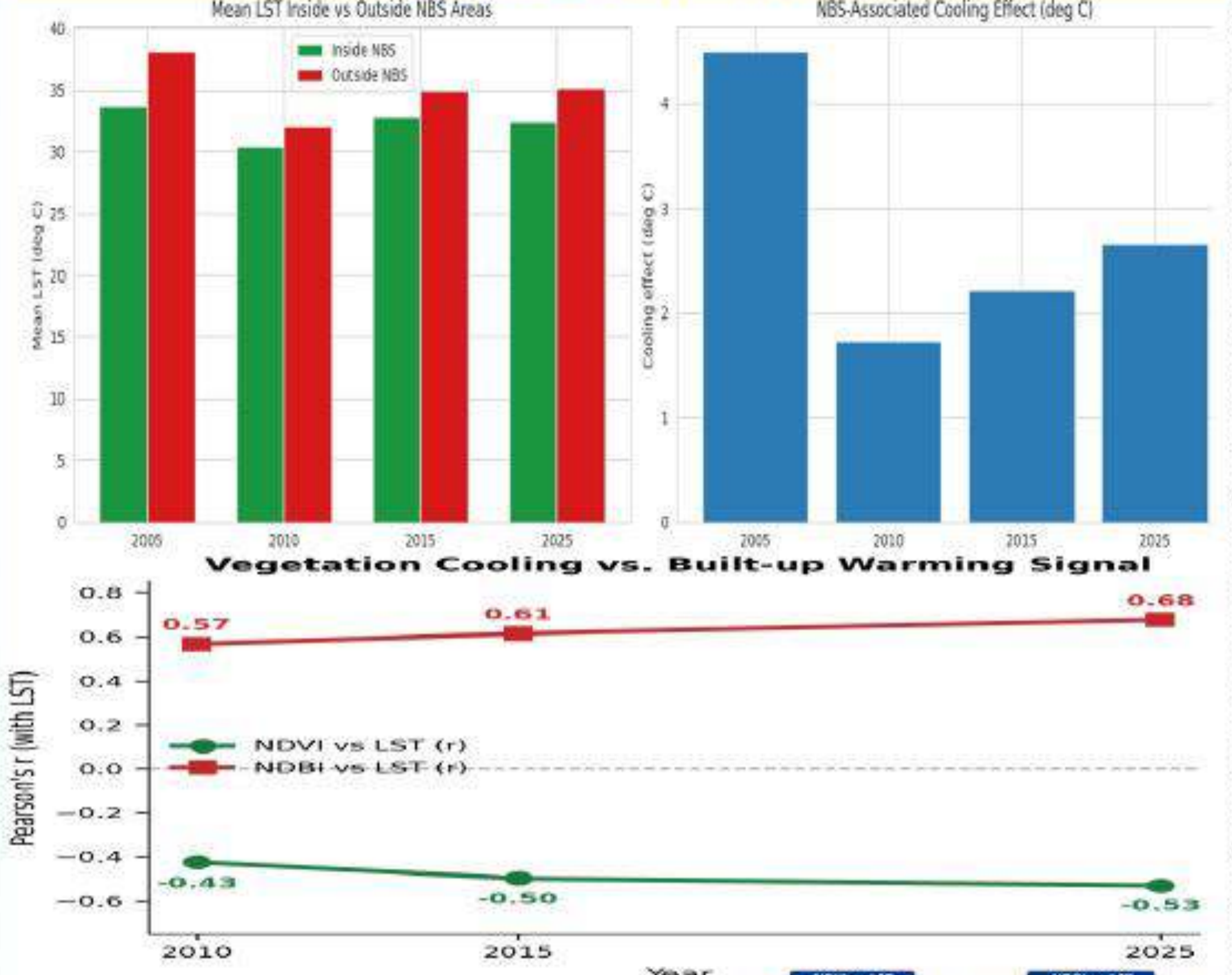
Multi-temporal Landsat imagery (2005–2025) and sentinel 2 was preprocessed and harmonized to derive NDVI, NDBI, MNDWI and LST. Land cover was classified using Random Forest, benchmarked against SVM and XGBoost, then used to quantify Urban Heat Island intensity and Nature-Based Solutions cooling effects through zonal and regression analysis.



4.Results



5.Relationships



6.Conclusion

Between 2005 and 2025, Kigali experienced substantial impervious-surface expansion, green-space fragmentation, and rising LST and UHI intensity. Vegetation, parks, wetlands, and riparian corridors provided measurable cooling, supporting urban greening, green corridors, and nature-based solutions for climate-resilient development.

7.References

- Brou et al., 2026
- Safari et al., 2024
- (Id et al., 2021)

Multi-method causal evidence of depth-dependent precipitation-to-soil-moisture coupling across East Africa

Douanla A. Yaulande¹ · Mouhamadou B. Sylla¹ · Rob Parker² · Cristina R. Villena² · André Dembélé³

¹AIMS Research and Innovation Centre (AIMS-RIC) · ²University of Leicester · ³USTTB Bamako

1 · Why causal evidence?

- Drought monitoring usually starts with correlations, analog outlooks, and standardised indices.
- Correlation alone cannot tell local coupling from shared climate drivers.
- Does past rainfall improve soil-moisture prediction once we account for shared drivers? How does that link change with depth, lag, and direction?

2 · Data & causal framework

- CHIRPS v2.0 monthly precipitation and ERA5-Land soil moisture at 7, 28, 100, and 289 cm.
- 68,862 land pixels; 1980–2024; 540 monthly time steps.
- Robust STL de-seasonalisation, z-score standardisation, and a dual ADF–KPSS stationarity screen.
- Conditional Toda-Yamamoto Granger test with HAC inference.
- Back-door controls: ENSO, IOD, net radiation, VPD, and lagged neighbouring soil moisture.
- Benjamini-Yekutieli FDR and a 5×5 spatial block bootstrap.
- Acronyms: TY (Toda-Yamamoto), BY (Benjamini-Yekutieli), FDR (false-discovery rate), HAC (heteroskedasticity- and autocorrelation-consistent), VPD (vapour-pressure deficit).

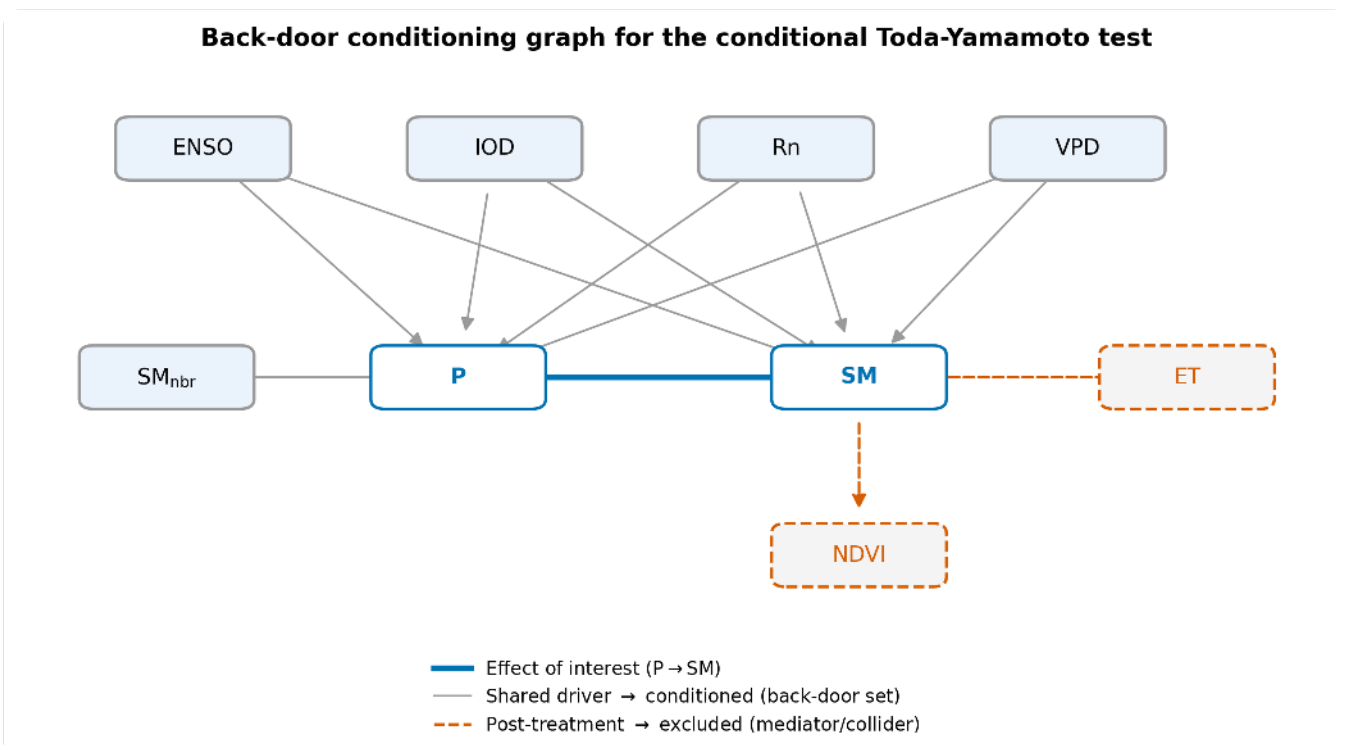


Fig. 1 | Back-door conditioning graph. Shared drivers are conditioned on, and mediators and colliders are excluded.

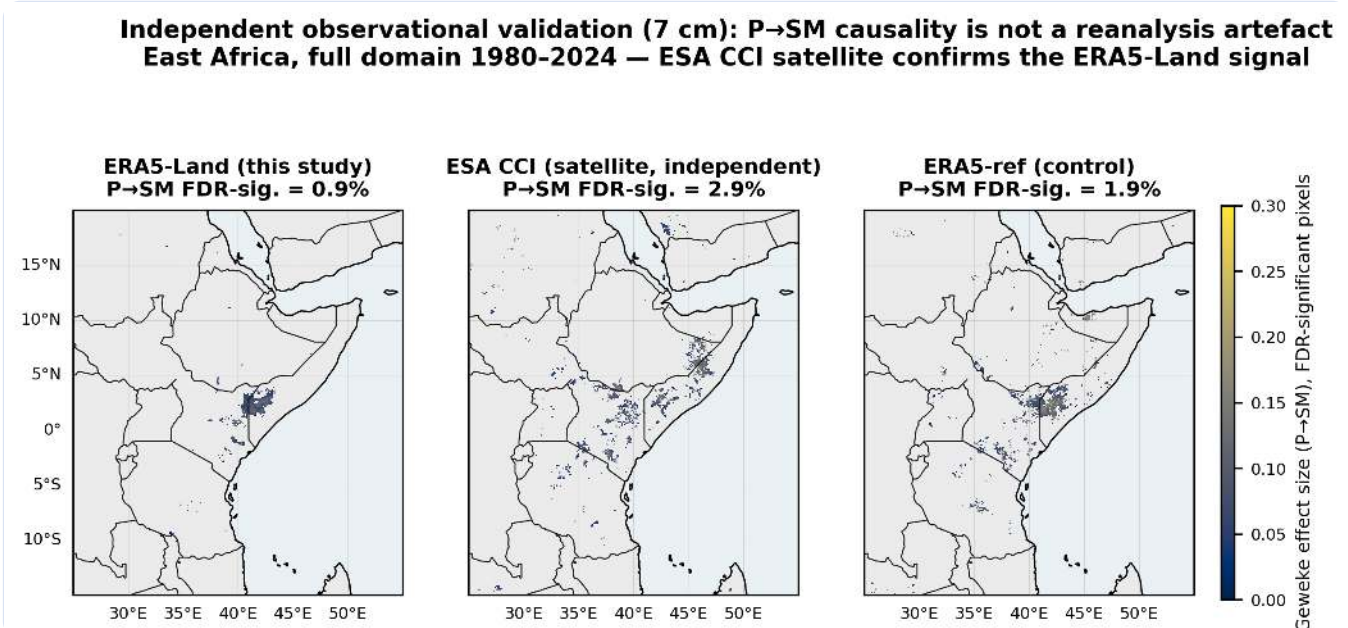


Fig. 2 | Independent surface validation. ESA CCI reproduces the aggregate surface signal, but pixel-level agreement is only modest.

5 · Limits & operational implications

- The results are predictive-causal, not interventionist proof.
- The fractions are BY-adjusted rejection fractions, not prevalence estimates or bounds.
- Deep validation is still limited, and root-zone confirmation is model-shared rather than independent in-situ.
- Root-zone monitoring deserves priority, but forecast skill still needs validation before operational use.

3 · Main depth result

- PSM coupling is strongest in the root zone.
- Significant coupling clusters in semi-arid transition belts and weakens in humid forest zones.
- Mean optimal lag rises slightly with depth, and most significant pixels select a one-month lag.

Depth: 7 / 28 / 100 / 289 cm
PSM after BY FDR: 0.9 / 5.0 / 9.5 / 2.6 %
Mean selected lag: 1.0 / 1.0 / 1.1 / 1.6 months

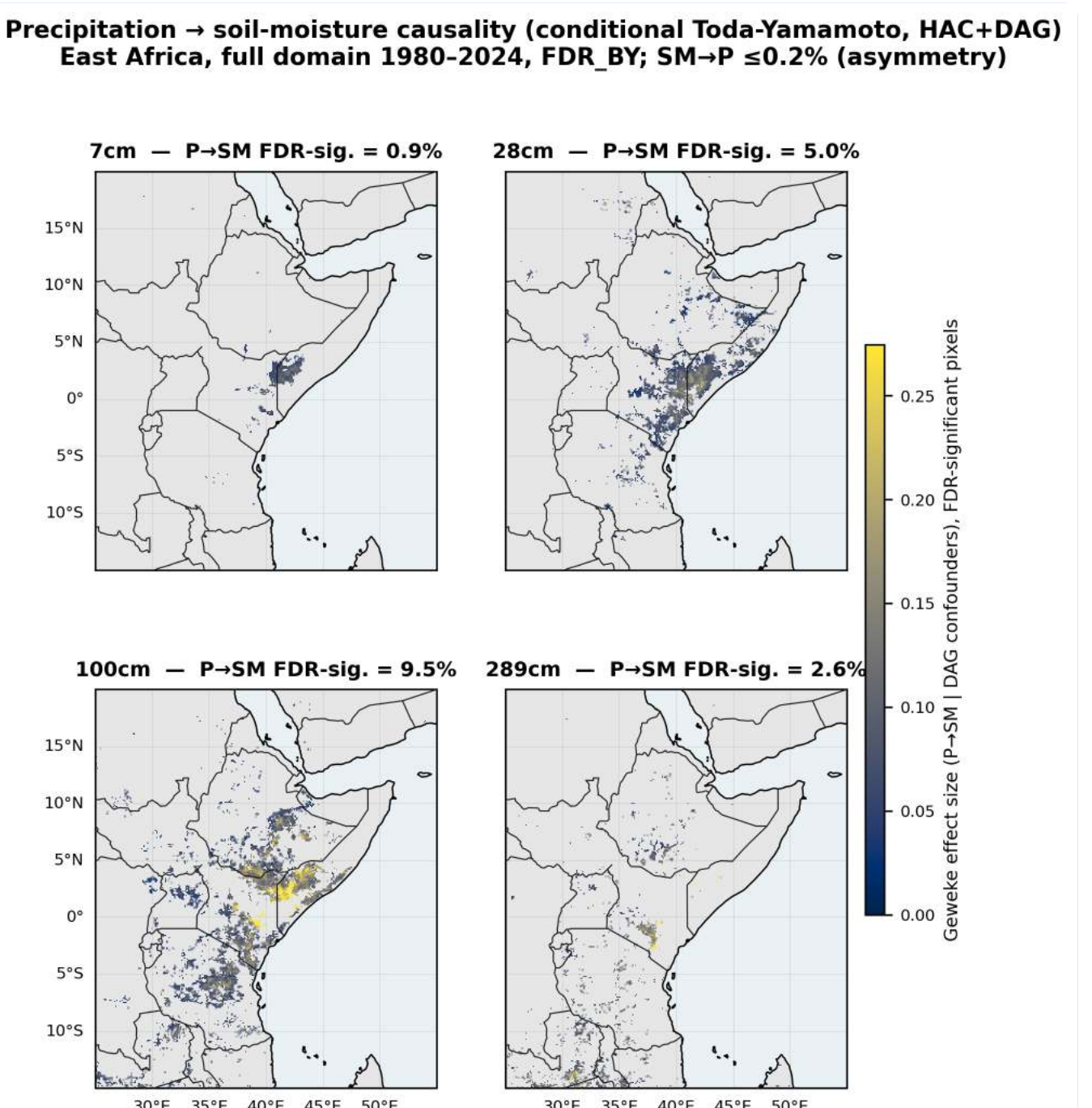


Fig. 3 | Conditional Toda-Yamamoto maps after BY FDR. Significant pixels cluster in semi-arid transition belts.

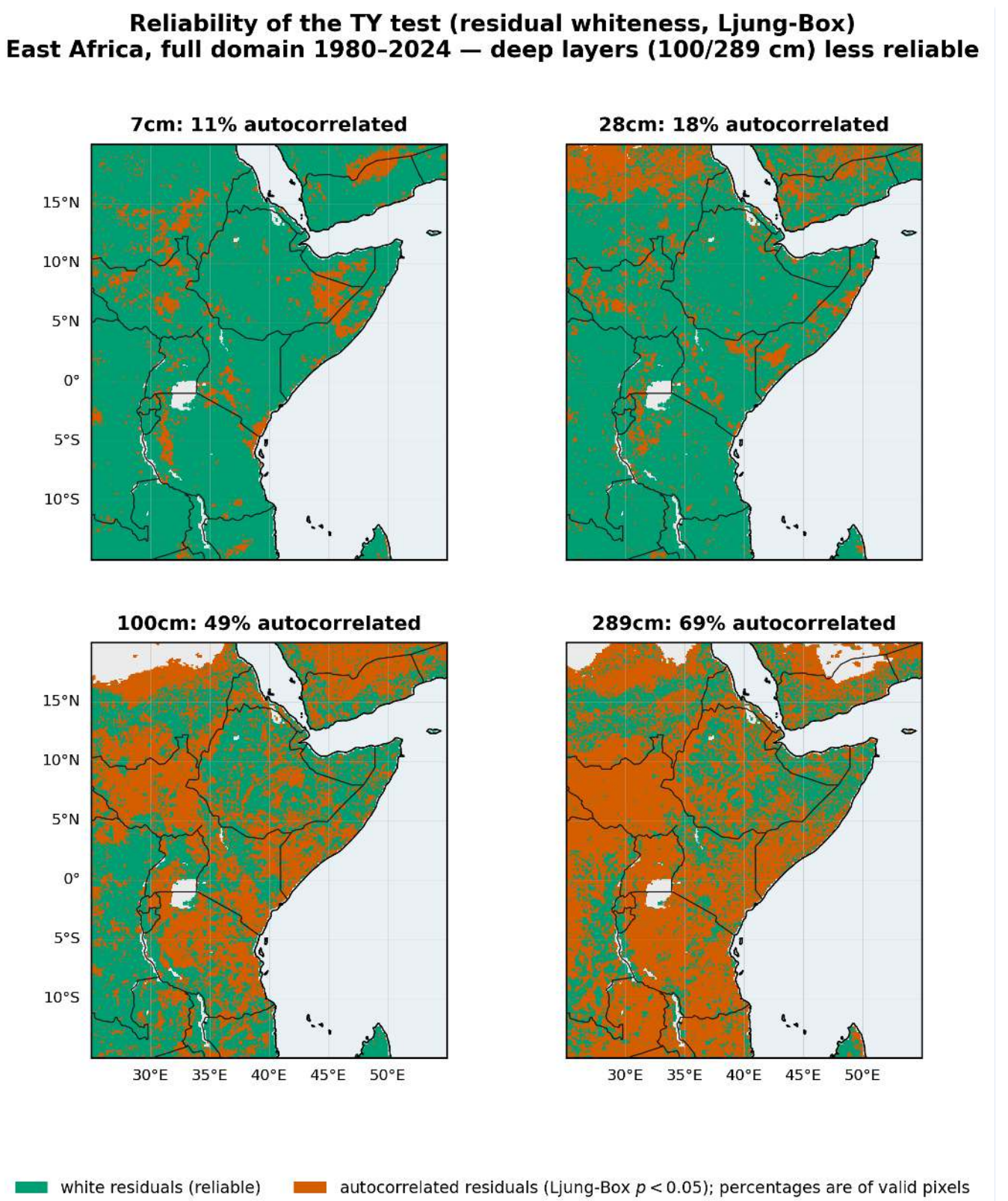


Fig. 4 | Reliability by depth. Residual diagnostics rise with depth, and 100 cm remains the strongest reliable layer.

- Reliability falls with depth, and 100 cm remains the strongest reliable layer.
- A well-specified-pixel screen preserves the root-zone maximum.
- Interpretation of the deepest layer remains cautious.

4 · Rigour, direction & triangulation

- Naive single-method statistics report much larger coupling fractions.
- At 100 cm, raw Granger gives 64.8%, FDR Granger 51.9%, the composite 22.0%, and conditional TY 9.5%.
- The reverse direction SMP stays at or below 0.2%, so no monthly-scale feedback survives correction.
- Triangulation at 100 cm gives TY 9.5%, Breitung-Candelon 7.8%, and transfer entropy 16.8% raw.
- The methods differ in estimand and null, so the differences measure sensitivity rather than prove false positives.

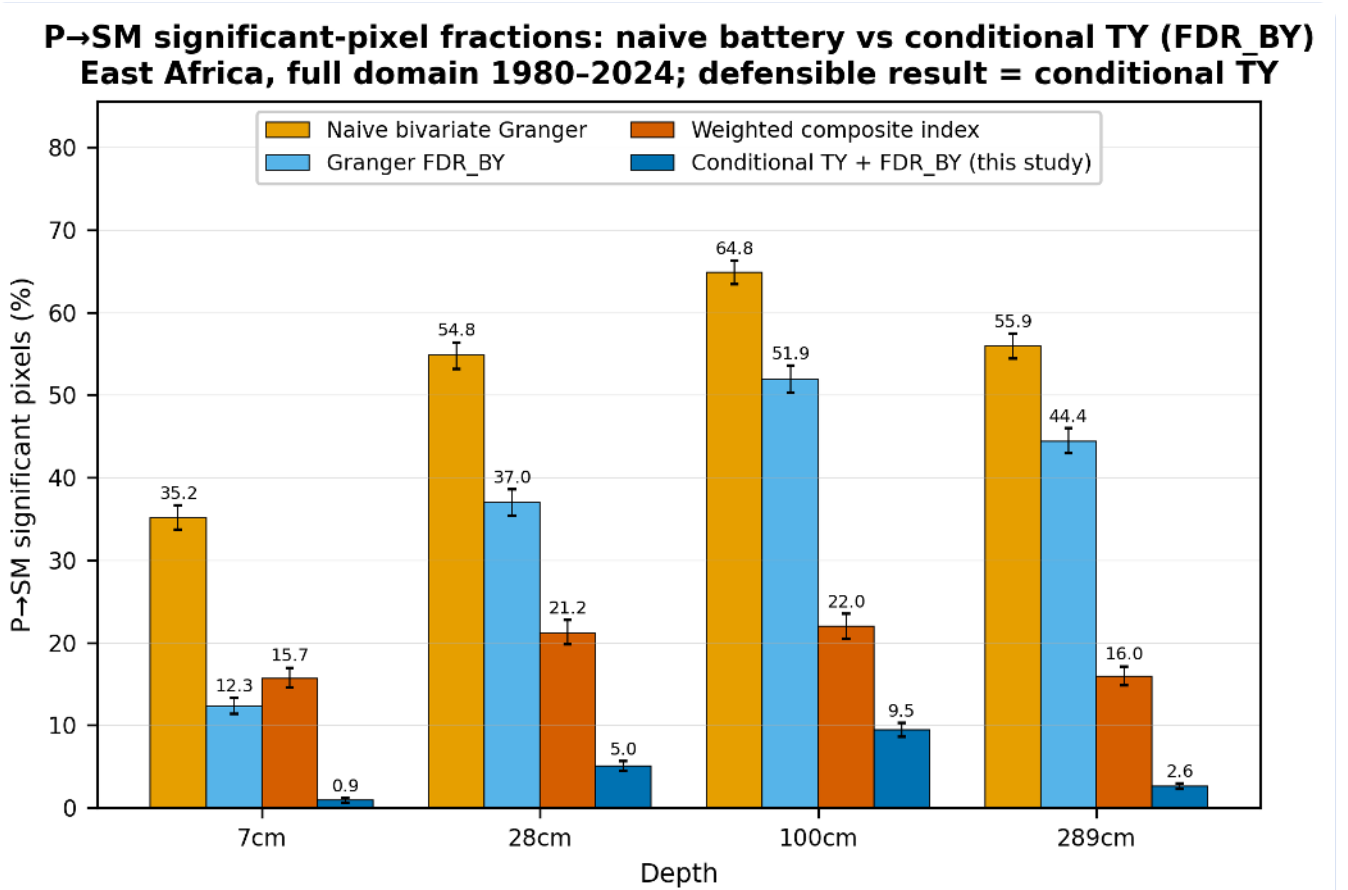


Fig. 5 | Naive vs rigorous estimators. Every naive estimator exceeds the conditional headline at every depth.

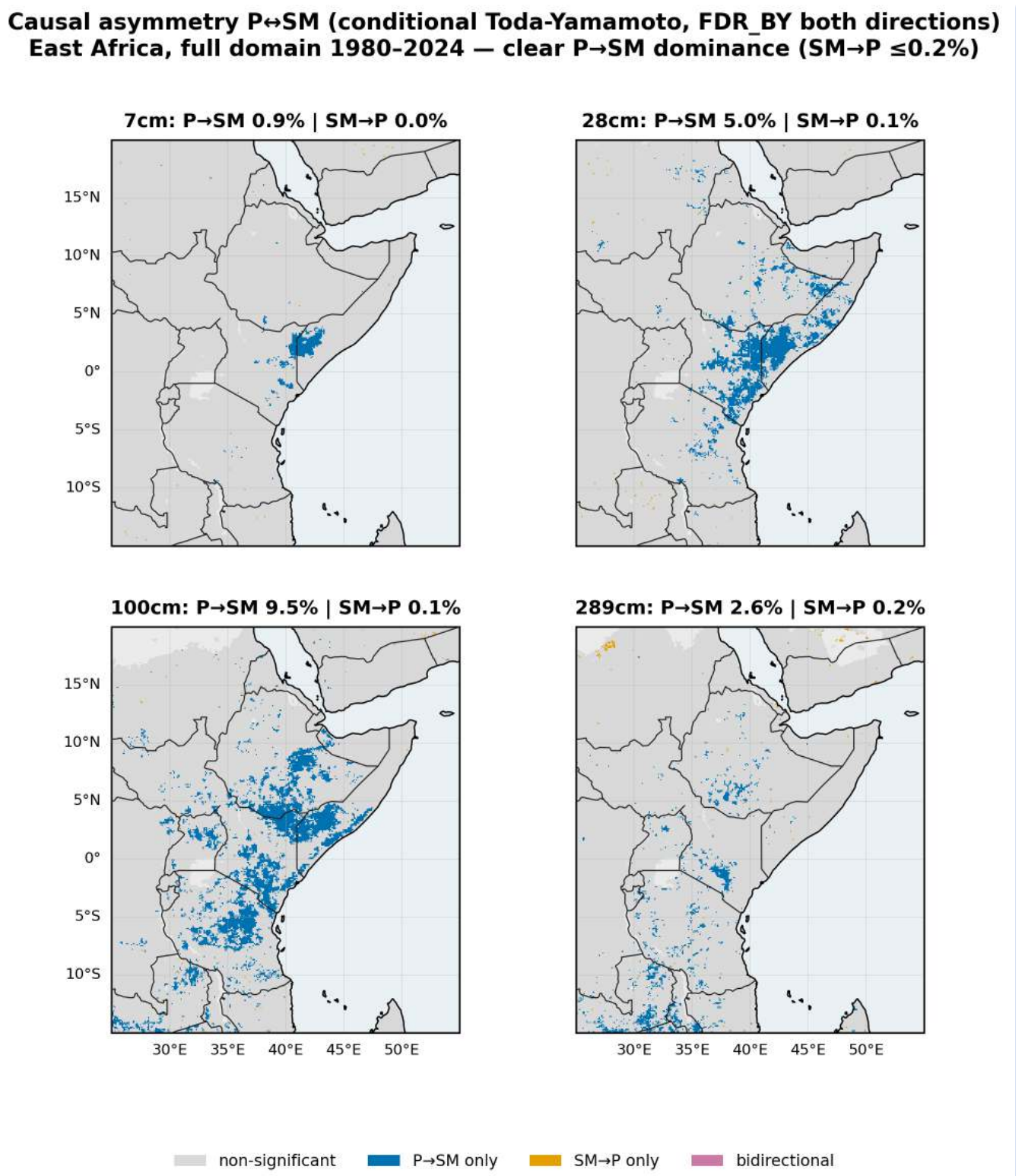


Fig. 6 | Directional asymmetry. SMP stays at or below 0.2%, so no monthly-scale feedback survives correction.

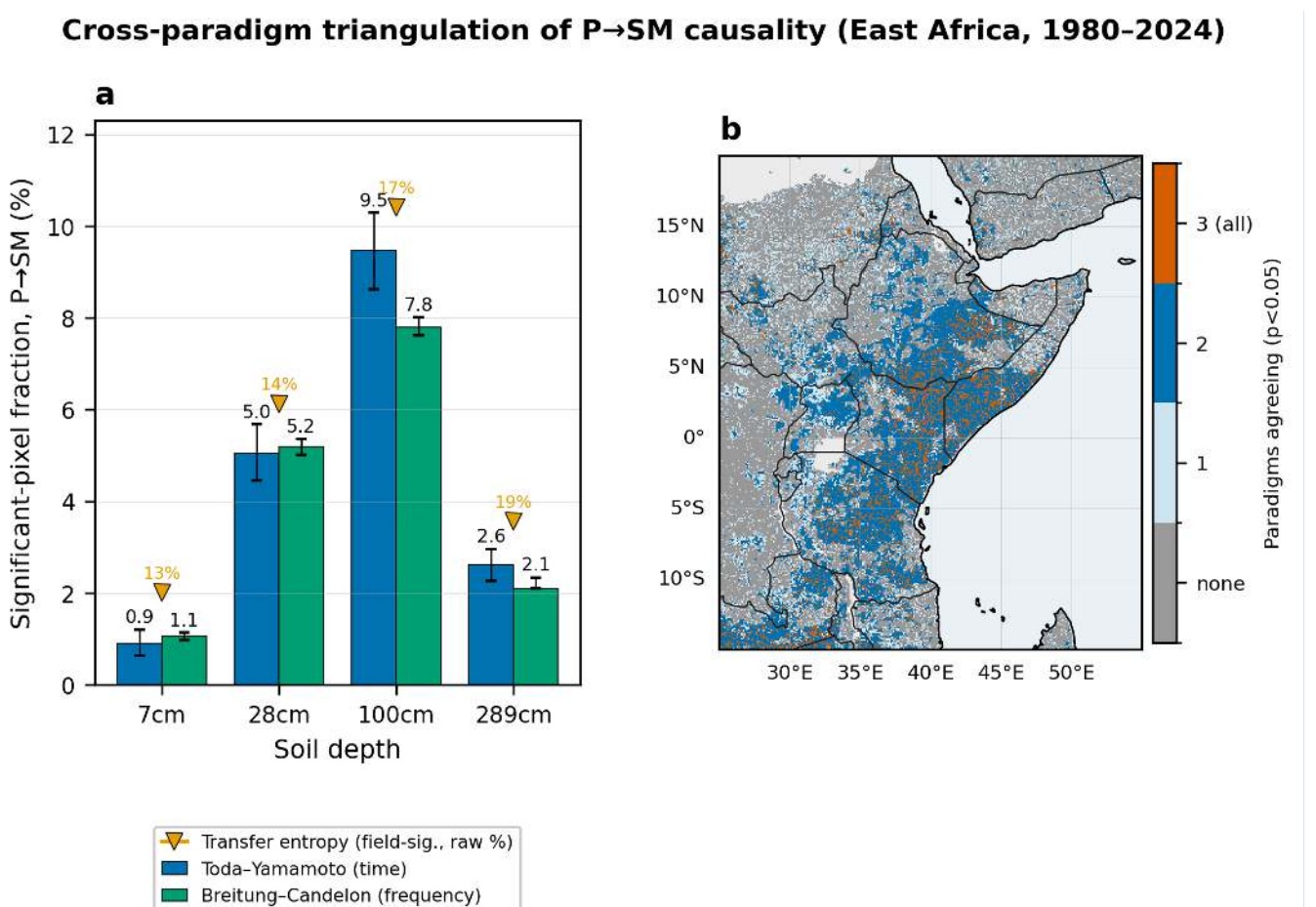


Fig. 7 | Cross-paradigm triangulation. Time, frequency, and information-theoretic tests all show the increase through 100 cm.

- Root-zone soil moisture shows the strongest reliable coupling.
- We find no monthly-scale SMP feedback, and sub-monthly feedback remains unresolved.
- Use confounder-conditioned, dependence-robust causal diagnostics before deploying them operationally.
- Main methods: Toda-Yamamoto, Newey-West HAC, Benjamini-Yekutieli FDR, and spatial block bootstrap.



UNIVERSITY OF
GOTHENBURG

Growth and Biomass Responses to Warming in Afrotropical Native Trees

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1. Introduction

- Montane forest are potential refuge for Species migration under warming pressure
- Warming will decline biomass productivity of montane tree species in the tropics
- Tree communities are experiencing directional shifts in composition towards greater relative abundances of species with ranges centred at lower, warmer elevations: **Thermophilization**(Duque et al., 2015; Fadrique et al., 2018, Ntirugulirwa et al 2023)
- Macaranga kilimandscharica(Mki) and Syzygium guineense(Sgu) together comprise 18% of tree individuals of Nyungwe Afromontane forest(Prumtre et al 20202).

2. Objectives

This study assessed warming effects on growth performance, and biomass production of Macaranga kilimandscharica (pioneer) and Syzygium guineense (climax), dominant species in Nyungwe Forest

3. Material and Methods

- Rwanda Tropical Elevation Experiment (Rwanda TREE) mixed forest plantation:<https://www.rwandatree.com>
- Plant material: 20 Afromontane native tree species
- 3 sites with an approximate warming gradient difference of 6.9 °C
- Measurements: Survivors, Allometry, Fresh mass(destructive tree harvest after 4.5 years)- Mki &Sgu

Site and Treatment description in Rwanda TREE

High Elevation - Sigira
2400 m. a. s. l.
17.1/23.1 °C, 2100 mm

Mid Elevation - Rubona
1600 m. a. s. l.
22.4/28.3 °C, 1600 mm

Low Elevation - Makera
1300 m. a. s. l.
24.0/31.3 °C, 1100 mm

Treatments:

LN	Control	Shelter -500 mm	Shelter -900 mm
HN	Fertilizer	Shelter -500 mm & Fertil.	Shelter -900 mm & Fertil.
	HW	MW	LW

Treatments:

LN	Irrigation +500 mm	Control	Shelter -400 mm
HN	Irrigation +500 mm & Fertil.	Fertilizer	Shelter -400 mm & Fertil.
	HW	MW	LW

Treatments:

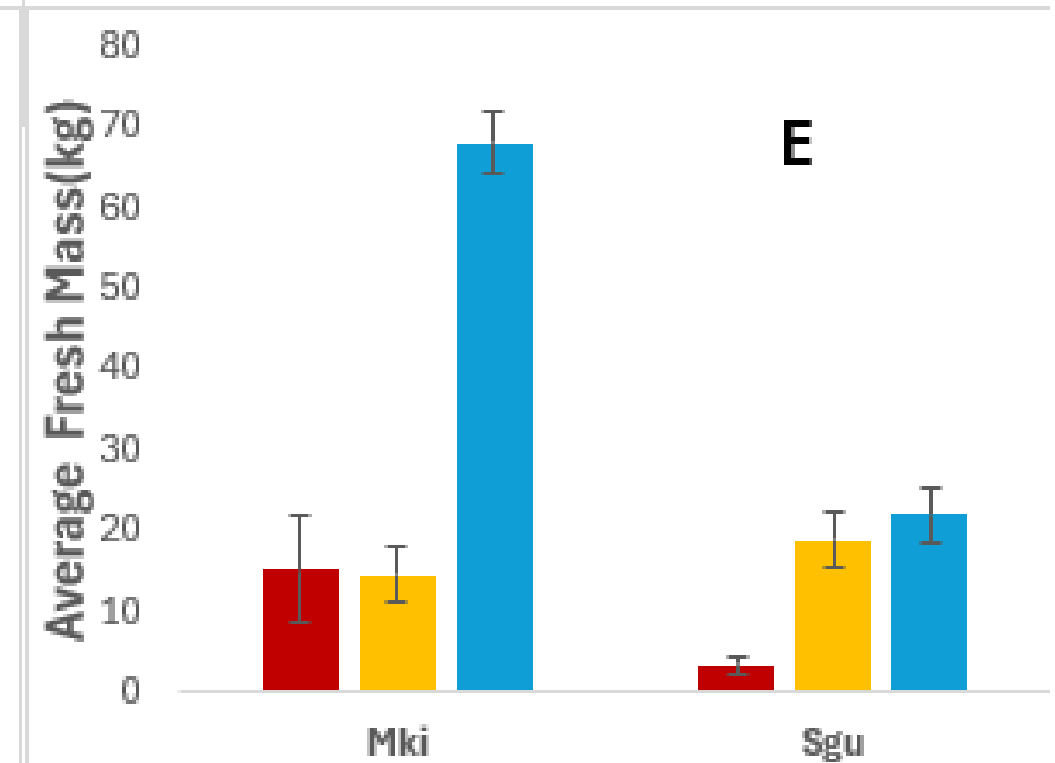
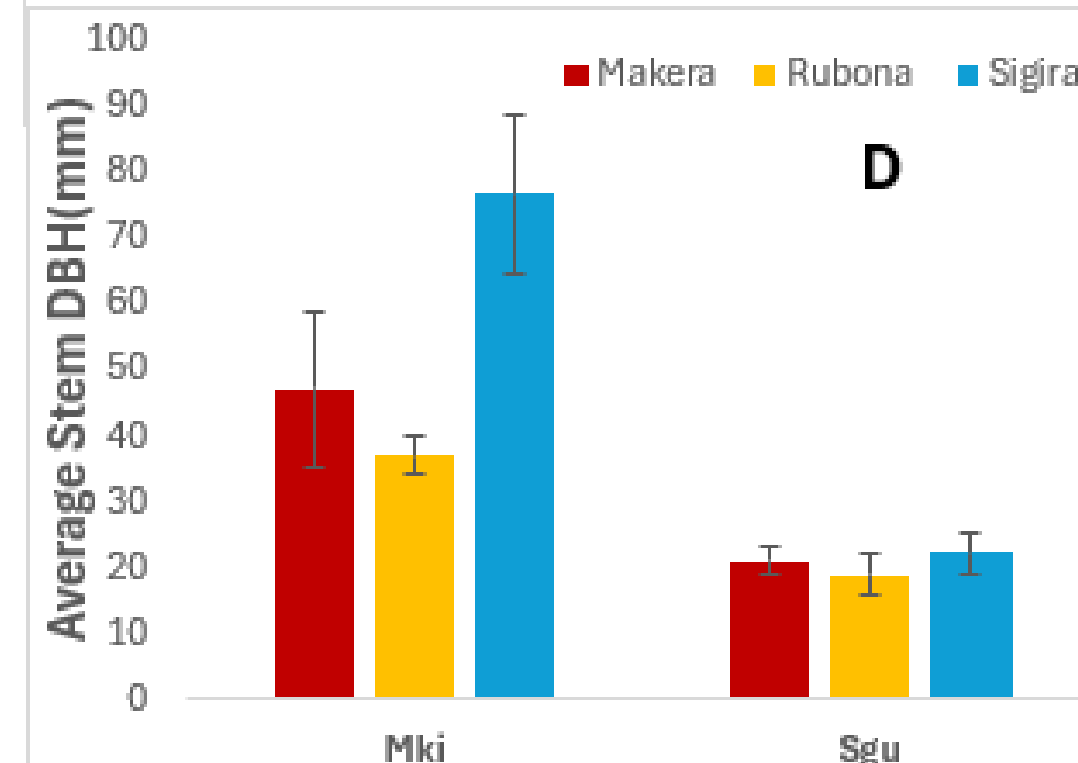
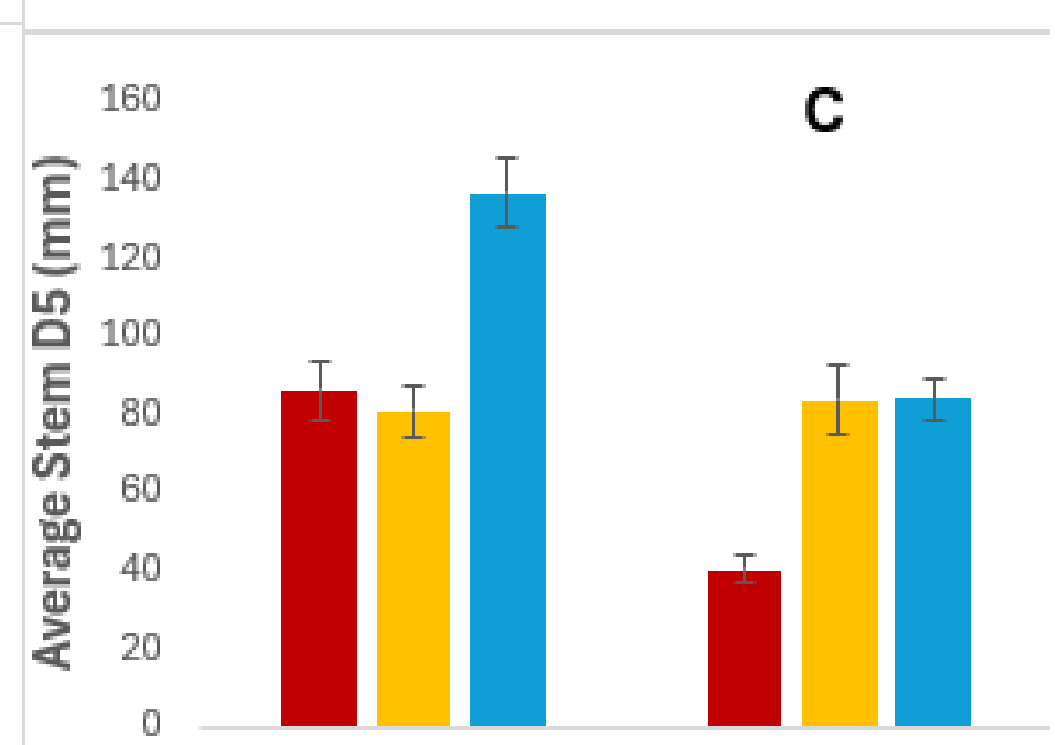
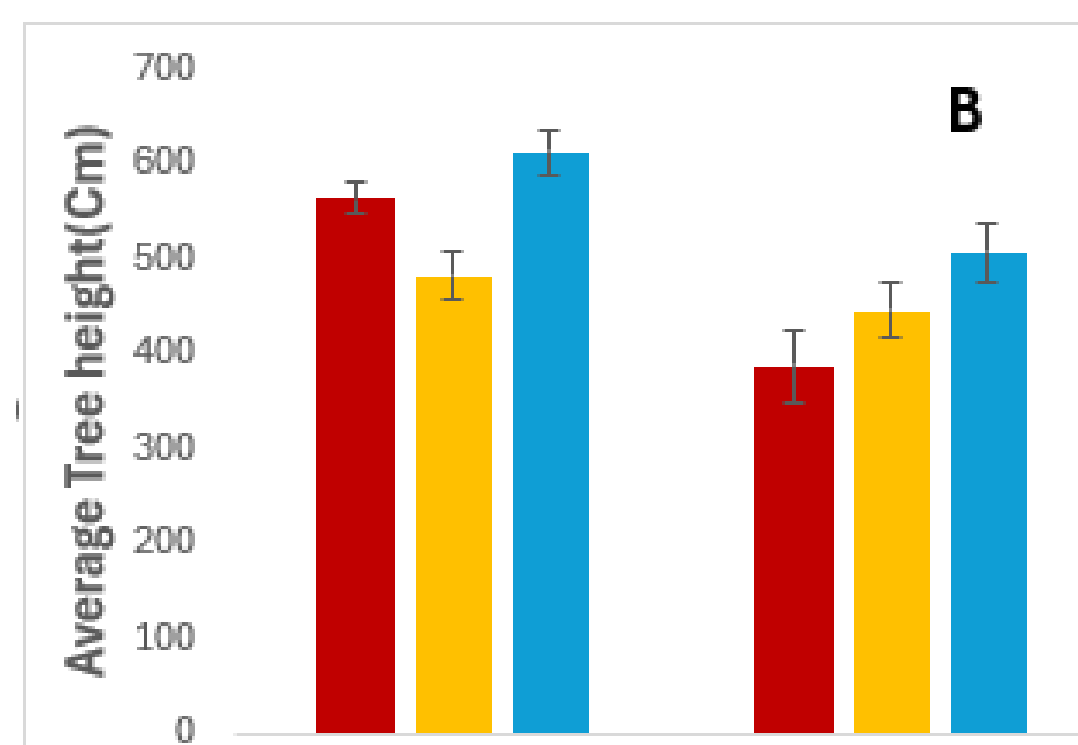
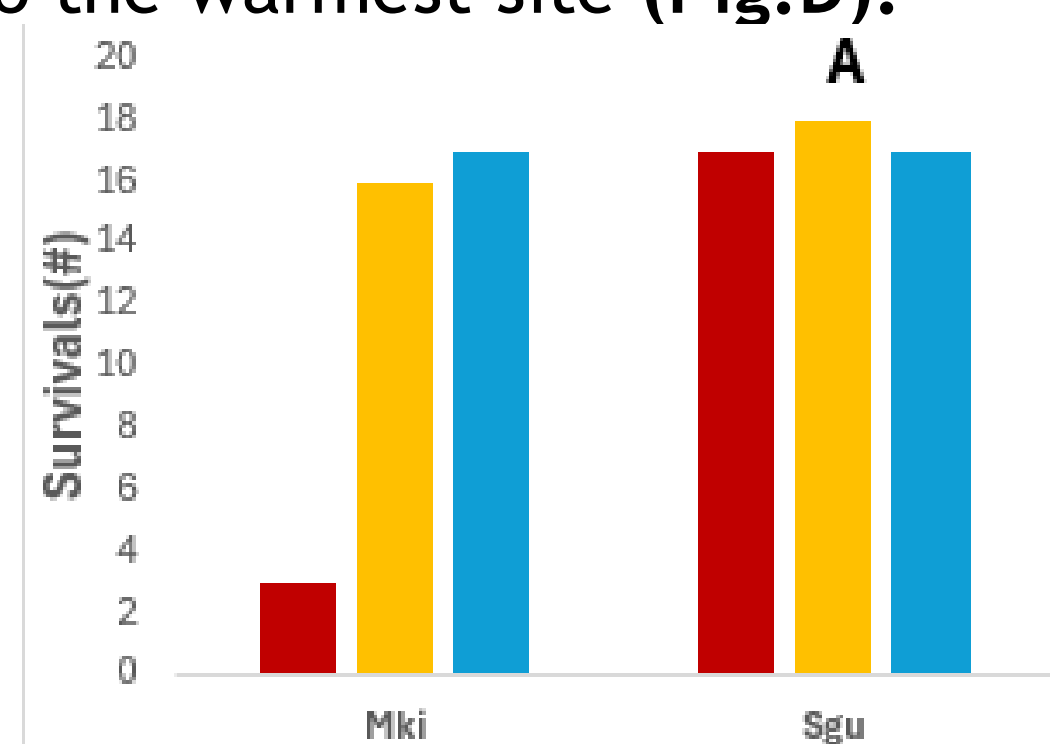
LN	Irrigation +900 mm	Irrigation +400 mm	Control
HN	Irrigation +900 mm & Fertil.	Irrigation +400 mm & Fertil.	Fertilizer
	HW	MW	LW

LN = low nutrient (control)
HN = high nutrient (fertilised)
LW = low water supply
MW = medium water supply
HW = high water supply



4. Results

- Survival:** Sgu remained high (94-100%), whereas Mki declined sharply to 16.7% at the warmest site(Fig. A).
- Allometry:** Tree height declined by ~21% and ~22% in Mki and Sgu, respectively, from the coolest to the warmest site (Fig B). Stem base diameter (D5) declined by ~37% in Mki and ~52% in Sgu from the coolest to the warmest site(Fig C). Stem DBH declined by ~39% in Mki but only ~5% in Sgu from the coolest to the warmest site (Fig.D).
- Fresh mass production declined substantially in both species, decreasing ~77.9% in Mki and ~ 81.8% in Sgu(Fig. E)



5. Conclusion & Policy/Practice relevance

Warming and drought strongly constrain Afromontane tree growth, with pioneer species more vulnerable than climax species. These findings support climate-smart restoration, species selection, and adaptive forest management in Rwanda's montane ecosystems.

6. Acknowledgement



2ND

RWANDA CLIMATE SCIENCE SYMPOSIUM 2026
Where Rwanda's climate research meets policy

“From Waste to Worth: NutriFarm’s Circular Bioeconomy Model for Climate Mitigation, Green Jobs, and Nutrition Security in Rwanda”

Authors: Alexis Musabirema et al., NutriFarm-Rwanda Cricket Farming Ltd
Email: ceo.office.nutrifarm@gmail.com



1. Introduction

- Rwanda faces rising climate and nutrition challenge with high organic waste generation, greenhouse gas emissions from unmanaged waste, pressure on conventional livestock systems, and persistent malnutrition among vulnerable populations.
- These challenges are stark in scale: 27% of Rwandan children under five are stunted (RDHS 2025, NISR 2026), 60% of Kigali's organic waste is never repurposed (Rwanda Waste Management Report, 2024), and globally, 2.8 billion people cannot afford a healthy diet (FAO SOFI 2024).
- These interconnected challenges call for integrated solutions that advance climate mitigation, adaptation, food security, and sustainable livelihoods together. Yet no operational, biotechnology-driven waste-to-protein system currently exists at scale in Rwanda.

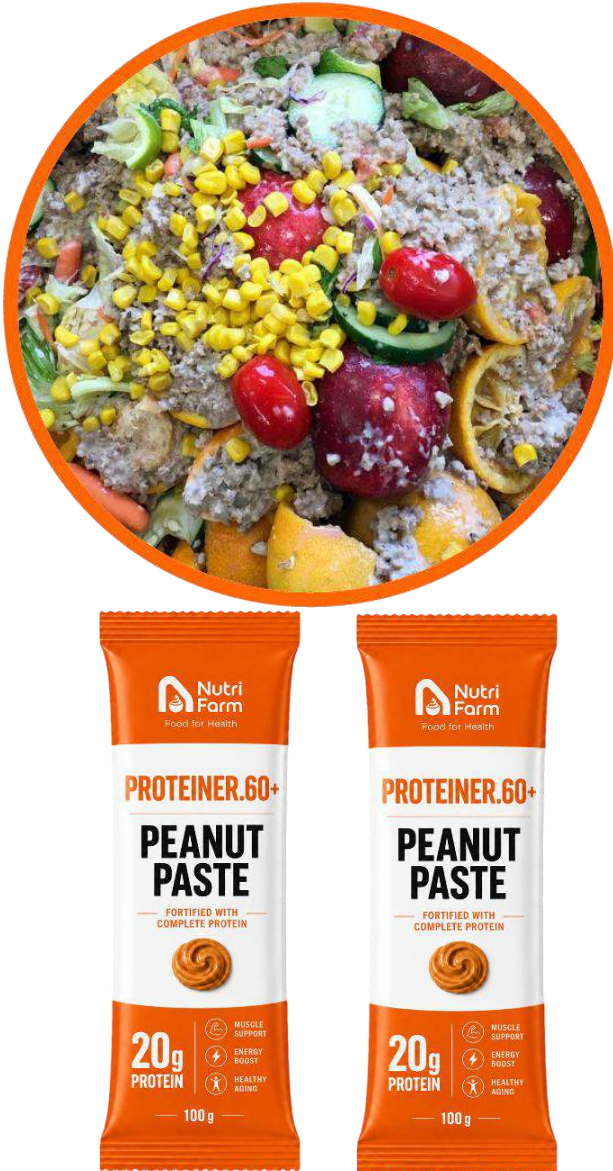


Figure 1: From agri-by products to High Proteins Foods.

2. Research & Industrial Biotech



Figure 2: Repurposed agro-industrial by products to crickets pellet feed.



Figure 3: Powder of Crickets farmed in a Climate Smart Agriculture facility.

- Repurposing agro-industrial by-products into optimized cricket pellet feed, validated through nutrient and safety trials.
- Rearing crickets on bio-circular pellets within a climate-smart agriculture facility, monitoring growth, yield, and feed-conversion indicators.
- Bioconversion and transformation of harvested crickets via controlled drying and grinding into Industrial Cricket Protein Powder.
- Quality-testing each batch for microbial safety, protein content, and human-edibility standards.
- Applying biotechnology research to close the loop between waste, protein, and climate action, cutting emissions while creating green manufacturing jobs.
- Generating reproducible process data (yield, conversion ratios, safety indicators) that positions the model for scale-up and replication across Rwanda's nutrition-insecure communities.

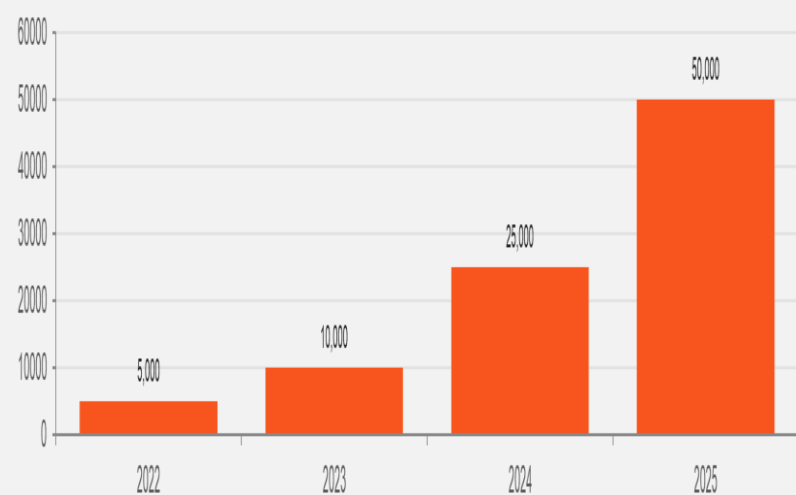
3. Methodology

- **Research design:** A mixed-methods approach combined quantitative process trials (waste characterization, feed conversion, protein yield) with qualitative assessments (sensory panels, customer feedback) to validate the model's technical and human-impact dimensions.
- **Feed & rearing trials:** Agro-industrial by-products and kitchen waste were characterized and formulated into pellet feed at varying ratios; crickets were reared on the optimal formulation under controlled climatic conditions (temperature, humidity, ventilation), with growth rate, survival, and feed-conversion ratio measured to identify optimal breed-feed-climate combinations.
- **Inputs & sampling:** Waste inputs were measured by tonnage at intake; cricket biomass was sampled at harvest for weight, moisture, and microbial load, ensuring traceability from waste input to final product.
- **Processing & equipment:** Harvested crickets were dried and milled into Industrial Cricket Protein Powder (~69% protein, Rwanda Standard Board approved), then fortified into peanut paste/butter using industrial mixers, fortification units, and an automated packaging line.
- **Safety & scale-up:** Each batch underwent microbial safety, heavy-metal, and nutrient-profile testing before release, with process data logged under patent RW/P/2025/2 ("Protein Powder with data") and used to standardize SOPs for industrial-scale production.

4. Results



Figure 4: High Protein Mix for improved nutrition and health.



- 120+ tons of organic waste repurposed
- 18 tons CO₂e emissions avoided
- 21 green jobs created (majority women and youth)
- 69% protein content, Rwanda Standard Board approved
- 50% lower cost than comparable fortified/therapeutic protein foods10:1 waste-to-protein conversion ratio (10 tons waste → 1 ton protein powder)
- Aligned with 8 SDGs (nutrition, health, gender equality, green jobs, industry, sustainable cities, responsible production, climate action).
- 1,224 customers served, with 91% positive feedback, validating demand and product acceptance
- 10× revenue growth (\$5K to \$50K) between 2022 and 2025, demonstrating a scalable, market-ready model

- Waste-to-protein conversion: NUTRIFARM has repurposed over 120 tons of organic waste, avoiding ~18 tons of CO₂e emissions, validating the climate-mitigation potential seen in earlier trials.
- Green employment: Scale-up to industrial production created 21 green jobs, with strong inclusion of women and youth.
- Resource efficiency: Substituting animal protein with insect-based protein lowers land, water, and feed demands, strengthening climate resilience through resource-efficient production.
- Affordability & nutrition impact: Fortified products are priced ~50% lower than comparable protein foods, improving affordability for malnourished infants and food-insecure households.
- Product safety & quality: Batch testing confirmed consistent ~69% protein content and safety thresholds, supporting reliable Rwanda Standard Board-approved output.
- Policy alignment: Outcomes align with 8 SDGs spanning nutrition, health, gender equality, green jobs, industry, and climate action.
- Strong customer response (1,224 served, 91% positive feedback) signals genuine market acceptance of fortified insect-based protein, addressing typical sensory concerns with alternative proteins.
- Meanwhile, 10× revenue growth (\$5K to \$50K, 2022–2025) demonstrates financial viability alongside nutritional impact, together supporting continued investment and policy backing to scale the model nationally.

5. Conclusion

- NutriFarm's model proves agro-industrial waste can be transformed, through biotechnology and industrial bioconversion, into safe, nutrient-complete protein, turning waste into worth.
- With 120+ tons of waste repurposed, 18 tons of CO₂e avoided, and 21 green jobs created, it delivers climate mitigation and inclusive economic impact together.
- By making affordable, fortified nutrition accessible to food-insecure populations, NutriFarm offers a scalable pathway for Rwanda's climate and nutrition security goals, aligned with 8 SDGs.

6. References

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- Van Huis et al. (2013). Edible insects: Future prospects for food and feed security (FAO Forestry Paper No. 171).NutriFarm Ltd. (2025). Protein powder with data (RW Patent No. RW/P/2025/2).

7. Acknowledgment

- NCST and ACTS.

Mapping the Drivers of Tomato Waste: Developing a Stakeholder-Informed Framework for Climate-Resilient Food Systems in Botswana

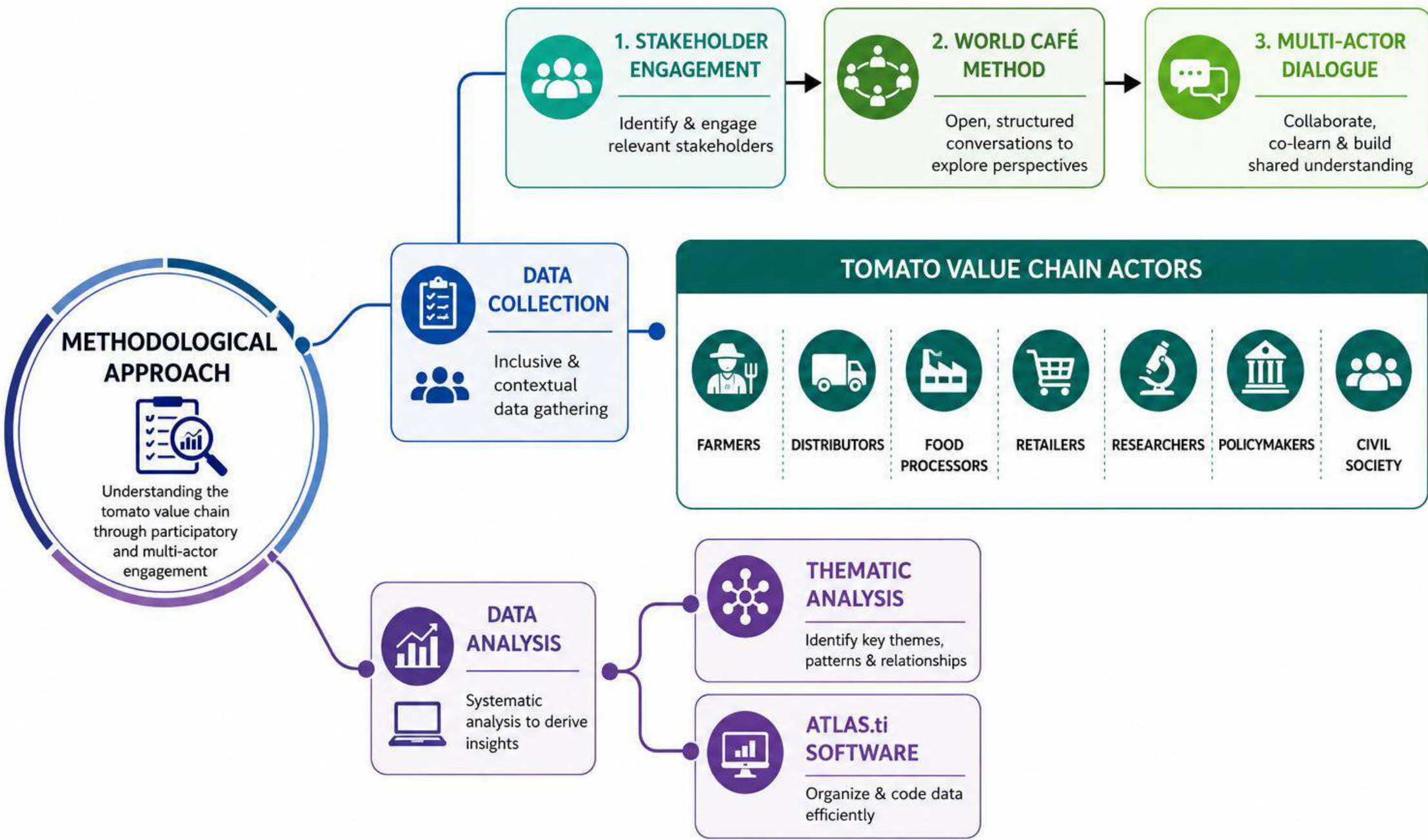
Boineelo Pearl Lefadola^{1,2}, Mohammad Naushad Emmambux³, Dikabo Mogopodi⁴, Nwabisa Mehlomakulu³

¹Future Africa – University of Pretoria, South Africa, ²Department of Family and Consumer Sciences, University of Botswana, Botswana, ³Department of Consumer and Food Sciences, University of Pretoria, South Africa, ⁴Department of Chemistry, University of Botswana, Botswana

Introduction

In Botswana, tomato loss and waste remain a major challenge to sustainable food systems, accounting for nearly 30% of the total agro-produce loss. As climate variability intensifies, reducing food waste becomes increasingly important for strengthening climate-resilient agricultural systems. The study explored stakeholder perspectives on the drivers of tomato waste in Botswana and developed a stakeholder-informed tomato waste driver framework to support climate-resilient food system interventions.

Methodology



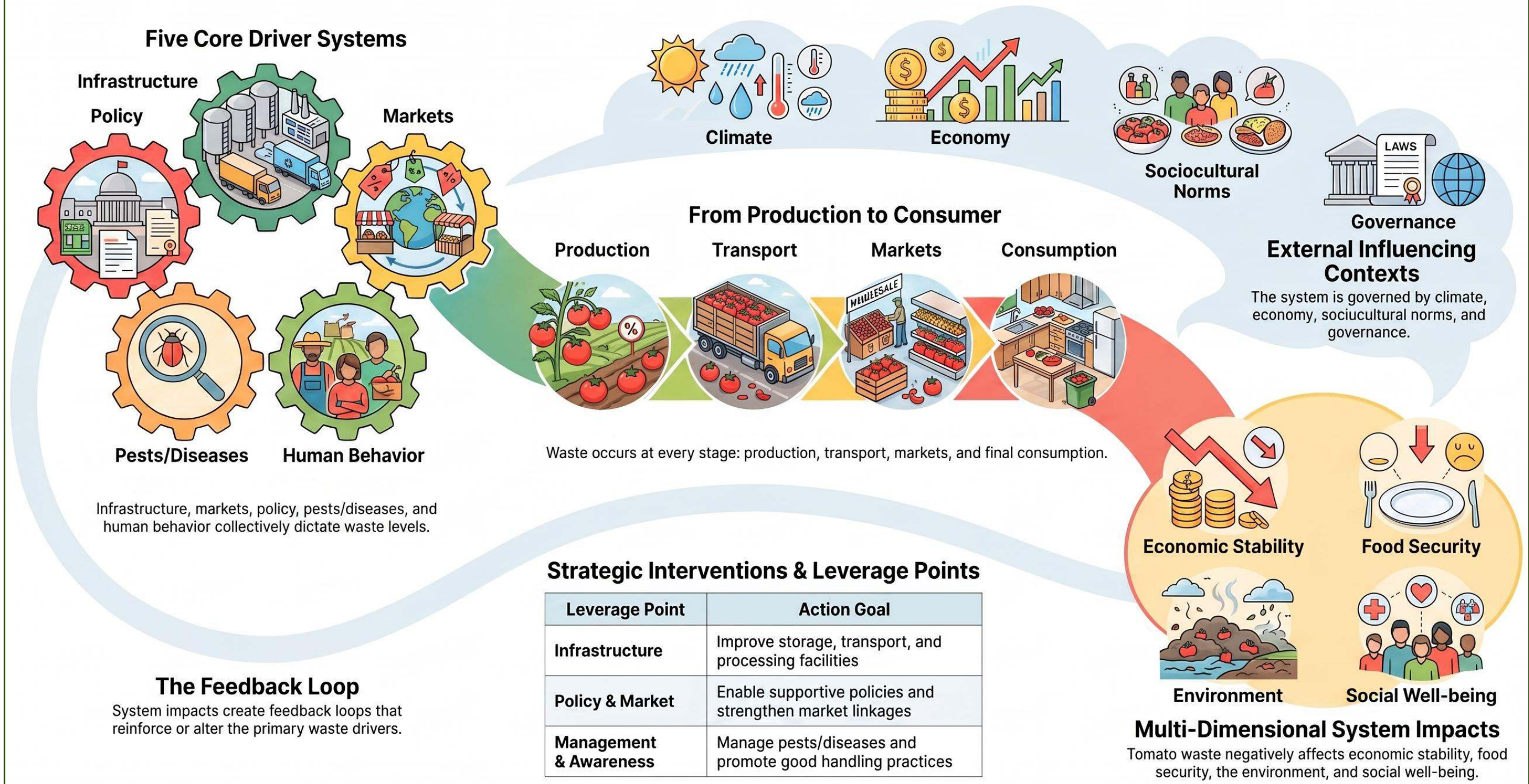
Findings

- Tomato waste occurs across multiple stages of the value chain.
- Market instability and limited market access are major waste drivers.
- Inadequate post-harvest infrastructure accelerates quality deterioration.
- Pests, diseases and handling practices contribute to avoidable losses.
- Policy gaps and weak value-chain coordination amplify tomato waste.
- Stakeholders identified value addition and circular-economy pathways as opportunities to reduce waste.
- These findings informed a Tomato Waste Driver Framework linking production, market, infrastructure, governance and climate factors to waste across the supply chain.

Conclusions

- Supportive policies and targeted investment are essential to reduce tomato waste.
- Improved post-harvest management and resource efficiency can strengthen value-chain resilience.
- The Tomato Waste Driver Framework integrates key waste drivers across the value chain.
- Integrating waste reduction with climate adaptation can support a more resilient, resource-efficient and sustainable tomato value chain in Botswana.
- Collaborative, evidence-based action can accelerate tomato waste reduction and value-chain resilience.

The Tomato Waste Driver Framework (TWDF): A Systems Perspective



Select References

- Boiteau, J. M., & Pingali, P. (2022). Food loss of perishable produce from farm to retail: evidence from tomato supply chains in South India. The American Journal of Clinical Nutrition, 115(6), 1535-1548.
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Socio-ecological resilience of restored freshwater ecosystem: Species diversity, landscape connectivity, and stakeholder integration in Sironko River wetland, Uganda



Muwaza Andrew Remmy, Isimemen Osemwegie, and Sileshi Nemomissa
SPIBES program, Addis Ababa University, Ethiopia



BACKGROUND

- Uganda is endowed with freshwater ecosystems that sustain biodiversity and drive economic growth.
- Yet these ecosystems are degrading unprecedentedly.
- Uganda has pursued restoration, but this alone is insufficient; these systems must be built to withstand shocks, maintain functionality, and adapt over time.
- No published study has integrated ecological, structural, and governance dimensions of resilience in restored wetlands in Uganda.
- This study aimed to fill this gap and inform the design of future restoration interventions.

RESEARCH OBJECTIVES

- Assess the spatial differences in macroinvertebrate diversity across river reaches and tree diversity in riparian forests.
- Analyse the fragmentation and connectivity of wetland patches in the restored landscape in 2016, 2020, and 2026.
- Assess the local community participation, traditional ecological knowledge integration, and institutional inclusivity in the restoration process.

STUDY AREA & METHODS

Conducted in Sironko River wetland landscape (Fig 1).

Ecological assessments and social survey data

- 10 macroinvertebrate sampling sites across restored and unrestored river sections
- 15 tree plots (50 × 10 m) in adjacent riparian forests.
- A 10-year (2016–2026) landscape assessment using GIS and FRAGSTATS.
- Random 292 household interviews across 12 villages.
- A social network analysis of institutional actors.

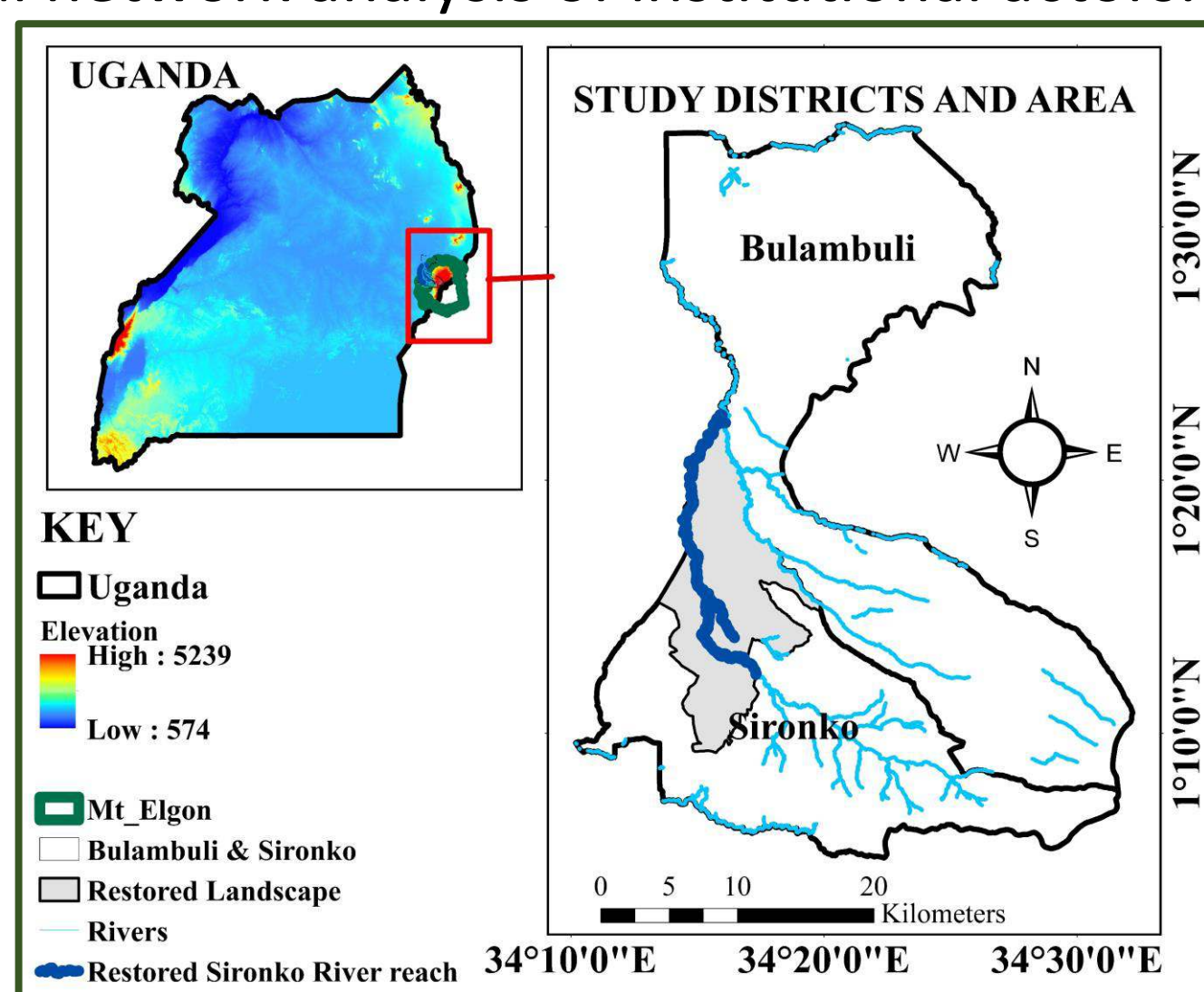


Fig 1: Map showing the study area

CONCLUSION

This study shows that restoration has not produced convergent signs of socio-ecological resilience in the Sironko River wetland. In an era of environmental change, policy and practitioners must move beyond structural rehabilitation to pursue functional species recovery, landscape-scale connectivity, and inclusive governance as interdependent, not separate, pathways to resilience of freshwater ecosystems.

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- Ostrom, E. (2009). A General Framework for Analyzing Sustainability of Social-Ecological Systems. *Science*, 325(5939), 419–422. <https://doi.org/10.1126/science.1172133>
- Stockholm Resilience Centre. (2014). Applying resilience thinking: Seven principles for building resilience in social-ecological systems. <https://www.stockholmresilience.org/download/18.10119fc11455d3c557d6928>

RESULTS

Objective 1: Species diversity

1a, Macroinvertebrate: remained low with no significant difference between restored and unrestored sections (Fig 2).

1b, Riparian tree: generally, low with significant difference between sites but dominated by *Eucalyptus* spp (Fig 3).

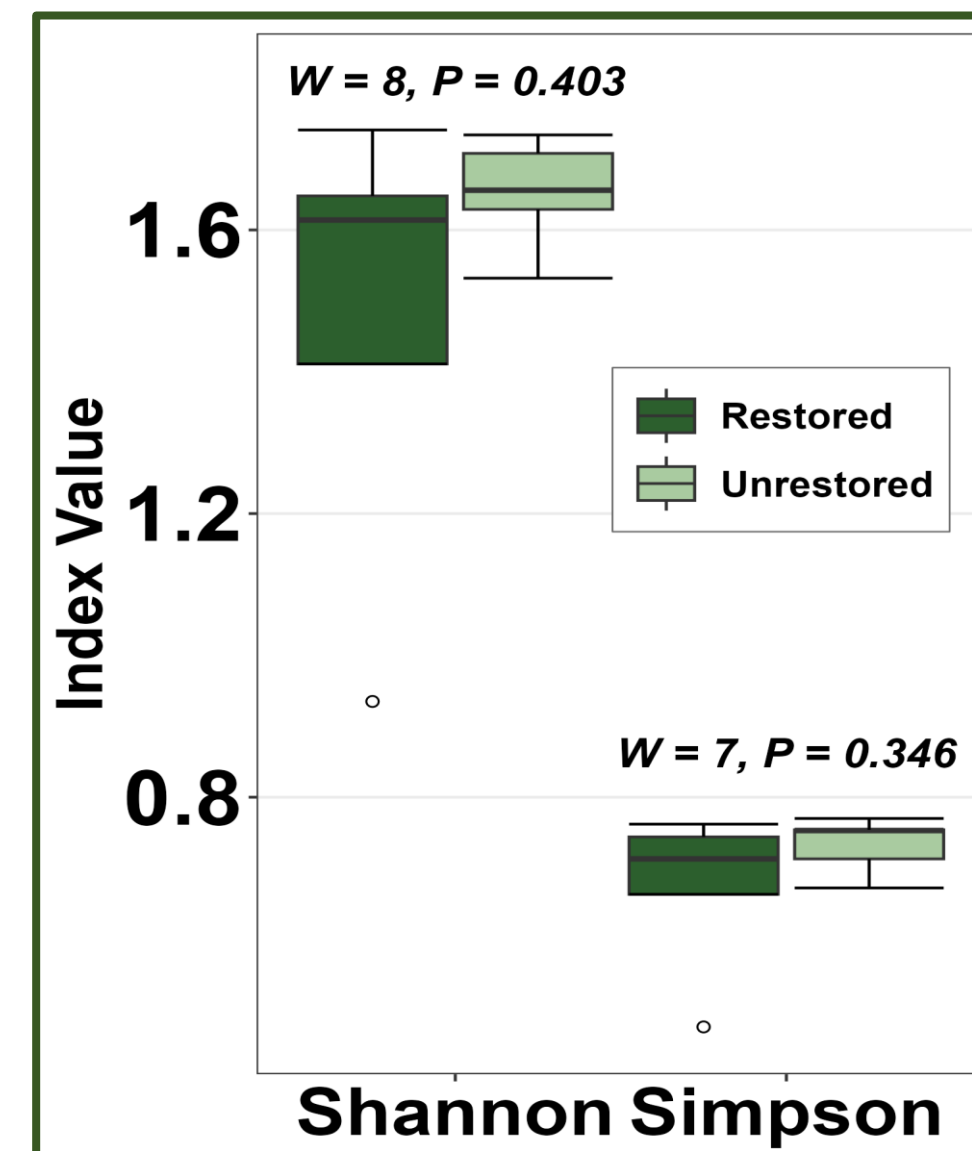


Fig 2: Macroinvertebrate diversity

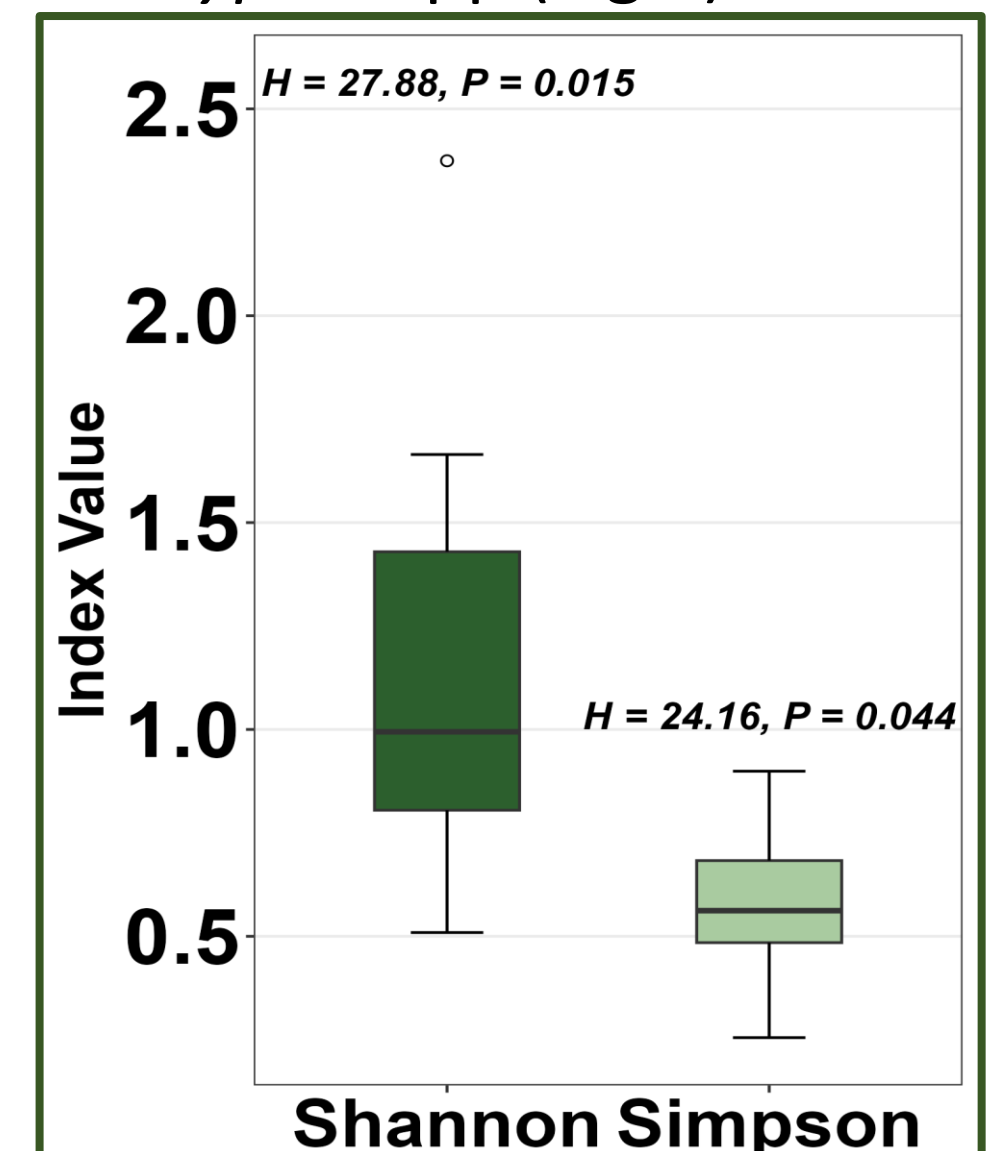


Fig 3: Tree diversity

Objective 2: Landscape connectivity

Sironko Wetland continues to experience progressive loss, fragmentation, and increasing isolation (Fig 4).

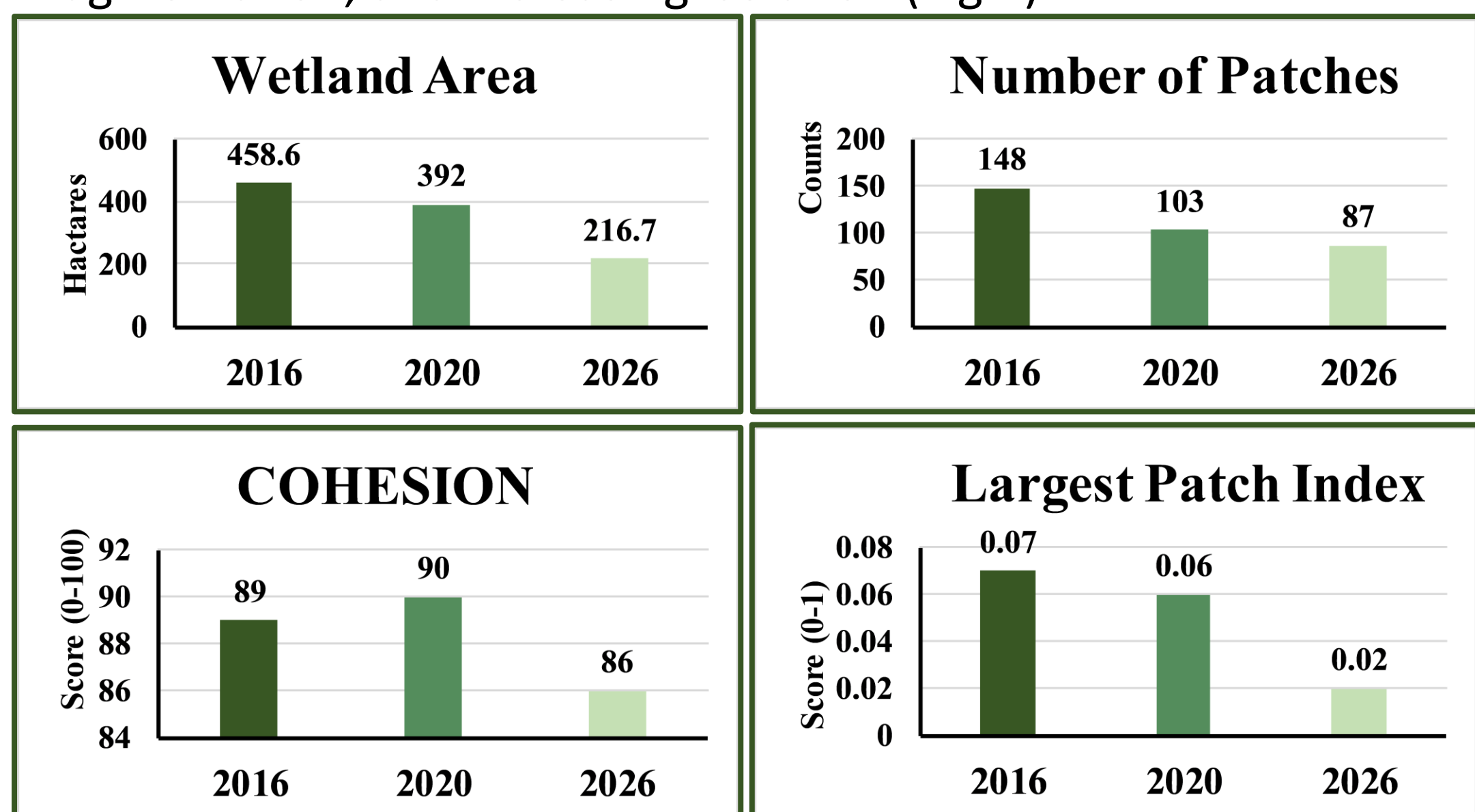


Fig 4: Sironko wetland fragmentation and connectivity trends

Objective 3: Stakeholder participation

3a, Riparian community members are informed and consulted yet exercise minimal influence over decisions, planning, and on-the-ground restoration activities (Fig. 5).

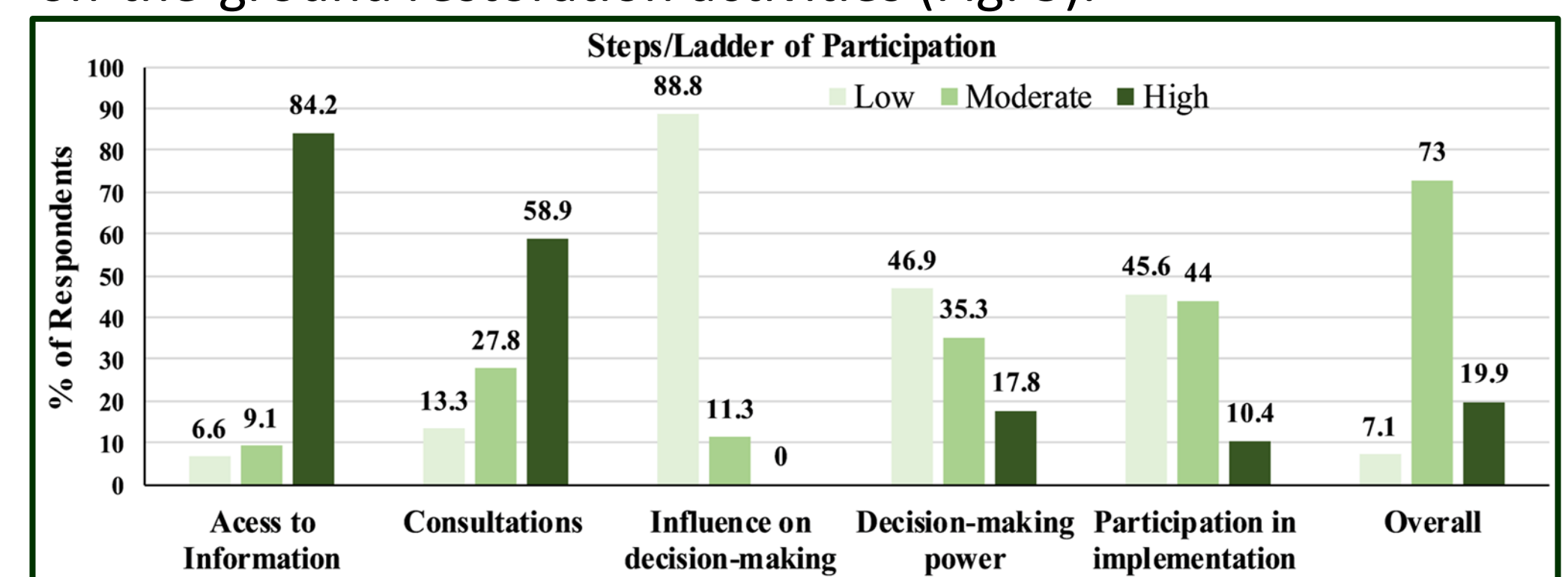


Fig 5: Community participation across the ladder of participation

3b, Respondents held TEK but opined that their knowledge was not integrated into formal restoration programmes.

3c, Institutional governance was low (Density = 0.05), fragmented (Index = 0.91), and highly centralized.

Supported by:



A Predictive Climate Model for Africa Capable of Identifying Precise Extreme Event Periods, Recommending Adapted Crops and Generating Targeted Institutional Alerts

Mazoya Valère — Founder, AgriPredict5 — Ouagadougou, Burkina Faso

8
Countries covered

10
Crops modeled

0.9761
Model R² score

~6,000
Producers in active pilot

INTRODUCTION

Climate volatility is intensifying across Africa, yet millions of smallholder farmers and the institutions that finance them still operate with limited visibility into agricultural and climate risk.

Existing global climate models are rarely precise enough at the local scale needed for actionable decisions on crop choice, credit, or emergency response.

AgriPredict5 was built to close this gap: a machine-learning platform developed in West Africa, from consolidated field data, turning climate complexity into clear, timely decision intelligence for farmers, financial institutions and public

OBJECTIVES

- Predict crop yield and revenue potential by crop and by zone
- Identify precise windows for extreme climate events, 2026–2030
- Recommend climate-adapted crops based on local risk profiles
- Generate targeted alerts for banks, cooperatives and public agencies

METHODOLOGY

The predictive engine is a Random Forest Regressor trained on consolidated field and climate data spanning 8 West African countries and 10 crops. Yield prediction integrates long-term climate-change trend factors together with 10-year soil degradation trends observed per zone. Outputs include yield prediction under 3 climate scenarios (dry, normal, wet), risk-by-zone analysis, and exportable institutional risk briefs designed for credit committees and field decision-makers.

MODEL PERFORMANCE

The current model achieves an R² of 0.9761 and a mean absolute error of 396 kg/ha across covered crops and countries.

Performance is validated against consolidated field-data benchmarks and continuously refined as new field data is integrated from active deployments and pilots.

DEPLOYMENT & PARTNERSHIPS

AgriPredict5 is deployed as an operational SaaS platform (agripredict5.netlify.app), with tiered access for individual producers, cooperatives and institutional clients.

A commercial partnership is signed with Agro SENECA (Senegal).

A field pilot is in progress with the Sasakawa Africa Association in Mali's Kita and Ségou regions, covering close to 6,000 producers with maize as the standardized reference crop.

INSTITUTIONAL ENGAGEMENT

- In discussion: Banque Agricole du Faso, ADEPME (Sénégal), AGRIDEV (Mali)
- Regional research collaboration under discussion with INERA, IER and ISRA
- Positioned as an African-built alternative that does not depend on heavy data-center infrastructure

CONCLUSION & PERSPECTIVES

This work demonstrates that high-precision, locally-grounded agricultural and climate intelligence can be built in Africa, for Africa — without dependence on external data infrastructure.

By linking yield prediction to extreme-event forecasting and institutional alerting, AgriPredict5 offers a practical decision-support layer for the actors most exposed to climate risk: producers, lenders, and public agencies.

Next steps: extend coverage to additional countries (a pilot is underway in Egypt), integrate hybrid quantum machine learning for next-generation prediction, and deepen institutional integration for agricultural credit-risk assessment.

CONTACT

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INTEGRATING AI-DRIVEN SATELLITE EARTH OBSERVATION INTO CLIMATE DISASTER RISK REDUCTION: A GOVERNANCE FRAMEWORK FOR RWANDA

1. INTRODUCTION

- Climate-related hazards are increasing pressure on disaster risk management systems.
- Satellite Earth Observation (EO) and Artificial Intelligence (AI) can transform satellite data into timely risk intelligence.
- The key challenge is integrating predictive analytics into national decision-making.
- Rwanda provides a relevant case for linking AI, EO and disaster risk reduction.
- Earth observation and Artificial Intelligence (AI) can convert satellite data into timely, actionable risk information.
- The key challenge is institutional integration of predictive analytics into national decision-making.
- Rwanda provides an illustrative case for a governance framework linking AI, satellite Earth observation and DRR.

THE GAP: Technical AI capability → Institutional decision-making

- Fragmented data governance limits access, interoperability and operational use of EO data.
- AI models can remain isolated technical pilots rather than becoming institutional tools.
- Responsible AI requires accountability, transparency, data quality and oversight.
- Sustainable adoption requires capacity in AI, geospatial analytics and disaster management.
- Predictive models may remain isolated technical pilots instead of becoming part of institutional workflows.
- Responsible AI requires attention to accountability, transparency, data quality and operational oversight.
- Long-term adoption depends on sustained capacity in AI, geospatial analytics and disaster management.

3. RWANDA CASE CONTEXT

WHY RWANDA?

- Mountainous terrain and rainfall variability
- High exposure to floods and landslides
- Growing digital governance capacity
- Increasing need for anticipatory, data-driven disaster risk reduction
- Exposure to floods and landslides
- Growing digital governance capacity
- Need for anticipatory, data-driven DRR

Case focus: governance readiness for AI-enabled Earth observation.

4. RESEARCH APPROACH

- Policy-oriented framework development using Rwanda as an illustrative national case.
- Integration of four dimensions: technology, institutions, capacity/youth and partnerships.
- Alignment with the Sendai Framework and SDGs 11 and 13.
- Focus on moving from satellite data → risk intelligence → early action.
- Integration of four dimensions: technology, institutions, capacity/youth, and partnerships.
- Alignment with the Sendai Framework for Disaster Risk Reduction and SDGs 11 and 13.
- Focus on moving from satellite data to risk intelligence and early action.

KEY POLICY PRINCIPLE

Technology creates value only when it is embedded in institutional workflows, supported by people, regulation, financing and accountability.

5. PROPOSED GOVERNANCE FRAMEWORK

Four interdependent pillars connect technical capability with institutional action

1

TECHNICAL INTEGRATION

- Multispectral satellite acquisition
- AI hazard detection
- Predictive risk modelling
- Automated early-warning outputs

2

INSTITUTIONAL EMBEDDING

- AI analytics capacity in disaster institutions
- Inter-agency data-sharing protocols
- Responsible AI governance
- Operational decision workflows

3

CAPACITY & YOUTH

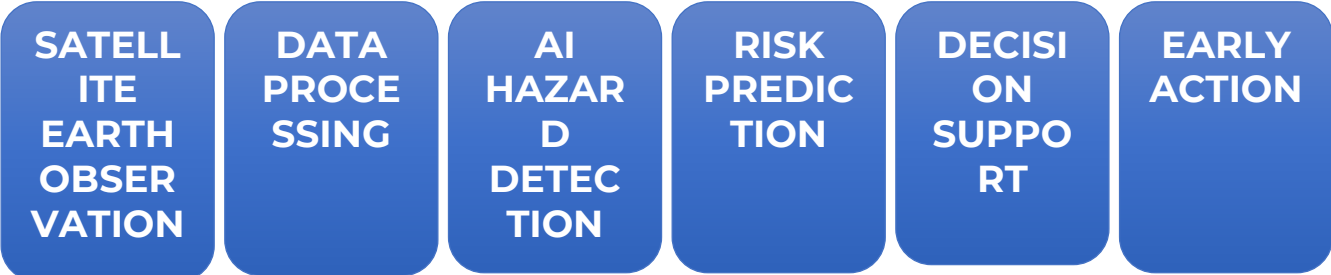
- AI + Earth observation training
- University–government research
- Youth innovation ecosystems
- Continuous skills development

4

MULTI-STAKEHOLDER PARTNERSHIPS

- Public–private collaboration
- International space cooperation
- Climate adaptation finance
- Knowledge and technology transfer

6. SYSTEM WORKFLOW



7. IMPLEMENTATION PHASING

SHORT-TERM | 1-2 YEARS
Pilot AI-based hazard detection; develop governance and regulatory guidance.

MEDIUM-TERM | 3-5 YEARS
Scale nationwide integration; incorporate predictive analytics into planning systems.

LONG-TERM | 5+ YEARS
Institutionalize AI-enabled disaster governance and strengthen regional leadership.

EXPECTED OUTCOMES

- Faster hazard detection and early-warning communication
- Evidence-based planning and resource prioritization
- Stronger national AI, EO and geospatial capacity
- More anticipatory and coordinated disaster governance
- Evidence-based planning and resource prioritization
- Stronger national AI, EO and geospatial capacity
- More anticipatory and coordinated disaster governance

8. BROADER IMPLICATIONS

- AI-enabled EO can translate satellite investments into operational public value.
- Governance, technology, people, regulation and financing must evolve together.
- The framework supports a shift from reactive response → anticipatory risk governance.
- The approach may inform other climate-vulnerable countries developing EO and digital resilience capabilities.
- Governance alignment is essential: technology, institutions, people, regulation and financing must evolve together.
- The framework supports a shift from reactive disaster response toward anticipatory risk governance.
- The approach can inform other climate-vulnerable countries developing Earth observation and digital resilience capabilities.

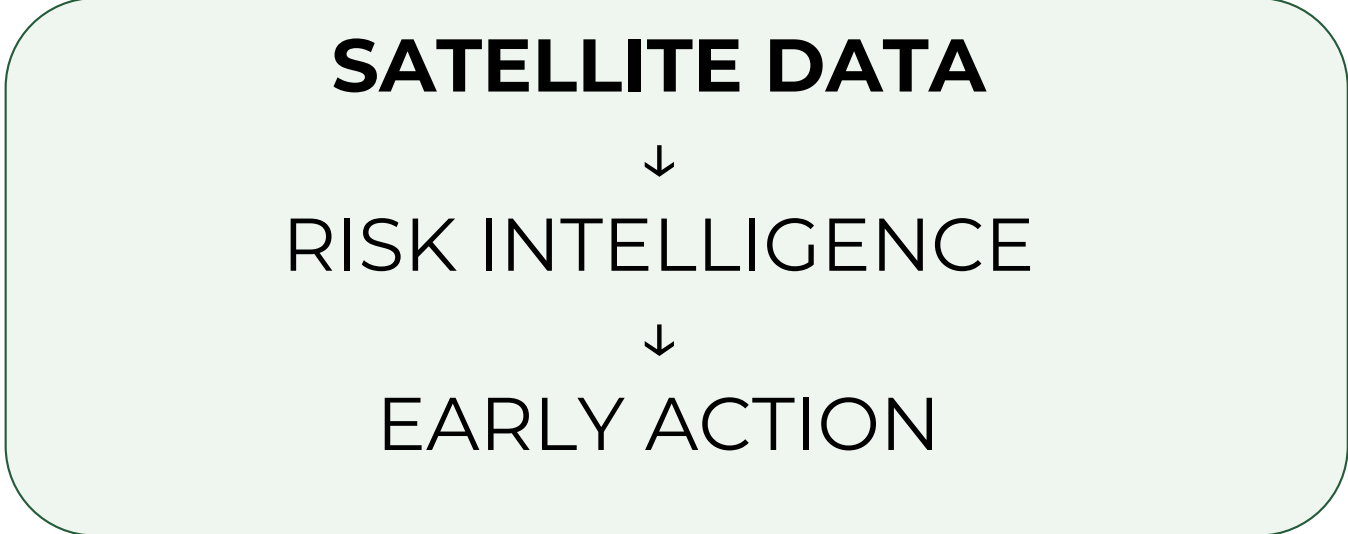
9. CONTRIBUTION TO CLIMATE RESILIENCE

FROM DATA TO DECISION
Embedding predictive analytics within national DRR systems can strengthen anticipatory action, institutional coordination and climate resilience.

10. CONCLUSION

AI-driven satellite image analysis is more than a technical enhancement; it can become a governance transformation mechanism. Embedding predictive analytics within national disaster risk reduction systems enables a shift from reactive response to anticipatory resilience.

POLICY MESSAGE



SDG & SENDAI ALIGNMENT

- Sendai Framework: understanding disaster risk and strengthening governance.
- SDG 11: safer and more resilient settlements.
- SDG 13: strengthened climate action and adaptation.

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KEYWORDS

Artificial Intelligence • Satellite Earth Observation • Disaster Risk Reduction • Climate Resilience • Rwanda • Governance • Early Warning



WARMING HIGHLANDS, CHANGING HARVESTS: FOUR DECADES OF CLIMATE VARIABILITY AND POTATO PRODUCTION IN THE SANTA–BABADJOU CORRIDOR, CAMEROON

Mary Lum Fonteh Niba ¹ & Besende Didien Njumba ²

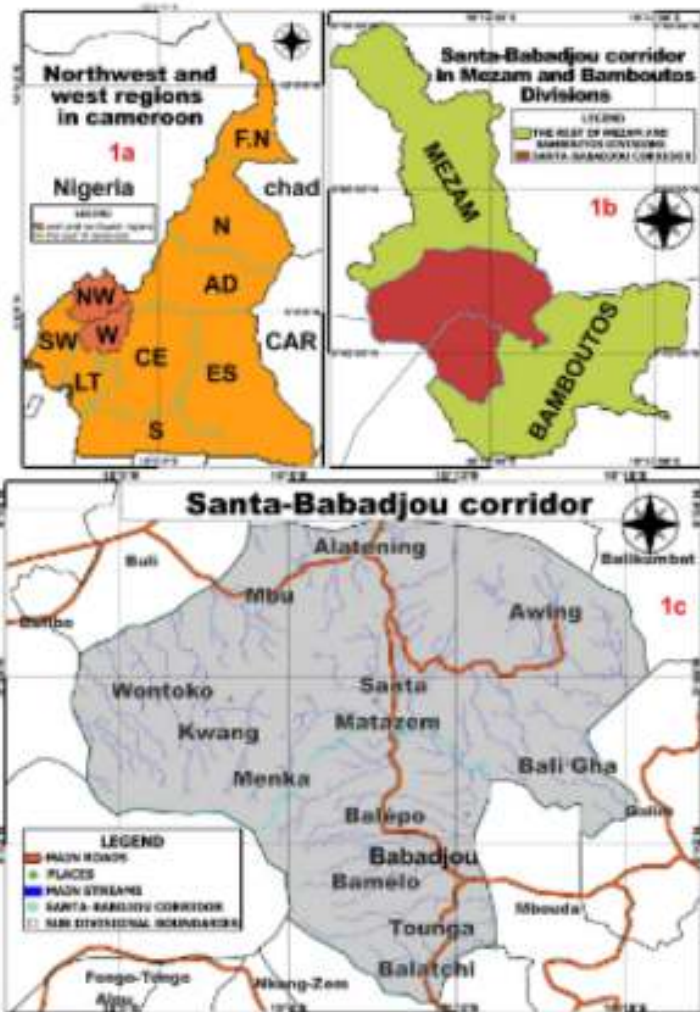
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INTRODUCTION

- 1.The Santa–Babadjou Corridor is a major highland potato-producing landscape in Cameroon, supporting rural livelihoods and regional food security. Potato production is highly sensitive to temperature and rainfall conditions, making the sector particularly vulnerable to climate variability.
- 2.Over the past four decades, rising temperatures, shifting rainfall patterns, recurrent dry spells, and increasing hydroclimatic instability have created growing uncertainty for potato production. However, the long-term relationship between climate variability and potato production across the corridor remains insufficiently quantified.
- 3.This study analyses 1980–2026 climate and potato-production records to identify long-term climate trends, characterize climatic variability, and assess their influence on production dynamics. The findings provide an evidence base for climate-smart adaptation, resilient potato production, and food-security planning in Cameroon’s highlands.

STUDY AREA



As illustrated on fig 1,The Santa–Babadjou Corridor spans the highlands of Cameroon’s Northwest and West Regions, between 5°42’–5°54’ N and 10°00’–10°18’ E, covering approximately 1,292 km². The corridor links Santa and Babadjou, forming an important agricultural and transport gateway between the two regions.

Characterized by a Guinea-type climate, the corridor receives 2,000–3,000 mm of annual rainfall and experiences temperatures of 15–25°C, with elevations ranging from 1,300 to 2,703 m. Its complex terrain of mountains, valleys, forests, cultivated fields and rural settlements creates strong spatial contrasts in agricultural and climatic conditions.

The Santa Stream and its tributaries provide critical water resources, while diverse soils including alluvial, orthic and humic soils support intensive agriculture. These environmental gradients make the corridor a climate-sensitive highland landscape for potato production and an important setting for assessing changing climate conditions and agricultural vulnerability.

Methodology

As illustrated in Figure 2, the methodology involved a variety of complementary approaches, integrating climate, agricultural, statistical, and spatial analyses to assess the relationship between climate variability and potato production. The workflow comprised seven main components:

1. **Data acquisition:** 1980–2026 daily rainfall and temperature data from 8 meteorological stations, potato production/area statistics, and DEM, LULC and administrative GIS layers were compiled.
2. **Data quality control:** Climate and agricultural datasets underwent screening, validation, missing-data treatment, outlier detection, homogenization and temporal/unit standardization.
3. **Climate & drought analysis:** Rainfall–temperature variability was assessed using CV, Mann–Kendall, Sen’s slope and change-point analysis, while SPI and SPEI (3-, 6- and 12-month) quantified drought frequency, duration and severity.
4. **Potato production analysis:** Production and cultivated area trends were evaluated using CAGR and production anomalies, while yield (production/area) was calculated to separate productivity changes from cultivated-area expansion.
5. **Climate–production relationship:** Pearson correlation, lag/cross-correlation and multiple regression were used to identify climate–potato relationships, delayed responses and dominant climatic controls on production variability.
6. **Spatial analysis:** GIS/remote sensing, spatial interpolation and overlay analysis integrated climate, drought, topography, LULC and potato-production layers to delineate climate exposure, production concentration and vulnerable areas.
7. **Integrated assessment:** Statistical and spatial evidence were synthesized to identify climate-sensitive periods, vulnerable locations and dominant climate pressures, informing climate-

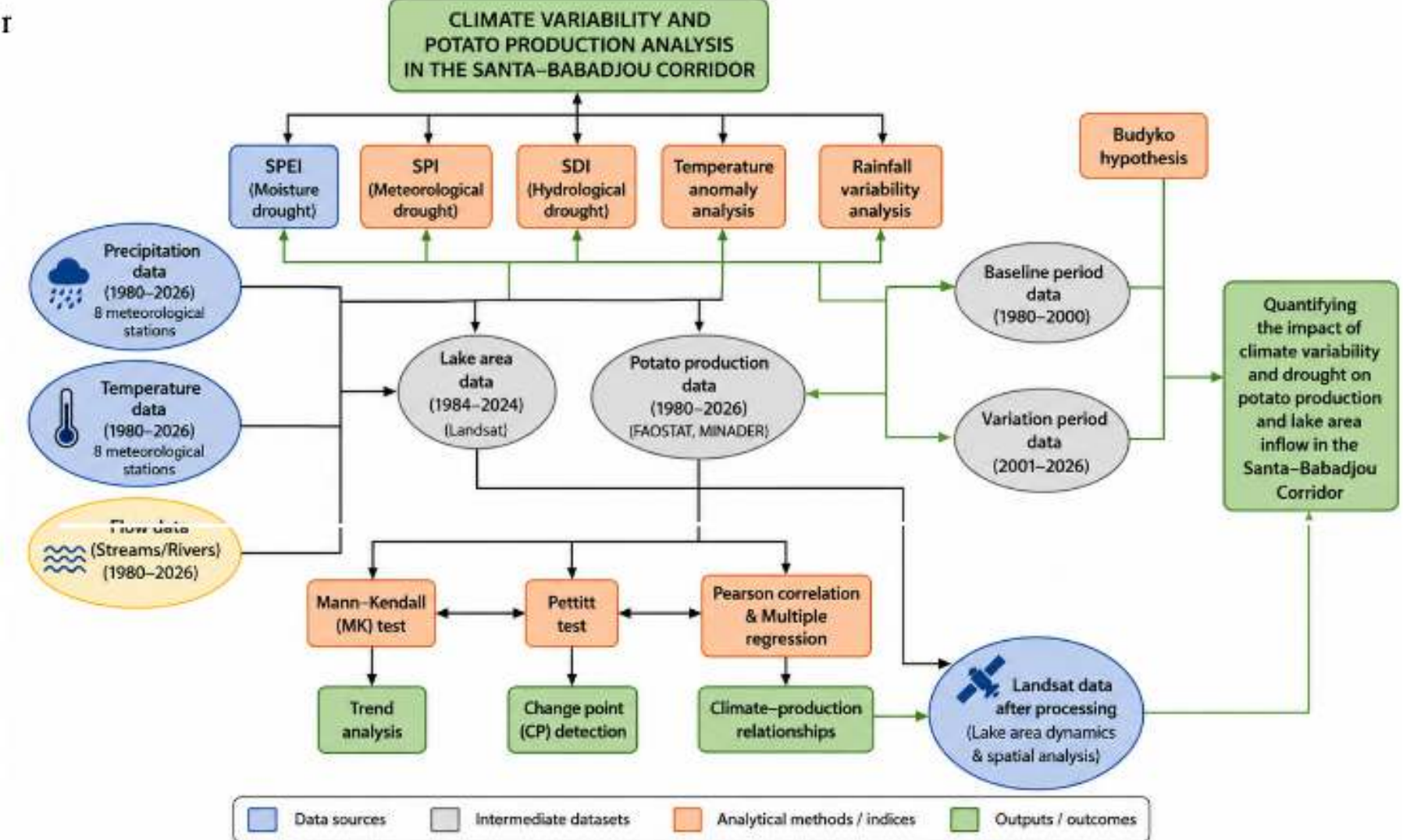


Figure 2: the methodological framework

Results

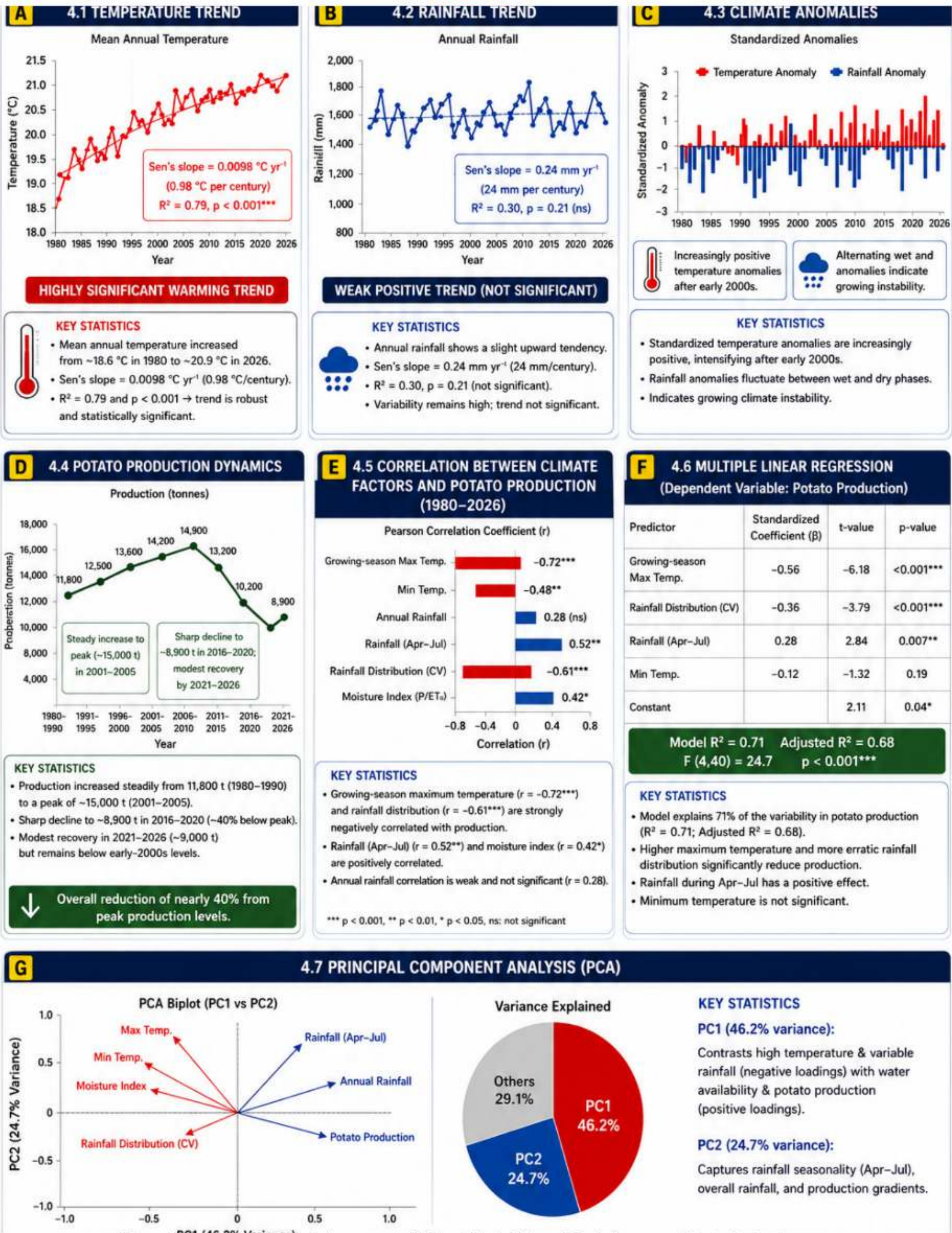


Figure 3.Integrated Statistical Assessment of Climate Variability and Its Influence on Potato Production in the Santa–Babadjou Corridor

The results presented in Figure 3 illustrate the temporal trends in climate variables, potato production dynamics, and the statistical relationships between climatic factors and potato production in the Santa–Babadjou Corridor from 1980 to 2026.

A. Temperature trend

Mean annual temperature increased from 18.6°C in 1980 to 20.9°C in 2026, a rise of 2.3°C, with a Sen's slope of 0.0098°C yr⁻¹ (approximately 0.98°C per century). The strong fit (R² = 0.79) and highly significant trend (p < 0.001) indicate persistent regional warming and make temperature the strongest climatic signal in the study.

B. Rainfall trend — weak and statistically insignificant increase

Annual rainfall shows a weak positive trend (Sen's slope = 0.24 mm yr⁻¹; approximately 24 mm per century), but the relationship is not statistically significant (R² = 0.30; p = 0.21). Thus, the main concern is not a substantial change in total rainfall, but increasing variability in its timing and distribution.

C. Climate anomalies

The anomaly analysis shows that positive temperature anomalies became more frequent after 2000, while rainfall increasingly alternated between wet and dry extremes, reaching approximately -2.5 to +2.5 standard deviations. The greater frequency of extremes during 2005–2026 indicates increasing hydro-climatic instability and less predictable conditions for agriculture.

D. Potato production dynamics

Potato production increased from 11,800 tonnes (1980–1990) to a peak of 14,900 tonnes (2006–2010) before declining to 8,900 tonnes by 2021–2026. This represents an approximately 40% decline from the peak, despite some recent recovery, suggesting that the earlier production gains have not been sustained under changing climatic conditions.

E. Climate–production relationships — heat and rainfall distribution are critical

Pearson correlations show that growing-season maximum temperature (r = -0.72) and rainfall distribution variability (r = -0.61) have the strongest negative relationships with potato production, whereas April–July rainfall (r = 0.52) has a positive relationship. In comparison, total annual rainfall has only a weak, non-significant association (r = 0.28). These results indicate that heat stress and the timing and consistency of rainfall are more important for production than annual rainfall totals.

F. Multiple linear regression

The regression model explains 71% of the variation in potato production (R² = 0.71; adjusted R² = 0.68; p < 0.001). Maximum temperature is the strongest negative predictor (β = -0.56; p < 0.001), followed by rainfall distribution variability (β = -0.36; p < 0.001), while April–July rainfall has a positive effect (β = 0.28; p = 0.007). Minimum temperature is not significant (β = -0.12; p = 0.19). Overall, the model confirms that increasing heat and erratic rainfall are the principal climatic constraints on potato production.

G. Principal Component Analysis — two dominant climatic dimensions

The PCA shows that PC1 (46.2%) and PC2 (24.7%) together explain 70.9% of total variability. PC1 represents the interaction between heat stress and water availability, while PC2 reflects rainfall seasonality and production dynamics. Thus, most of the environmental variation relevant to potato production can be summarized by two major processes: warming and rainfall seasonality.

Conclusions

1. The Corridor has experienced significant warming, with mean annual temperature increasing by 2.3°C from 1980–2026 (p < 0.001).
2. Although total annual rainfall shows no significant trend, rainfall distribution has become increasingly erratic, with more frequent wet and dry anomalies and growing hydro-climatic instability.
3. Potato production declined by approximately 40% from its peak, with rising growing-season temperatures and rainfall variability emerging as the strongest climatic constraints.
4. The combined statistical and spatial evidence highlights the need for timely growing-season rainfall management, improved moisture availability, heat-resilient production practices, and targeted adaptation in vulnerable areas.

AN ASSESSMENT OF THE ROLE OF CLIMATE-SMART URBAN PLANNING IN REDUCING FLOOD RISKS IN KIGALI CITY

Author: Aline CYUZUZO

Affiliation UNIVERSITY OF RWANDA



Kigali wetland rehabilitation project, Rwanda, 2025. Image courtesy of the original provider, via The New Times Rwanda/Africa Press. Used for non-commercial educational purposes. [Original Africa Press source](#)

BACKGROUND & CONTEXT

Kigali City faces recurrent flooding driven by rapid urbanization, wetland encroachment, expanding impervious surfaces, informal settlement growth, and inadequate stormwater management infrastructure.

These pressures threaten urban resilience, public safety, and sustainable development. Despite Rwanda's strong commitment to climate adaptation and resilient urban growth, limited empirical evidence exists on how effective climate-smart urban planning approaches are at reducing flood risk in Kigali's rapidly expanding urban environment.

OBJECTIVES

- Analyze land-use change patterns and their relationship with flood-prone areas
- Evaluate the effectiveness of existing urban planning policies and climate-responsive interventions
- Identify climate-smart planning strategies with the greatest potential for flood risk reduction

METHODS & APPROACH

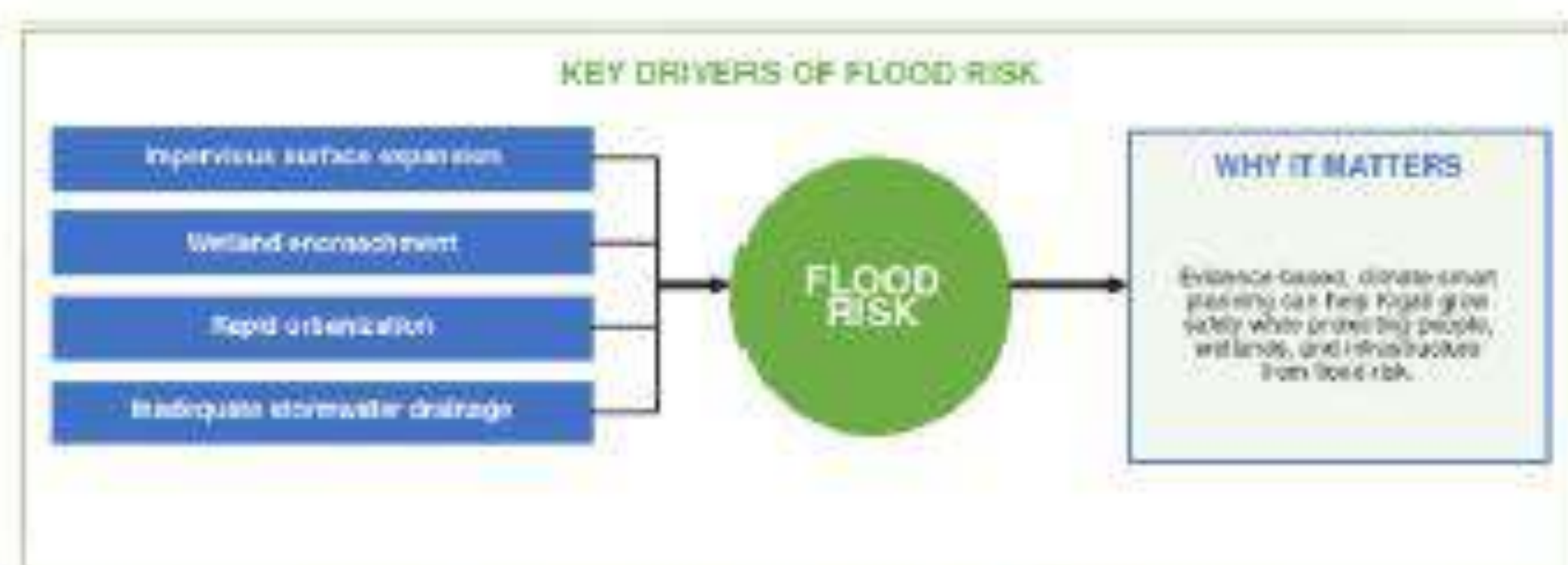
A mixed-methods design combining GIS spatial analysis, policy document review, and key informant interviews with urban planners, environmental authorities, and community stakeholders.

PRELIMINARY / EXPECTED FINDINGS

- Uncontrolled land-use change, wetland degradation, and fragmented institutional coordination significantly increase flood vulnerability in Kigali
- Green infrastructure, sustainable urban drainage systems (SUDS), and ecosystem-based wetland conservation show strong potential to reduce flood risk and improve resilience
- Greatest impact is expected when these measures are integrated into planning and land governance frameworks

CONCLUSION & POLICY RELEVANCE

The study will provide evidence-based recommendations for integrating climate-smart planning into Kigali's urban development strategies supporting policymakers, urban planners, and climate adaptation stakeholders in strengthening flood risk management, promoting sustainable urban growth, and advancing Rwanda's climate resilience objectives.



Kigali wetland rehabilitation project, Rwanda, 5 September 2025. Photo © Cyuzuzozo/Africa Press. Used for non-commercial educational purposes. [Original Africa Press source](#)



Scan for the full report

When Climate Shocks Collide with Grid Failure

Measuring the value of distribution-level data for predicting climate-driven grid vulnerability

Kwame Donkor, June Lukuyu

Department of Electrical & Computer Engineering

Background & Motivation

Climate change is leading to an increased frequency and severity of extreme weather events on the continent.

Africa will need robust power grids to adapt to climate change, rapid urbanization, and increasing electrification.

African grids are already characterized by high losses, frequent power outages and poor voltage quality; which could also be further weakened by weather events.

In Accra, relatively mild weather events are significantly associated with grid disturbances

These associations are spatially heterogeneous and analysis at coarse resolutions can miss such nuances in experiences

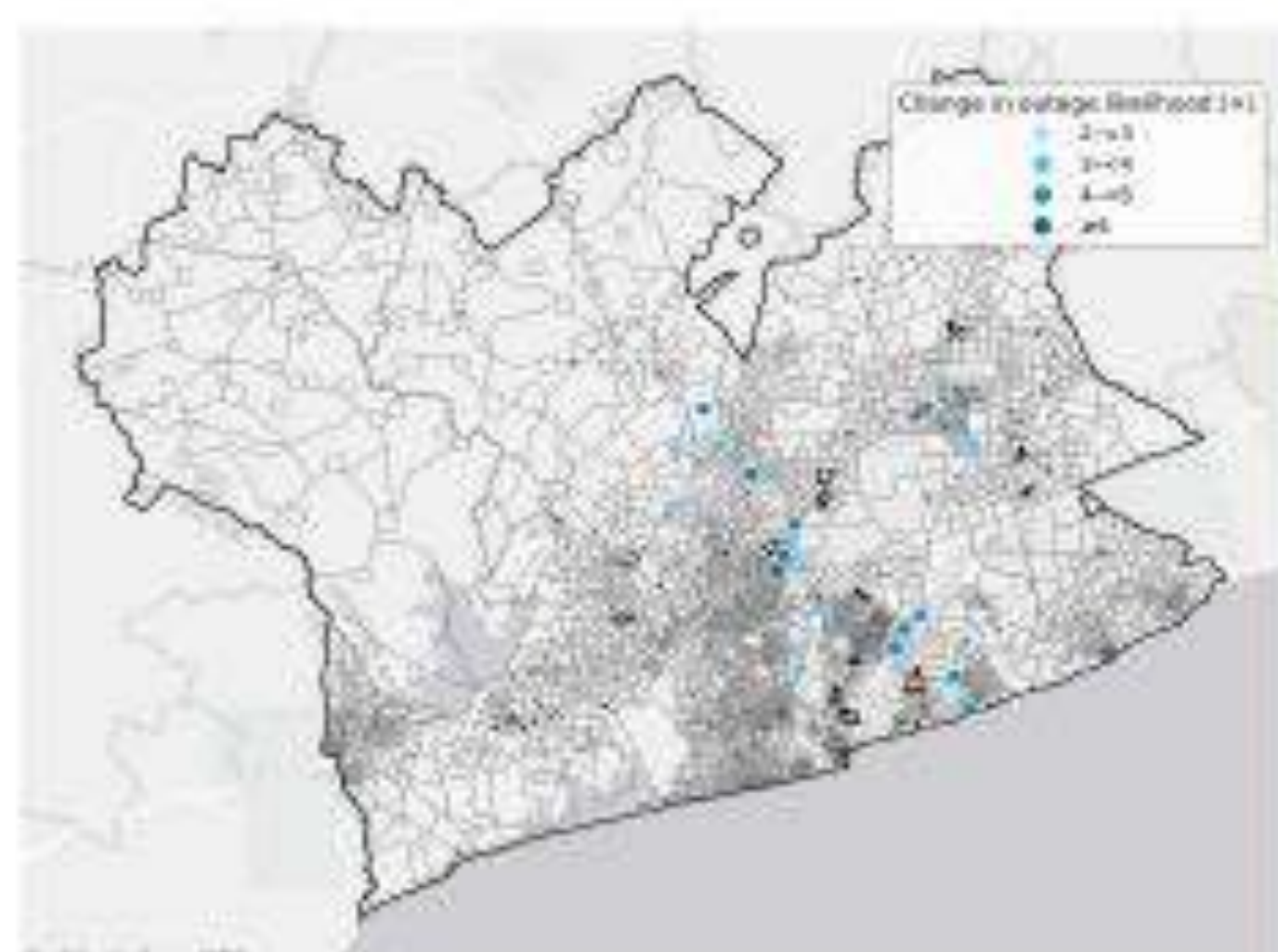


Figure 1: Change in outage likelihood on intense-rainfall days (≥ 17mm/day) for neighborhoods with significant rain-outage association. Values are multiplicative; the largest observed increase was ~14x.

The same weather event raises outage likelihood ~14x in the hardest-hit neighborhoods but only 1.38x when averaged across the study area — a 10-fold gap that coarse-resolution data would miss.

Moreover, these weather-grid disturbance associations can be more pronounced in vulnerable communities.

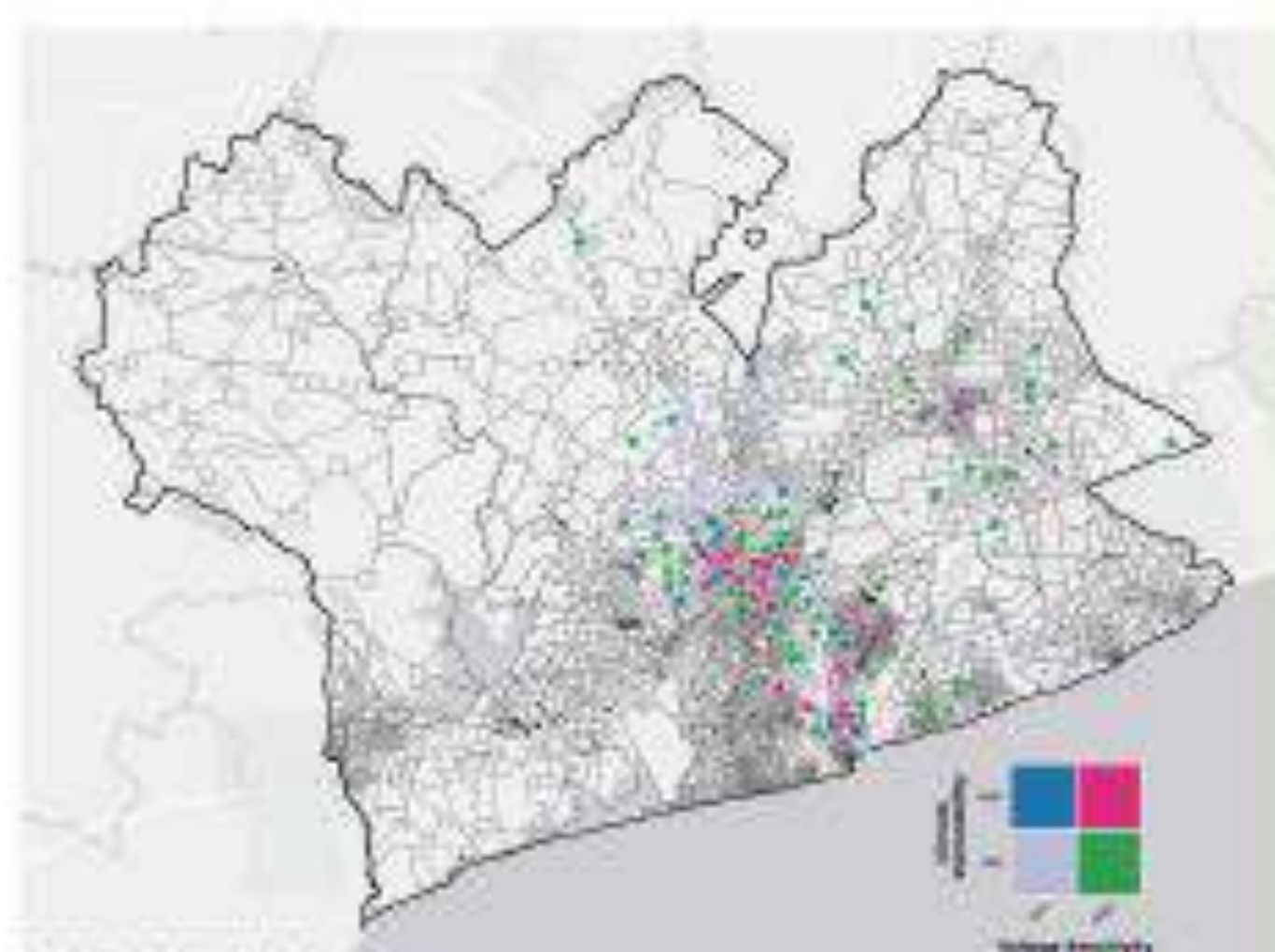


Figure 2: Power quality and reliability (PQR) sensors in Greater Accra, Ghana with a significant voltage-temperature association, classified by neighborhood climate vulnerability and degree of voltage sensitivity. High voltage sensitivity clusters within highly vulnerable areas (magenta).

This suggests that climate-informed grid-resilience planning could benefit from finer, neighborhood-scale climate and grid data.

Yet, data in the sub-region is often limited across two dimensions; historical records and spatial coverage.

Research Objective

To characterize how the performance of grid vulnerability prediction varies with the amount of historical weather and outage data.

Representation of Neighborhoods in Accra as a Graph Network

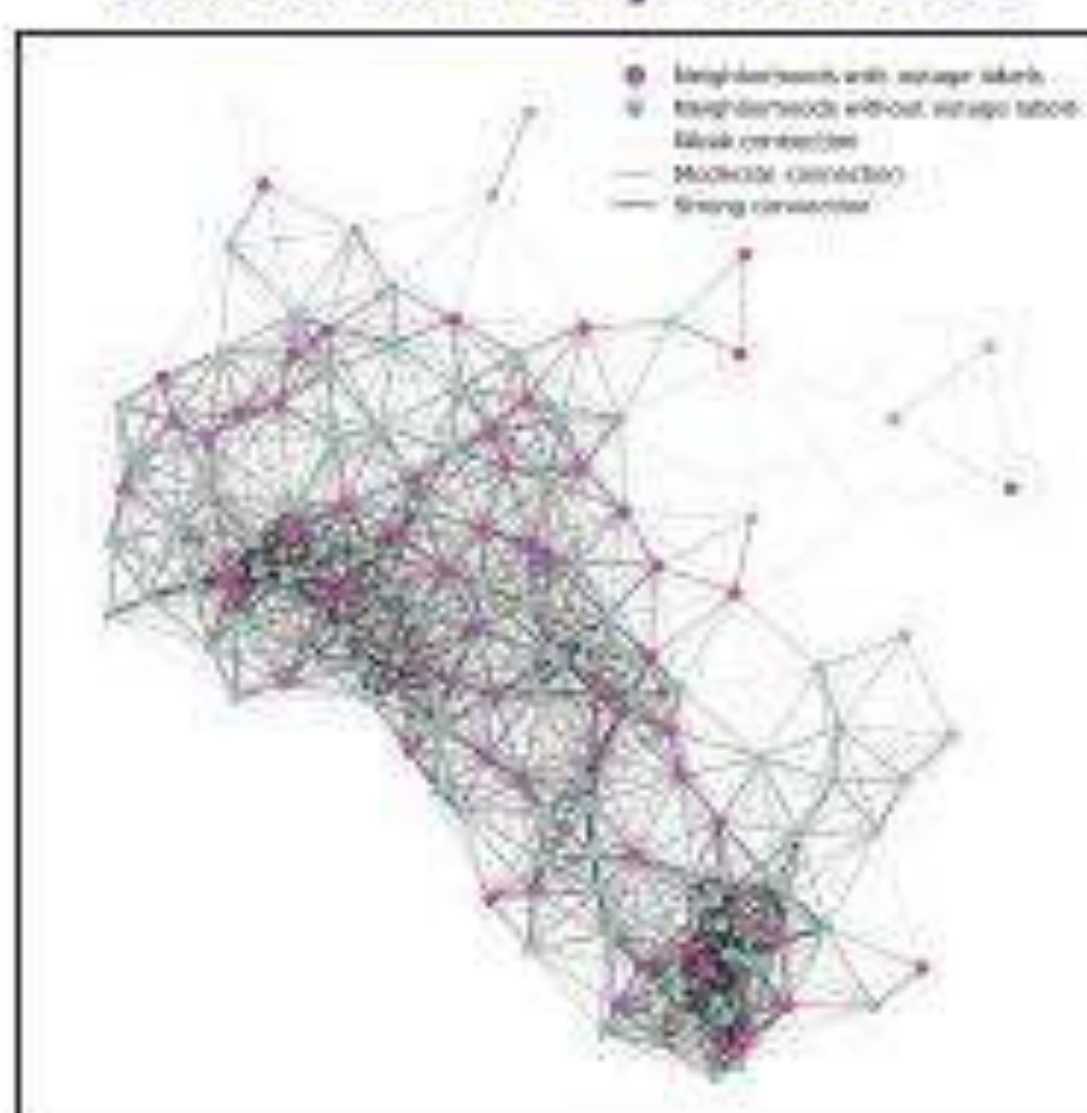


Figure 3: Visualization of graph network. The circles represent neighborhoods, while the gray lines represent edge connections between them. For visual clarity, only the 2,000 strongest edge connections are shown.

- Edge connections are weighted based on proximity.
- Nodes close to each other have high weights; distant nodes are weakly connected.

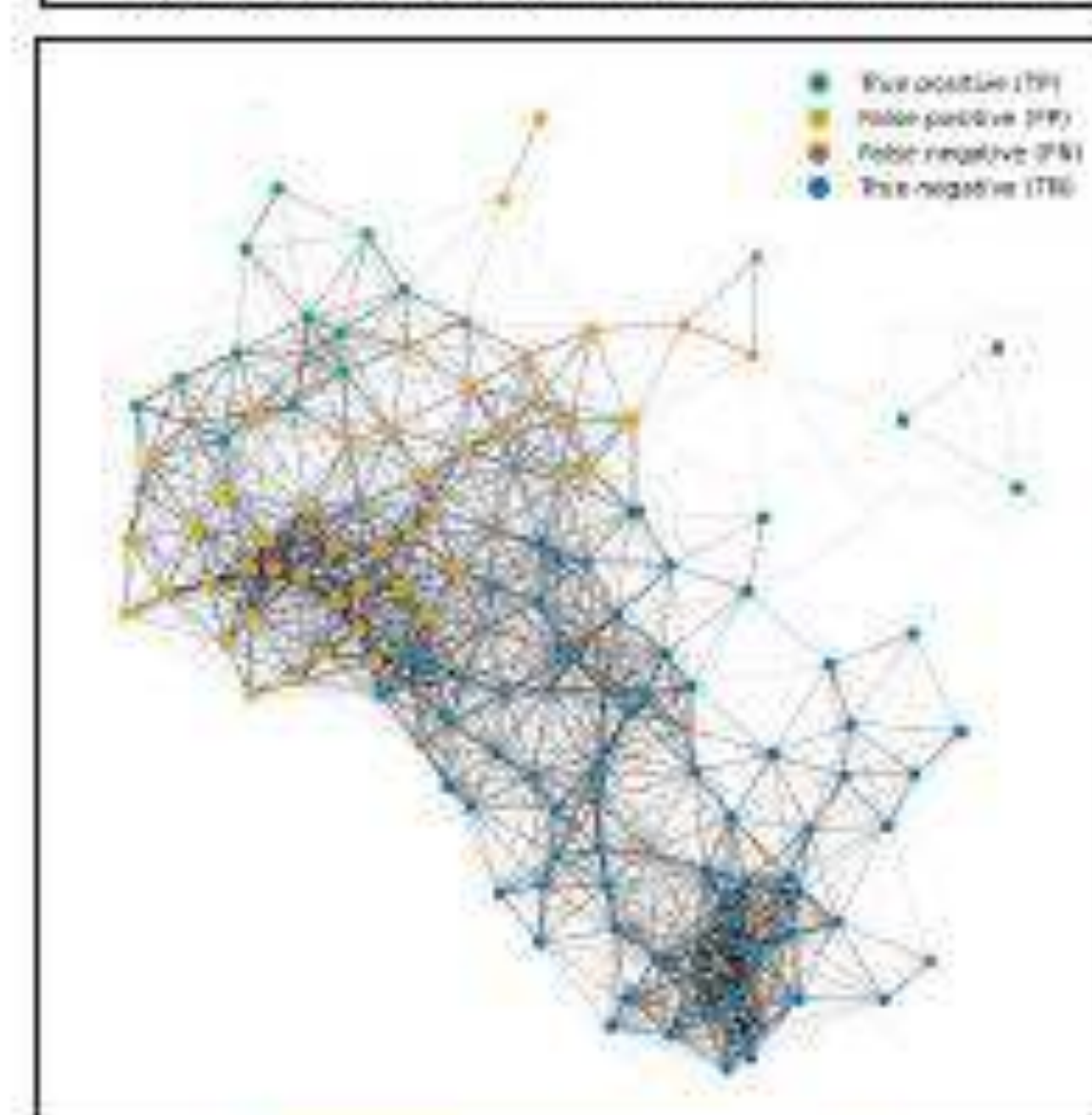
Outage Prediction Pipeline



Figure 4: Flowchart showing the Outage Prediction Pipeline.

Example Results - 25th October 2023 (20:00)

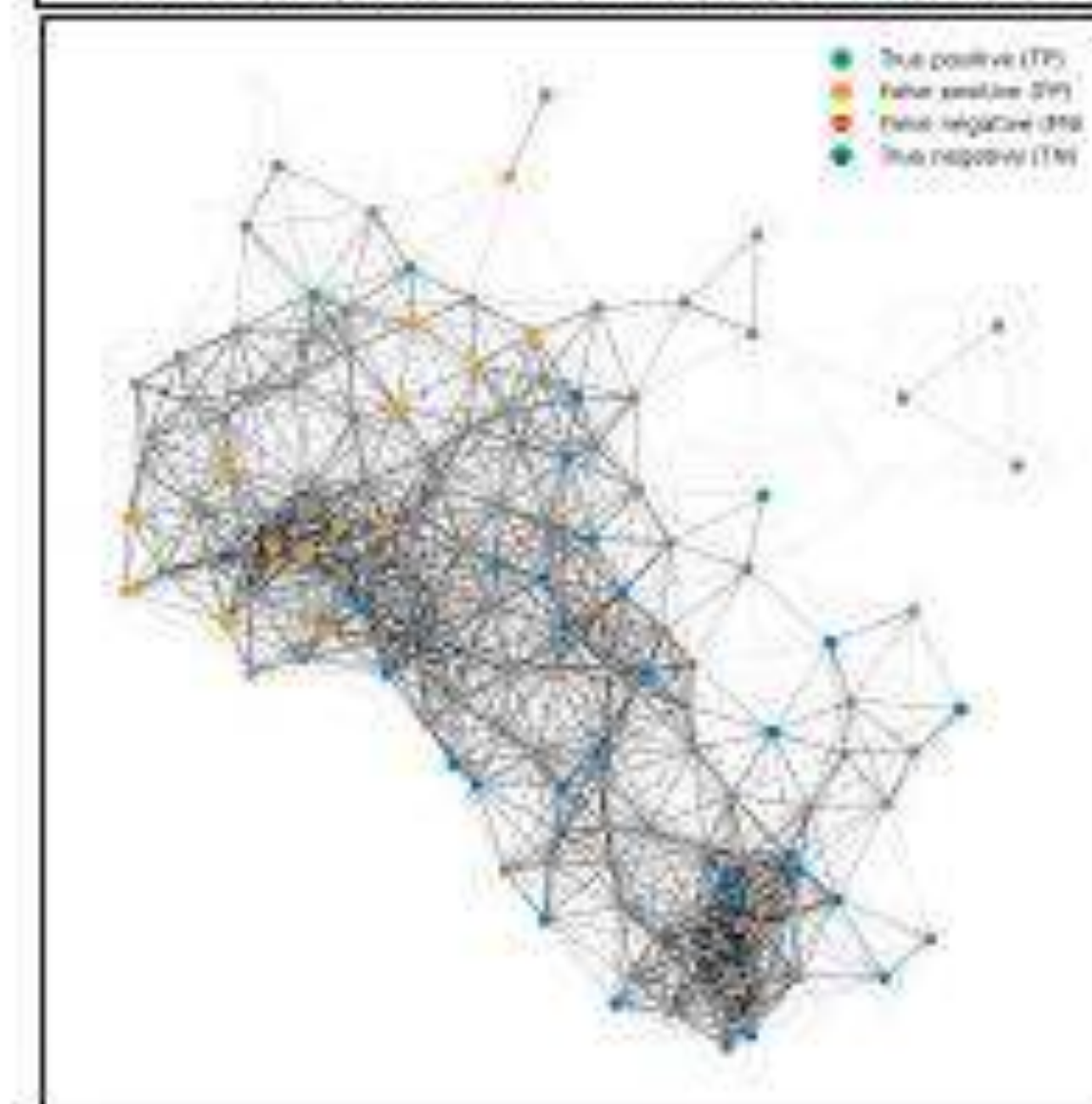
10% of the neighborhoods are instrumented and have outage labels



	Predicted No Outage	Predicted Outage
Actual No Outage	85 (TN)	54 (FP)
Actual Outage	1 (FN)	15 (TP)

- False alarms (FPs) could misdirect investment away from areas that genuinely need it.
- While missed outages (FNs) could leave neighborhoods overlooked for needed grid upgrades.

70% of the neighborhoods are instrumented and have outage labels



	Predicted No Outage	Predicted Outage
Actual No Outage	99 (TN)	40 (FP)
Actual Outage	1 (FN)	15 (TP)

Next Steps

- Incorporate a temporal lookback window to capture node feature evolution over time
- Enrich the node feature set with additional covariates, including topological and geographic attributes

Strengthening Climate Data and Monitoring Systems to Support Climate Resilience and Sustainable Development in Rwanda

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Republic of Rwanda
Ministry of Environment



Deutsche Gesellschaft
für Internationale
Zusammenarbeit (GIZ) GmbH



ROSS
2026
RWANDA CLIMATE
SCIENCE SYMPOSIUM

1. INTRODUCTION

- Climate change poses increasing risks to Rwanda's development gains, affecting agriculture, water resources, infrastructure, health, and ecosystems.
- High-quality climate data and effective monitoring systems are essential for evidence-based decision-making, early warning, adaptation planning, and sustainable development.
- Rwanda has made progress, but gaps remain in data density, timeliness, integration, and accessibility.
- This study highlights current progress, key gaps, and priority actions to strengthen climate data and monitoring systems.

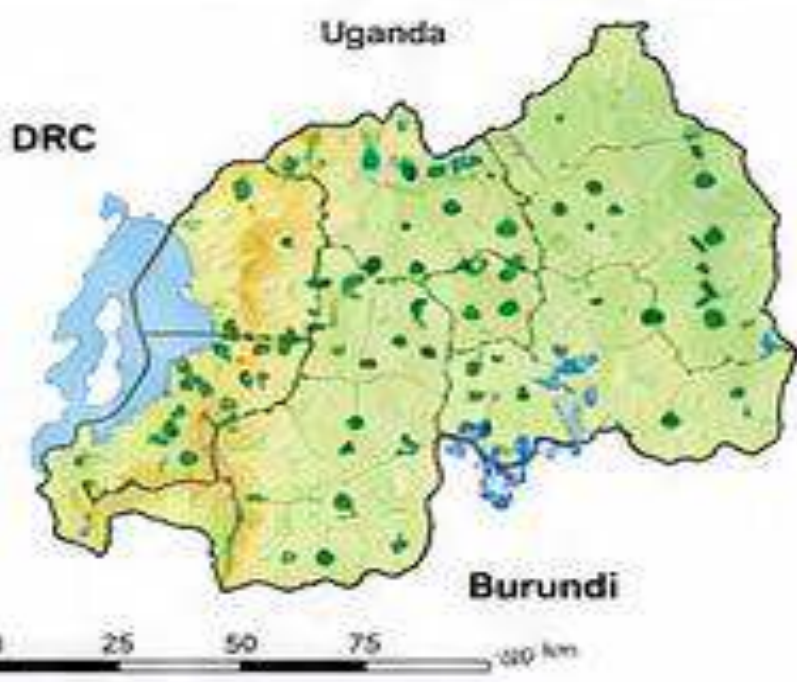


Automatic Weather Station (Meteorological Station)



Hydrometeorological monitoring (Matters for water and climate resilience)

2. STUDY AREA & DATA



Legend

- Weather Stations
- Rainfall Stations
- Hydrological Stations
- Rwanda Boundary
- Lakes
- District Boundaries

- Study Area:** Entire Rwanda (30 districts)
- Climate Data Sources:**
 - Rwanda Meteorology Agency (Meteo Rwanda)
 - Rwanda Water Resources Board (RWB)
 - Remote Sensing Data (CHIRPS, MODIS, Landsat, Sentinel)
- Data Period:** 2000 – 2024
- Variables:**
 - Rainfall, Temperature, Humidity, Wind
 - River Discharge, Water Level
 - Land Surface Temperature, Vegetation (NDVI), Soil Moisture

3. METHODOLOGY



Data Collection & Integration
Collect and integrate in-situ observations with satellite and reanalysis datasets.



Quality Control & Gap Filling
Apply standard QC procedures and statistical methods to ensure data quality and completeness.



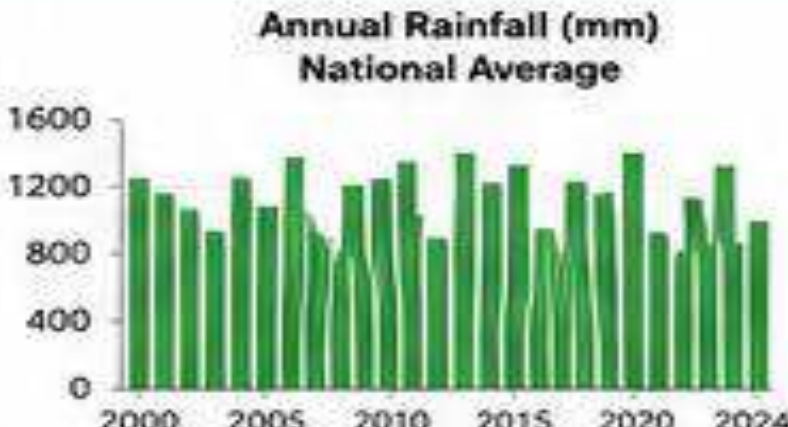
Analysis & Assessment
Evaluate data availability, trends, extremes, and spatial coverage.



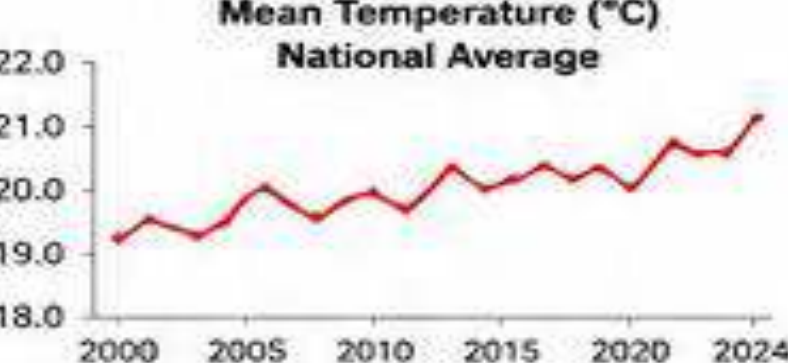
System Assessment
Assess observing systems against WMO standards for density, timeliness, accessibility, and sustainability.



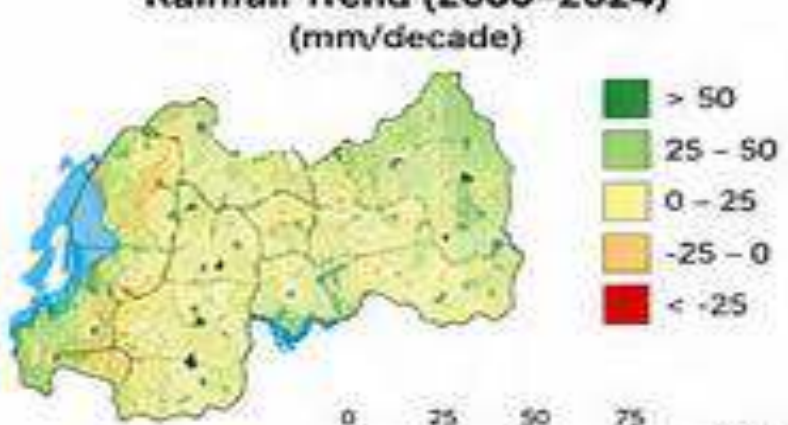
Recommendations
Propose actions to strengthen infrastructure, capacity, data systems, and partnerships.



Annual Rainfall (mm)
National Average



Mean Temperature (°C)
National Average



Rainfall Trend (2000–2024)
(mm/decade)

4. RESULTS

4.1. Current Observing Network

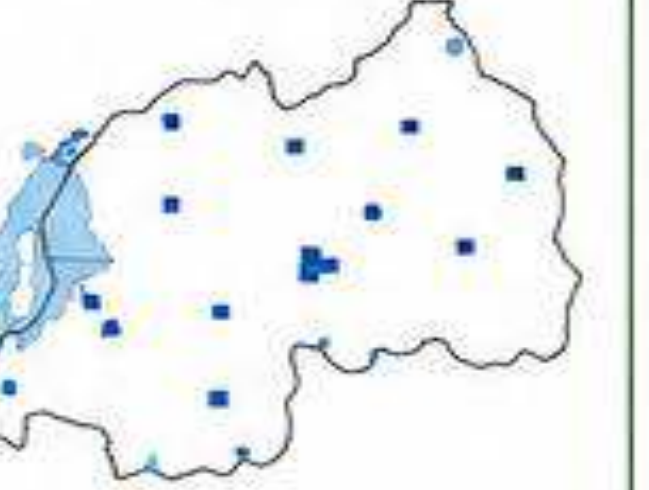
Weather Stations



Rainfall Stations



Hydrological Stations



4.2. Data Availability

Variable	Stations (Operational)	Data Availability (%)	Timeliness (%)
Rainfall	~160	78	70
Temperature	~50	72	68
Humidity	~35	65	60
River Discharge	~45	70	65
Water Level	~45	68	63

4.3. Key Findings

- Increasing temperatures across Rwanda (~0.3 °C per decade).
- High inter-annual variability in rainfall with more extreme events.
- Data gaps in eastern provinces and high-altitude areas.
- Timeliness and data sharing need improvement.
- Strong potential of satellite data to complement in-situ networks.

4.4. Extreme Events (2000–2024)



Flood Events
41
Major floods recorded



Droughts
7
Drought years identified



Heat Waves
12
Significant heat wave events



Landslides
> 300
Landslides linked to extreme rainfall

4.5. System Gaps Identified



Sparse station distribution



Aging equipment & maintenance gaps



Data management systems need strengthening



Delays in data availability



Limited human resource capacity

5. CONCLUSIONS & RECOMMENDATIONS

5.1. Conclusions

- Strengthened climate data and monitoring systems are vital for climate resilience and sustainable development in Rwanda.
- Significant progress has been made, but gaps in coverage, data quality, timeliness, and integration remain.
- Leveraging technology, partnerships, and capacity development will improve climate services and decision-making.

5.2. Recommendations

- Expand and modernize observing networks, especially in data-scarce areas.
- Improve data quality assurance, management, and timely dissemination.
- Enhance integration of in-situ, satellite, and model data.
- Invest in capacity development and institutional strengthening.
- Promote data sharing, open access, and multi-sector collaboration.
- Ensure sustainable financing for climate data and monitoring systems.



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Special thanks to GIZ for supporting climate science and data initiatives in Rwanda.

Together for a climate-resilient and sustainable Rwanda.

2ND

RWANDA CLIMATE SCIENCE SYMPOSIUM 2026

Where Rwanda's climate research meets policy

The Role of Faith-Based Organizations in Tackling Food Loss and Waste in Rwanda: A Preliminary Study

Jules Kazungu
Regional Research Centre for Integrated Development (RCID, Rwanda)
www.rcidcentre.com

Resilient Food Systems
for a Sustainable Future



Observed Variability and Trends of Rainfall and Climate Extreme Indices in Kirehe District, Eastern Rwanda: Implications for Climate-Sensitive Planning

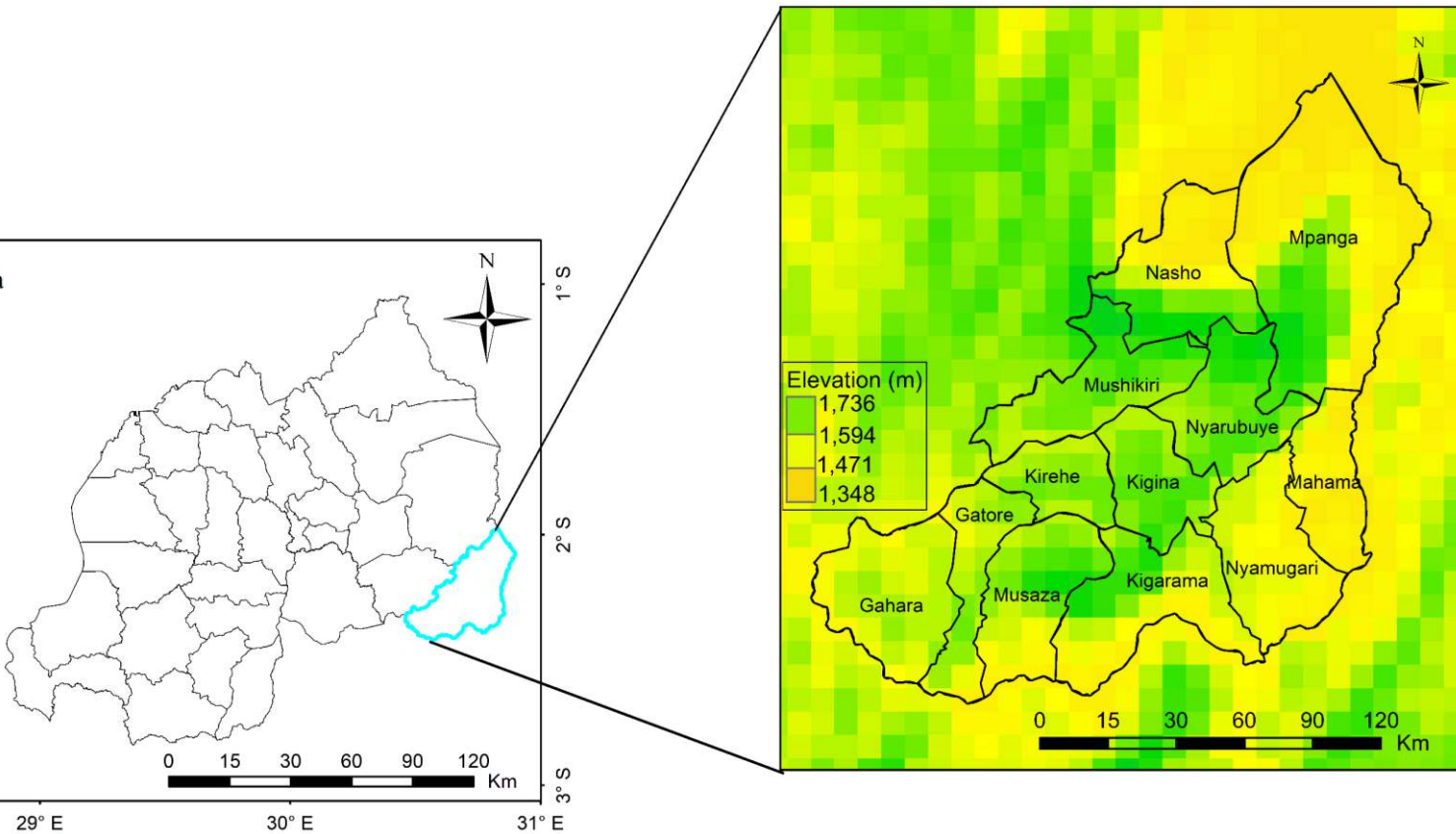
Nizeyimana, A., Sebaziga N.J., Kazora J., Mudakikwa E. R., Hakuzimana H., Twahirwa A., Safari A.K., Bavuge B., Ukwishaka D., Niyigena B., Nduwimana O., Byukusenge O., Nkunsi P.,

Nibagwire D, Hakizimana P.C, Nyiraneza C., Rutabuzwa A.M., Rwema M.

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Link to full paper: <https://doi.org/10.1007/s44274-025-00495-1>

Kirehe District is located in the southeastern part of Rwanda, within the Eastern Province, in the eastern lowland climate zone. The district experiences a bimodal rainfall pattern, with the two main rainy seasons occurring from March to May (MAM) and September to December (SOND) and two dry seasons extending from January to February (JF) and June to August (JJA). The district's topography is characterized by hills and valleys, influencing its rainfall distribution. Predominantly an agricultural region, Kirehe's livelihoods are heavily reliant on rainfed farming, making it particularly vulnerable to rainfall variability and extreme weather events. Understanding rainfall patterns and extreme indices is therefore critical for informing climate-resilient agricultural practices, water resource management, and disaster preparedness in this drought-prone district.



Geographical location of Kirehe district in Rwanda (a) and administrative with elevation map of Kirehe district (b)

Objective:

Spatial analysis of variability and trends for seasonal and annual rainfall and their related extreme rainfall indices in Kirehe district.

Data:

Gridded rainfall at 4kmx4k resolution from 1983 to 2021 obtained from the Rwanda Meteorology Agency.

Method:

- i) Variability: Coefficient of variation (CV)
- ii) Trends: Mann-Kendall test and Sen's slope.
- iii) extreme rainfall indices: Computed following the methodology of the Expert Team on Climate Change Detection and Indices (ETCCDI).

Rainfall extreme indices	Units
Consecutive dry days (CDD)	Days
Consecutive wet days (CWD)	Days
Total annual precipitation (PRCPTOT)	mm
Heavy precipitation days (R10mm)	Days
Very heavy precipitation days (R20mm)	Days
Precipitation from very wet days (R95pTOT),	mm
Maximum 1-day precipitation (RX1day)	mm
Maximum 5-day precipitation (RX5day)	mm
Simple daily intensity index (SDII)	mm/day

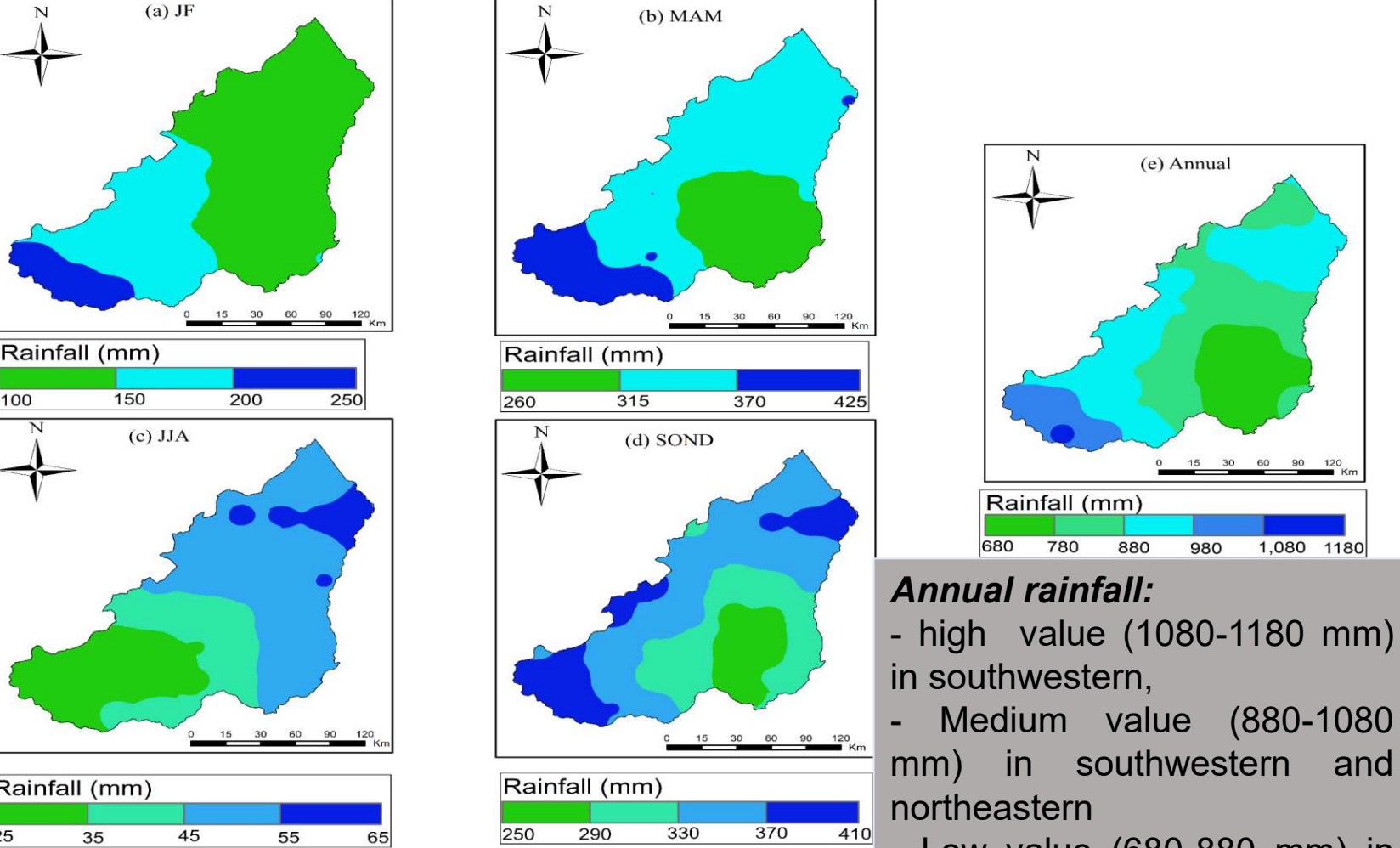
Spatial distribution of Seasonal and annual rainfall

JF: high values (200-425 mm) in southwestern, medium values (150-200 mm) in southern and low values (100-150 mm) in central, southeastern

MAM: high values (370-250 mm) in southwestern, medium values (315-370 mm) in central to northern and low values (260-315 mm) in

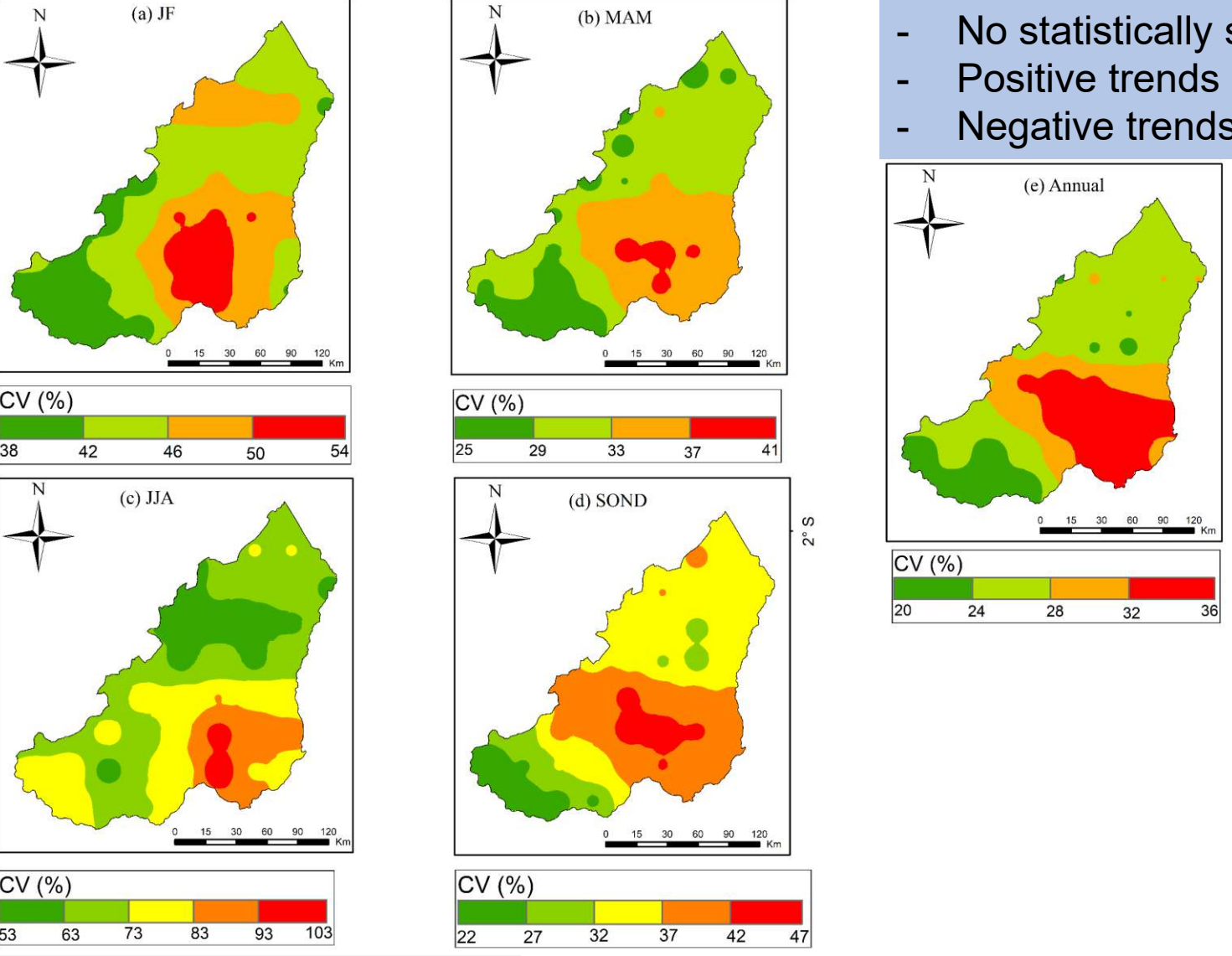
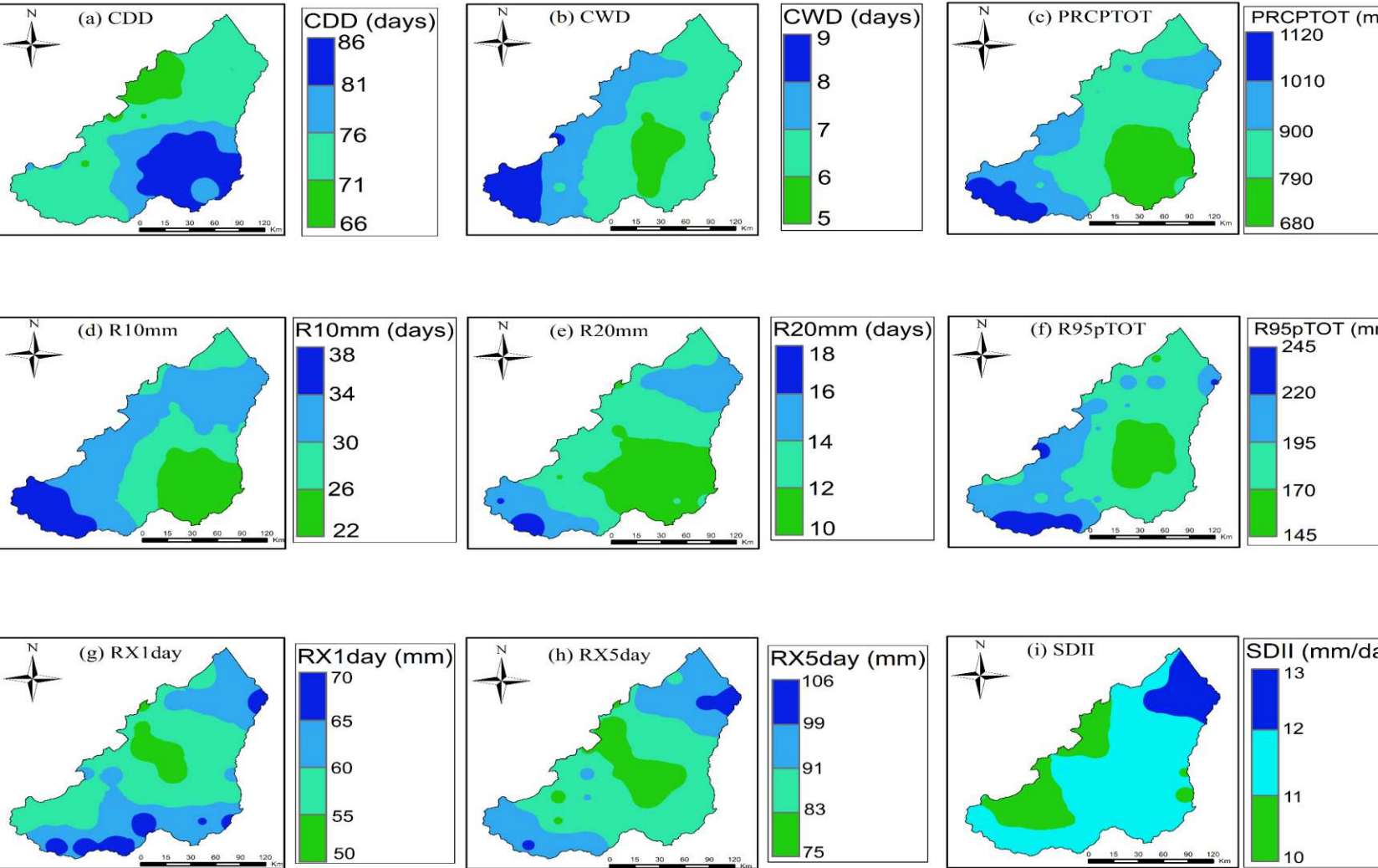
JJA: high values (55-65mm) in eastern, central and northern and low values (25-45 mm) in central to southern

SOND: high value (330-410 mm) in southern, western and northern and low value (250-330 mm) in central and eastern



Annual rainfall:
- high value (1080-1180 mm) in southwestern,
- Medium value (880-1080 mm) in southwestern and northeastern
- Low value (680-880 mm) in central and eastern

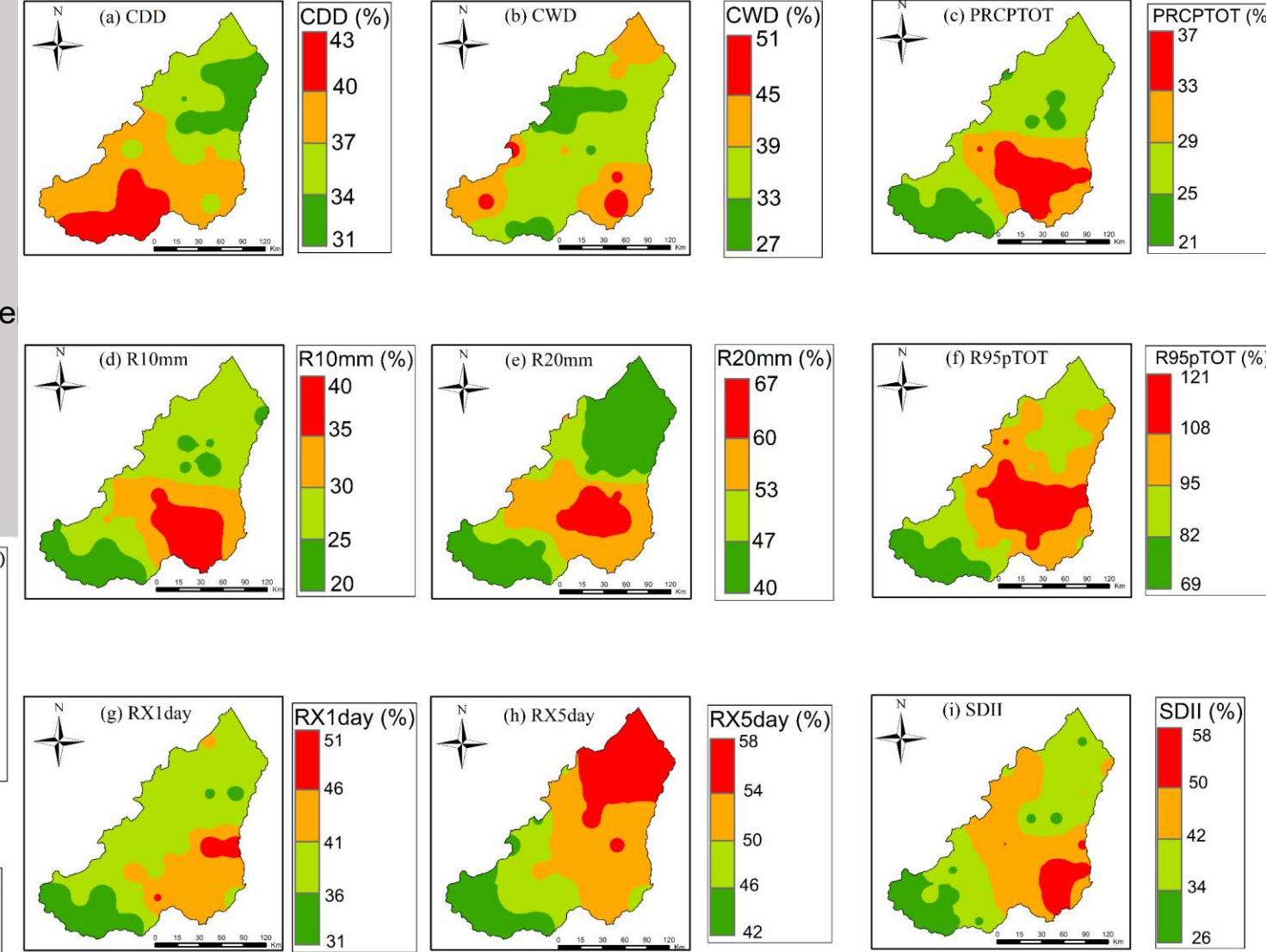
- CDD: shows high value (76-86 days) in southeastern and low (66-76 days) in other areas
- CWD: high values (7-9 days) in southern and western and low (5-7 days) in other areas
- PRCPTOT: high values (900-1120 mm), in southern, western and northeastern and low values (680-900 mm) in other areas
- R10mm: high values (30-38 days) in southern, western and northeastern and low values (22-30 days) in other areas
- R20mm: high values (14-18 days) in southern and northeastern and low values (10-14 days) in other areas
- R95pTOT: high values (195-245 mm) in southern and western and low value (145-195 mm) in other areas
- RX1day: high values (60-70 mm) in southern and northeastern and low value (50-60 mm) in other areas
- RX5day: high value (91-106 mm) in southern and northern and low value (75-91 mm) other areas
- SDII: high value (12-13 mm/day) pin northeastern and low value (10-12 mm/day) in other areas



Southwestern and northern areas are the areas with low variability:
JF: 38-46%
MAM: 25-33%
SOND : 22-37%
Annually : 20-28%

Central to southeastern parts are the areas with high variability:
JF: 46-54%
MAM: 33-41%
JJA: 73-103%
SOND : 37-47%
Annually : 28-36%

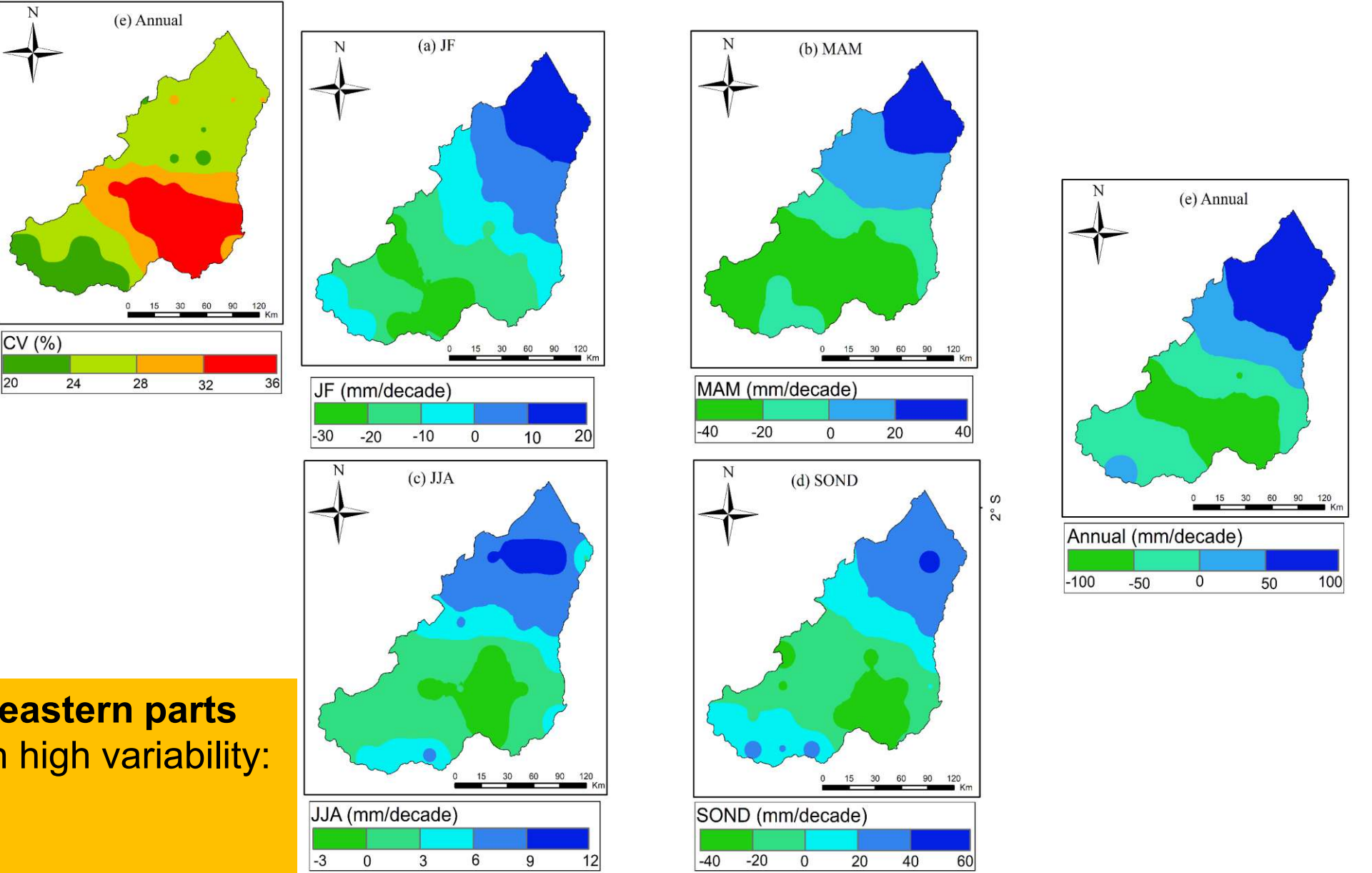
Areas with low variability present reliable rainfall while areas with high variability present more erratic rainfall.



- ❖ CDD: vary highly in southern and central areas (37-43%);
- ❖ CWD: vary highly in the southeast, southwest, and north (39-51%);
- ❖ The southeast shows high variability in:
 - R10mm (30-40%),
 - R20mm (53-67%),
 - R95PTOT (95-121%),
 - RX1day (41-51%),
 - SDII (42-58%),
- ❖ RX5day varies highly in central, eastern, and northern parts (50-58%); other areas show lower variation.

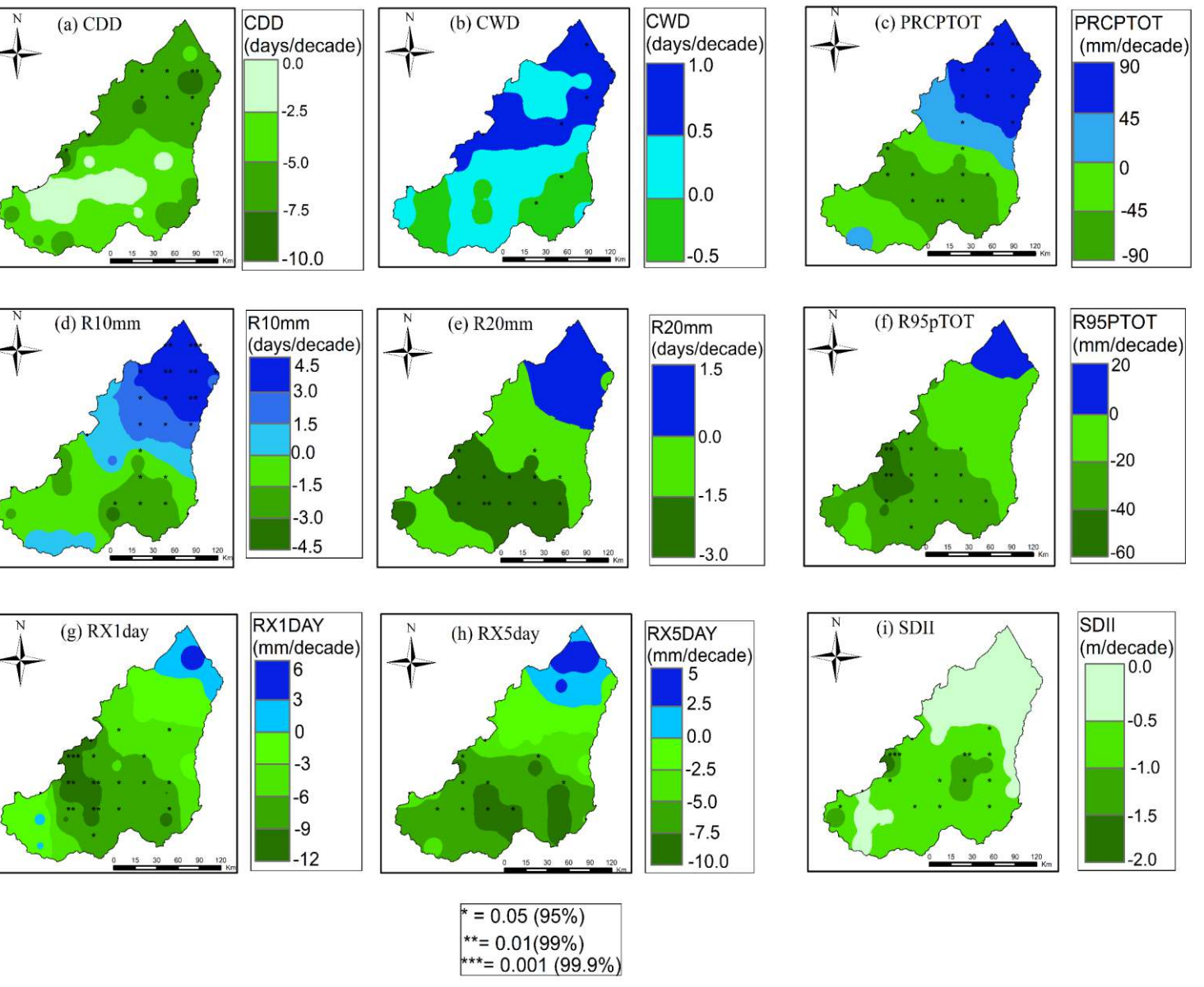
➤ Remaining areas show low variability

- No statistically significant btrends observed for all seasons and on annual timescale
- Positive trends are observed in northern areas
- Negative trends are observed in central, southern and southeastern areas



- Statistically significant Negative trends in central areas for:
 - PRCPTOT: [-90, -45] mm/decade
 - R10mm: [-4.5, -3.0] days/decade
 - R20mm: [-3.0, 1.5] days/decade
 - R95pTOT: [-60, -20] mm/decade
 - RX1day: [-12, -6] mm/decade
 - RX5day: [-10.0, -5.0] mm/decade
- ❑ Statistically significant Negative trends in northern for:
CDD:[-10, -5.0] days/decade

- ❖ Statistically significant positive trends in northern areas for:
 - CWD: [0.5, 1.0] days/decade
 - PRCPTOT: [45, 90] mm/decade
 - R10mm: [1.5, 4.5] days/decade



Spatial disparities in rainfall variability and extreme indices expose Kirehe District to uneven risks for agriculture, water security, and disaster preparedness. Targeted adaptation such as climate-resilient crops, irrigation, water conservation, infrastructure reinforcement are urgently needed.

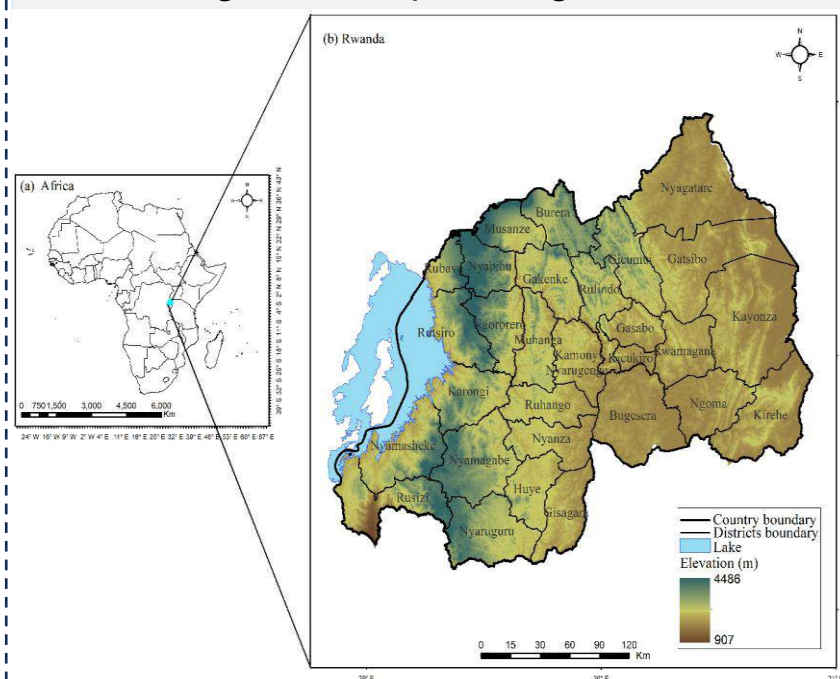
Projected Change in Precipitation and Temperatures under a Changing Climate in Rwanda

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Rwanda Environment Management Authority

Link to full paper: <https://doi.org/10.1007/s44274-026-00547-0>

Rwanda, often referred to as “the land of a thousand hills,” is situated in Eastern-Central Africa between 1°4'-2°51'S and 28°53'-30°53'E, encompassing an area of 26,338 km². Rwanda's landscape is highly diverse, ranging from lowlands to volcanic highlands, at an altitude of 900m in Bugarama Valley to 4507 m at Mount Karisimbi. This complex terrain strongly influences the geographical variations in rainfall and temperatures (Ntwali et al., 2016). The western highlands are wetter and cooler than the lower, drier and warmer eastern plains (Siebert et al., 2019; Sebaziga et al., 2023; Sebaziga et al., 2024). Rwanda has four distinct seasons, comprising two wet seasons (March-May, MAM, and September-December, SON) and two dry seasons (January-February, JF, and June-August, JJA) (Siebert et al., 2019; Kazora et al., 2021; Sebaziga et al., 2023; Sebaziga et al., 2024). Peak rainfall occurs in April and November (Ntwali et al., 2016). These patterns align with the country's climatology and agricultural calendar (Siebert et al., 2019).

In Rwanda, numerous studies have investigated observed rainfall and temperature variability and trends, consistently reporting increasing rainfall variability and rising temperatures at both seasonal and annual timescales (Kazora et al., 2021; Ngarukiyimana et al., 2021; Safari & Sebaziga, 2023; Sebaziga et al., 2021; Sebaziga et al., 2023; Sebaziga et al., 2024). Given that Rwanda's agricultural systems are predominantly rain-fed, changes in rainfall and temperature have direct implications for crop productivity and food security (Rwanyiziri & Rugema, 2013). While observational evidence is well documented, **there remains a critical gap in understanding how these climatic variables are likely to evolve in the future at seasonal timescales**, which is essential for climate-resilient agricultural planning.



Objective:

Assess the seasonal Projected Change in Precipitation and Temperatures under a Changing Climate in Rwanda

Data:

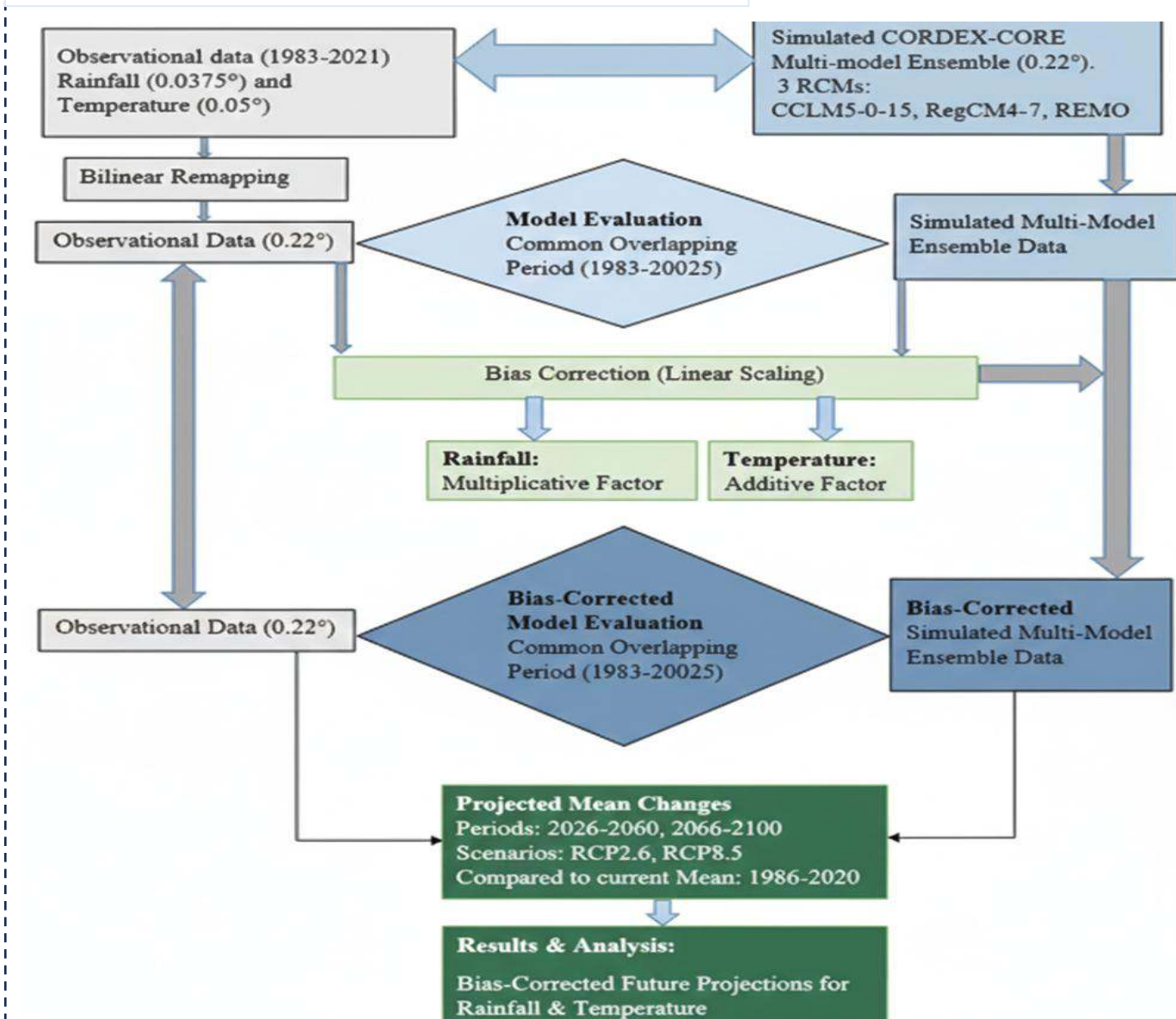
1. Observed :

- Gridded rainfall (4kmx4km) and temperatures (5kmx5km) resolution from 1983 to 2021 obtained from the Rwanda Meteorology Agency.

2. Model:

-CORDEX-CORE multimodel ensemble (RCP2.6 and RCP8.5)

Rwanda's location within Africa (a) and its administrative and elevation map (b)



Procedural workflow for climate data processing and projection

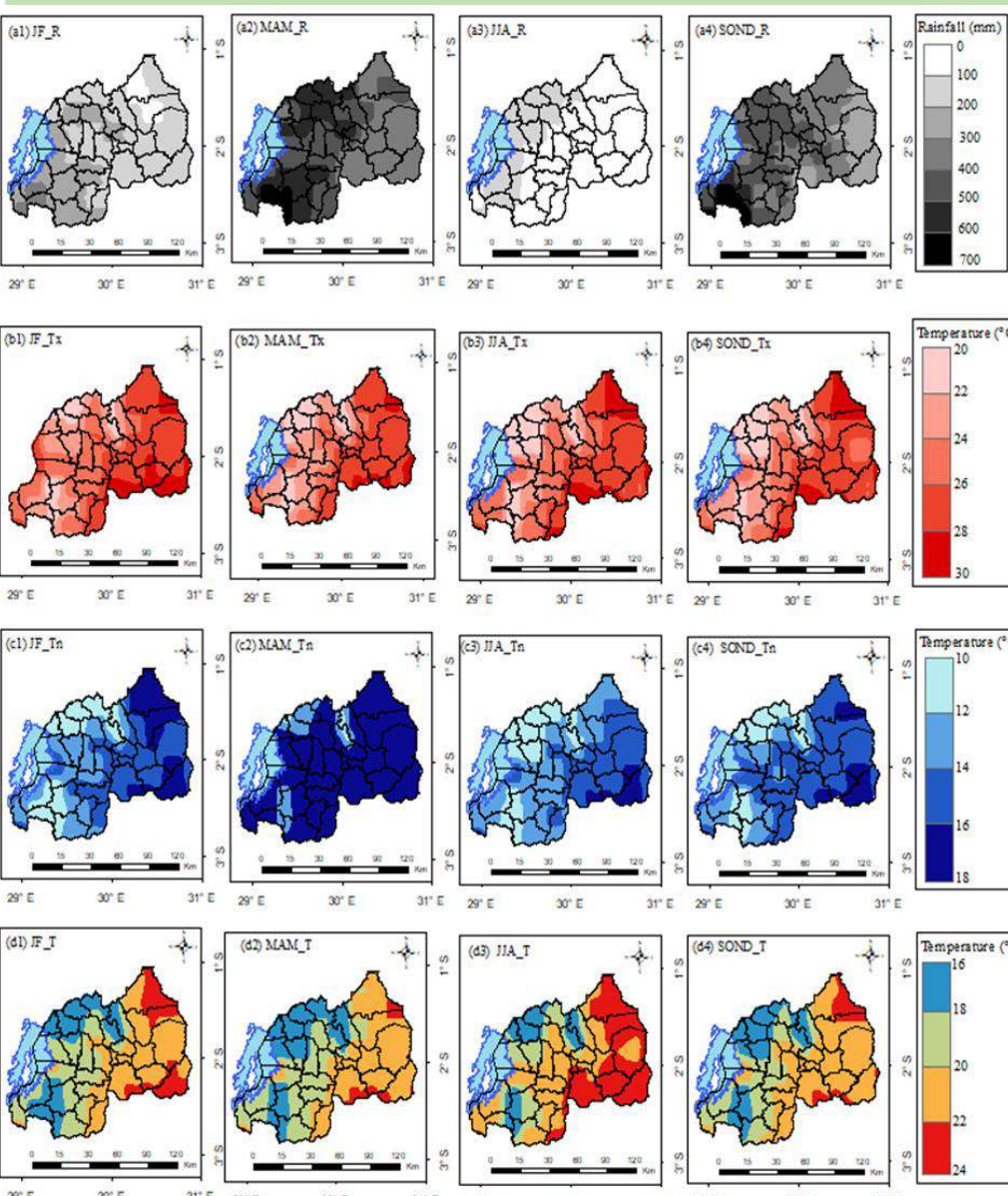
Spatial distribution of observed Seasonal rainfall

JF: high values (200-300 mm) in southwestern, western and northern, and low values (0-2000 mm) in central and eastern

MAM: High values (600-700 mm) in southwestern, northwestern and northern highland, medium values (400-500mm) in central plateau, central parts of southern and western regions and low values (300-400

JJA: High values (100-200 mm) in western and northern and low values (0-100mm) in eastern, central and southern

SOND: High values (500-600 mm) in southwestern, medium values (300-400mm) in western, southern and northern highland low values (100-300 mm) in central and eastern



Spatial distribution of observed Seasonal temperatures

Across all seasons, temperatures (maximum, minimum, and mean) exhibit nearly identical geographical patterns.

- ❖ The cooler zones consistently align with the northern highlands, volcanic regions, and the Congo Nile Trail.

✓ Maximum temperature: 20-22°C

✓ Mean temperature: 16-18°C

✓ Minimum temperature: 10-12°C

- ❖ Intermediate temperature ranges persist over the central plateau and western regions.

✓ Maximum temperature: 22-26°C

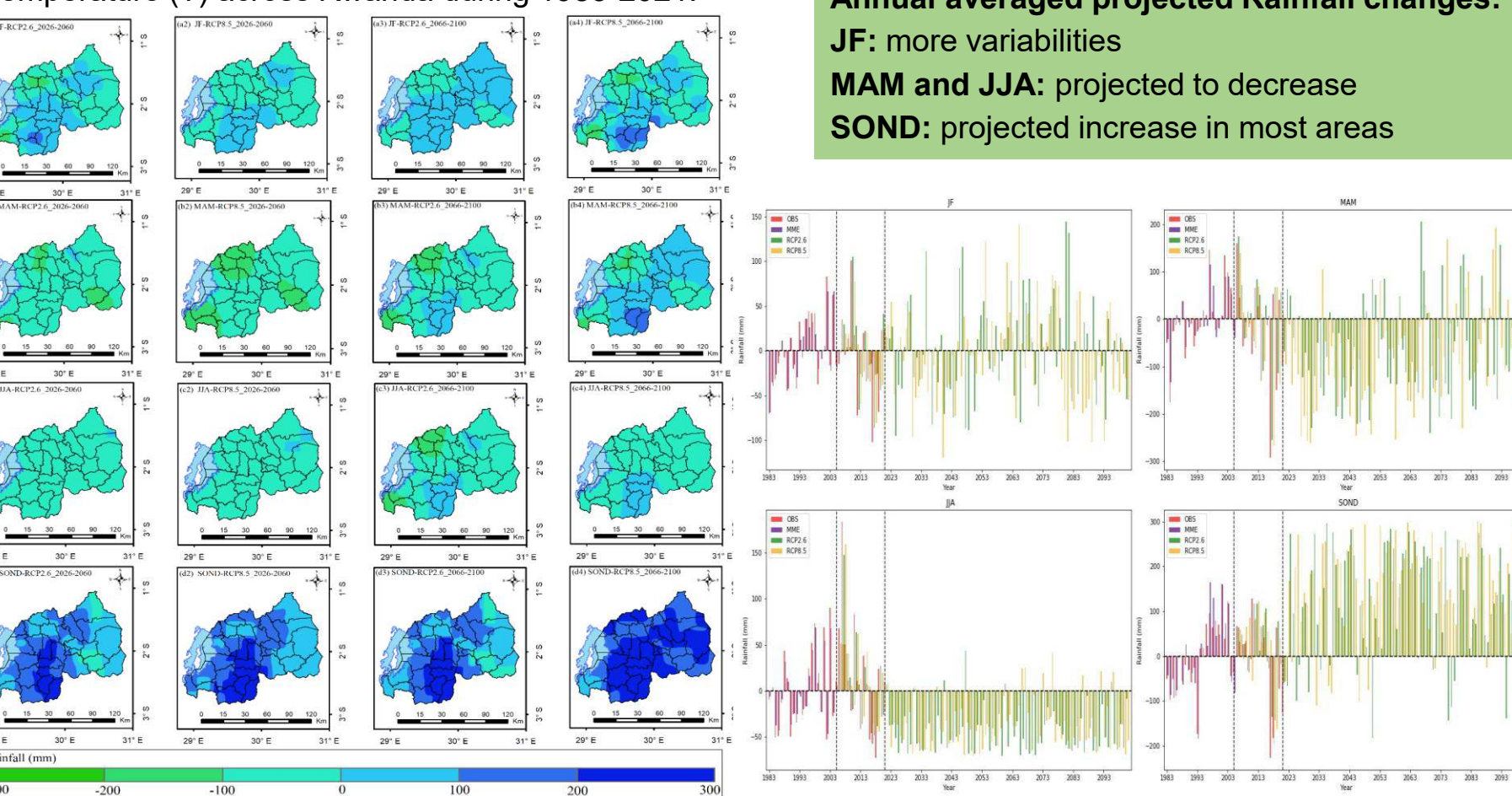
✓ Mean temperature: 18-22°C

✓ Minimum temperature: 12-16°C

- ❖ The warmer zones are concentrated in the southcentral, southeastern, northeastern and Bugarama valley.
- ✓ Maximum temperature: 26-30°C
- ✓ Mean temperature: 22-24°C
- ✓ Minimum temperature: 16-18°C

- ❖ This spatial consistency highlights that, despite seasonal fluctuations, Rwanda's temperature distribution is largely governed by its topography and regional geography rather than seasonal shifts.

Spatial patterns of observed seasonal mean rainfall, maximum temperature (Tx), minimum temperature (Tn), and mean temperature (T) across Rwanda during 1983-2021.



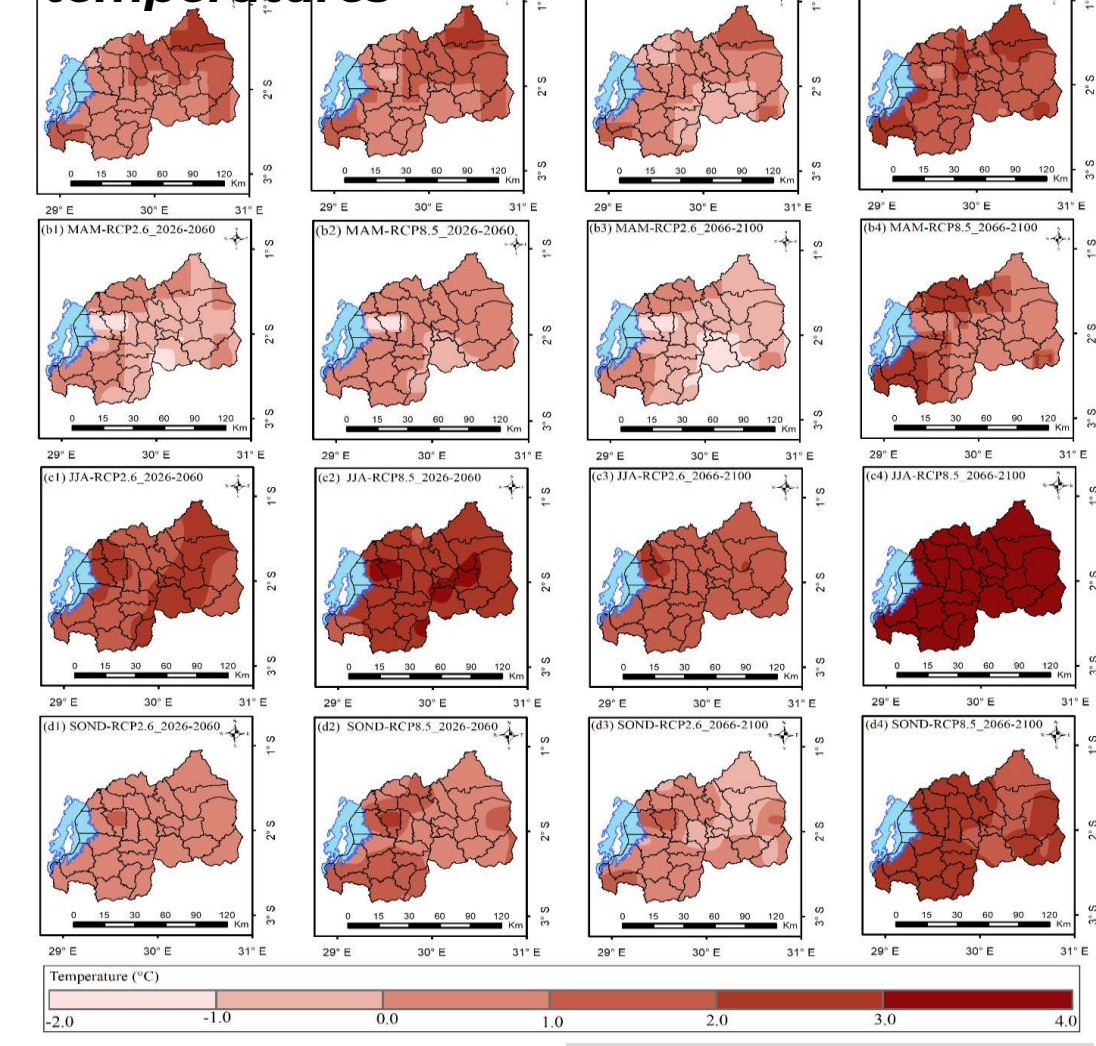
- Rainfall projections show **high spatial and temporal variability** compared to temperature.
- Under **RCP2.6**, changes are generally small to moderate, with mixed signals (increases in some regions, decreases in others).
- Under **RCP8.5**, changes intensify, with stronger wetting or drying depending on season and location.
- Late-century (2066–2100)** scenarios show larger deviations than **mid-century (2026–2060)**.

JF: Increase in southcentral and eastern and decrease in remaining areas.

MAM and JJA: projected decrease in most areas and increase in southcentral and northeastern

SOND: projected increase in most areas except the southeastern area

Projected changes in maximum temperatures



Seasonal Patterns:

JF (Jan-Feb):

Mid-century (2026–2060):

RCP2.6: Moderate warming (+0.5 to +1.5 °C) across most regions.

RCP8.5: Stronger warming (+1.5 to +2.5 °C), especially in eastern plateau and Kigali.

Late-century (2066–2100):

RCP2.6: Warming (+1.0 to +2.0 °C) across most regions.

RCP8.5: Intense warming (+3.0 to +4.0 °C) widespread, with hotspots in northeastern and southwestern.

Seasonal Patterns:

JF (Jan-Feb):

Mid-century:

RCP2.6: Slight warming (+0.5 to +1.0 °C) in highlands, stronger (+1.5 to +2.0 °C) in lowlands.

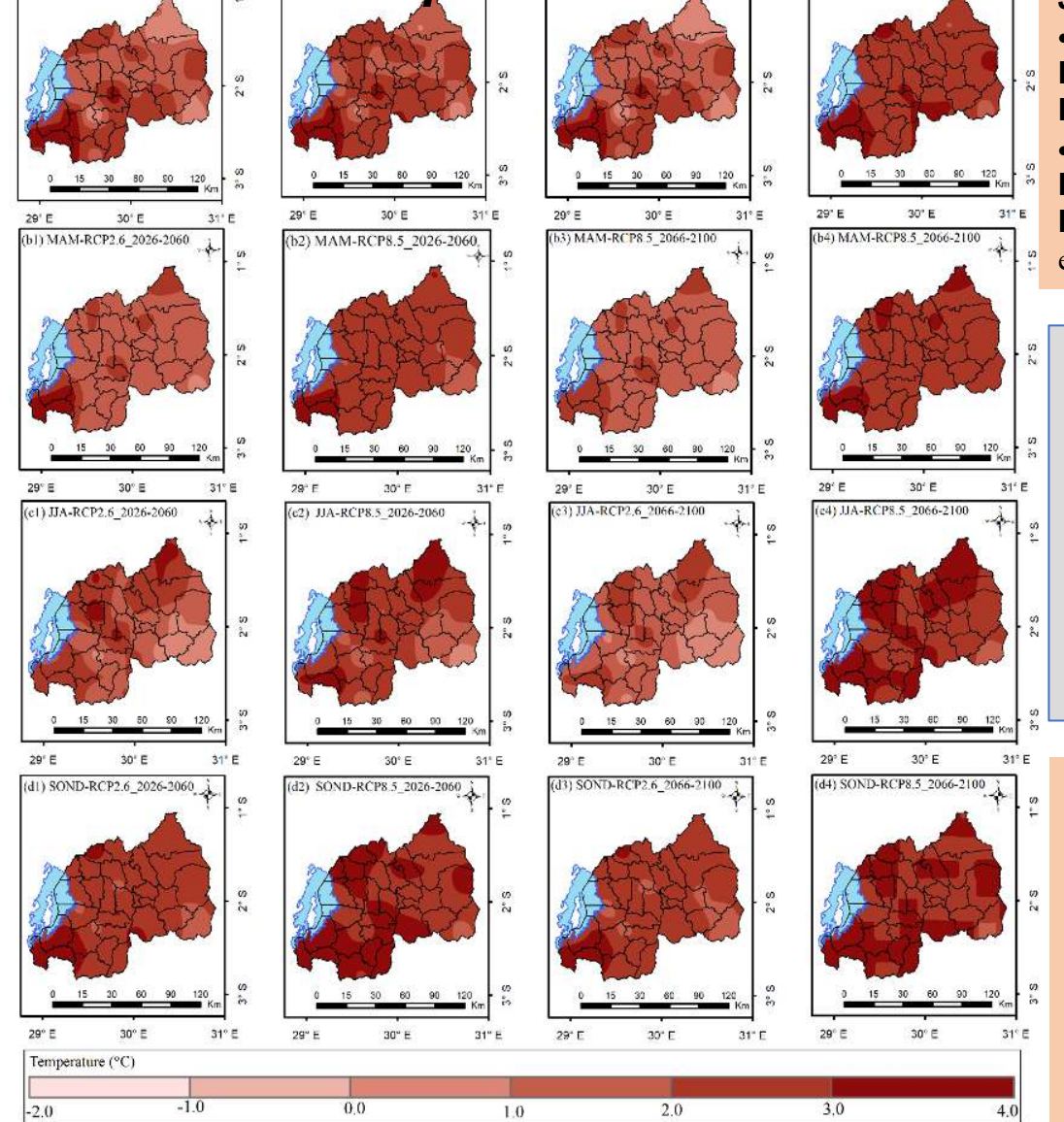
RCP8.5: Moderate warming (+2.0 to +2.5 °C).

Late-century:

RCP2.6: Warming remains moderate (+1.0 to +2.0 °C).

RCP8.5: Significant warming (+3.0 to +4.0 °C) widespread, especially in eastern and southern regions.

Projected changes in minimum temperatures



Seasonal Patterns:

JF (Jan-Feb):

Mid-century:

RCP2.6: Moderate warming (+0.5 to +1.5 °C).

RCP8.5: Stronger warming (+1.5 to +2.5 °C).

Late-century:

RCP2.6: Stabilized warming (+1.0 to +2.0 °C).

RCP8.5: Intense warming (+3.0 to +4.0 °C), especially in eastern lowlands.

MAM (Mar-May):

Mid-century:

RCP2.6: Mild warming (+0.5 to +1.5 °C).

RCP8.5: Moderate warming (+1.5 to +2.5 °C).

Late-century:

RCP2.6: Moderate warming (+1.0 to +2.0 °C).

RCP8.5: Strong warming (+3.0 to +4.0 °C) widespread.

JJA (Jun-Aug):

Mid-century:

RCP2.6: Slight warming (+0.5 to +1.0 °C).

RCP8.5: Moderate warming (+2.0 to +2.5 °C).

Late-century:

RCP2.6: Moderate warming (+1.0 to +2.0 °C).

RCP8.5: Significant warming (+3.0 to +4.0 °C), especially in eastern and southern regions.

SOND (Sep-Dec):

Mid-century:

RCP2.6: Mild warming (+0.5 to +1.5 °C).

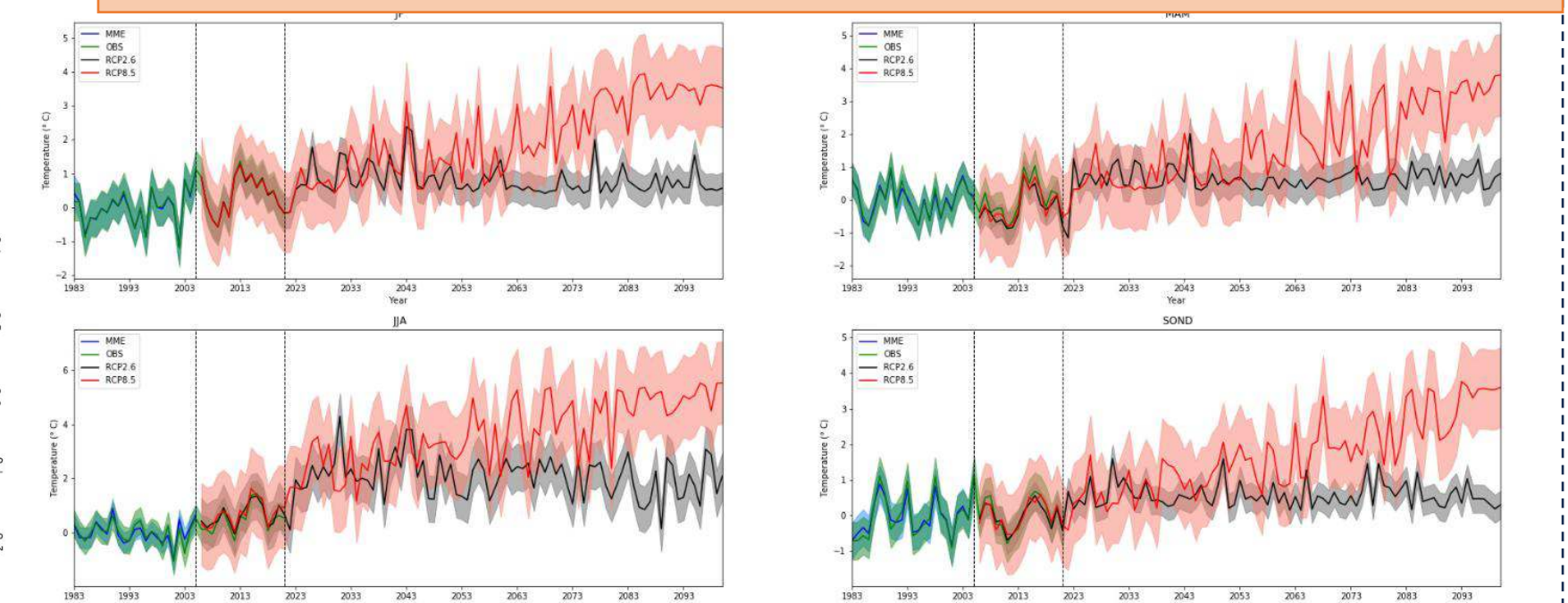
RCP8.5: Moderate warming (+1.5 to +2.5 °C).

Late-century:

RCP2.6: Moderate warming (+1.0 to +2.0 °C).

RCP8.5: Strong warming (+3.0 to +4.0 °C) across most regions.

Warming dominates across all seasons and scenarios. The magnitude of warming is stronger under RCP8.5 compared to RCP2.6, and greater in late-century (2066–2100) compared to mid-century (2026–2060).



Seasonal Patterns:

MAM (Mar-May):

Mid-century:

RCP2.6: RCP2.6: Decrease in southcentral and eastern (-2°C to 0°C) and Mild warming (+0.5 to +1.5 °C) in remaining regions.

RCP8.5: Moderate warming (+1.5 to +2.5 °C).

Late-century:

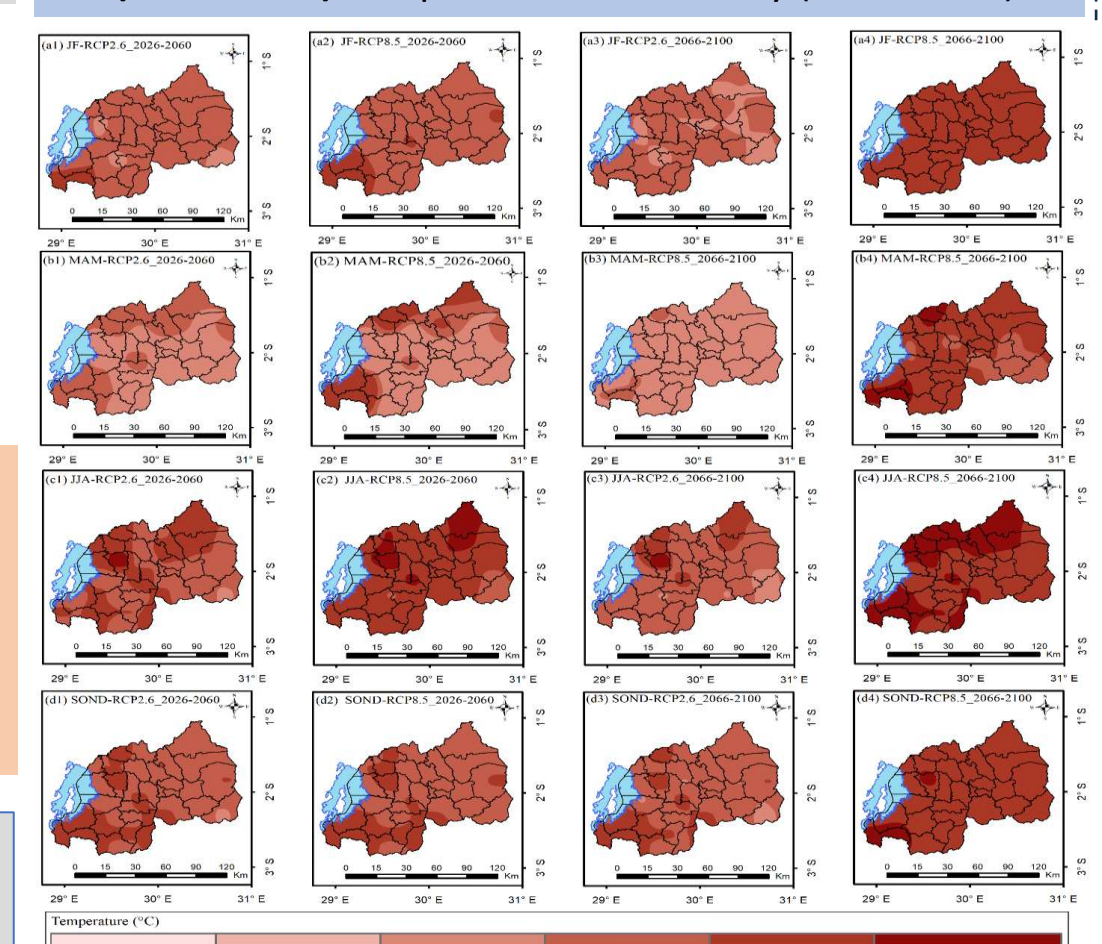
RCP2.6: Stabilized warming (+1.0 to +2.0 °C).

RCP8.5: Strong warming (+3.0 to +4.0 °C) across most of Rwanda.

Projected changes in mean temperatures

- ❑ Warming is consistent across all seasons and regions.

- ❑ The magnitude of warming is **higher under RCP8.5** compared to RCP2.6, and **greater in late-century (2066–2100)** compared to mid-century (2026–2060).



Seasonal Patterns:

MAM (Mar-May):

Mid-century:

RCP2.6: Mild warming (+0.5 to +1.5 °C).

RCP8.5: Moderate warming (+1.5 to +2.5 °C).

Late-century:

RCP2.6: Moderate warming (+1.0 to +2.0 °C).

RCP8.5: Strong warming (+3.0 to +4.0 °C) widespread.

JJA (Jun-Aug):

Mid-century:

RCP2.6: Slight warming (+0.5 to +1.0 °C).

RCP8.5: Moderate warming (+2.0 to +2.5 °C).

Late-century:

RCP2.6: Moderate warming (+1.0 to +2.0 °C).

RCP8.5: Significant warming (+3.0 to +4.0 °C), especially in eastern and southern regions.

SOND (Sep-Dec):

Mid-century:

RCP2.6: Mild warming (+0.5 to +1.5 °C).

RCP8.5: Moderate warming (+1.5 to +2.5 °C).

Late-century:

RCP2.6: Moderate warming (+1.0 to +2.0 °C).

RCP8.5: Strong warming (+3.0 to +4.0 °C) across most regions.

Conclusion

- Rainfall is projected to decrease during MAM and JJA and increase during SOND with more variability during JF.
- Reduction in MAM may affect agricultural seasons while more variability in JF may affect post-harvest.
- Temperatures are projected to increase throughout seasons and period with more increase under RCP8.5 than RCP2.8
- Minimum temperatures are projected to increase more than maximum temperatures.

Acknowledgements: The author sincerely acknowledges the Rwanda Meteorology Agency for providing the observed data and the Rwanda Environment Management Authority for the facilities provided.

Take away message: Spatial disparities in projected changes of rainfall and temperatures expose Rwanda to uneven risks for agriculture, water security, and disaster preparedness. Targeted adaptation such as climate-resilient crops, irrigation, water conservation, infrastructure reinforcement are urgently needed.

Rwanda, widely known as the “land of a thousand hills,” is located in Eastern-Central Africa between 1°4′–2°51′S and 28°53′–30°53′E, covering an area of 26,338 km². The country’s terrain is highly diverse, ranging from the low-lying Bugarama Valley at 900 m to the volcanic highlands, with Mount Karisimbi reaching 4,507 m. This complex topography exerts a strong influence on spatial variations in rainfall and temperature (Ntwali et al., 2016). The western and northern highlands are characteristically wetter and cooler, while the eastern plains are drier and warmer (Siebert et al., 2019; Sebaziga et al., 2023; Sebaziga et al., 2024). Rwanda experiences four distinct seasons: two wet seasons (March–May, MAM, and September–December, SOND) and two dry seasons (January–February, JF, and June–August, JJA) (Siebert et al., 2019; Kazora et al., 2021; Sebaziga et al., 2023; Sebaziga et al., 2024).

Rainfall characteristics in Rwanda have been the subject of several recent studies (Muhire et al. 2015, Ntwali et al. 2016, Siebert et al. 2019, Kazora et al. 2021, Umutohi et al. 2021, Umuhoza et al. 2021, Zhou et al. 2021, Safari et al. 2022, Sebaziga et al. 2022, Uwimbabazi et al. 2022, Sebaziga et al. 2023) with a converging result indicating a general variation in seasonal and annual total rainfall. Rainfall Onset Days (OD), Cessation Days (CD), Seasonal Length (SL), and Number of Rainy Days (RD) are crucial for crop production and food security in Rwanda yet scantily documented. This study aimed to analyze the spatial patterns and variabilities of Seasonal OD, CD, SL, and RD in Rwanda using an observational data set from 1983-2021. The study also aimed to classify Rwanda into near-homogeneous climate zones.

Objective:

- Classify Rwanda into near-homogeneous climate zones
- Analyze the spatial patterns and variabilities of Seasonal OD, CD, SL, and RD in Rwanda

Data:

Gridded rainfall (4kmx4km) and temperatures (5kmx5km) resolution from 1983 to 2021 obtained from the Rwanda Meteorology Agency.

Rwanda’s location within Africa (a) and its administrative and elevation map (b)

Methodology

1. Climate zone: K-means clustering

$$W(E_K) = \sum_{t_i \in E_K} (t_i - \mu_K)^2$$
$$D(n, m) = \frac{1}{n_p m_p} \sum_{i=1}^{n_p} \sum_{j=1}^{m_p} (t_{n_i} - t_{m_j})$$

t_i is i^{th} data point of cluster k (E_k), and μ_k is the mean value of points in cluster k ;
 $TWCSS$: total within cluster sum of square
 $D(n, m)$: distance between clusters n and m , and n_p, m_p are the number of elements in those clusters

2. Rainfall characteristics

Start of counting:

- February for LR and September for SR.

- ❖ Onset day (OD): Accumulation (25mm in 5 days), rainy days (3 rainy days), dry spell (7 days in the next 30 days)
- ❖ Cessation day (CD): Accumulation (10 days) < ½ PET
- ❖ Seasonal length (SL): = CD - OD
- ❖ Number of rainy days (RD) = days with rainfall >= 1mm

Climatological zones in Rwanda

Six climatological zones:

- Lake Kivu climate zone: located to the coast of Lake Kivu,
- Mountain climate zone, located in the area over Congo-Nile divide extended to the mountain areas of the northern volcanoes highland,
- Mountain forest climate zone: located on the southern and southwestern parts of Nyungwe National Park,
- Temperate climate zone of the central highlands: located in the central mountainous part extended from the southern region to the northern region
- Central plateau: located between the temperate climate zone of the central highlands in the west and,
- Eastern low land : located in the eastern part of the country.

Observed mean onset (OD) and Cessation (CD)

- ❖ Onset exhibits west-east (W-E) progression
- ❖ Cessation exhibits east-west (E-W) progression

Onset (OD):

- ❖ Early in the western and northern
- ❖ Later in central and eastern

Cessation (CD):

- ❖ Early in central and eastern
- ❖ Later in the western and northern

Variability of Observed onset (OD) and Cessation (CD)

- ❖ Areas with later OD and early CD exhibit higher variability
- ❖ Areas with early OD and later CD exhibit lower variability

Onset (OD):

- Low variability in western and northern highland and north-eastern
- High variability in eastern, central and southern

Cessation (CD):

- Low variability eastern and south-central
- High variability in central, southern, western and northern

Observed mean seasonal length (SL) and rainy days (RD)

Seasonal length (SL):

- ❖ Longer SL in the western and northern
- ❖ Shorter SL in central and eastern

Rainy days (RD):

- ❖ More RD in the western and northern
- ❖ Few RD in central and eastern

Variability of Observed seasonal length (SL) and rainy days (RD)

Seasonal length (SL):

- Low variability in south-western
- High variability in southern, northern-highland, central and eastern

SR:

- Low variability in eastern and south-western

Rainy days (RD):

- ✓ Low variability western, southern and northern
- ✓ High variability in central, south-central and eastern

SR:

- ✓ Low variability eastern, western and northern
- ✓ High variability in central, southern, western and northern

Trends of mean onset (OD) and Cessation (CD)

LR:

- OD: get late in western, central-southern, southern and central eastern and early in south-eastern, north-eastern and north-western
- CD: getting later in north-western and early and remaining areas

SR:

- OD: Early in south-eastern, central, north-eastern and north-western and later in remaining areas
- CD: Early in northern highland and later in remaining areas

Trends mean seasonal length (SL) and rainy days (RD)

LR:

- SL: statistically significant positive trend in northwestern and northeastern
- RD: statistically significant positive trend in central western, central and northeastern and negative trend in extreme southern

SR:

- SL: statistically significant positive trend in central western, southeastern northeastern
- RD: statistically significant positive trend in central western, central and northeastern and negative trend in extreme southern

Acknowledgements: The author sincerely acknowledges the Rwanda Meteorology Agency for providing the observed data and the Rwanda Environment Management Authority for the facilities provided.

Development and Evaluation of a Prototype Climate-Soil Decision Support Tool for Beans Production in Karongi District

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1 INTRODUCTION

Common bean is one of the major food and income crops in Rwanda but remains highly vulnerable to climate variability due to farmers' dependence on rain-fed agriculture, making key farm management decisions increasingly climate-sensitive. Despite the availability of climate, soil, and agronomic information, translating these data into localized, timely, and actionable farm-level guidance remains a challenge. This project addresses this gap by developing *a prototype Climate-Soil Decision Support Tool* that integrates these information sources to support timely decisions on planting, weeding, and harvesting in Karongi District.



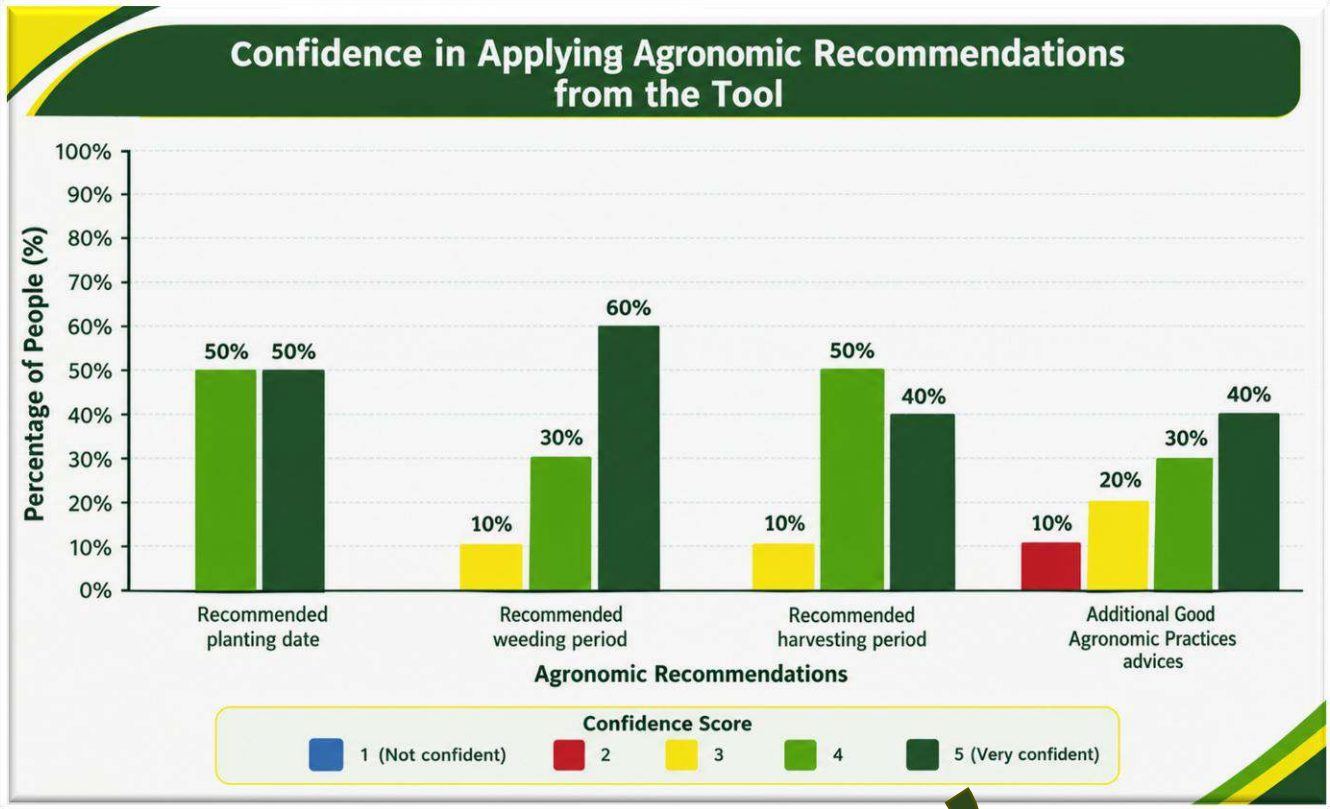
2 RESEARCH OBJECTIVE

The main objective of this study is to develop and evaluate a prototype Climate-Soil Decision Support Tool for common bean production in Karongi District, enabling extension agents and cooperative leaders to generate context-specific management recommendations.

3 METHODOLOGY

1. Literature Review & Data Collection
2. Data Analysis & Decision-Rule Development
3. Excel Dashboard Development
4. Testing & Refinement
5. Finalization & Reporting

The decision rules were developed using published agronomic guidelines by RAB and validated climatological data, providing the prototype with a strong scientific foundation.



Participants demonstrated generally high confidence in applying the tool's agronomic recommendations, particularly for planting and harvesting decisions.

5 CONCLUSION

This study demonstrated that climate, soil, and agronomic information can be translated into localized, actionable bean production advisories through a user-centred decision support tool. With 13 evidence-based decision rules, the prototype provides a strong foundation for further field validation and scaling of climate-informed agricultural advisory services in Rwanda.

4 RESULTS

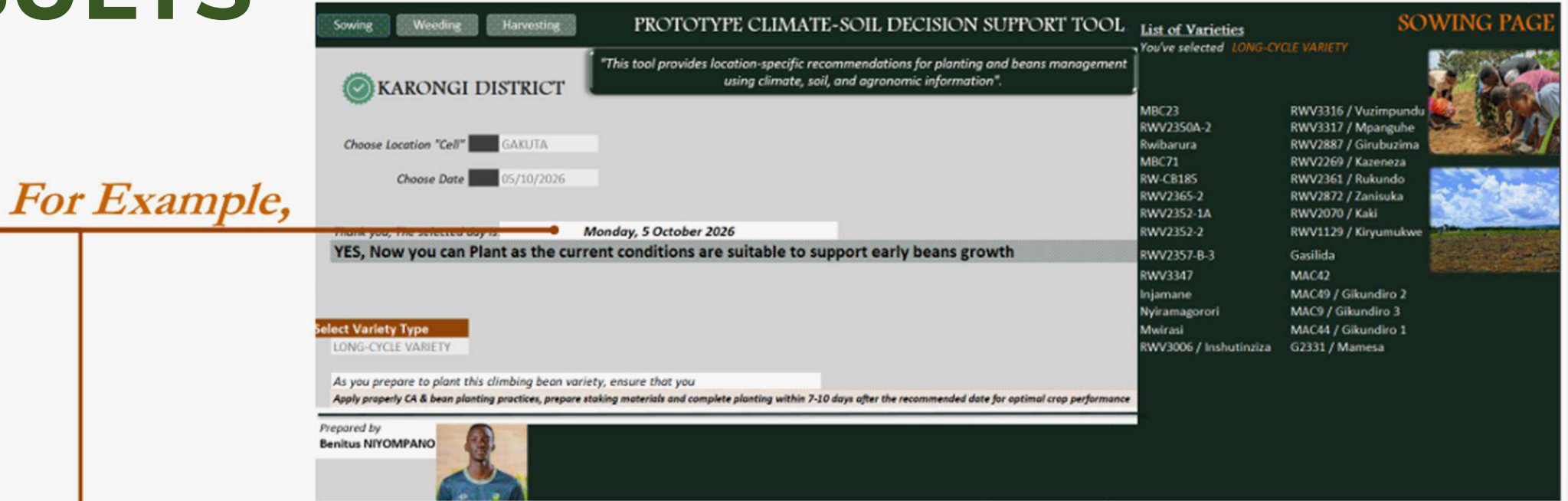
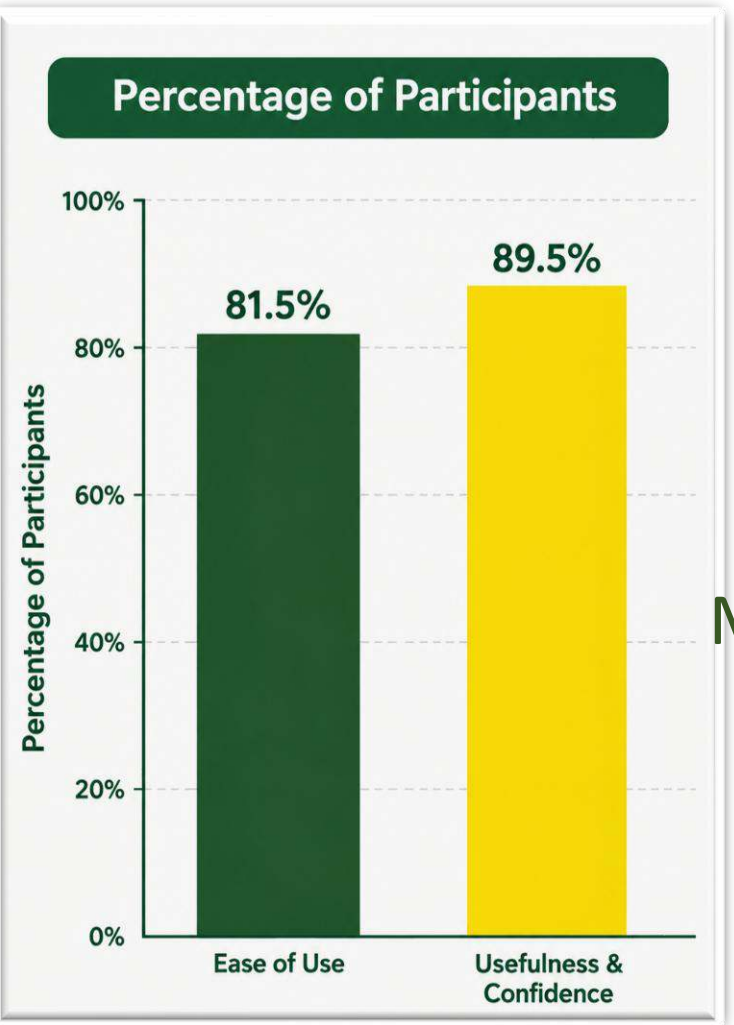


Table 6: Mean Onset and Cessation Dates for the short rains season from 1981 to 2017 over all delineated zones (Lon: Longitude and Lat: Latitude)

Zones	Stations	Lon	Lat	Mean Onset Dates	Mean Cessation Dates	Rainfall Duration
I	Ntendezi	29.05	-2.43	19 th of Sept	24 th of Dec	97 days
II	Kibuye	29.35	-2.05	2 nd of Oct	7 th of Dec	67 days
III	Tamira	29.35	-1.56	13 th of Sept	5 th of Dec	84 days
IV	Save Paroisse	29.76	-2.55	5 th of Oct	15 th of Dec	72 days
V	Cyinzuzi	30	-1.76	7 th of Oct	10 th of Dec	65 days
VI	Rugabagoba	29.88	-2.05	17 th of Oct	4 th of Dec	49 days
VII	Rwamagana	30.43	-1.93	20 th of Oct	4 th of Dec	46 days
VIII	Gabiro	30.4	-1.55	23 rd of Oct	4 th of Dec	42 days
IX	Busoro	29.91	-2.28	14 th of Oct	4 th of Dec	51 days
X	Bukora	30.78	-2.3	26 th of Oct	3 rd of Dec	39 days

The prototype's planting recommendations closely matched the 37-year historical rainfall onset for the Kibuye zone by Ayabagabo (2018), differing by only 3-7 days (as it bases on the actual weather conditions).



Most participants rated the tool positively, with 81.5% reporting ease of use and 89.5% indicating usefulness and confidence in its recommendations.

6 WAY FORWARD

- ❖ Transform this prototype into a web or mobile-based decision support platform using real-time climate and soil data for timely and accessible advisory services.

The Impact Of Maize Farming Support on Food Security Of T2DM Smallholder Farmers In Eastern Rwanda

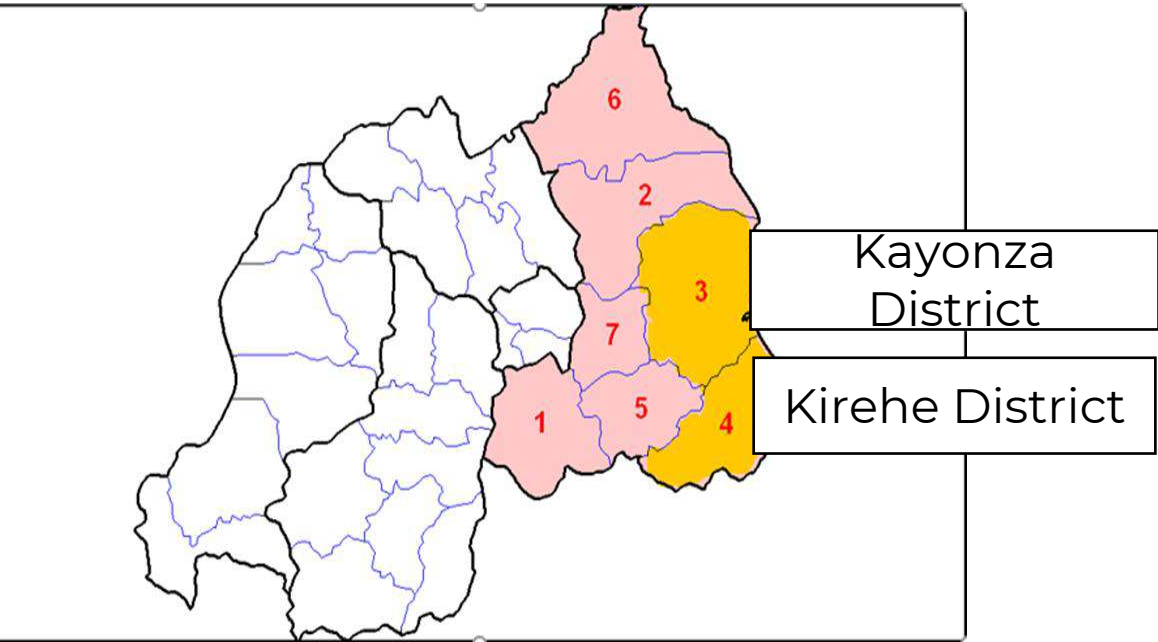
Dushimimana D^{1, 2*}, V Mukandayisenga², P Hagenimana¹, C Bigirimana¹, E Mutamuliza¹, JA Manirere¹, A Karangwa¹

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²Partners In Health, Rwanda

1.Introduction: The Rwandan GDP per capita increased from US\$ 235 in 2002 to US\$ 1,004 in 2022, and agriculture has contributed to 33% on average, 86.3 percent of agricultural households practice agriculture as the main livelihood activity. Despite that, small holder farmers in Rwanda are chained by the poverty, and unfavorable socioeconomic conditions. In rural community, the 54.9 percentage of agricultural households rely on subsistence agriculture for families' food security, and maize farming provides main household food and more income compared to other food crops. Farming support programs do not pay much attention to the differential access to assets and knowledge between healthy and non-health farmers. Healthy farmers improve productivity and boost their food security and incomes compared to sick farmers. Type 2 Diabetes Mellitus (T2DM) affects rural farmers, and struggle with the cost of continuous care which increases the risk of poverty. This paper analyzed the food security status of maize farmers with T2DM who benefit from maize farming support in Kayonza and Kirehe districts.

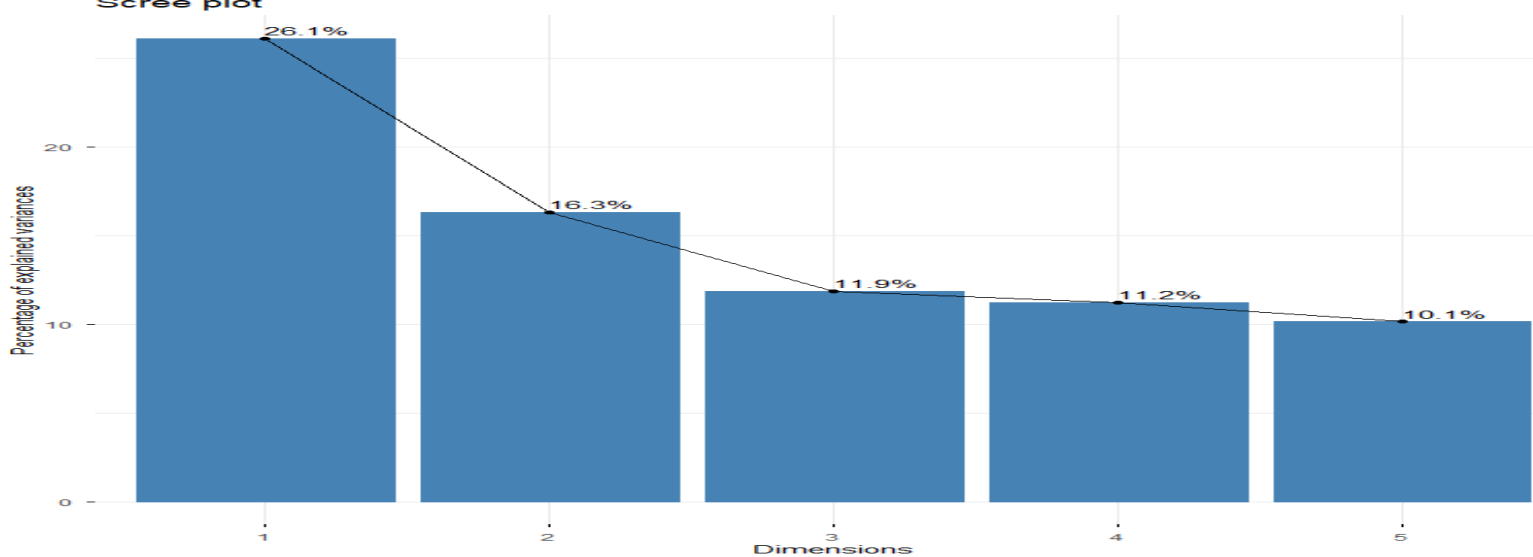
2. Study area & Data



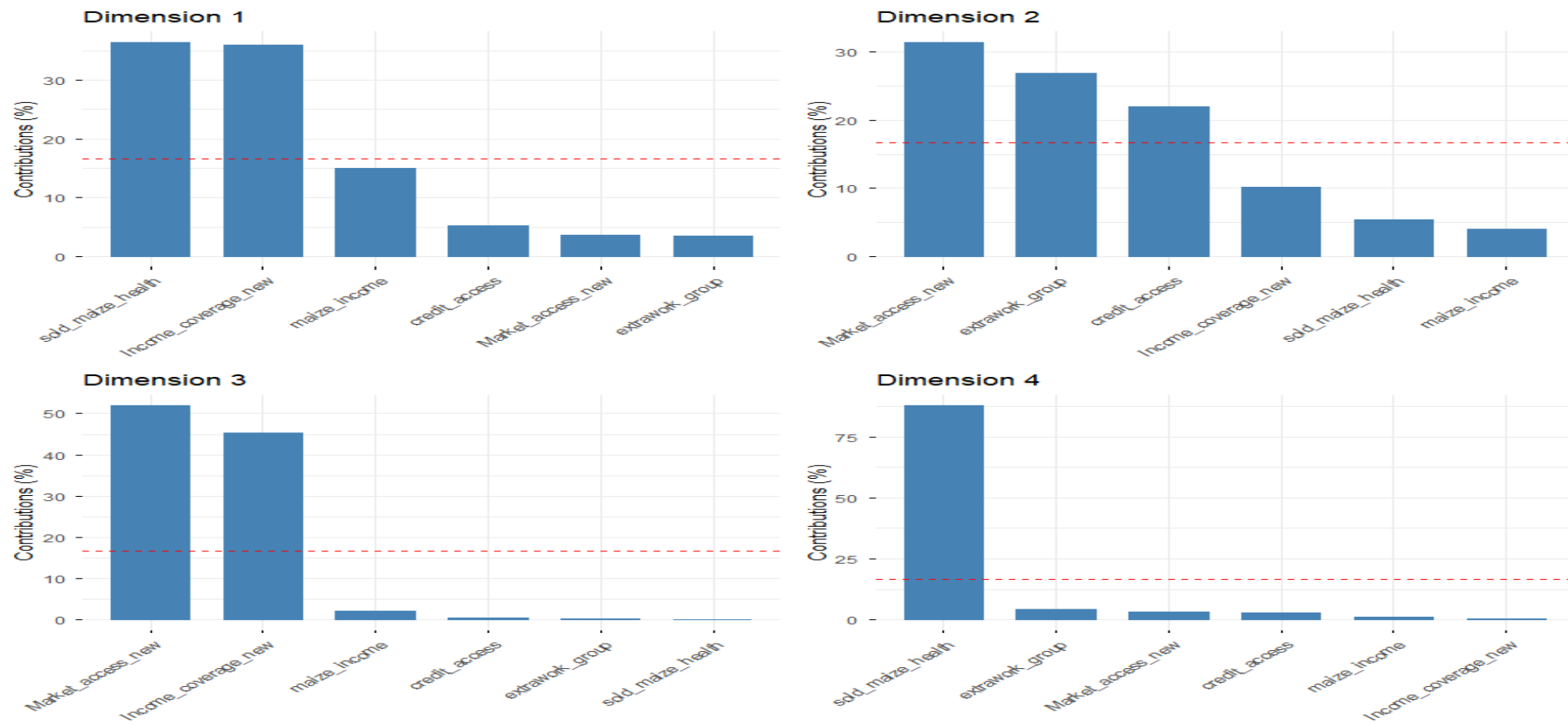
- 1. Districts of Kayonza, and Kirehe (Fig.1).
- 2.The area of 1,954 km² and 1,118.5 are the key economic activities km², and altitude of 1,400 to 1,600 m, with the average annual temperature is 19.4 °C, with an average rainfall of 898 mm.
- 3.The fertile soil and agro ecological conditions are suitable for maize production.

3.Methodology: Data on T2DM patients was accessed through NCD program electronic database storage in both Rwinkwavu/Kayonza and Kirehe district hospitals. In the registry of agriculture supporting program , the study identified T2DM patients in NCD program who benefit from maize farming support, and those who do not. A sequential quasi-experimental method was used for sampling, and data were collected to 254 participants who were stratified into two groups (127 benefiting from the support, and 127 who do not. Primary data on the three dimensions of food security (food availability, food access and food utilization).To describe study participants characteristics, descriptive statistics were used with mean and standard deviation for continuous variables, and frequencies and percentages for categorical variables. Prevalence of food security was estimated using Factorial Analysis for Mixed Data (FAMD) followed by Hierarchical Clustering on Principle Components(HCPC). Scores were extracted from FAMD results and were used to classify participants into different food security categories using standard deviation as a cut-off. Bivariate analysis was done to test the association between food security status and participants' characteristics using chi square for categorical variables and Wilcoxon sum test for continuous variables (Table 4). To assess factors of food security, binary logistic regression was used R Studio was used for data analysis.

4. Results



Scree plot for the overall explained components of food access



Percentage contribution of each variable in the explained components of food access

Food security analysis by dimension of food access

Non-support recipients 71 (55.9%) are food secured compared to 37 (29.13%) of supported participants. The analysis has shown that none of the personal characteristics were associated with food security status.

Food security analysis by dimension of food availability

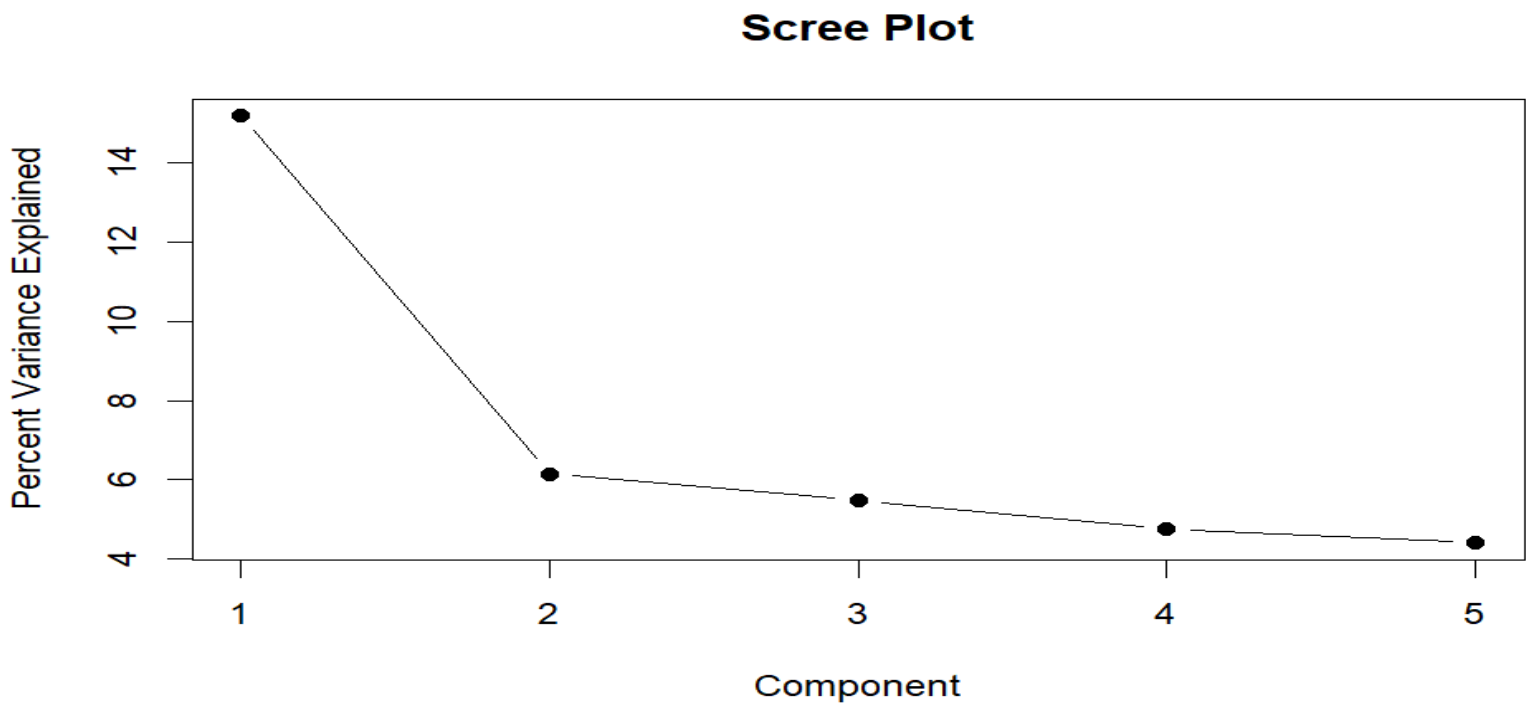
Non-support recipients 63 (49.6%) are food secured against 13(10.23%) of supported participants. Age, district of residence and number of clinical visits per month are associated with food security status. A one-year increase in the age (AOR=0.95, 95%CI: 0.93, 0.97) and (p-value=0.001) of the participant decreases the odds of severe food insecurity in terms of food availability by 5% (OR=0.95). Being a resident of Kirehe district (AOR=0.504, 95%CI: 0.28, 0.86) and (p-value=0.014) influences a decrease of 5% in likelihood of being food insecure. As the number of clinical visits per month (AOR=2.96, 95%CI: 1.58, 5.71) and (p-value=0.001) increases, the odds of having severe food insecurity in terms of food availability was 2.96 times more (OR=2.96).

Food security analysis by dimension of food utilization

Supported recipients 68 (53.54%) are food secured against 0(0. %) of non-supported participants. Enrollment in the support, number of clinical visits per month, and education are associated with food insecurity status in term of utilization. A supported participant (AOR=0.11, 95%CI: 0.05, 0.21) and (p-value=0.001) of the participant decreases the odds of severe food insecurity in terms of food utilization by 11% (OR=0.11). Holding a secondary education (AOR=2.93, 95%CI: 1.30, 6.76) and (p-value=0.01) increases the odds of being food secured 2.93 times. The number of clinical visits per month (AOR=0.37, 95%CI: 0.14, 0.79) and (p-value=0.0187) decrease, the odds of having severe food insecurity in terms of food utilization was 0.37 times more.

Overall prevalence of Food security

Supported farmers 124(77.5%) are food secured against 36(22.5%) of those who are not enrolled in the support. The female headed households 120 (75.0%) are more food secured than 40(25.0%) of male headed households. Taken for reference (Female), being a male headed household. The odds of having severe food insecurity for households with male head are 1.86 times (AOR=1.86, 95%CI: 1.07, 3.23) and (p-value=0.026). Elderly farmers Age (Mean age: 60.1, and SD: 10.1) were food insecure. Having more clinical visits per month (Mean: 1.23, and SD: 0.476) is linked to food security status. Farmers with many years with T2DM (Mean: 8.14, and SD: 5.69) are food insecure. Participant' age, gender, district of residence and number of hospital visits per month are statistically associated with food security status. The other variable associated with being food secured in is the district. Patients from Kirehe district have less odds (OR=0.44) of having severe food insecurity than patients living in Kayonza district, (AOR=0.44, 95%CI: 0.26, 0.74) and (p-value=0.02). As the age (AOR=1.057, 95%CI: 1.033, 1.083) and (p-value=0.001) of maize householder farmers with T2DM patients increases by one year, the odds for the households of having severe food insecurity increases by 5.7% (OR=1.057). The other factor of food insecurity is number of visits per month (AOR=1.167, 95%CI: 1.0001, 1.36) and (p-value=0.001). The increase of one more clinical visit per month, increases the odds of being food secured 1.167 times.



Scree plot for the overall explained components of food security

5. Conclusion:

The Rwandan agriculture has been the main driver of growth and poverty reduction. Despite their vital, small holder farmers are chained by the poverty, and diseases such as type 2 diabetes mellitus which affect their food security. Factorial Analysis for Mixed Data (FAMD), logit regression, bivariate analysis were used to analyze the food security status of maize farmers with T2DM who benefit from maize farming support. Findings show that the average age of non-maize farming support participants is 59.9 years with standard deviation of 10.5, while the average age of support enrolled participants 50.8 years with standard deviation of 13.1..Among 160 participants who are food secured. 86(42.5%) in Kayonza and 92 (57.5%) in Kirehe are food secured while 124(77.5%) of supported farmers were found to be likely food secured against 36(22.5%) of those who are not enrolled in the support.

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Multi – temporal LULC detection for climate impact assessment: Bird as bioindicator in Karago lake ecosystem, Rwanda

Josiane NIYONKURU^{1,2} - ¹University of Rwanda, ²Rugezi Ornithology Center

1. Introduction

LULCchange is degrading ecosystem health and biodiversity across Rwanda's lake waterland, challenging NBSAP(2025-2030).

- At Karago lake,Northern Province,Agricultural expansion, wetland encroachment, and vegetation loss are compounded by climate variability, weaking ecosystem's capability to buffer climate impacts.
- Birds are sensitive indicators of ecological change, their mobility, habitat specificity and rapid response to disturbance make them ideal for tracking LULC driven ecosystem stress. Yet relationship between LULC dynamics and bird population Rwanda lake ecosytem.
- This study aim to map the multi- temporal LULC change (2005-2025) at Karago lake and evaluate the bird community composition as bioindicator for ecosystem based monitoring.

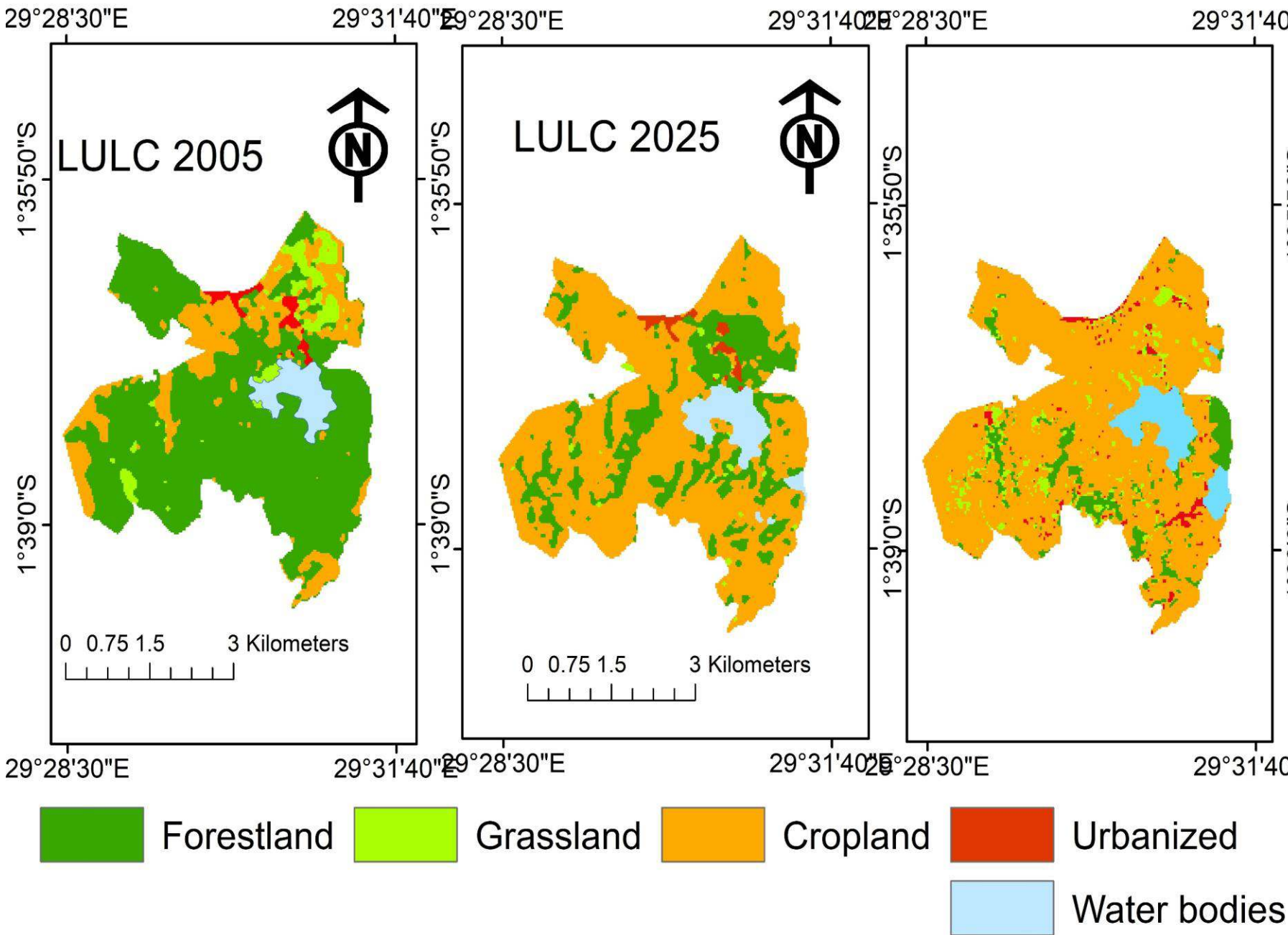
2. Methods

•Five land cover classes (Forestland, Grassland, Cropland, Built-up, Water bodies) were mapped across three Nyabihu District cells enclosing Karago Lake, using Landsat imagery from 2005, 2015, and 2025.

•Supervised classification and post-classification change detection quantified land cover transitions across the 20-year period.

•Bird abundance and richness were recorded at 10 point-count plots around the lake (2010, 2015, 2025), supplemented by eBird records.

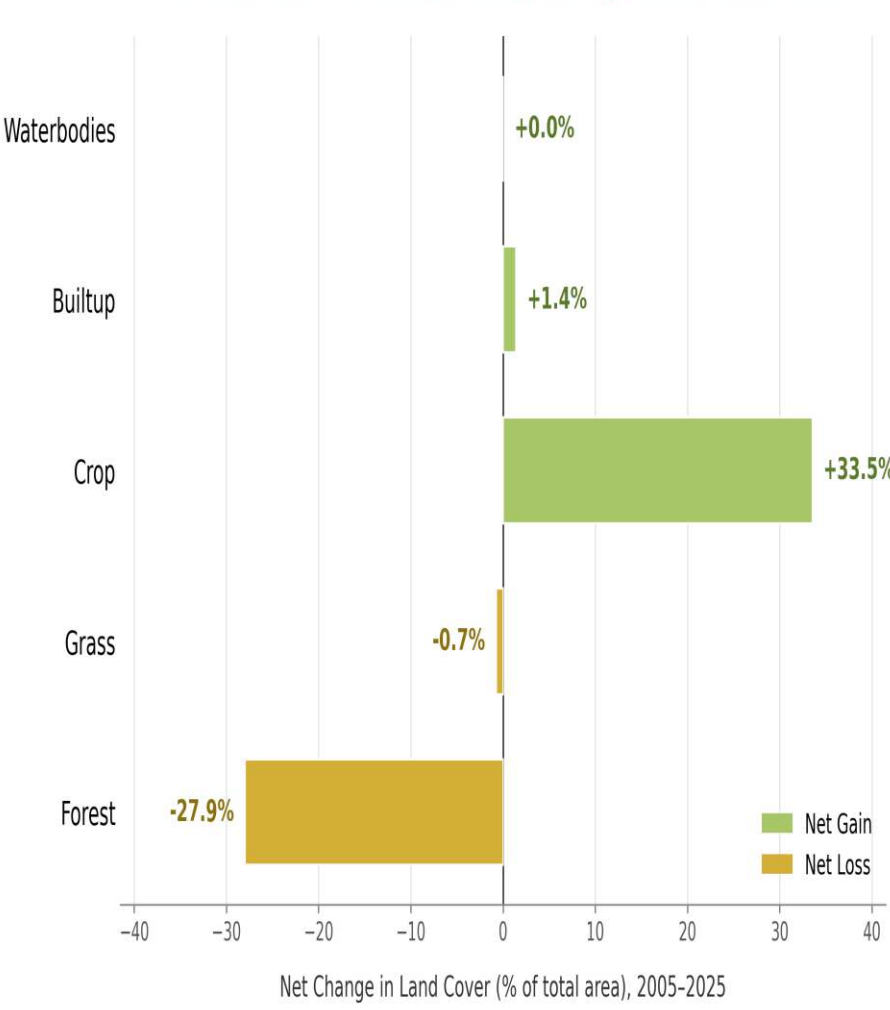
•LULC composition within 150 m of each plot was linked to bird data, and all correlation and regression analyses were performed in RStudio.



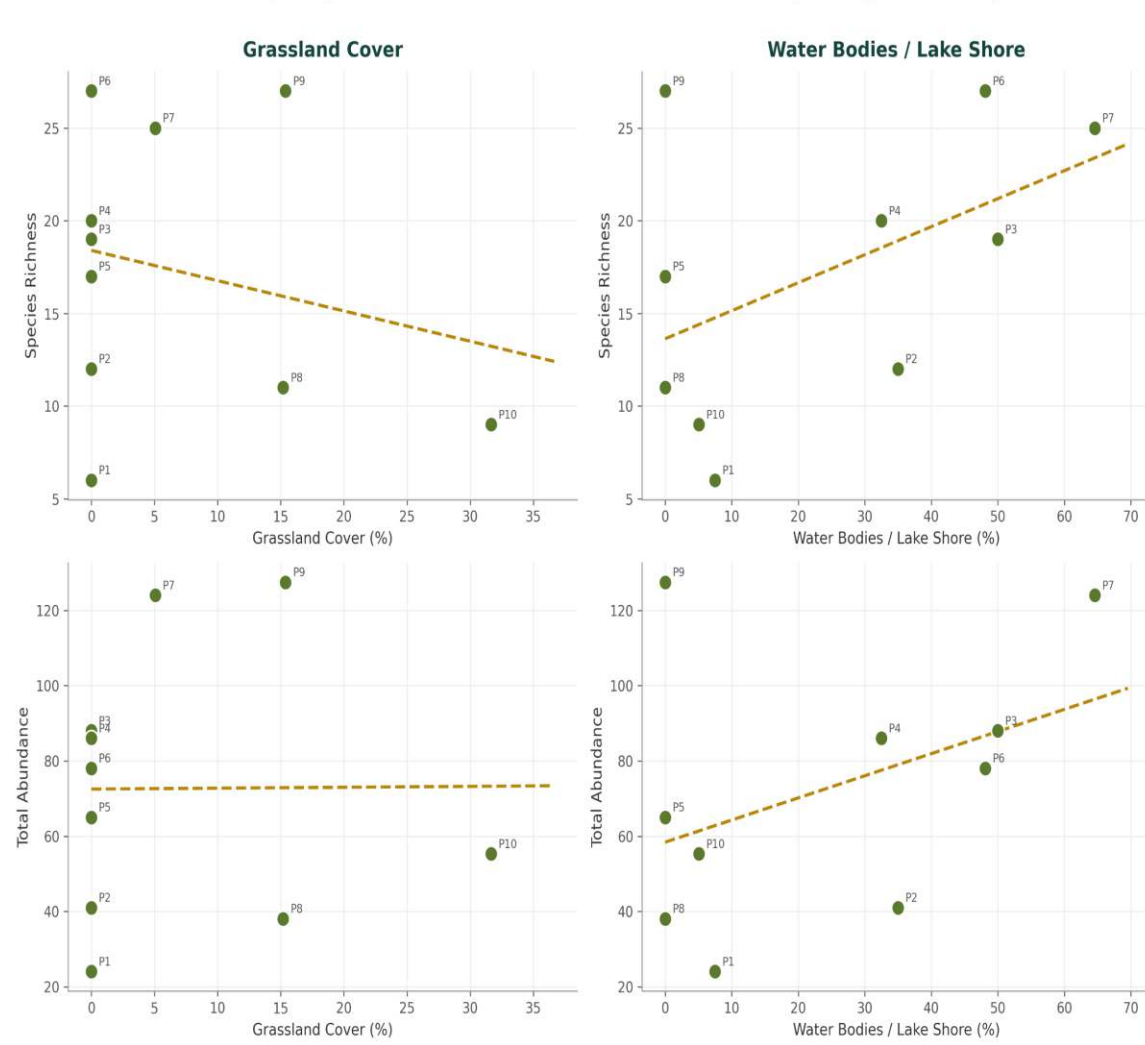
- Forestland declined from 43.3% to 15.4% (a net loss of 27.9 percentage points), while grassland remained comparatively stable (15.0% to 14.3%). Cropland the primary driver of change expanded from 24.8% to 58.3% (a net gain of 33.5 percentage points), and built-up area rose from 0.5% to 1.9%, together accounting for nearly all of the area lost from forestland.
- Approximately 2 acres of papyrus vegetation was cleared for agricultural expansion, leaving only the legally mandated 50 meters lake buffer zone intact.
- Despite compliance with the buffer requirement, on-the-ground habitat quality within it has declined: bird nests within the remaining buffer were destroyed, and muddy shoreline habitat previously used by wader species is no longer present.

3. Result

Net Gain and Net Loss in LULC, Karago Lake, 2005-2025



Bird Community Response to Grassland and Lake Shore Proximity, Karago Lake (10 plots)



- Wader birds like African Pipit and Wood Sandpiper, both recorded in high numbers in earlier surveys, showed a marked decline in observation frequency by 2025 consistent with the near-total conversion of forestland to cropland and the associated loss of muddy, open shoreline habitat.
- Plot-level analysis (n=10, 150 m buffer) showed a moderate negative association between cropland cover and both bird species richness (r = -0.44) and abundance (r = -0.48), and a moderate positive association between water body proximity and richness (r = 0.50), though none reached statistical significance at this sample size

4. Conclusion

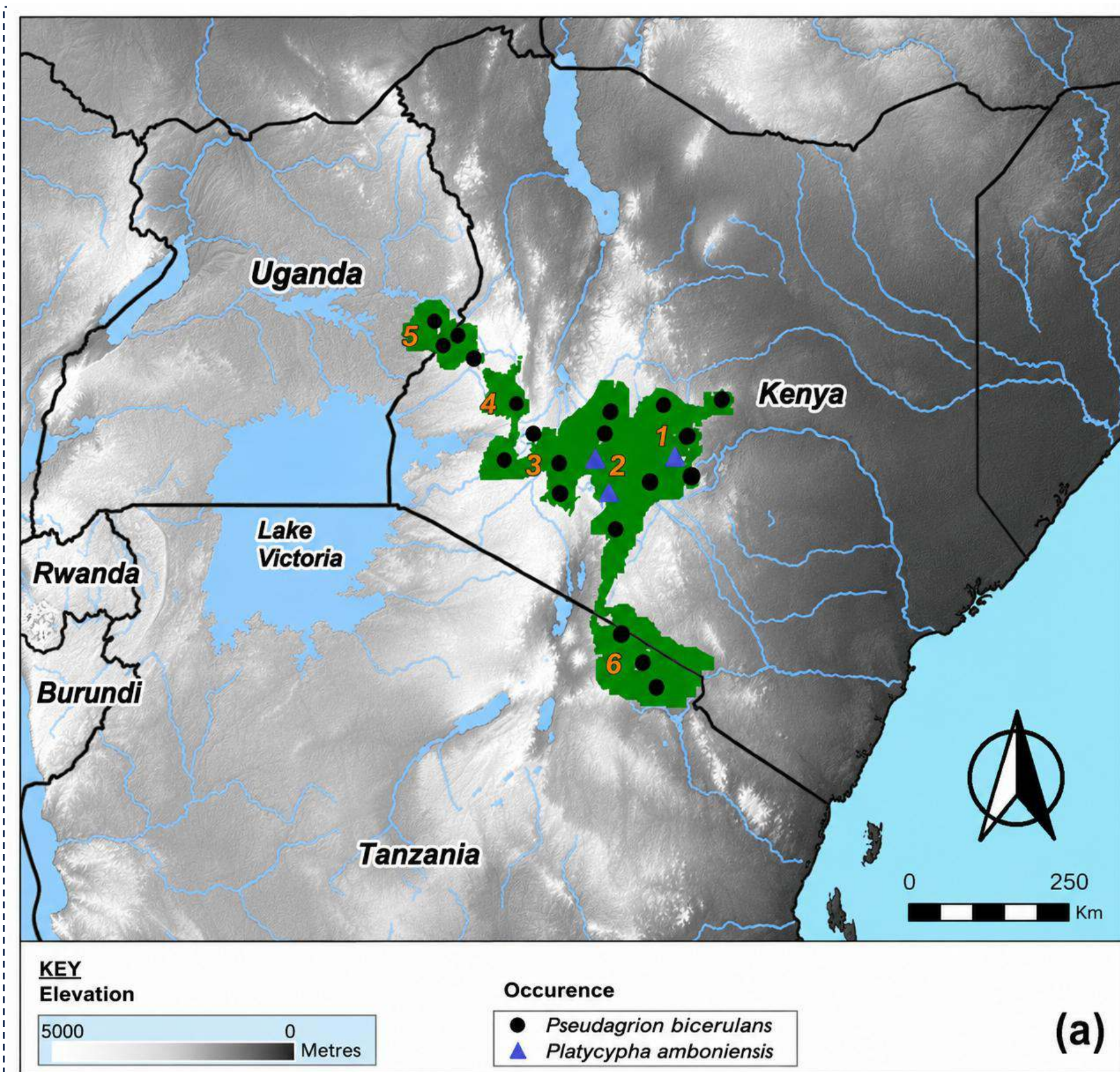
- LULC change at Karago Lake dominated by cropland expansion from 24.8% to 58.3% and forestland loss from 43.3% to 15.4% is linked to declining habitat quality and reduced abundance of wetland-dependent bird species, despite formal compliance with Rwanda's 50 m lake buffer regulation.
- This finding demonstrates that legal buffer compliance alone is insufficient to protect wetland ecosystem function, underscoring the need for stronger climate data and monitoring systems bird community monitoring offers a practical, low-cost, and replicable indicator capable of detecting ecological degradation that satellite-based LULC mapping and policy compliance checks alone cannot capture.
- By linking remote sensing-derived land cover trajectories with field-based biodiversity monitoring, this study contributes a scalable climate monitoring framework applicable to other lake ecosystems across Rwanda and the wider East African region.
- This work supports the translation of scientific evidence into practical climate resilience solutions, positioning integrated LULC-biodiversity monitoring as a tool for strengthening evidence-based climate action and the science-policy interface in Rwanda.

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Acknowledgement

I sincerely thank the RUGEZI Ornithology Center (ROC) for providing essential research materials, including binoculars and the *Birds of East Africa* field guide, which supported the field data collection for this study. I also extend my gratitude to fellow ROC colleagues who assisted with bird data collection at Karago Lake..



BACKGROUND

- Damselflies (Odonata: Zygoptera) are sensitive bioindicators of freshwater ecosystem health, making them useful models for examining how shifting stream conditions threaten co-occurring species.
- Recent studies have shown that the Kenya Jewel (*Platycypha amboniensis* Martin 1915) and the Giant Sprite (*Pseudagrion bicoerulans* Martin 1908) Inhabit the same montane forest streams, but occupy contrasting microhabitats (Karani et al., 2026).

OBJECTIVE

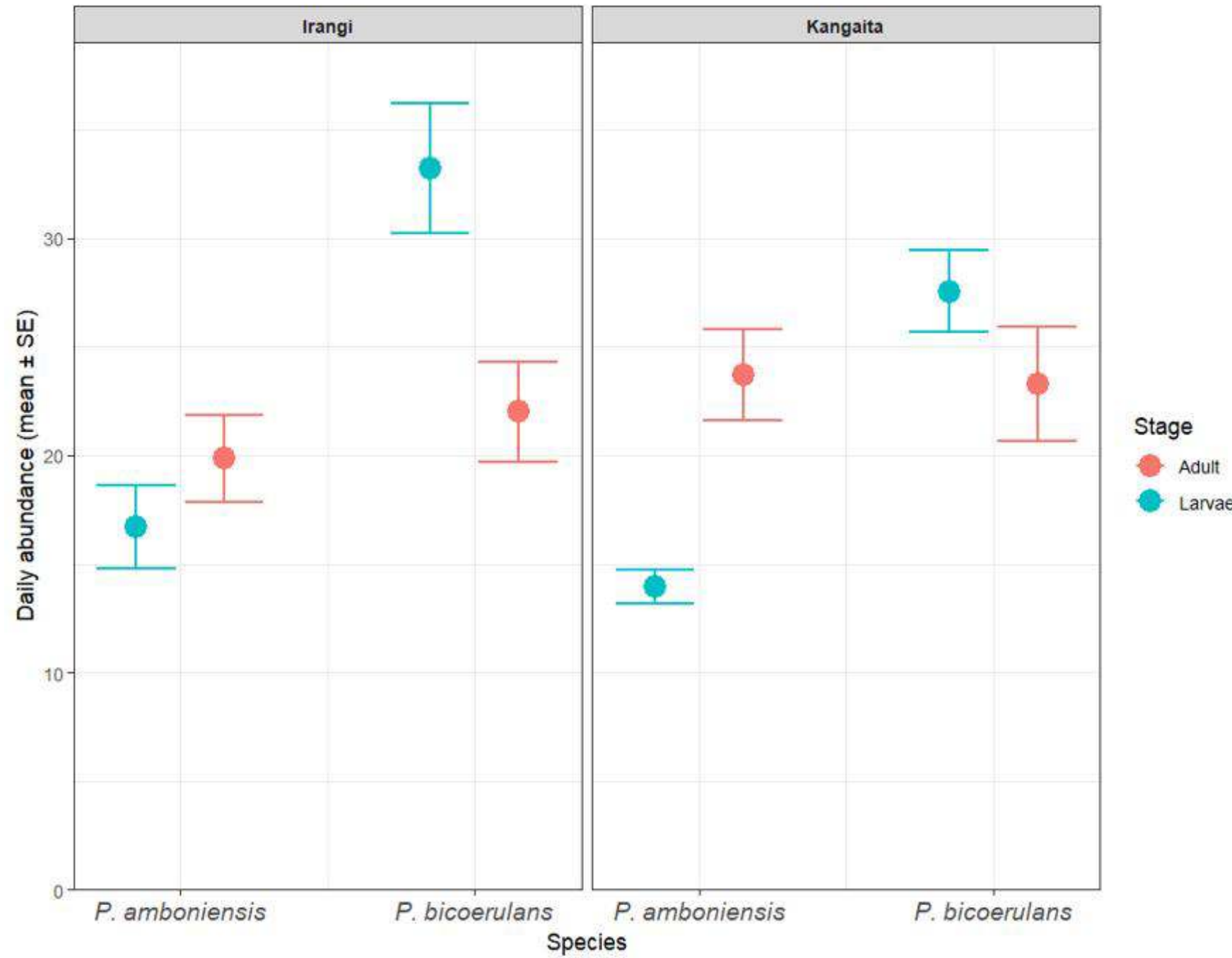
- We aimed to establish the variation in abundance of larval damselflies in wet and dry seasons in Mt. Kenya forest.

METHODS

- We estimated the abundance using replicated counts in the wet and dry seasons. Occupancy and detection probabilities were determined using a two-species conditional occupancy model.
- We measured functional traits of larvae, environmental parameters, substrate availability and for associations using a generalized linear model.



Co-occurrence	Larvae	Adults
ψ_A	0.995±0.049	0.915±0.061
ψ_{BA}	0.969±0.060	0.971±0.032
ψ_{Ba}	1.000±0.000	1.000±0.000
p_A	0.473±0.390	0.625±0.122
p_B	0.140±0.589	0.504±0.497
r_A	0.334±0.036	0.338±0.065
r_{BA}	0.429±0.117	0.328±0.090
r_{Ba}	0.401±0.048	0.308±0.076
γ	0.999±0.002	0.997±0.002
ψ_B	0.960±0.042	0.973±0.018
ψ_{AB}	0.926±0.044	0.888±0.043



Distributional map (left), point range diagram of daily abundance (mean ± SE) (top) and Estimates of occupancy (ψ), detection probability (p and r), and species interaction factor (SIF or γ) for *Platycypha amboniensis* Martin, 1915 (second right), and *Pseudagrion bicoerulans* Martin, 1907 (first right).

Acknowledgement

Part of this study was funded by the Mohamed bin Zayed Species Conservation Fund under the project '220529140: Research and Conservation of the Critically Endangered Kenya Montane Dancing Jewel (*Platycypha amboniensis*) in Mount Kenya

KEY RESULTS

- We found that, while the abundance of adults was not affected, the abundance of larvae differed significantly between seasons ($p < .05$).
- We established that substrate availability and turbidity was associated with larval abundances, consistent with the expected effects of stream flow conditions in the dry season ($p < .05$).

CONCLUSION AND PRACTICE RELEVANCE

- These results show that habitat loss and altered stream flow linked to a changing climate threaten both species through distinct pathways tied to their microhabitat requirements.
- We recommend further studies using experimental manipulation of drying conditions to understand how these associations will affect species under future climate change.

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Integrated optimization of biogas recovery and solar photovoltaic energy systems on Municipal Solid Waste Landfill hills in Rwanda.

Case Study: Nduba Municipal Solid Waste Landfill Hill, Kigali.

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1. Introduction

Global urbanization has resulted in increased municipal solid waste generation, creating severe environmental and public health challenges. Landfills contribute significantly to methane emissions, one of the most potent greenhouse gases responsible for climate change. According to international estimates, landfill methane accounts for approximately 11% of global anthropogenic methane emissions. Simultaneously, renewable energy demand continues to rise as countries seek pathways toward low-carbon development. Rwanda has demonstrated strong commitment to climate resilience and renewable energy development through Vision 2050, the Green Growth and Climate Resilience Strategy, and Nationally Determined Contributions (NDCs). The Nduba Municipal Solid Waste Landfill presents a unique opportunity to transform environmental liabilities into productive energy assets through integrated landfill gas recovery and solar energy generation.

2. Research aim and objectives

Overall aim:
To develop, optimize and validate an integrated biogas and solar photovoltaic energy system for renewable energy generation and greenhouse-gas mitigation at Nduba Municipal Solid Waste Landfill.

Four objectives

1. **Quantify** methane-generation potential and solar-energy resources.
2. **Design and optimize** an integrated biogas-solar PV system.
3. **Develop** IoT-enabled monitoring and digital-twin capabilities.
4. **Evaluate** environmental, economic and social sustainability and develop replication strategies.

3. Problem statement

1. Large quantities of biodegradable waste at Nduba generate methane.
2. A significant proportion of landfill methane remains uncaptured.
3. Solar-energy opportunities at landfill surfaces remain underutilized.
4. Environmental monitoring is currently limited.
5. There is no established integrated landfill-to-energy optimization framework for Rwanda.
6. Scientific evidence is needed to determine the technically, economically and environmentally optimal configuration.

4. Methodology

Stage 1 — Resource Characterization
Waste quantity → waste composition → organic fraction → moisture/volatile solids

Stage 2 — Methane Assessment
CH₄ measurements → spatial sampling → IPCC First-Order Decay model

Stage 3 — Solar Assessment
Global Horizontal Irradiance → temperature → humidity → wind → satellite/ground data

Stage 4 — Hybrid System Optimization
Biogas + PV + battery → energy management → GA/PSO/MAOM

Stage 5 — Intelligent & Sustainability Assessment
IoT → digital twin → AI → LCA → NPV/IRR/payback → social impact.

5. Preliminary assumptions

Because actual Nduba measurements are not yet available, we developed a transparent baseline scenario.

Parameter	Assumed value	Purpose
Daily MSW intake	650 t/day	baseline
Organic fraction	58%	feedstock
CH ₄ yield	120 m ³ CH ₄ /t organic	FOD input proxy
CH ₄ fraction in biogas	55%	midpoint of proposal range
CH ₄ capture efficiency	55%	screening case
PV area	4 ha	available-area proxy
Mean GHI	5.0 kWh/m ² /day	solar resource proxy
PV efficiency	20%	module conversion
Performance ratio	80%	system losses

6. Modeling Framework

A. Methane generation — IPCC First Order Decay:

$$CH_4 = \sum_x \left(W_x \times DOC_x \times DOC_f \times MCF \times F \times \frac{16}{12} \right)$$

Where: W_x : waste quantity, DOC_x : degradable organic carbon, MCF : fraction of DOC dissimilated and F : methane correction factor and methane fraction.

B. Solar PV energy:

$$E_{PV} = A \times r \times H \times PR$$

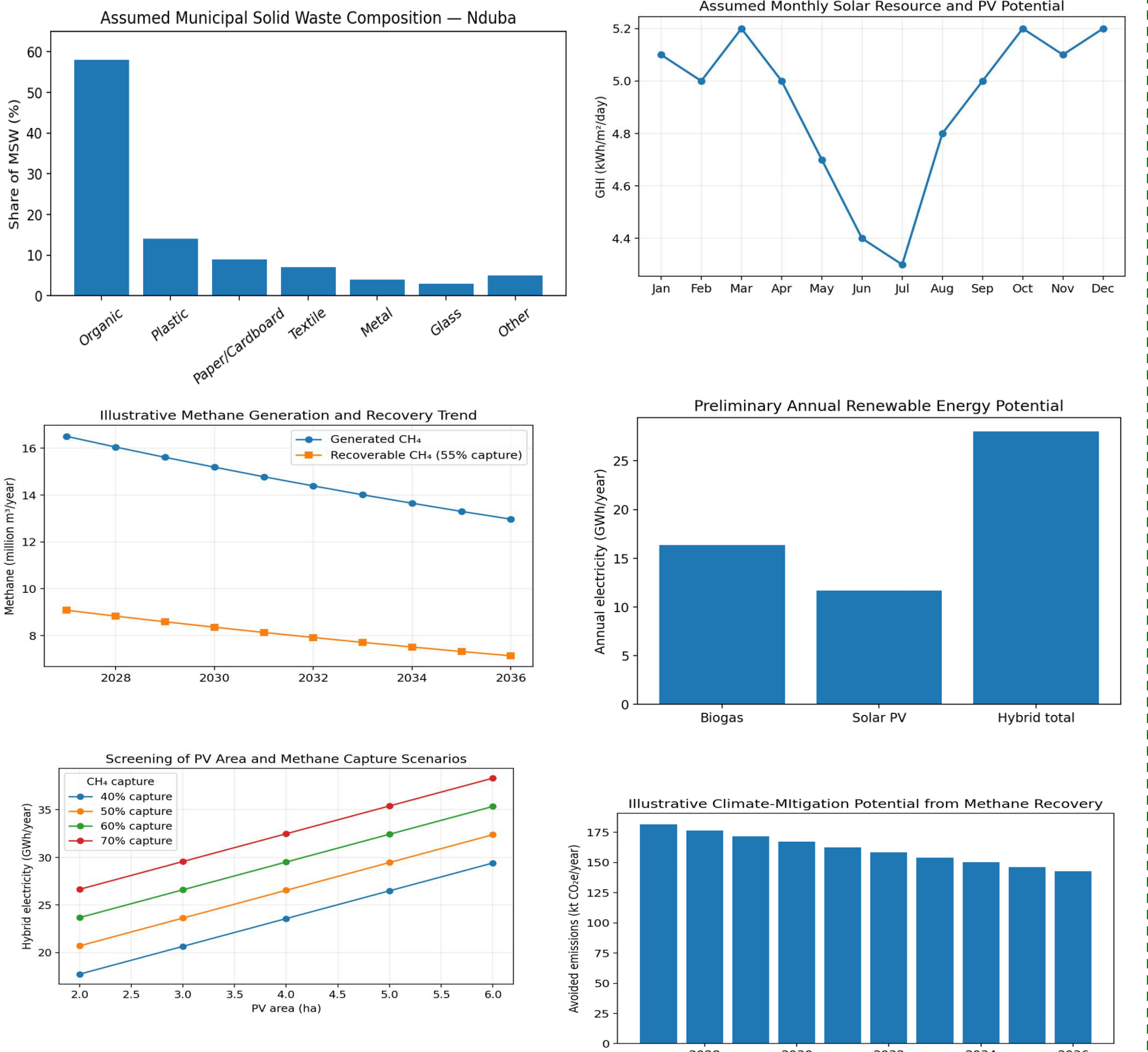
where:

A = available PV area , r = PV conversion efficiency , H = solar irradiation and PR = performance ratio.

7. Preliminary Results

650 t/day: Assumed MSW input
377 t/day: Estimated organic fraction
45,240 m³/day: Illustrative CH₄ generation
24,882 m³/day: CH₄ recovered at 55% capture
16.35 GWh/year: Biogas electricity
11.68 GWh/year: Solar PV electricity
28.03 GWh/year: Combined hybrid electricity

8. Results Analysis



9. Conclusion

- Preliminary modelling indicates that Nduba Landfill Hill could support a significant hybrid renewable-energy system combining landfill methane recovery and solar PV generation.
- Under the assumed baseline scenario, approximately 28 GWh/year of renewable electricity could be produced. Sensitivity analysis indicates that methane-capture efficiency and PV capacity are key determinants of system performance.
- The proposed research will replace these assumptions with field measurements and apply multi-objective optimization to identify the technically, economically and environmentally optimal configuration.

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Adaptation Research for Impact: The Role of Climate Risk Knowledge and Adaptation Evidence in Strengthening Rwanda’s Adaptation Innovation Ecosystems and Entrepreneurship Support

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Climate Adaptation Research & Consulting (CARC) Rwanda, a PlanAdapt Affiliate

1. Background and Context

Rwanda’s private sector is central to the country’s economic transformation, job creation and future prosperity, with small and medium-sized enterprises (SMEs) forming a particularly important part of its economic fabric. At the same time, businesses and the communities they serve are becoming increasingly exposed to climate-related risks.

Climate change therefore represents not only a growing risk for Rwanda’s private sector, but also an important opportunity for entrepreneurship and innovation. Locally rooted SMEs are uniquely positioned to understand the everyday climate risks faced by farmers, households and businesses and to translate these needs into accessible and context-appropriate adaptation innovations - from climate-resilient agricultural inputs, irrigation and water-management technologies to resilient construction materials, cooling solutions, insurance products and other new products and business models that strengthen climate resilience.

Yet adaptation and resilience (A&R) innovators often operate within fragmented entrepreneurship support systems and innovation ecosystems. Furthermore, they lack usable climate-risk evidence, adaptation impact measurement frameworks, patient capital and links to research institutions.

2. Research Questions and Objectives

The study examined how climate adaptation research and climate risk knowledge can strengthen innovation ecosystems for A&R enterprises in Least Developed Countries and Small Island Developing States, including in Rwanda. The guiding research questions were:

- Which design options and criteria determine suitable entrepreneurship programmes and innovation ecosystems that are focused on A&R?;
- In which way can climate risk knowledge and adaptation research be integrated entrepreneurship programmes and innovation ecosystems that are focused on A&R?

3. Research Design

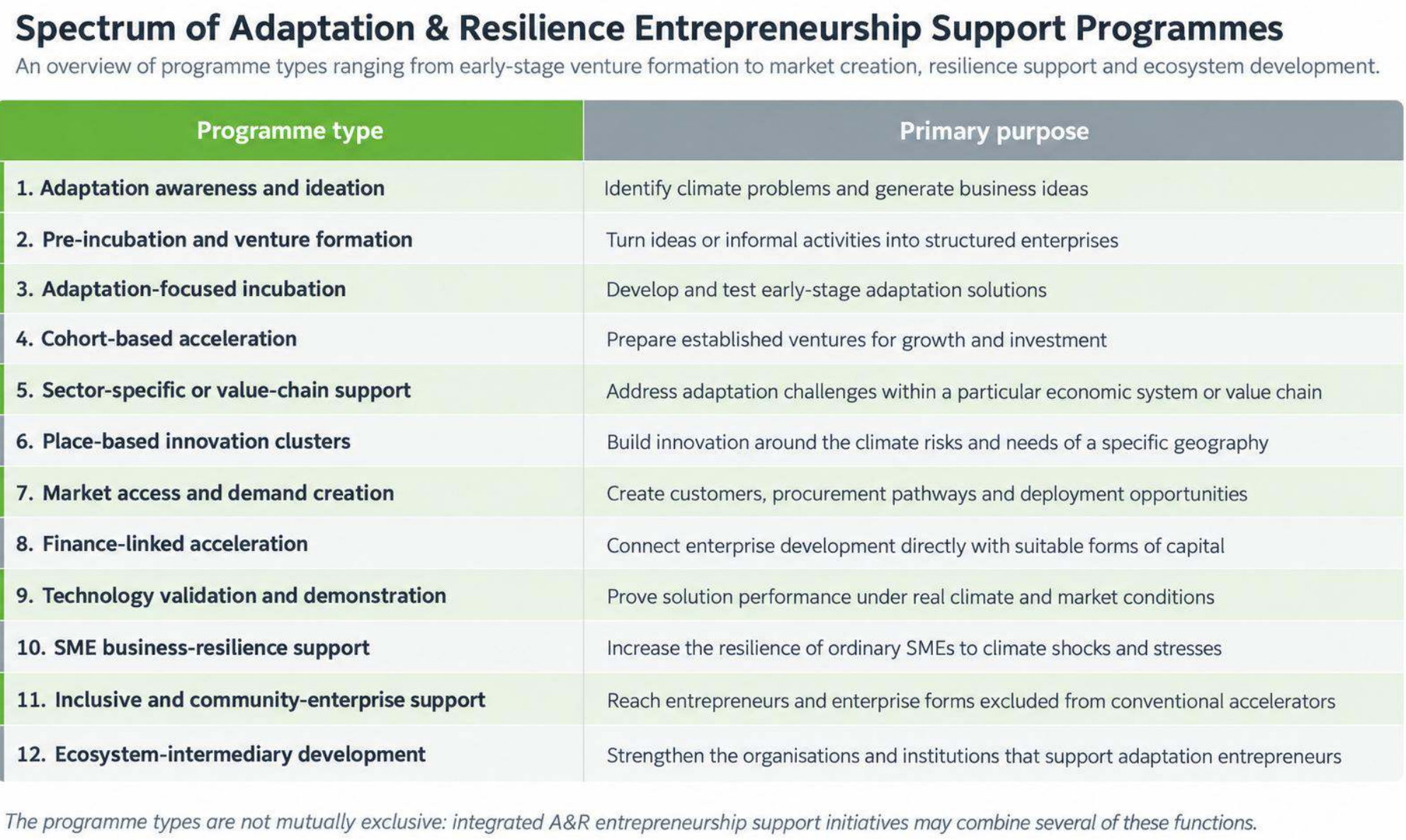
The study builds on two years of field-level learning generated through Climate-KIC’s global Community of Practice (CoP) on MSME Incubation and Acceleration, convened under the GEF-financed, UNIDO-implemented CAIL project since 2024. Across nine convenings — in Nairobi/ Kenya, Recife/ Brazil, and seven virtual sessions — the CoP engaged over 526 practitioners across Africa, Asia and Latin America, surfacing a set of contested, field-tested questions on innovation ecosystem design, blended finance and locally led adaptation that the existing literature had not yet resolved.

The research took a mixed methods approach using a combination of (a) AI-agent (SciSpace) based systematic literature review of scientific and gray literature across theme adaptation finance, incubation and acceleration models, blended finance mechanisms, and gender and social inclusion; (b) semi-structured key informant interviews and (c) field visits to adaptation SMEs, providing evidence as to how these SMEs can be best supported in order to establish reliable, sustainable and measurable adaptation outcomes. The study was embedded in the Climate Adaptation Innovation and Learning initiative (by Climate-KIC, UNIDO and GEF etc.). The analysis covered incubators and accelerators, Living Labs, the Quintuple Helix model, innovation ecosystem intermediaries, blended finance instruments, indigenous and local knowledge, and locally rooted scaling mechanisms, anchored throughout by the Adaptation SME Accelerator Project (ASAP) taxonomy.

4. Findings

4.1 Landscape of A&R Entrepreneurship Support Programming

The study revealed a wide spectrum of existing A&R entrepreneurship programmes.



not be able to pay its full cost. Entrepreneurship support therefore needs to connect climate-risk and adaptation analysis with questions of business-model innovation, public procurement, subsidies, blended finance, insurance, results-based finance or B2B/B2G models.

4.2 The Situation in Rwanda

The study found an ecosystem-level gap in Rwanda: there is considerable climate and adaptation knowledge in institutions such as RAB, Rwanda Meteorology Agency, REMA, universities and international research organizations, and there is considerable entrepreneurship infrastructure—but knowledge producers and ESOs are not consistently connected outside the agrifood sector. We found three levels of maturity:

Level 1 – Adaptation-integrated ecosystem: Agriculture/agrifood.

Level 2 – Climate-relevant ecosystem where adaptation entrepreneurship is emerging: water, NbS, urban resilience, productive energy/cooling.

Level 3 – General entrepreneurship or green-growth ecosystem where adaptation knowledge is largely absent: much of energy, circular economy, tourism, construction and mainstream digital entrepreneurship.



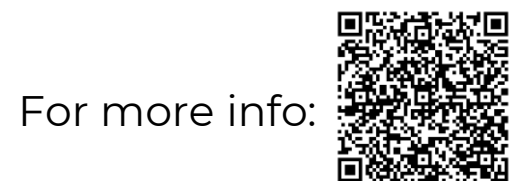
Key cross-cutting considerations to embed climate risk knowledge and adaptation research in entrepreneurship support programmes:

- the sophistication of climate knowledge should be proportionate to the enterprise and decision being made. A small agricultural enterprise usually does not need a complex climate model. It may need a robust understanding of changing rainfall patterns, farmer vulnerability and plausible future scenarios. Entrepreneurship programmes should therefore translate climate science into decision-useful knowledge;
- climate knowledge needs to be combined with local and user knowledge. Adaptation is unusually context-dependent. Scientific risk data can indicate increasing drought probability, for example, but farmers, water utilities or local businesses may know much more about how that risk actually manifests, existing coping mechanisms and why previous interventions have failed. Effective innovation therefore often requires co-design and iterative testing.
- adaptation SMEs frequently operate where there is a gap between social value and private willingness to pay. The populations that benefit most from an adaptation solution may

5. Conclusion

The study has found that entrepreneurs in LDCs and SIDS routinely lack access to downscaled and robust climate risk knowledge, adaptation research evidence, and testing facilities needed to validate a concept, a service or a product before it becomes a business. Where this information gap exists, it does not just slow entrepreneurs down — it constrains which adaptation problems get identified and pursued at all, since climate information services sit alongside finance, technology and policy as one of the external factors that enable or constrain adaptation action in the first place.

Research institutions are positioned to close this gap, but the study finds their role in practice remains narrow: applied R&D and knowledge production, with weak translational linkages to entrepreneurs and adopters. Innovation systems in LDCs and SIDS, including Rwanda, are often fragmented, marked by limited domestic R&D capacity, weak university-industry linkages, and inadequate technology transfer mechanisms. The more effective models move researchers beyond this narrow function into orchestration, facilitation and co-production — working directly with entrepreneurs and communities in climate adaptation contexts to co-design and validate solutions against local risk, for instance in Living Labs.



Community Willingness to Participate in Innovative Ecosystem-Based Adaptation

Evidence from a Butterfly Farming Project in the Ibanda-Makera Forest, Eastern Rwanda

Intwarinkase Mutaganzwa Dorine¹, Uwizelimana Jean de Dieu³, Ian Gordon⁴, Gashumba Damascene⁵, Ian Gordon, Andrew Stainback²

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Introduction

- Climate change is increasingly affecting Rwanda, especially smallholder farmers and agriculture.
- Affordable and practical adaptation options are needed for smallholder farmers, these include Ecosystem-based Adaptation (EbA)
- EbA are adaptation techniques to climate change through the conservation, sustainable management, and restoration of ecosystems
- Butterfly farming is an EbA approach that incentivizes farmers to conserve existing butterfly species for income and plant indigenous host trees needed to sustain them



Photo: American Museum of Natural History

Research objectives

Rationale: Understanding the local ecological, economic and social context before establishing an EbA project helps tailor its design and improve long-term success.

Objectives:

- To assess the willingness of communities surrounding Ibanda-Makera Forest to participate in an EbA butterfly farming project and identify factors influencing their willingness.
- To gather community insights on project implementation

Study area

- Communities surrounding Ibanda-Makera Forest, Kirehe District, Eastern Rwanda
- The forest actively conserved by local communities
- support rich tree diversity, including potential butterfly larval host plants.
- Home to at least 112 butterfly species, making Ibanda-Makera a suitable site for butterfly farming.
- Surrounded by smallholder agriculture land

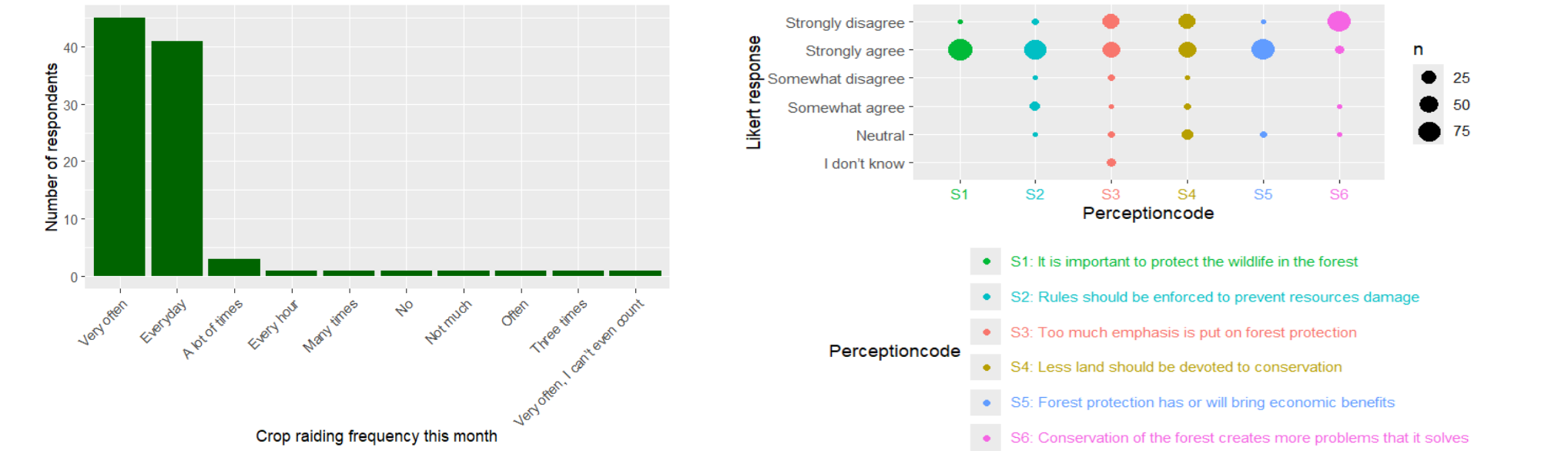


Methodology

Step	Method	Participants	Purpose/ Data obtained
1	Preliminary workshops x2	Farmers, beekeepers, traditional healers, local leaders and REDO representatives (23 and 17 participants)	To understand the local ecological, and socio-economic context & gather community perspectives on project implementation
2	Sampling	96 farmers	Purposive selection of farmers adjacent to the forest, followed by random sampling for gender and age representation
3	Pilot survey	16 farmers	Survey testing and refinement
4	Semi-structured survey	80 farmers	Forest use, perceptions, attitudes, expected benefits/challenges & willingness to participate
5	Data analysis	96 surveys + qualitative data	Descriptive/comparative statistics, chi square tests and thematic analysis; mixed-methods triangulation

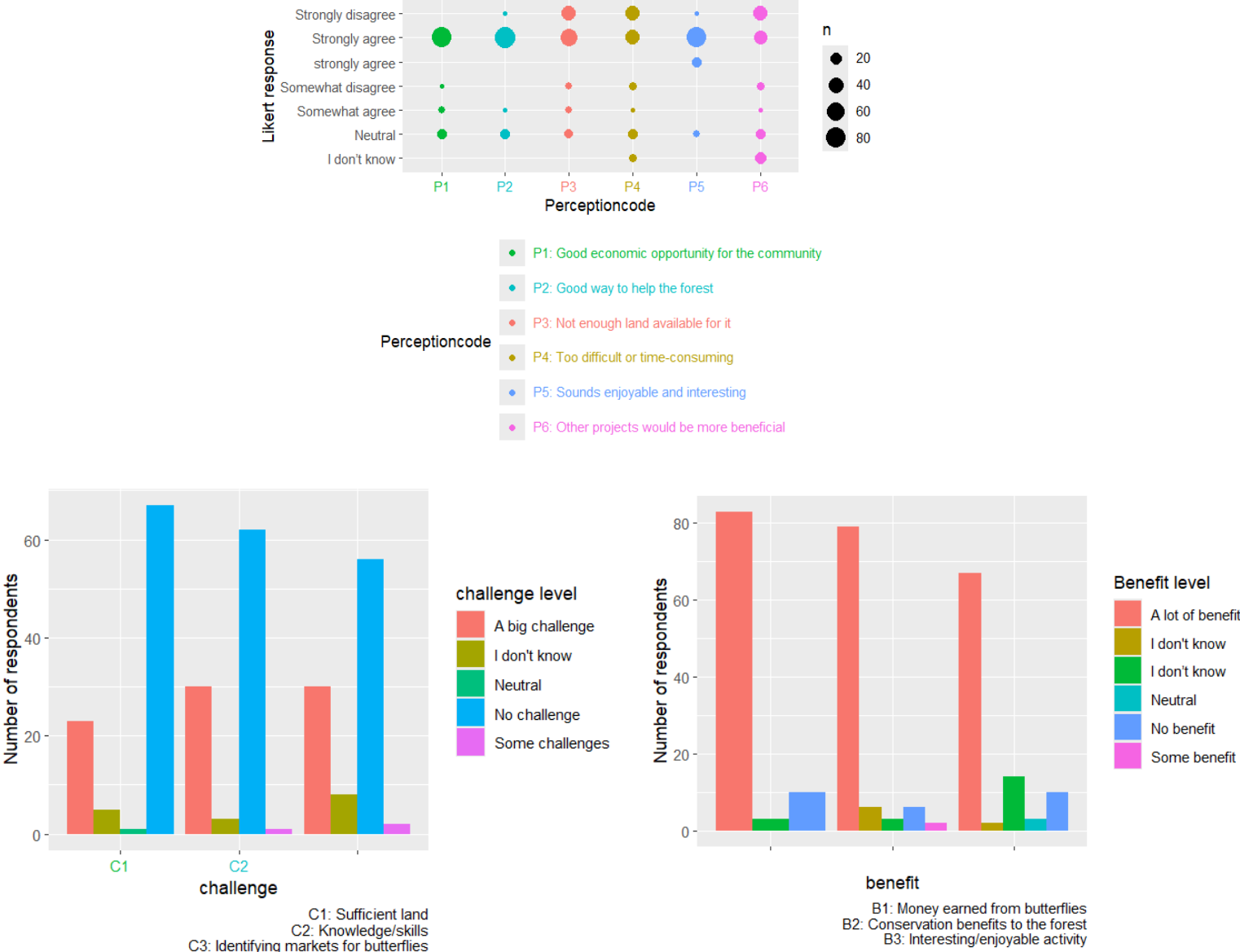
Results and interpretation

Perceptions of Ibanda-Makera



Contradiction	Protecting biodiversity is important vs Reducing conservation land	Conservation brings economic benefits vs Conservation creates problems
x2	47.49	35.11
df	4	6
p_value	< 0.001	< 0.001
% Strong	45.8	7.3
% Moderate	12.5	1

Perceptions of Butterfly farming



Conclusion and recommendations



- The positive attitudes toward conservation, cooperative traditions and prior experience with similar livelihood projects, create a favourable environment for butterfly farming
- Weaknesses such as technical knowledge gaps, and dependence on external support must be carefully addressed
- Success will depend on participatory training, accessible markets, and consistent institutional backing
- To address the weakness of dependence on external funding, self-sustainability should be the primary goal
- Given the complexity and novelty of this intervention, we recommend that the project adopt an adaptive management approach
- **Adaptive management:** A structured, iterative process of decision-making that involves implementing actions, monitoring outcomes, and adjusting strategies in response to new information and changing conditions

EbA Butterfly Farming Project: Implementation Pathway

Community-led implementation following adaptive management principles

1 Secure Funding

Obtain financing to cover training, materials, transport & project startup costs

2 Build Partnerships

Partner with ecotourism operators, butterfly exhibits & local sites (e.g., Nyandungu) to develop domestic & international markets

3 Form Cooperatives

Mobilize interested community members identified through the study into butterfly farming cooperatives

4 Train Members

Provide comprehensive, in-depth training on rearing, host plants, markets & conservation

5 Begin Farming & Sales

Start active butterfly rearing and commence sales of pupae to domestic and international buyers

6 Monitor & Adapt

Ongoing follow-up, updated training, new technologies & innovations - continuously tailored to emerging realities

Adaptive Management: Monitor outcomes at every stage → learn → adjust → improve

References

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Acknowledgment

We thank smallholder farmers around Ibanda-Makera Forest for accepting to be part of this study, Rwanda Environment Management Authority (REMA) for funding the project, Rural Environment and Development Organization (REDO) for their help on the field, and CoEB for bringing us all together.



2ND

RWANDA CLIMATE SCIENCE SYMPOSIUM 2026

Where Rwanda's climate research meets policy

IMPACTS OF LANDSLIDE DISASTERS ON COMMUNITY LIVELIHOODS IN RUTSIRO DISTRICT, RWANDA

Salim Kabano^{1*} | Thompson Faraday Edigbonya^{1,2} | Christopher Mupenzi¹

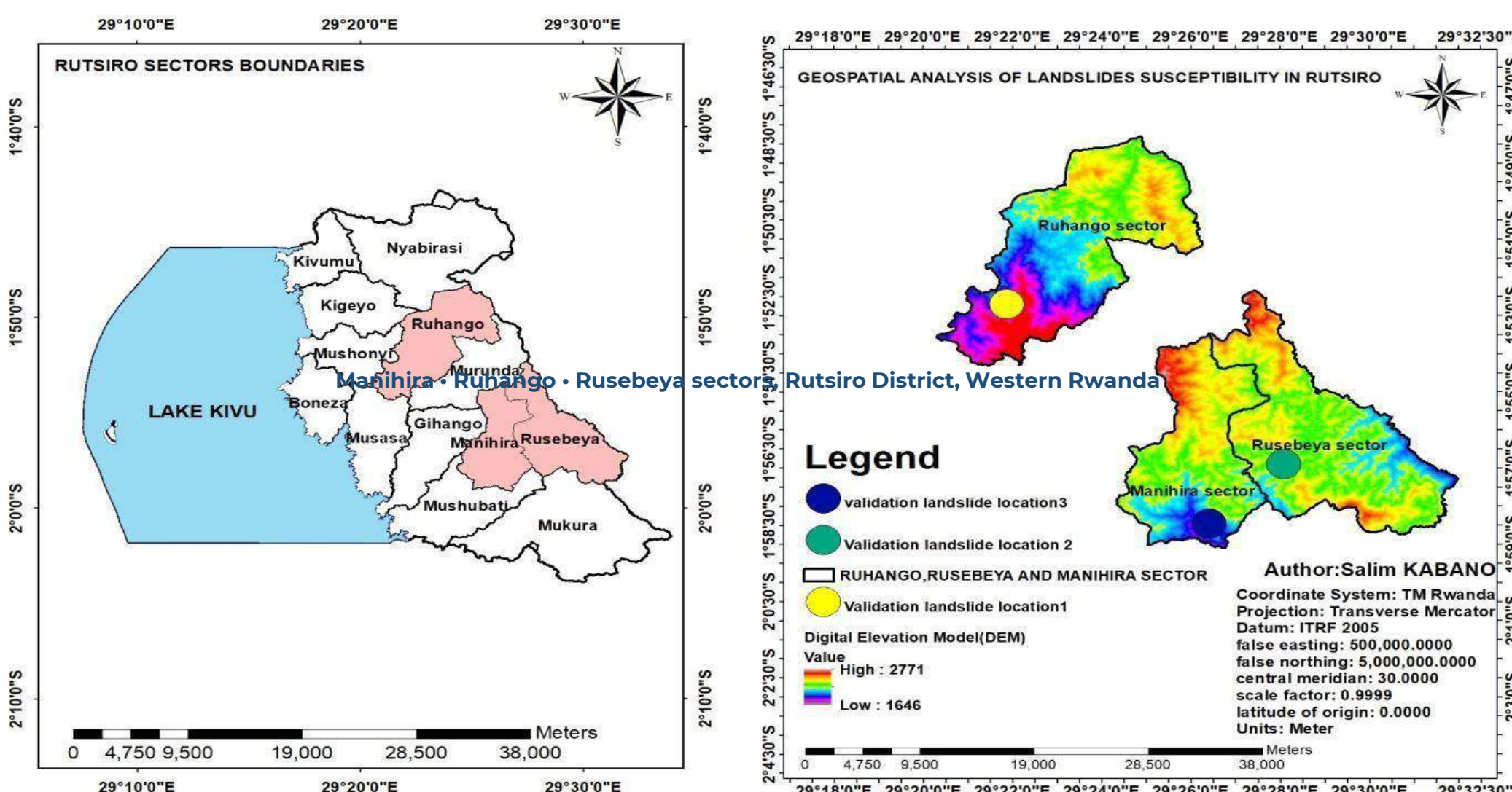
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BACKGROUND & RESEARCH OBJECTIVES

Landslides are recurrent geomorphological hazards in Rwanda's Western Province. In Rutsiro District, steep terrain, intense rainfall, deforestation and unsustainable land use interact with high dependence on agriculture, creating repeated livelihood and environmental losses.

- Assess the frequency and perceived causes of landslides.
- Quantify socio-economic, health and environmental impacts on households.
- Examine community coping and mitigation strategies.
- Identify gaps in preparedness, institutional support and recovery.

STUDY AREA & RESEARCH DESIGN



METHODS AT A GLANCE

- Concurrent mixed-methods, cross-sectional design.
- 400 randomly selected household respondents.
- 12 key informant interviews and 3 focus groups (24 participants).
- Fieldwork: September–December 2024.
- SPSS 26 quantitative analysis; two-cycle thematic coding.

Figures and findings are derived from the supplied article.

KEY FINDINGS

53% reported experiencing landslides annually

72% reported farmland loss

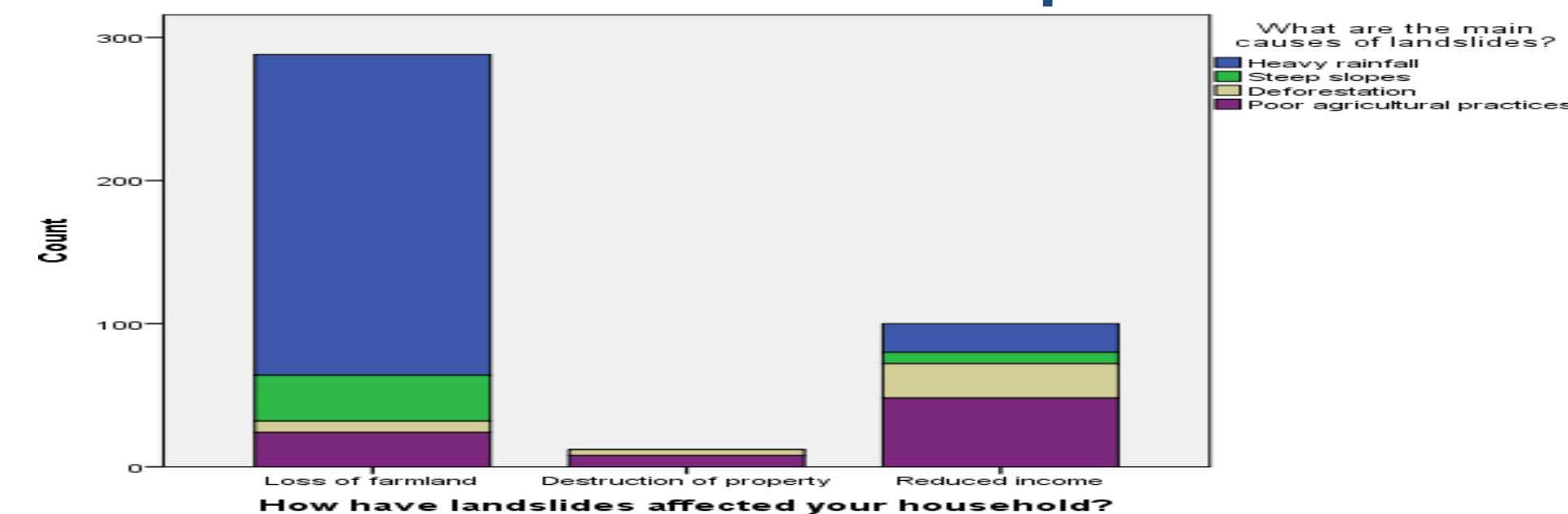
81% reported water-source contamination

38% reported no post-disaster assistance

Preparedness & institutional reach

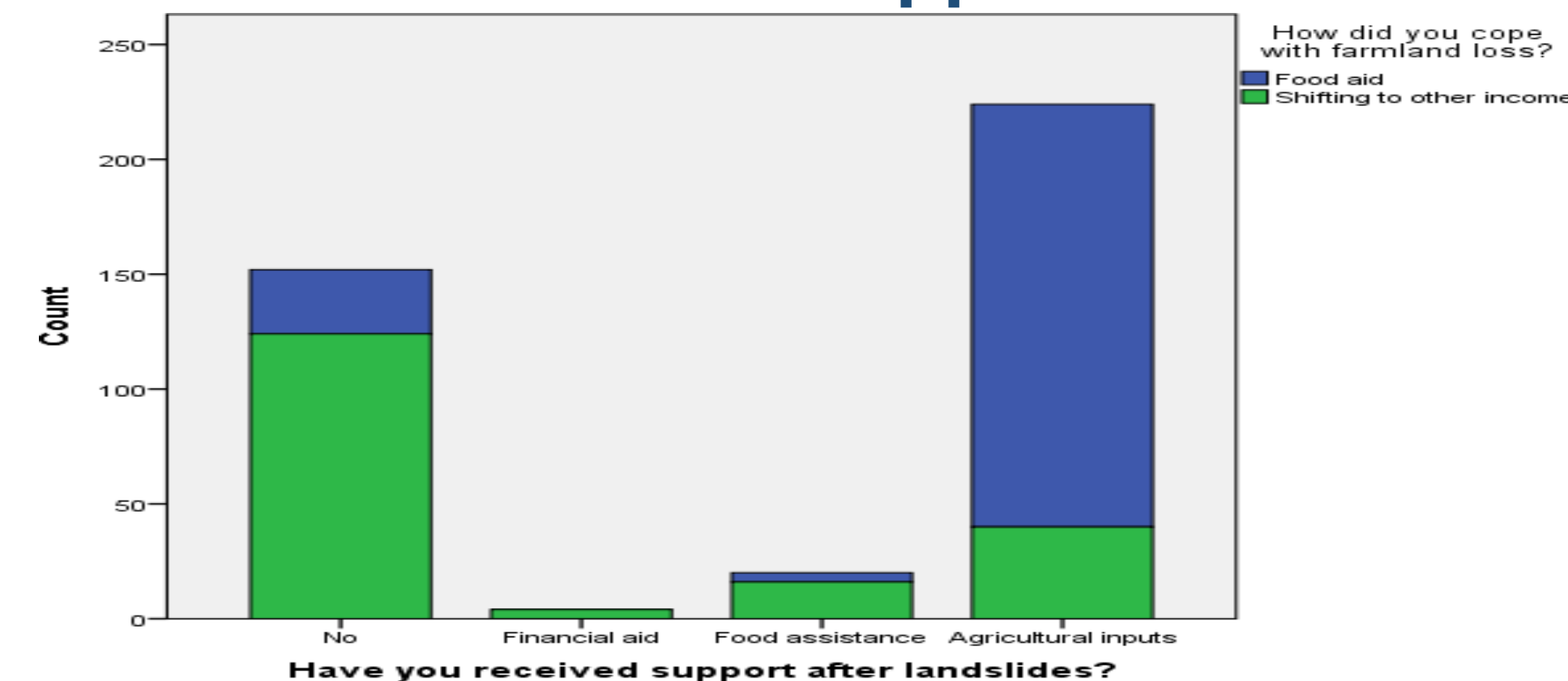
98% perceived community preparedness · 97% reached by government outreach

Household livelihood impacts



Farmland loss was the dominant reported livelihood impact.

Post-disaster support



Relief: agricultural inputs 56% · cash assistance 1% · food support 5%.

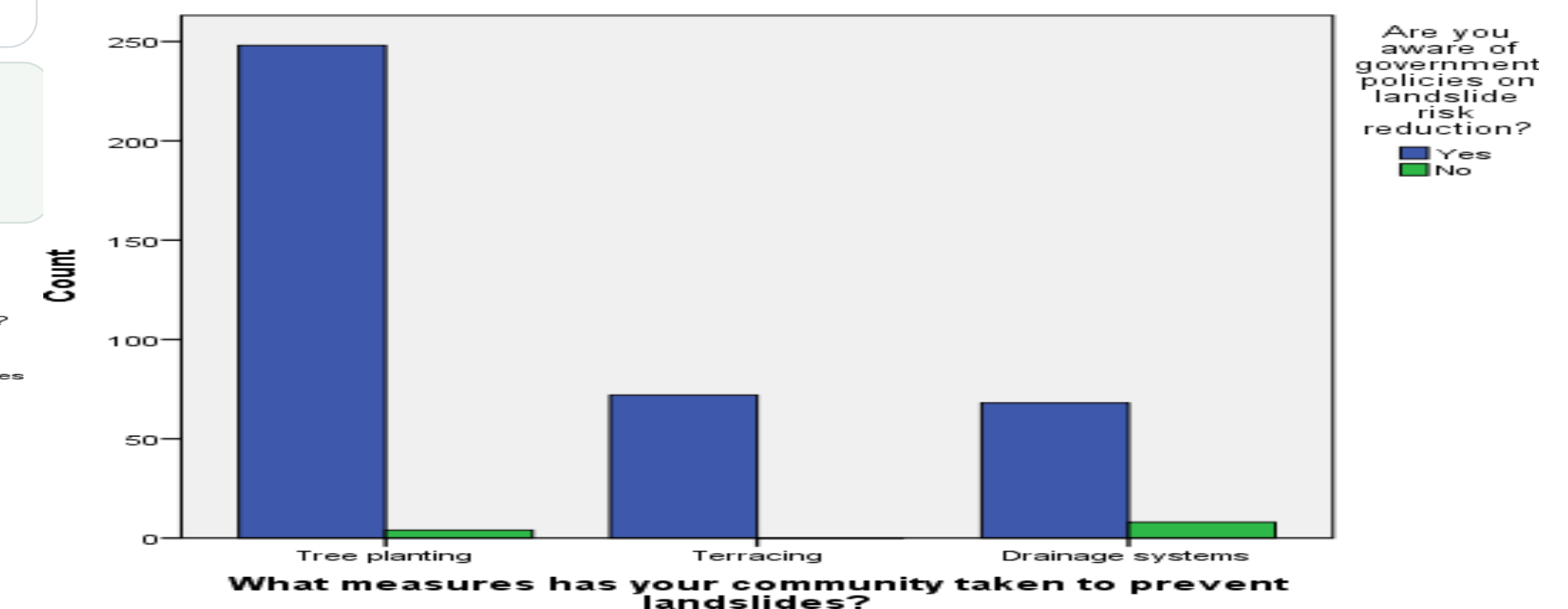
Infrastructure link

Household impact was positively correlated with water-source impact: $r = 0.148$, $p = 0.003$ ($n = 400$).

MITIGATION, IMPLICATIONS & RECOMMENDATIONS

Community-led mitigation

Afforestation/tree planting was reported by 63%; bench terracing by 18%. Community measures also included drainage channels.



Community mitigation actions and reported policy awareness ($n = 400$).

WHAT THE FINDINGS MEAN

- Landslides have evolved from localized physical hazards into chronic socio-economic disruptions.
- Agricultural dependence amplifies food-security and income vulnerability.
- Water contamination adds a public-health burden to property and livelihood losses.
- High awareness and preparedness do not necessarily translate into effective, maintained mitigation.

PRIORITY ACTIONS

- Scale regenerative land management and agroforestry using deep-rooted native species such as *Alnus acuminata* and *Grevillea robusta*.
- Strengthen land-use zoning and combine terracing with engineered drainage.
- Localize bilingual early-warning systems and integrate risk education into farming cooperatives.
- Close the 38% support gap through decentralized recovery finance, crop insurance and rapid cash relief.

CONCLUSION

Rutsiro's landslide burden is simultaneously environmental, economic and public-health related. A coordinated disaster-risk-reduction framework linking sustainable land management, resilient infrastructure, community education and equitable recovery is required to build long-term climate resilience.

2ND

RWANDA CLIMATE SCIENCE SYMPOSIUM 2026

Where Rwanda's climate research meets policy

Assessing the Impact of Community Awareness and Adoption of Climate Adaptation Strategies on Flood Risk Reduction in Rusizi District, Western Rwanda

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1 Introduction

Climate change increasingly threatens developing regions through flooding, droughts and erratic rainfall, with Sub-Saharan Africa especially vulnerable due to limited resources and low adaptive capacity (IPCC, 2022). Rusizi District, Western Rwanda, is highly exposed to flooding because of steep slopes, proximity to Lake Kivu/Tanganyika, high rainfall intensity and dense river networks (Gebrechorkos et al., 2018). While community awareness and adoption of adaptation strategies are widely promoted, their combined impact on actual flood risk reduction in Rusizi District has not been empirically assessed.

2 Research Objectives

- Assess community awareness of climate change and flood risks in Rusizi District.
- Examine the adoption of climate adaptation strategies among residents.
- Determine the impact of awareness and adoption on flood risk reduction outcomes.

3 Methodology

Design: Descriptive cross-sectional survey with analytical (correlation/regression) components.

Sample: 399 households in flood-prone sectors, selected via stratified random sampling (Yamane, 1967; 95% CI, 5% error) from ~95,247 households (NISR, 2022).

Data: Structured questionnaires + key informant interviews (KIIs) with local leaders, district officials and disaster management practitioners; secondary rainfall data from Meteo Rwanda.

Analysis: SPSS v26: descriptive statistics, chi-square, correlation and multiple regression; KIIs analysed thematically.

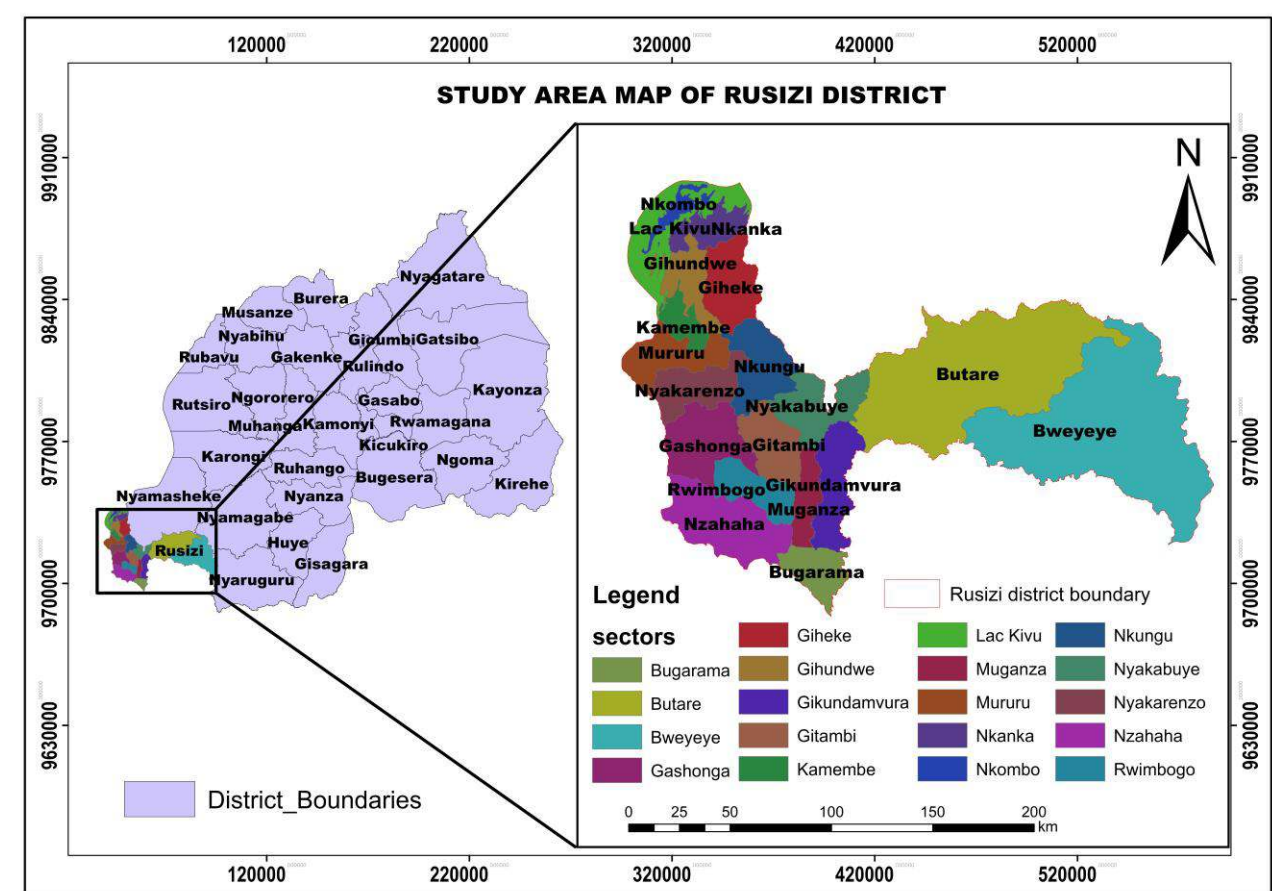


Figure 1. Rusizi District, Western Rwanda (Source: NISR, 2023).

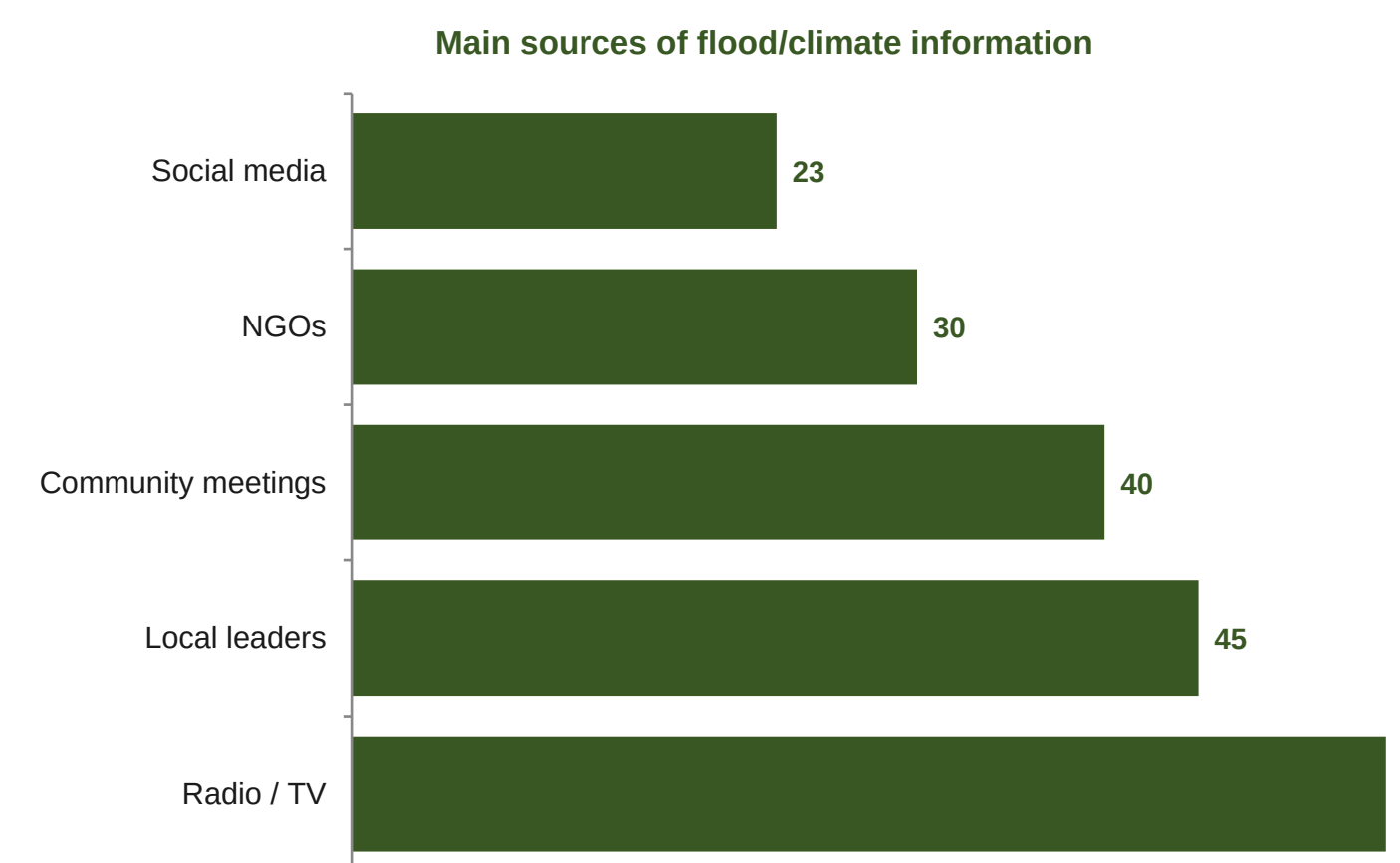
4 Respondent Profile (n = 399)

Most respondents were economically active (37.6% aged 31–45), slightly more female (52.4%) and married (57.6%). Over half farm for a living (52.6%); household incomes are largely low (37.6% earn <50,000 RWF/month), and 54.9% have resided in the area over 10 years.



5 Community Awareness

80.2% of residents had heard of climate change and 77.7% were aware of flood risks, yet depth of understanding varied, only 35.1% reported moderate and 12.3% very high understanding of impacts. Radio/TV (55.1%), local leaders (45.1%) and community meetings (40.1%) were the leading information sources.

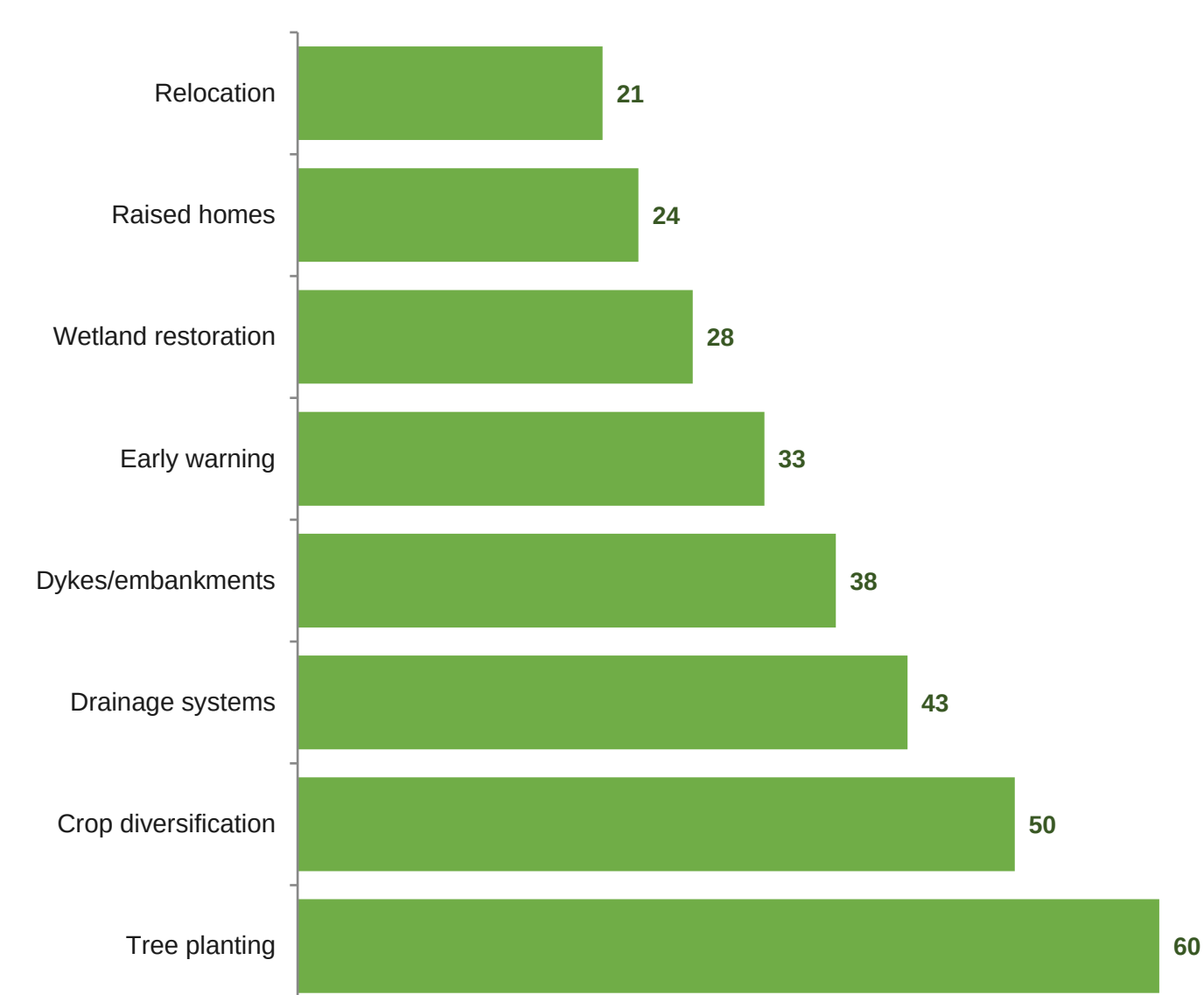


80.2%
aware of climate change

77.7%
Aware of flood risks

6 Adoption of Adaptation Strategies

Tree planting/reforestation (60.2%), crop diversification (50.1%) and drainage systems (42.6%) were the most widely adopted strategies; costlier measures, raised housing (23.8%) and relocation (21.3%) were far less common. Most efforts (37.6%) have run for just 1–3 years.



7 Institutional Support & Impact

Institutional support was uneven: 52.6% knew of government programmes but only 40.1% had received flood-risk training, and 12.3% never received assistance during flood events. Barriers to adoption centred on **limited finances (57.6%)** and **lack of technical support (45.1%)**. Despite this, 72.5% of households reported some reduction in flood impact (slight, moderate or significant) after adopting adaptation measures.

57.6%
Limited financial resources

45.1%
Lack of technical support

8 Regression Results

Community awareness and adoption of adaptation strategies jointly explained 58.1% of the variation in flood risk reduction ($R = 0.762$, $R^2 = 0.581$, $F(2,396) = 45.76$, $p < 0.001$). Both predictors were significant: adoption ($\beta = 0.368$, $p < 0.001$) had a slightly stronger effect than awareness ($\beta = 0.321$, $p < 0.001$).

R² = 0.581
Variance explained

F = 45.76
p < 0.001

$\beta = 0.368$
Adoption effect

Predictor	β	t	Sig.
Community awareness	0.321	6.08	0.000
Adoption of strategies	0.368	6.63	0.000

9 Conclusion

Community awareness, adoption of adaptation strategies and institutional support jointly play a critical role in reducing flood risk in Rusizi District. Yet effectiveness remains constrained by socio-economic limitations, weak technical capacity and inconsistent institutional response — strengthening these areas is essential for durable community resilience.

Key Recommendations

- Diversify awareness channels beyond radio/TV to reach under-informed households.
- Expand flood-risk training — currently only 40.1% of households have received it.
- Address financial and technical barriers to adopting structural measures.
- Strengthen consistency of institutional/disaster response during flood events.

10 Selected References: IPCC (2022) Ch.6, Cambridge Univ. Press • Gebrechorkos et al. (2018) HESS 22(8) • Havugimana, Edigbonya & Mupenzi (2025) • Jannat & Kusakabe (2024) Soc. Sci. 13(7) • Kumaresen, Tan & Rahman (2025) Water 17(15) • NISR (2023) Rusizi District Profile

Risk Assessment and Seasonal Variation of Greenhouse Gases in Agricultural Farmland in Nigeria

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1 Introduction

Greenhouse gases (GHGs) like CO₂ and CH₄ regulate Earth's energy balance but pose health risks at elevated levels. While CO₂ is abundant, CH₄ has ~25x the global warming potential over 100 years (IPCC, 2021). In Nigeria, limited studies investigate seasonal GHG variations and associated health impacts in agricultural settings. This study assesses atmospheric concentrations of CO₂ and CH₄ across six locations in Ondo State and evaluates non-carcinogenic health risks using Hazard Quotients (HQ).

2 Research Objectives

- Assess atmospheric concentrations of CO₂ and CH₄ in diverse land-use areas (Cattle, Rice, Palm, Residential).
- Evaluate seasonal variations (Wet vs. Dry) in GHG levels and meteorological influences.
- Determine non-carcinogenic health risks using USEPA-based Hazard Quotients (HQ & THQ).

3 Methodology

Study Area: Ondo State, SW Nigeria. Six sites: Cattle farms (Okitipupa/Ondo City), Oil palm plantations, Rice farm (Ogbese), Residential area.

Sampling: Wet (Jun-Oct 2023) and Dry (Nov 2023-Feb 2024) seasons. ~6,576 measurements per gas using KP826 Multi-Gas Detector (NDIR for CO₂, Catalytic for CH₄).

Meteorology: Temperature, humidity, and wind speed monitored via Benetech GM8902 digital anemometer.

Analysis: SPSS v26. ANOVA (p<0.05), Pearson correlation, and Health Risk Assessment (HQ = C_{measured} / RfC). Reference concentrations: CO₂ (1,800,000 µg/m³), CH₄ (3,280,000 µg/m³).

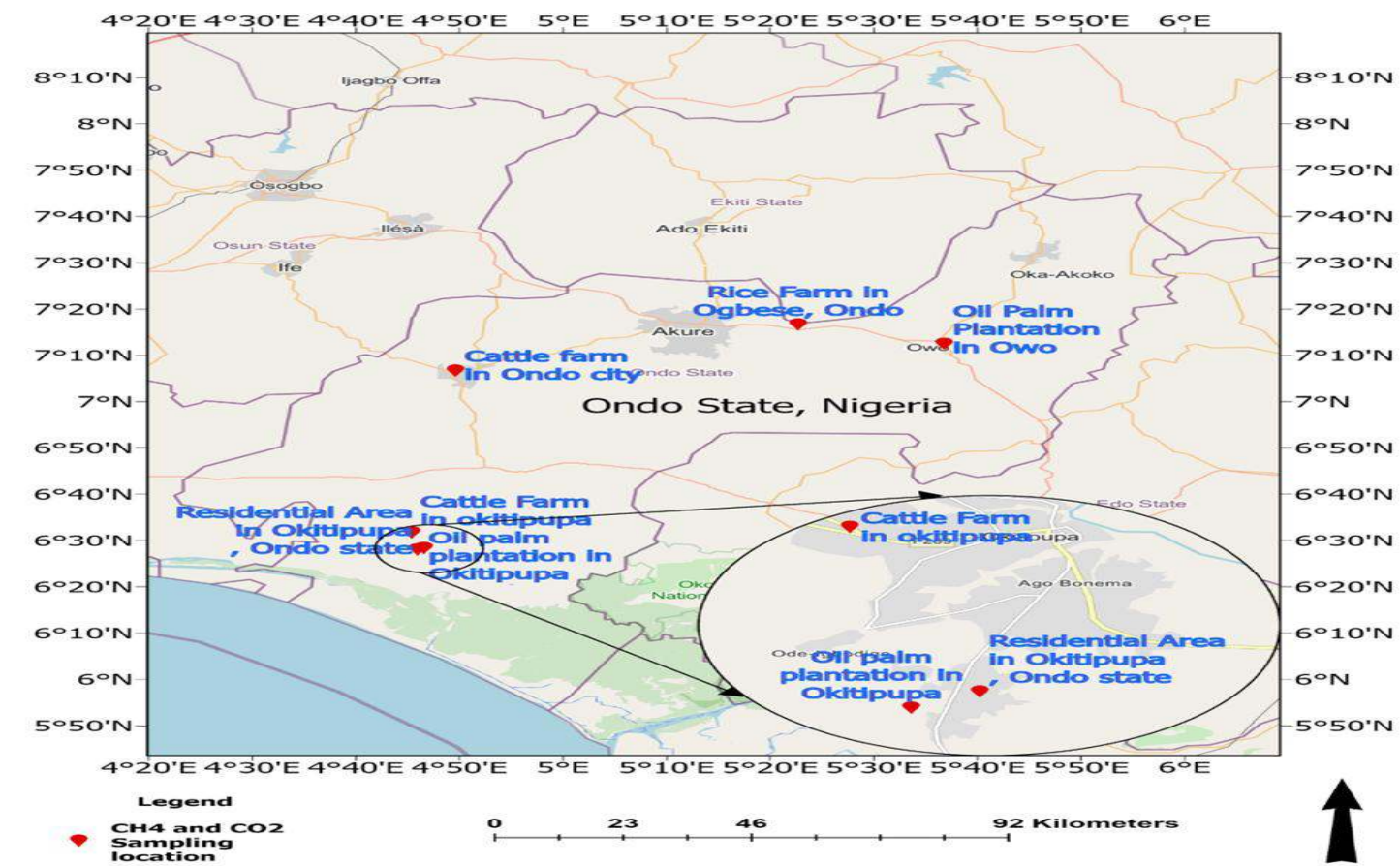
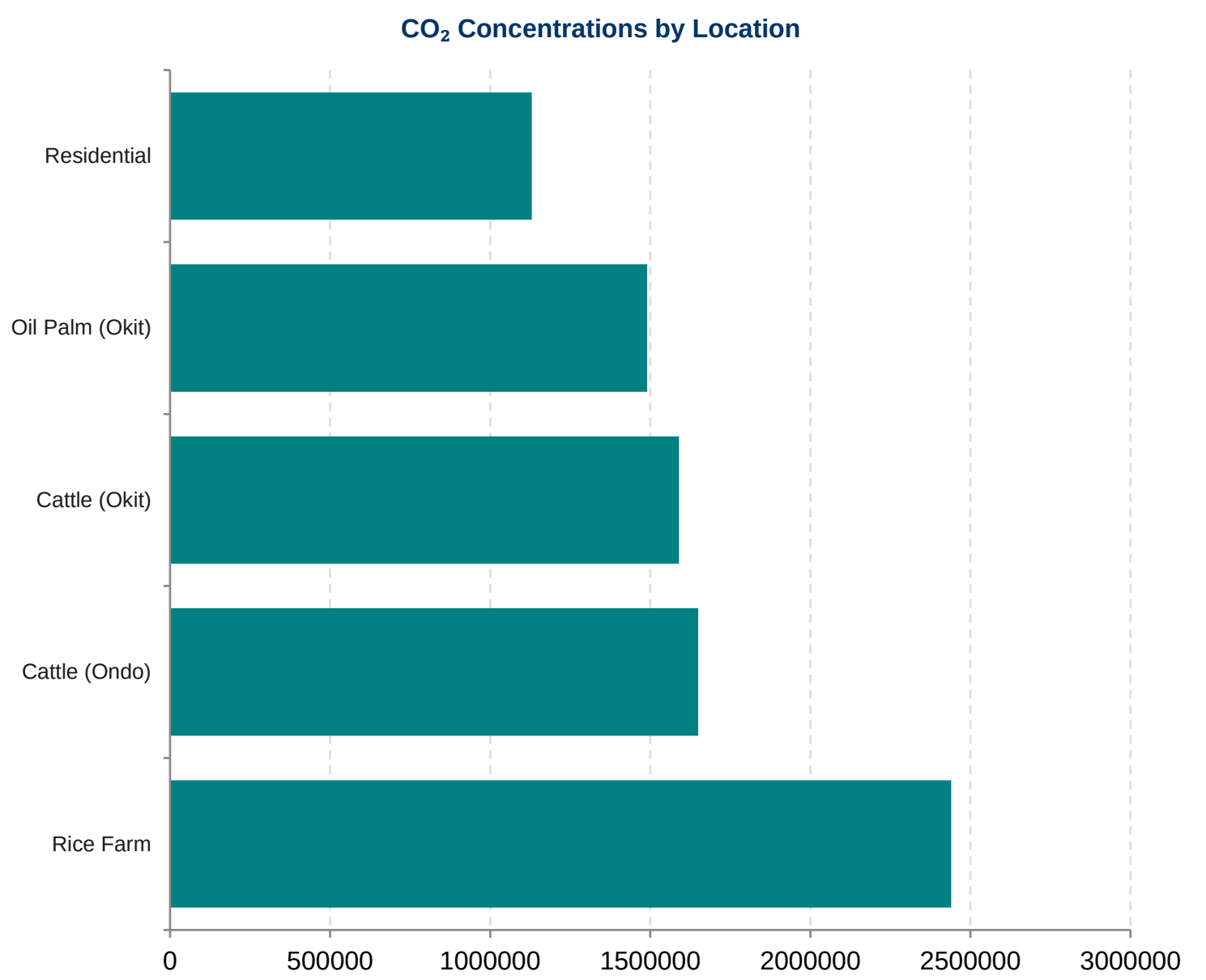


Figure 1. Map of Study Area: Ondo State, Nigeria

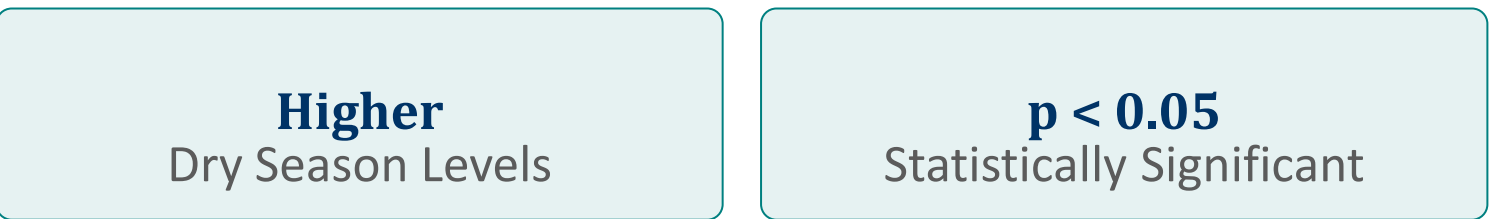
4 Spatial Variation (Combined)

Significant spatial differences observed (p < 0.05). Agricultural sites recorded highest emissions. Rice Farm (Ogbese) had the highest CO₂ (2.44×10⁶ µg/m³) and CH₄ (2.24×10⁶ µg/m³), driven by anaerobic decomposition in flooded soils and microbial activity. Cattle farms followed due to enteric fermentation.



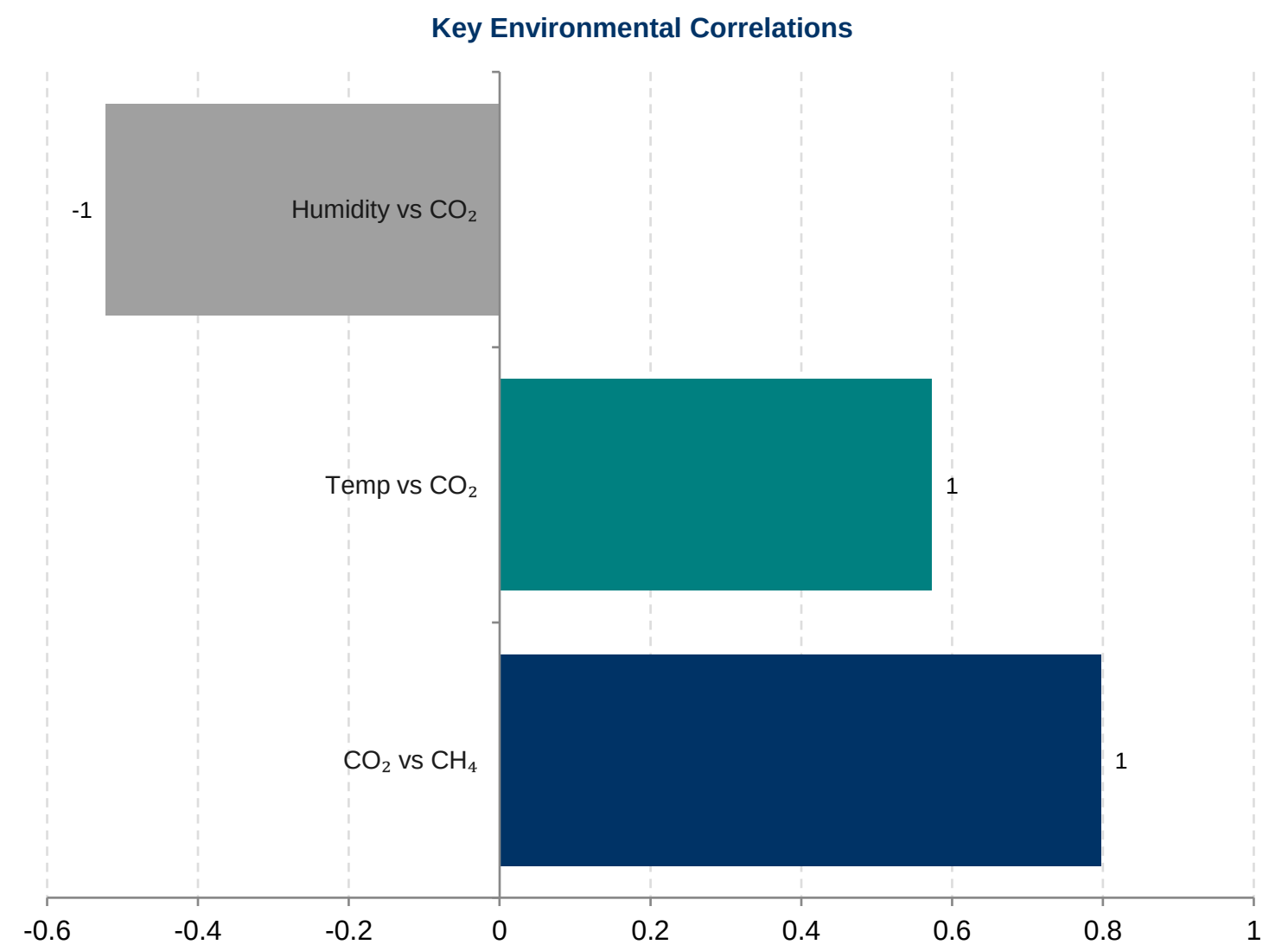
5 Seasonal Trends

Dry season concentrations were generally higher than wet season for both gases (p < 0.05). **CO₂:** Driven by biomass burning, soil respiration and reduced vegetation cover in dry months. Wet season showed lower levels due to wet deposition and photosynthetic uptake. **CH₄:** Rice farms remained high in both seasons due to anaerobic conditions, but peaked in dry season likely due to irrigation practices and heat stress enhancing microbial methanogenesis.



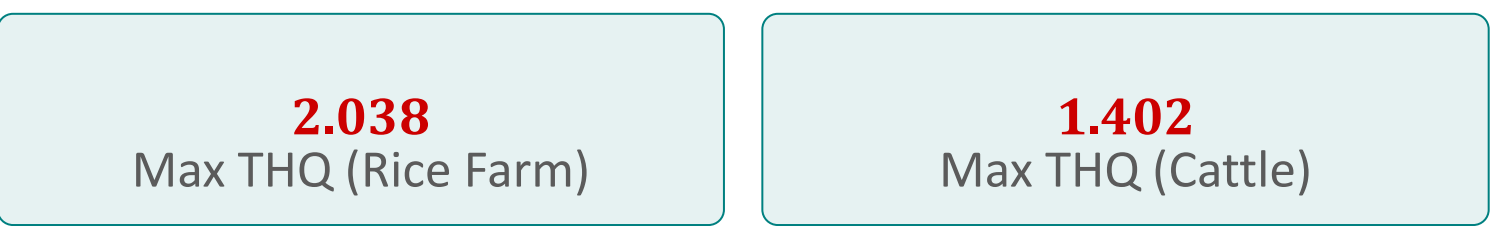
6 Meteorological Correlations

Strong positive correlation between CO₂ and CH₄ (r = 0.797, p < 0.01), suggesting common anthropogenic/agricultural sources. Temperature positively correlated with both gases (CO₂ r=0.573; CH₄ r=0.701), while humidity showed negative correlation (CO₂ r=-0.522), indicating complex dispersion dynamics where heat enhances emission rates but moisture aids dispersion or dissolution.



7 Health Risk Assessment

Hazard Quotient (HQ) > 1 indicates potential health concern. **CO₂ HQ:** Exceeded threshold only at Rice Farm (HQ = 1.355). Other sites ranged 0.62–0.92. **CH₄ HQ:** All sites < 1 (Max 0.683 at Rice Farm). **Total HQ (THQ):** Combined exposure exceeded 1 at Rice Farm (2.038) and Ondo Cattle Farm (1.402), indicating cumulative risk for farmers/residents in these zones.



8 Discussion

Agricultural activities are major drivers of GHG emissions in Ondo State. Rice cultivation (anaerobic decomposition) and livestock (enteric fermentation/manure) contribute significantly to local atmospheric loading, consistent with global findings (Zhao et al., 2020). Elevated dry-season emissions highlight the impact of biomass burning and heat stress on microbial activity. The strong CO₂-CH₄ correlation confirms shared source profiles in these agrarian landscapes. Health risks are localized but significant for occupational groups.

9 Conclusion

1. Agricultural zones (Rice/Cattle) exhibit significantly higher GHG levels than residential/plantation areas. 2. Dry season exacerbates emissions due to climatic and anthropogenic factors like burning. 3. Cumulative health risk (THQ) exceeds safe limits at specific agricultural hotspots (Rice Farm: 2.038), posing localized concerns for farmers and residents requiring immediate mitigation.

10 Recommendations

- Adopt sustainable farming: Alternate wetting/drying in rice fields to reduce CH₄.
- Improve livestock waste management to curb enteric emissions.
- Implement continuous air quality monitoring in high-risk agricultural zones.
- Promote community awareness on GHG health risks and mitigation strategies.

Selected References: IPCC (2021) Climate Change 2021 • Azuma et al. (2018) Indoor Air • Zhao et al. (2020) Atmos. Ocean. Sci. Lett. • Ediabonya & Olabiya (2023) Discover Env. • USEPA (1989) Risk Assessment Guidance.

FLUORINATED GREENHOUSE GASES AND CLIMATE CHANGE: A CRITICAL REVIEW OF EMISSIONS, IMPACTS, AND REGULATORY GAPS

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1 Introduction

Fluorinated gases (F-gases)—including HFCs, PFCs, and SF₆—are synthetic 'super greenhouse gases' with Global Warming Potentials (GWPs) thousands of times higher than CO₂. Unlike natural GHGs, they have no significant sinks and persist for centuries to millennia.

Despite their potency, F-gases remain underrepresented in climate policy compared to CO₂. This review synthesizes scientific and policy literature to evaluate their radiative properties, emission trends, and regulatory gaps, advocating for integrated mitigation strategies.

2 Research Objectives

- 1. Characterize comparative climate impacts of CO₂ vs. F-gases (molecular properties, atmospheric behavior).
- Evaluate sectoral emission trends and regional patterns.
- Assess global regulatory frameworks and identify enforcement gaps.
- Propose integrated mitigation pathways combining technology and policy.

3 Methodology

Systematic narrative review of 156 peer-reviewed articles and technical reports (2000–2023) from Web of Science, Scopus, IPCC, UNEP, and USEPA.

Data extraction focused on GWP values, atmospheric lifetimes, emission inventories, and policy efficacy. Thematic synthesis was used to organize findings into comparative analysis, regulatory challenges, and technological alternatives.

4 Comparative Properties

Property	CO ₂	HFC-134a	SF ₆
GWP (100-yr)	1	~1,300	~23,500
Atmospheric Lifetime	~100 yrs	~14 yrs	~3,200 yrs
Radiative Efficiency	Low	Moderate	Very High
Natural Sink	Yes	No	No

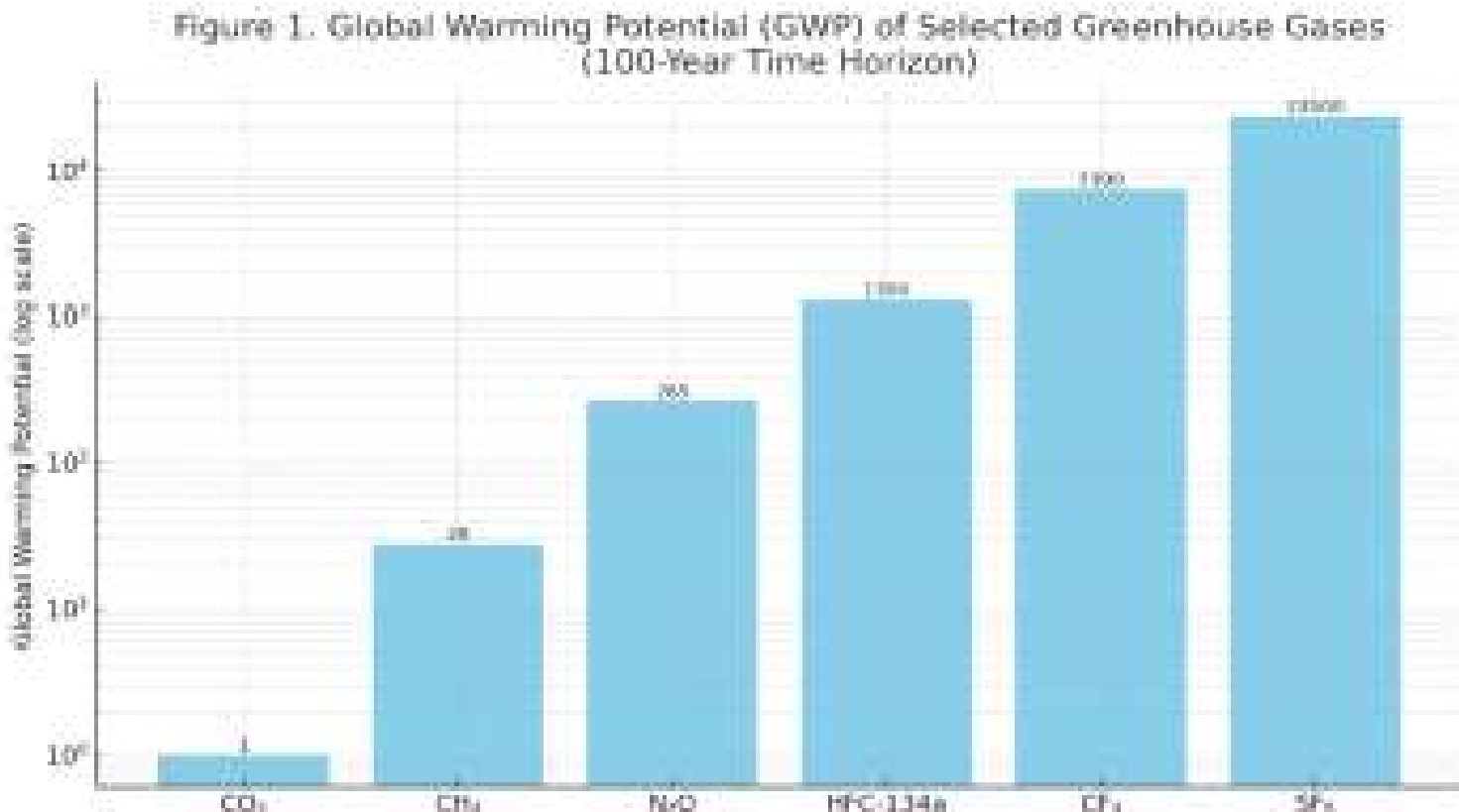


Figure 1: Global Warming Potential (100-yr) of Selected GHGs

5 Sources & Emission Trends

- F-gases are entirely anthropogenic. Key sectors include:
- Refrigeration & AC (HFCs): Leakage during use/disposal.
 - Electronics/Semiconductors (PFCs, SF₆): Plasma etching.
 - Magnesium Production (SF₆): Cover gas.
 - Electrical Transmission (SF₆): Insulation.

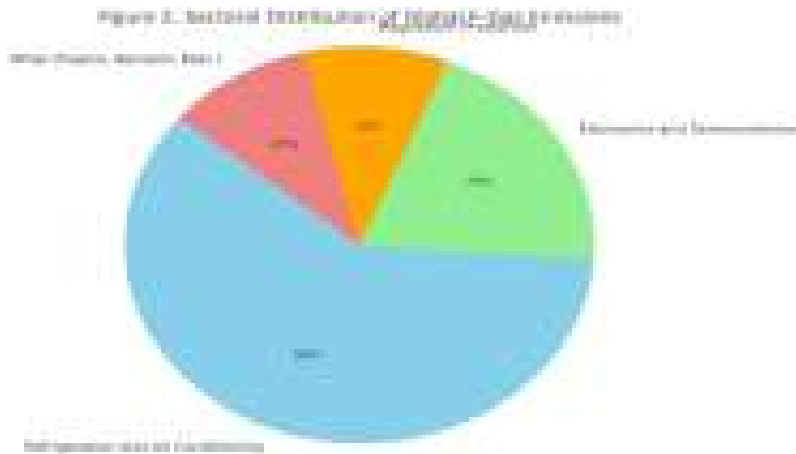


Figure 2: Sectoral Distribution of Global F-Gas Emissions

Global Emissions Trend (Mt CO₂e):

Year	CO ₂	F-Gases
1990	21,000	~500
2005	29,000	~750
2020	34,000	~1,200

6 Atmospheric Behavior

Unlike CO₂, which mixes globally and has natural sinks (oceans, biosphere), F-gases lack removal mechanisms. SF₆ persists >3,000 years; CF₄ >50,000 years. They accumulate linearly with emissions, making every ton released a permanent climate liability.

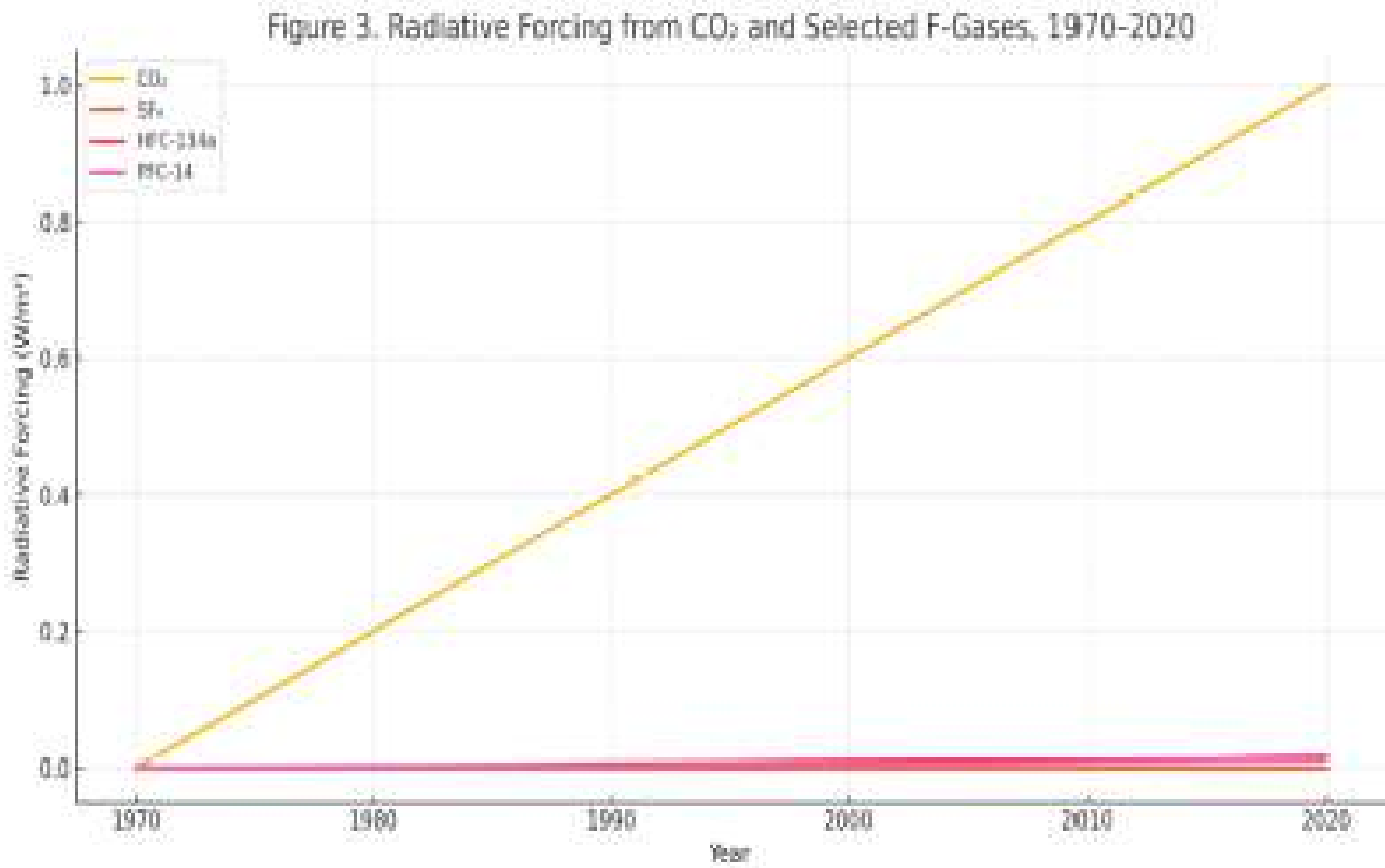


Figure 3: Cumulative Radiative Forcing Contributions

7 Regulatory Frameworks

While CO₂ is governed by UNFCCC/Paris Agreement, F-gases fall under Montreal Protocol (Kigali Amendment) and regional laws like EU F-Gas Regulation 517/2014.

Policy	Target	Status
UNFCCC/Paris	CO ₂ -centric	Global NDCs
Montreal/Kigali	HFC Phase-down	Binding Schedule
EU Reg 517/2014	All F-gases	Strict Quotas
National Policies	Variable	Often Weak

Policy Coverage Gaps:

Country	F-Gas in NDC?	Monitoring
USA	Partial	Strong
China	Yes	Moderate
India	No	Weak
EU	Yes	Strong
Brazil/Russia	No	Weak

8 Mitigation Strategies

- 1. Recovery & Destruction: Incineration/plasma arc for end-of-life equipment.
- Low-GWP Alternatives: HFOs, CO₂, Ammonia, Hydrocarbons.
- Leak Detection: Mandatory checks for industrial users.
- Energy Efficiency: Co-benefit of modern refrigerant systems.

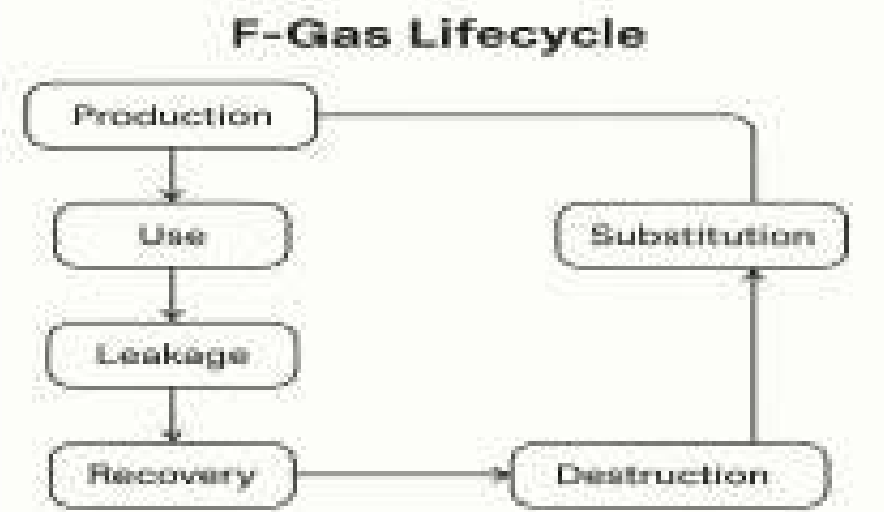


Figure 4: F-Gas Lifecycle & Intervention Points

9 Conclusions

- F-gases are 'silent but powerful' climate drivers. Current CO₂-centric policies are insufficient. Urgent actions needed:
- 1. Integrate F-gas targets explicitly into Paris Agreement NDCs.
 - 2. Strengthen monitoring infrastructure in Global South.
 - 3. Accelerate transition to natural refrigerants.
 - 4. Harmonize international regulations to prevent illegal trade.

Without integrated action, F-gas growth will undermine global warming limits.

NATURE-BASED FLOOD ADAPTATION MEASURES IN MPAZI SUB-CATCHMENT

City of Kigali, Rwanda

Tuyikunde Gloria Divine

Rwanda Young Water Professional (RYWP) · with support from Rwanda National Commission for UNESCO (CNRU)

2ND EDITION
RWANDA CLIMATE
SCIENCE SYMPOSIUM
2026

Where Rwanda's climate research meets policy

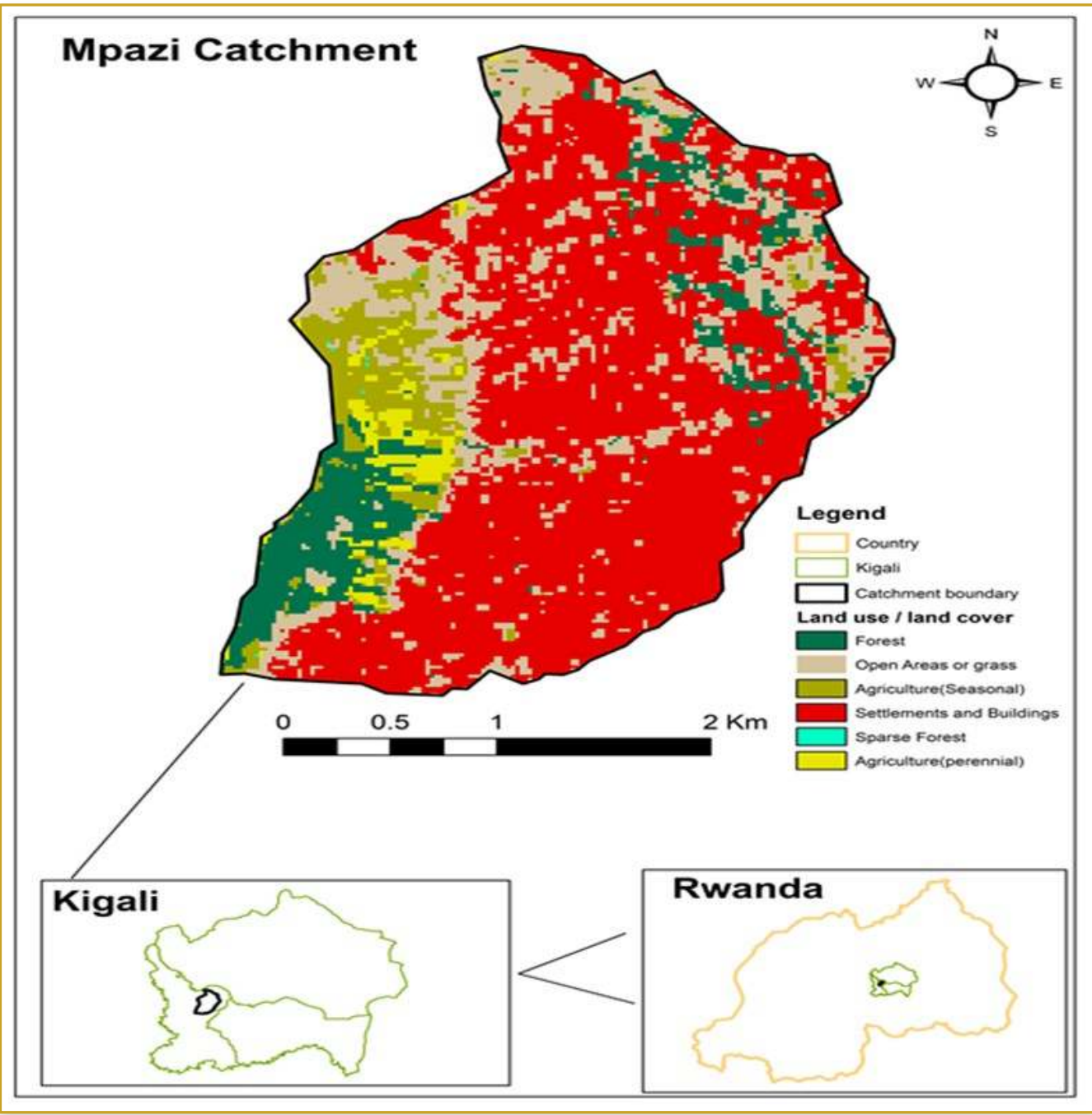
THE CHALLENGE

Mpazi is a densely settled, highly urbanised tributary of the Nyabugogo River that floods heavily and regularly. Since 2014, flood control has relied on enlarging the channel — research shows nature-based solutions can meaningfully complement this grey infrastructure.

8.45 km²

High

Rate of urbanisation



Mpazi Sub-Catchment — Nyarugenge District, Kimisagara Sector

OBJECTIVES

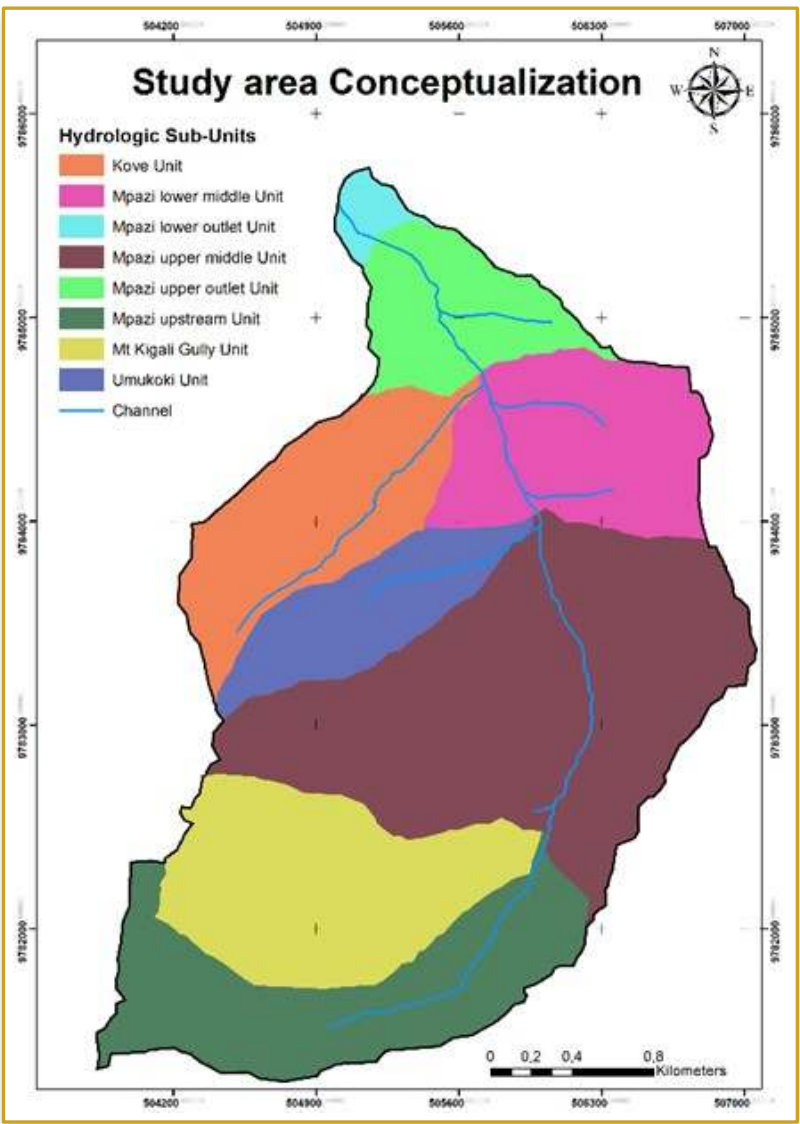
Conceptualize nature-based flood control measures for Mpazi, grounded in the catchment's hydrological behaviour.

- Model rainfall-runoff to estimate upstream runoff
- Produce flood maps across the sub-catchment
- Conceptualize NbS measures affecting flood mechanisms
- Assess NbS impact via hydrological-hydraulic modelling

METHOD & DATA

Upstream inflows were estimated with a rainfall-runoff model. Extreme rainfall events were derived by combining a Gumbel distribution with rainfall IDF curves at sub-daily timesteps.

- Rainfall — Gitega station time series, 1981–2019
- Topography — DTM & channel geometry via GPS
- Land, soil & geology data across the catchment



Hydrologic sub-units of the Mpazi catchment

PROPOSED SOLUTIONS

Reforestation 961,571 m ²	Conservative agriculture 290,784 m ²
Green spaces 37 sites	Bio-retention basins 7 sites
Permeable paving 48,532 m ²	River buffer zones 467,267 m ²
Rainwater harvesting all settlements	Flow control structures
Net-Tech filters	
	all drains
8 sites	

FLOOD SIMULATION



Simulated flood extent along the Mpazi channel

The bridge at Avenue de Nyabugogo is overtopped, with flood extending onto the road. Flooding at Nyabugogo Bus Park is attributed to the Mpazi-Nyabugogo confluence, outside the study area.

IMPACT OF NBS

~8 m³/s Reduction from infrastructure-related NBS	~20 m³/s rainwater harvesting	~28 m³/s discharge effect
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CONCLUSION

The Mpazi Upper Middle Unit was the highest contributor of runoff, followed by the Upstream Unit. Modelled NBS reduced discharge by almost 28 m³/s across the catchment.

- Establish a 5–10 m buffer zone on both channel banks
- Study the Mpazi-Nyabugogo confluence to clarify flood origins
- Apply new LiDAR DEM data to refine future flood modelling

A LOW-COST IoT AND MOBILE BASED URBAN FLOODING EARLY WARNING AND RESPONSE SYSTEM

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1. BACKGROUND

Urban areas in growing countries face increasing flood risk due to intense rainfall, rapid urbanization and inadequate drainage. Early warning can save lives and reduce economic losses



2. PROBLEM STATEMENT



3. OBJECTIVES

- ✓ To design a low-cost IoT system for real time monitoring of rainfall and water levels in urban drainage
- ✓ To develop a mobile based alert platform that delivers timely flood warnings
- ✓ To enhance community and authority response through accessible and actionable information

6. POLICY AND PRACTICAL RELEVANCE 7. SYSTEM ARCHITECTURE



For Communities

Timely warnings enable earlier evacuation and protection of lives and property.



For Local Authorities

Real-time, localized information supports evidence-based decisions and resource allocation.



For Urban Planners

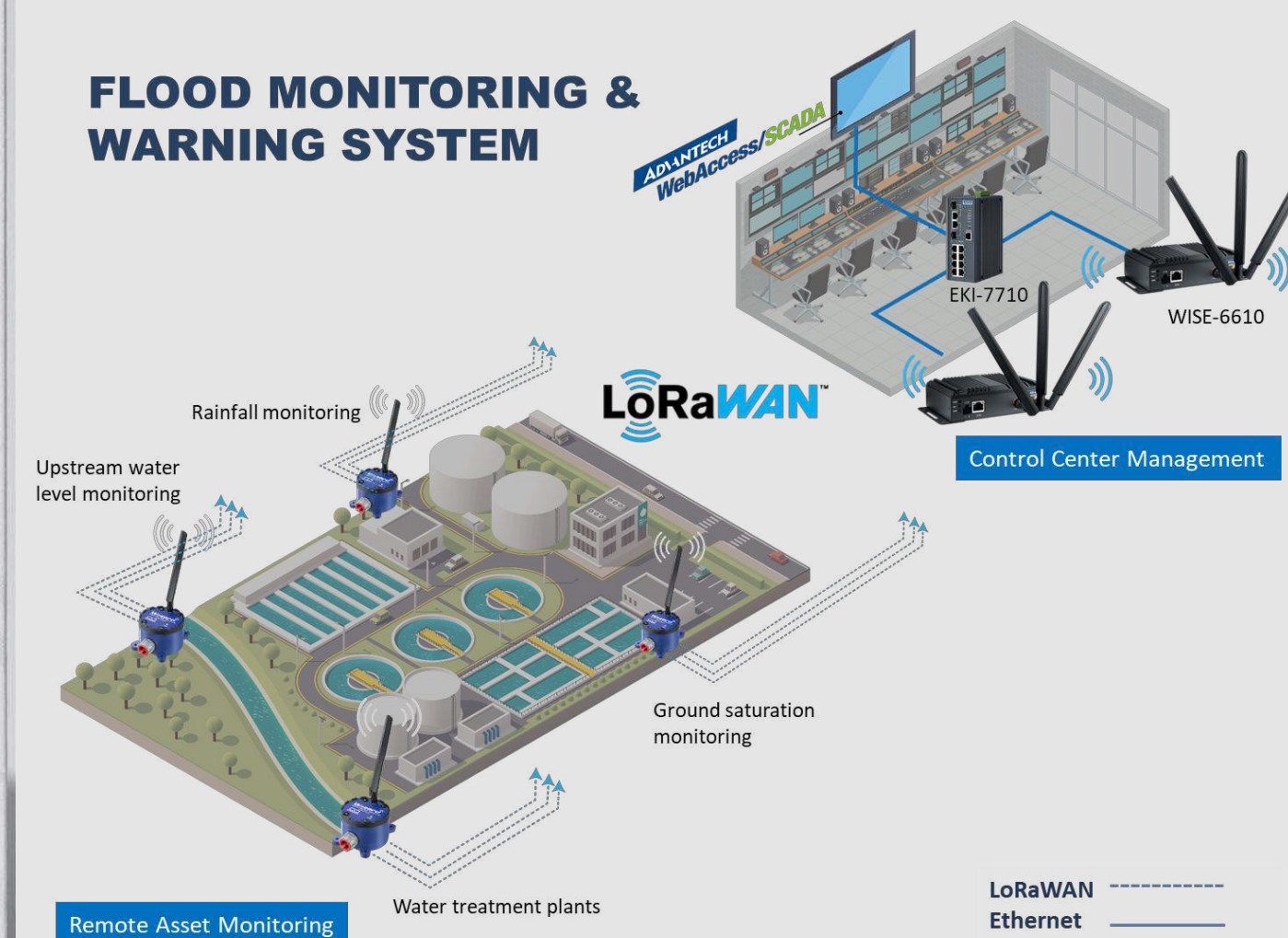
Data-driven insights inform climate-resilient infrastructure and land-use planning.



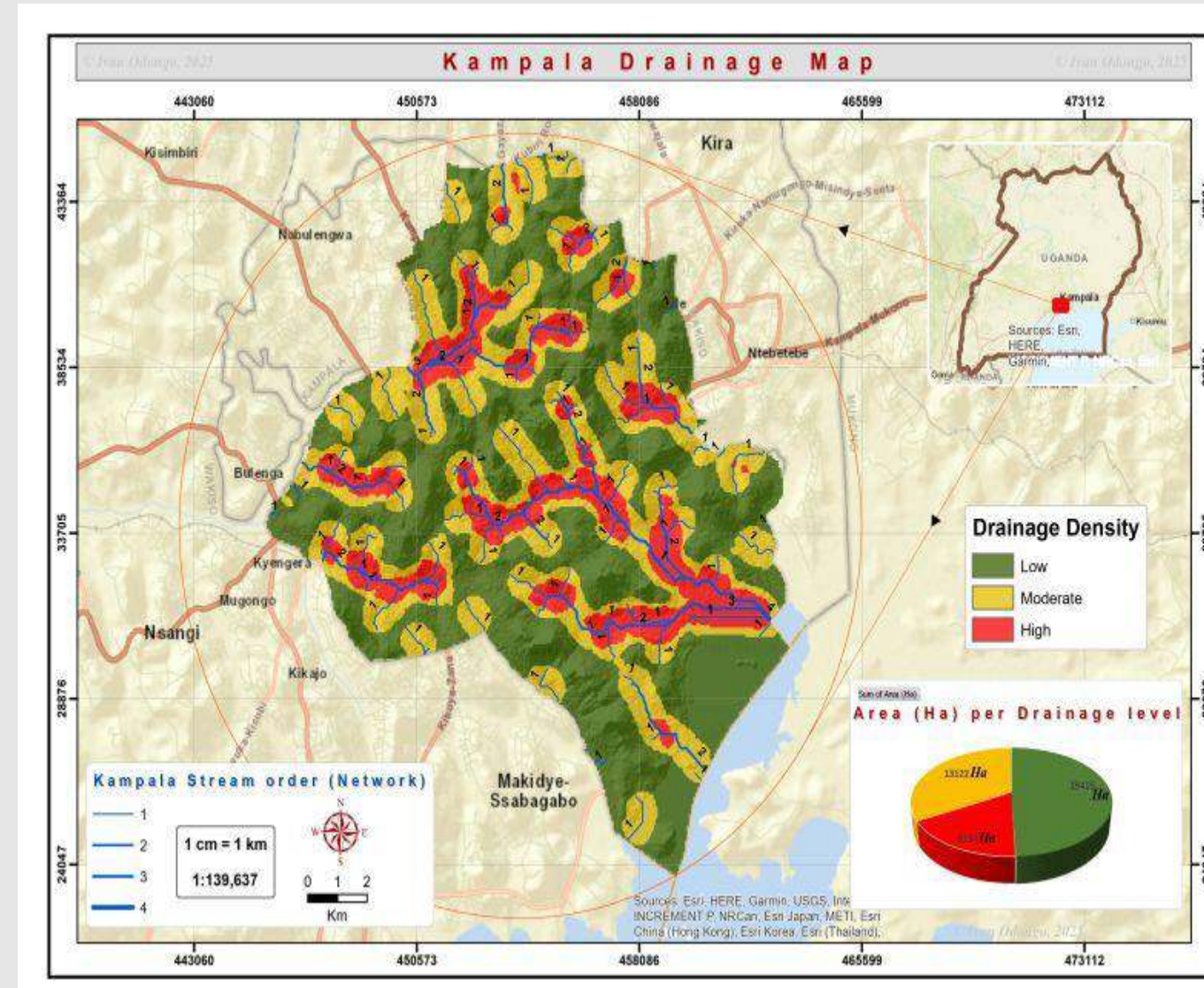
For Climate Resilience

A scalable, affordable solution that strengthens adaptive capacity in rapidly growing cities.

FLOOD MONITORING & WARNING SYSTEM



8. STUDY AREA FOCUS



5. METHODOLOGY



Site Selection

Identify flood-prone drainage points



Sensor Deployment

Install rainfall and water level sensors



Data Acquisition

Continuous real-time data collection



Data Transmission

Wirelessly send data to cloud platform



Risk Assessment

Analyze data & classify flood risk levels



Alert Generation

Trigger and disseminate alerts



Response & Feedback

Action by users; feedback for system improvement

EXPECTED RESULTS / IMPACT



REAL-TIME MONITORING

Continuous monitoring of rainfall and water levels enables timely detection of rising flood risk.



EARLY WARNINGS & ALERTS

Timely and accurate alerts are delivered to communities and authorities via SMS/mobile notifications.



IMPROVED COMMUNITY PREPAREDNESS

Communities have more time to prepare and evacuate, reducing exposure to flood disasters.



REDUCED FLOOD RISKS & LOSSES

Early intervention helps minimize loss of lives, property, and infrastructure damage.



DATA-DRIVEN DECISIONS

Reliable real-time data supports authorities in planning, resource allocation, and effective flood management.



SUSTAINABLE & SCALABLE SOLUTION

Low-cost, energy-efficient, and scalable system that can be replicated in other urban areas.



SAVES LIVES



REDUCES DAMAGE



EMPOWERS COMMUNITIES



LOWERS ECONOMIC LOSSES



SUPPORTS SMART GOVERNANCE



BUILDS CLIMATE RESILIENCE

9. KEY INNOVATIONS



LOW-COST IoT SENSORS

Affordable, low-power sensors (rain gauge, water level) powered by solar energy for real-time monitoring in urban channels.



WIRELESS LoRa / 4G TRANSMISSION

Reliable long-range LoRa and 4G connectivity ensures continuous data transmission from field nodes to the cloud, even in harsh conditions.



CLOUD-BASED DATA PLATFORM

Scalable cloud server stores, processes and analyzes data in real-time using AI/ML models to predict flood risks early.



MOBILE ALERT SYSTEM

Automatic alerts and warnings are sent in real-time via SMS and mobile app to communities and authorities for quick action.



REAL-TIME DASHBOARD & VISUALIZATION

Interactive dashboard provides real-time visualization of data, risk levels, GIS maps and trends to support decision making.



SCALABLE & EASY MAINTENANCE

Modular design for easy installation, low cost maintenance and scalability to other urban catchments and cities.



INNOVATING FOR RESILIENT CITIES: Combining low-cost IoT, wireless communication, cloud computing, and smart analytics to deliver an early warning system that saves lives, protects property, and builds climate-resilient communities.



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RWANDA CLIMATE SCIENCE SYMPOSIUM 2026
Where Rwanda's climate research meets policy

Assessing the Climate Mitigation Potential of Shared Commuting in Kigali

Evidence from the GreenCommute Rwanda Pilot

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¹ SDG Coordinator, UR-CST | ² President, Rwanda Young Generation in Nuclear (RYGN)

ONGOING
STUDY

25–40
tCO₂e/year modelled

300
pilot participants

1. BACKGROUND & RESEARCH GAP

Kigali’s rapid urbanization is increasing congestion, fuel use, greenhouse-gas emissions and demand for parking infrastructure.

Rising fuel costs add pressure on households, students and public institutions. Yet limited local evidence exists on how shared commuting can reduce transport-related emissions while improving energy and infrastructure efficiency in the Rwandan context.

RWF 2,938/L
fuel price in Apr.
2026

90%
traffic-volume
indicator*

34%
private-car indicator*

*Indicators and fuel-price figures are of the current status

2. RESEARCH QUESTION & OBJECTIVES

Can synchronized shared commuting reduce the resource intensity of daily travel in Kigali?

Fuel & emissions	Assess changes in fuel consumption and transport-related greenhouse-gas emissions.
Congestion	Evaluate changes in commuting patterns and reliance on single-occupancy travel.
Parking	Assess whether shared commuting reduces parking demand and improves space use.
Policy	Generate evidence for sustainable urban mobility and climate-smart transport planning.

PRIMARY POLICY LINK Rwanda NDCs + sustainable urban transport

3. METHODS / APPROACH

GREENCOMMUTE RWANDA PILOT • ~300 PARTICIPANTS



Comparative analysis will examine travel patterns before and during implementation of a peak-hour shared transport system along selected commuting corridors.

Study status: Ongoing

4. INTERVENTION DESIGN

PEAK-HOUR SHARED MOBILITY MODEL

06:30 → 08:30 16:30 → 18:30

Five buses from local transport providers operate during peak hours. Routes are pre-mapped to residential clusters of the 300-person cohort. Outside peak periods, buses return to normal commercial service. Existing UR-CST / City of Kigali light vehicles provide an emergency mobility buffer.

5. PILOT CORRIDORS

01	Kuryanyuma	UR-CST / Kigali City Office
02	Kanombe	UR-CST / Kigali City Office
03	Gikondo / Rebero	UR-CST / Kigali City Office

Selected as high-demand commuting corridors in the pilot design.

6. EXPECTED RESULTS

25–40 tCO₂e/year
Preliminary modelling estimate

single-occupancy travel
Expected reduced reliance

fuel per passenger
Expected efficiency gain

parking demand
Expected infrastructure benefit

These are expected modelled outcomes, not completed-pilot measurements.

7. IMPLEMENTATION & EVALUATION

1	M1–2	Research	Surveys, route mapping, parking audit
2	M3–4	Development	Platform + route design
3	M4–5	Launch prep	Awareness + participation
4	M5–8	Pilot	Operate + monitor
5	M8–9	Outreach	Reinforce adoption
6	M10	Reporting	Evaluate + policy recommendations

8. POLICY & PRACTICE RELEVANCE

Evidence for low-carbon and climate-resilient urban mobility. Operational mobility data for future transport regulation and planning. Potential contribution to Rwanda’s NDC implementation and sustainable urban transport strategies. A targeted commuter intervention can link emissions reduction with better use of urban land.

KEYWORDS

Shared Mobility • Climate Mitigation • Urban Transport • Energy Efficiency • Kigali

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2ND

RWANDA CLIMATE SCIENCE SYMPOSIUM 2026
Where Rwanda’s climate research meets policy

A GIS-Enabled Decision Support System for Spatial Alignment of Climate Finance and Vulnerability in Zimbabwe: A Data-Driven Geospatial Approach

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1. INTRODUCTION & PROBLEM STATEMENT

Zimbabwe faces a major adaptation-finance challenge. While the country is highly vulnerable to climate change climate vulnerability is not evenly distributed across its 60 districts.

The few figures available at national or sector level mask critical local differences in needs. This study maps district-level climate vulnerability examines the spatial distribution of climate-finance flows and compares the two to identify areas where adaptation finance is most needed but least available and where finance is relatively higher but vulnerability is lower.

By providing a clear data-driven picture the study offers a simple and transparent basis for directing scarce climate-finance resources to districts with the greatest needs.

2. RESEARCH OBJECTIVES

- To map the spatial patterns of climate vulnerability across Zimbabwe's 60 districts.
- To identify districts that should be prioritised for climate-finance investment based on vulnerability and finance needs.
- To develop a GIS-enabled decision-support system that improves the spatial alignment transparency and equity of climate-finance allocation.

3. RESEARCH QUESTIONS

- What are the spatial patterns of climate vulnerability across Zimbabwe's 60 districts?
- Which districts should be prioritised for climate-finance investment based on their vulnerability and finance needs?
- How can a GIS-enabled decision-support system improve the spatial alignment transparency and equity of climate-finance allocation?

4. METHODS

Data Sources

Secondary data were collected from the World Bank Climate Change Knowledge Portal, ZIMSTAT (Poverty Atlas 2021), OpenStreetMap, WorldPop and NASA.

Indicator Framework

Indicators cover three dimensions: climate exposure (drought, flood, heat), socioeconomic sensitivity (poverty, population density, rural population) and adaptive capacity (infrastructure, water access, literacy rate).

Data Processing & Analysis

- Data were cleaned in Microsoft Excel and spatially processed in QGIS 3.34.
- Indicators were normalised (0–1) in Python (Pandas, NumPy).
- AHP weights were derived using Expert Choice 11.
- Weighted overlay analysis was performed in ArcGIS Pro 3.2 to compute the Composite Vulnerability Index (CVI).

Software: QGIS 3.34, ArcGIS Pro 3.2, Python (Pandas, NumPy), Microsoft Excel, Excel 2016.

Analysis: AHP weighting, Weighted Overlay (CVI), Spatial Analysis.

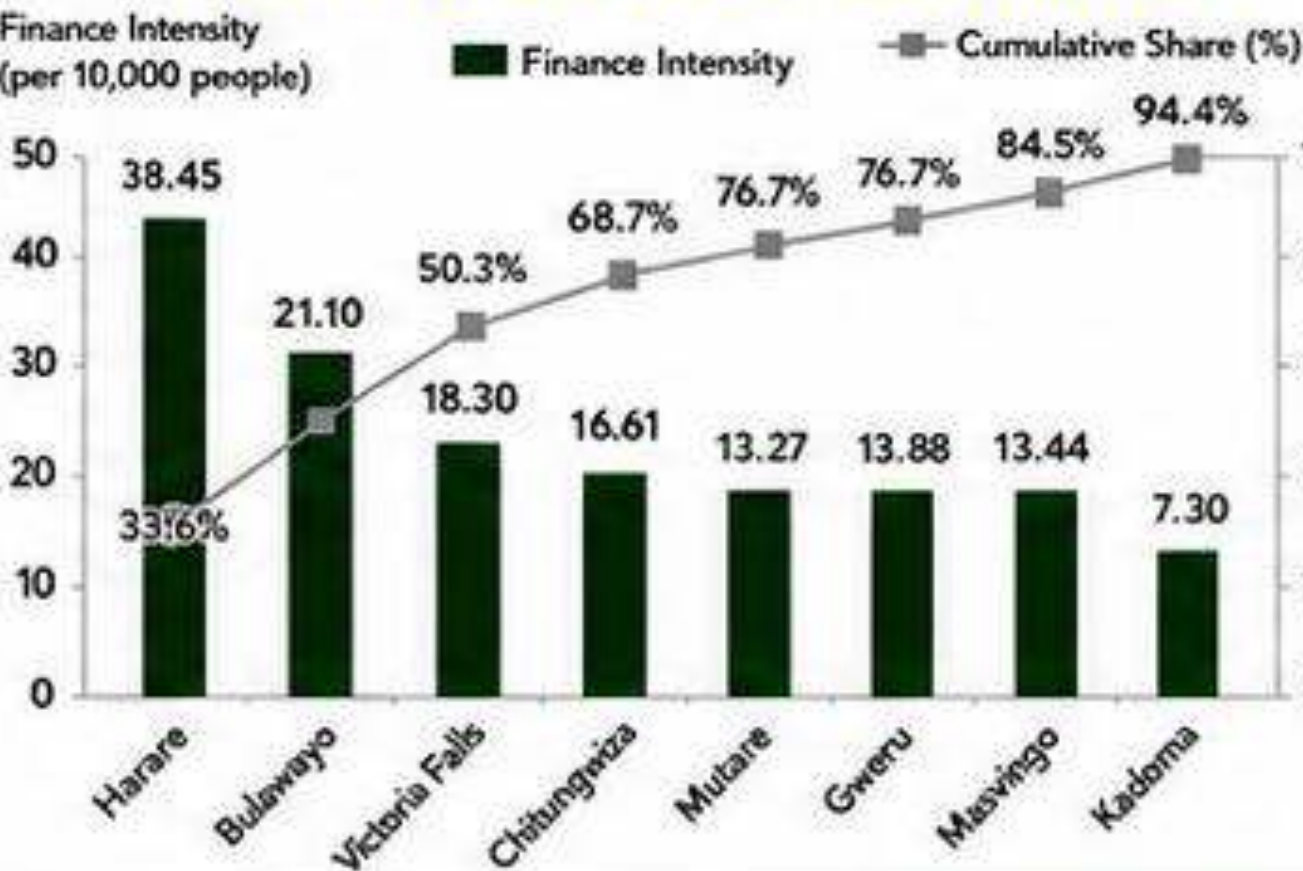
5.1 AHP WEIGHTS AND CONSISTENCY CHECK

Criteria	Weight (W)	Consistency Vector (AW)
Climate Exposure (CE)	0.539	1.62
Socioeconomic Sensitivity (SS)	0.297	0.89
Adaptive Capacity (AC)	0.164	0.49

Consistency statistics: $\lambda_{\max} = 3.07$; $CI = 0.035$; $CR = 0.047 (< 0.10)$, indicating acceptable pairwise consistency.

Climate exposure has the largest influence on the district vulnerability score (0.539), followed by socioeconomic sensitivity (0.297) and adaptive capacity (0.164).

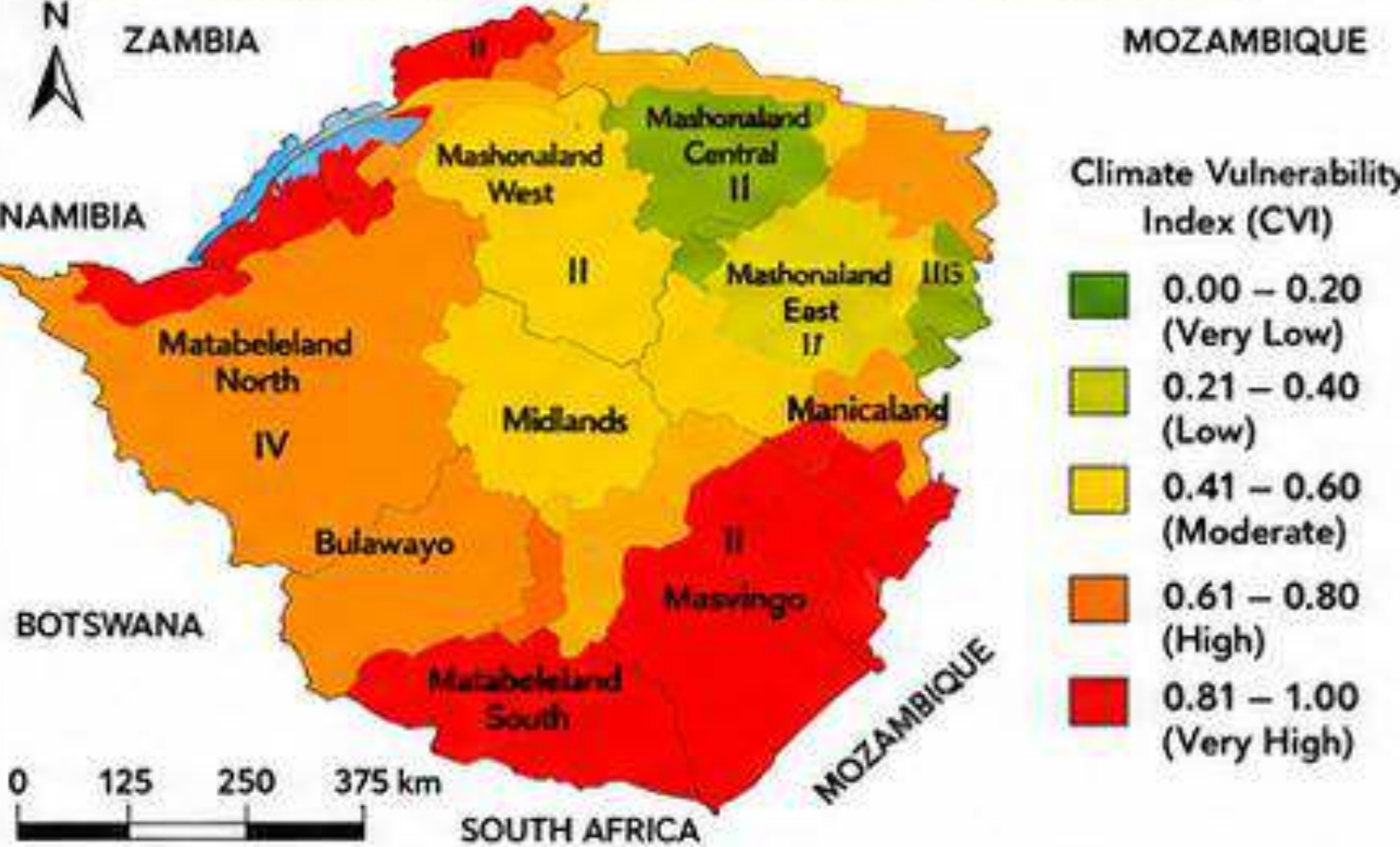
5.3 FINANCE INTENSITY INDEX RESULT



Harare has the highest finance intensity (38.45 per 10,000 people), followed by Bulawayo (21.10) and Victoria Falls (18.30). Chitungwiza, Mutare, Gweru, Masvingo, Kadoma, Norton and Chiredzi complete the top ten.

5. RESULTS

5.2 SPATIAL PATTERNS OF CLIMATE VULNERABILITY

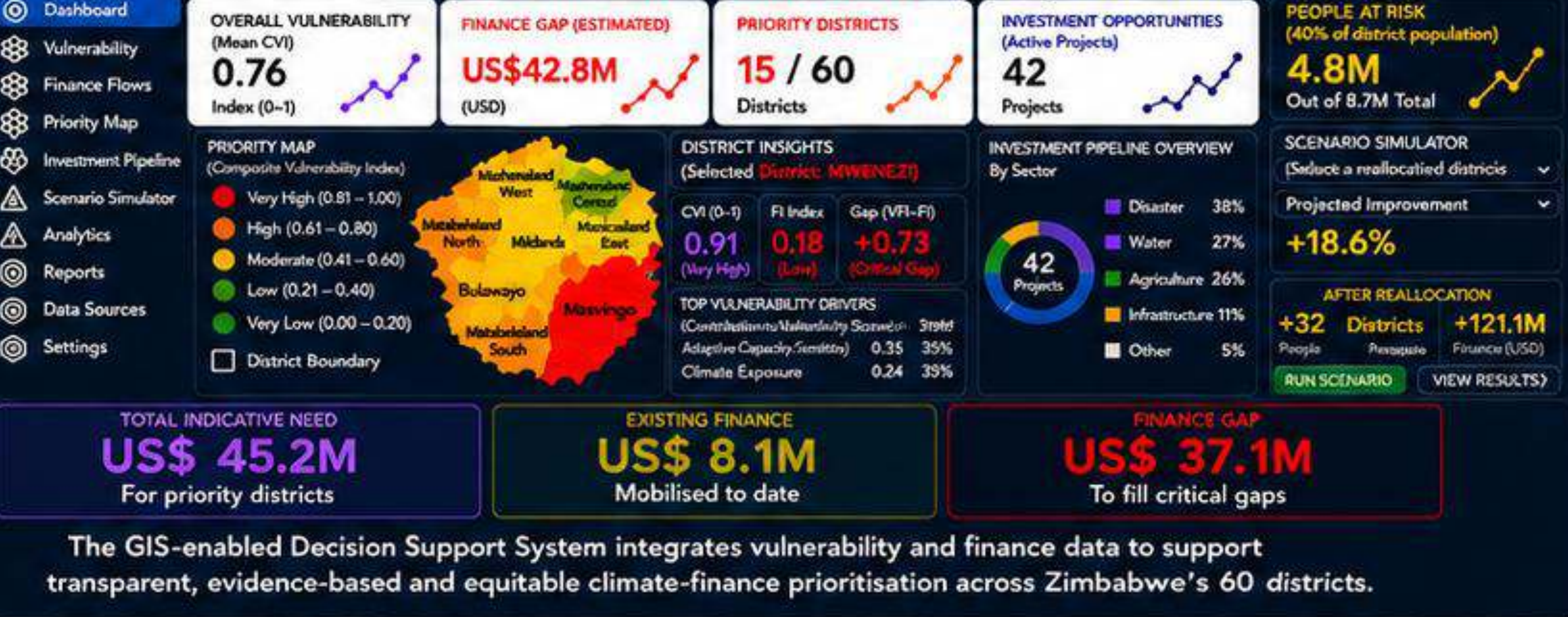


5.4 COMPARING VULNERABILITY AND FINANCE

District	CVI (0–1)	FI Index (0–1)	Vulnerability-Finance Gap (VFI-FI)	Alignment Category
Mwenezi	0.872	0.18	+0.692	Critical Underfunded
Chiredzi	0.842	0.21	+0.632	Critical Underfunded
Mutare	0.583	0.56	+0.023	Broad Alignment
Bulawayo	0.498	0.78	–0.312	Potential Over-allocation
Harare	0.412	0.92	–0.508	Potential Over-allocation

Mwenezi (0.692) and Chiredzi (0.632) show the greatest potential underfunding, while Harare (–0.508) and Bulawayo (–0.312) show potential over-allocation. Mutare (0.023) is almost balanced.

5.5 GIS-ENABLED DECISION SUPPORT SYSTEM (GIS-DSS)



6. DISCUSSION, CONCLUSION & CONTRIBUTION

6.1 DISCUSSION

- Vulnerability is spatially uneven across Zimbabwe reflecting differences in climate exposure socioeconomic sensitivity and adaptive capacity.
- Comparing vulnerability with finance reveals potential mismatches between adaptation need and finance concentration.
- Districts with high vulnerability but low finance are at greater risk of climate impacts and require urgent attention.
- The GIS-DSS enhances transparency and supports evidence-based prioritisation of scarce climate finance.

6.2 CONCLUSION

This study provides a practical data-driven approach for aligning climate-finance with vulnerability realities at district level. The results highlight critical underfunded districts especially Mwenezi and Chiredzi where adaptation finance should be prioritised to reduce climate risk and build resilience. The GIS-enabled decision-support system offers a replicable tool for continuous monitoring, scenario analysis and equitable resource allocation.

6.3. KEY CONTRIBUTIONS

- Comprehensive district-level climate vulnerability map for Zimbabwe using a Composite Vulnerability Index.
- Empirical evidence of spatial mismatches between climate vulnerability and finance allocation.
- Development of a GIS-enabled Decision Support System (GIS-DSS) for transparent data-driven climate-finance prioritisation.
- Practical tool for policymakers donors and planners to target resources to districts that need them most.
- Investment options and insights to attract climate investment and mobilise resources for priority districts.
- Support for clear investment options and project pipelines aligned to district needs.

6.4. LIMITATIONS

- Some datasets are outdated (e.g. ZIMSTAT 2021) and may not capture recent changes.
- Not all relevant vulnerability and adaptive capacity factors could be included due to data unavailability.
- AHP involves subjective judgment in pairwise comparisons.
- Climate-finance data is limited to reported flows and may not capture all private or informal financing.
- Spatial analysis is at district level intra-district variations are not captured.

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ASSESSING THE IMPACT OF SOCIO-ECONOMIC FACTORS TO THE ADOPTION OF LIQUEFIED PETROLEUM GAS AMONG HOUSEHOLDS IN THE CITY OF KIGALI – KIMIRONKO AND BUMBOGO SECTORS

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1. INTRODUCTION



- 2.3 billion people globally rely on traditional biomass for cooking (IEA, 2021), causing household air pollution (WHO, 2023).
- LPG is a clean, efficient, and practical transitional fuel for developing countries.
- Rwanda aims to increase modern cooking energy and reduce greenhouse gas emissions by 38% by 2030 (NDC 3.0).
- This study examines socio-economic factors influencing LPG adoption among households in Kimironko and Bumbogo sectors of Kigali City.

2. OBJECTIVES

- To examine the current socio-economic factors (household income, education level, household size, infrastructure, and employment status) influencing LPG adoption among households in Kimironko and Bumbogo sectors of Kigali City.
- To determine the current proportion of households using LPG for cooking in Kimironko and Bumbogo sectors of Kigali City.
- To assess the relationship between socio-economic characteristics and the level of LPG adoption among households in Kimironko and Bumbogo sectors of Kigali City.

3. STUDY AREA

KIMIRONKO SECTOR

1°38'26"S, 30.1301°E
17,612 Households

BUMBOGO SECTOR

1°29'9"S, 30.1524°E
30,892 Households

THE STUDY AREA MAP



8. CONCLUSION



Income, education and electricity access significantly increase LPG adoption, while larger household size reduces it. Although LPG adoption is progressing in Kimironko and Bumbogo sectors, affordability, infrastructure and behavioral factors remain key barriers. Integrated interventions are needed to achieve universal clean cooking access and improve household well-being.

4. METHODOLOGY

Research Design

Mixed-methods (cross-sectional descriptive + explanatory)

Sampling

Multi-stage sampling
787 Households
• 412 (Bumbogo)
• 375 (Kimironko)

Data Collection

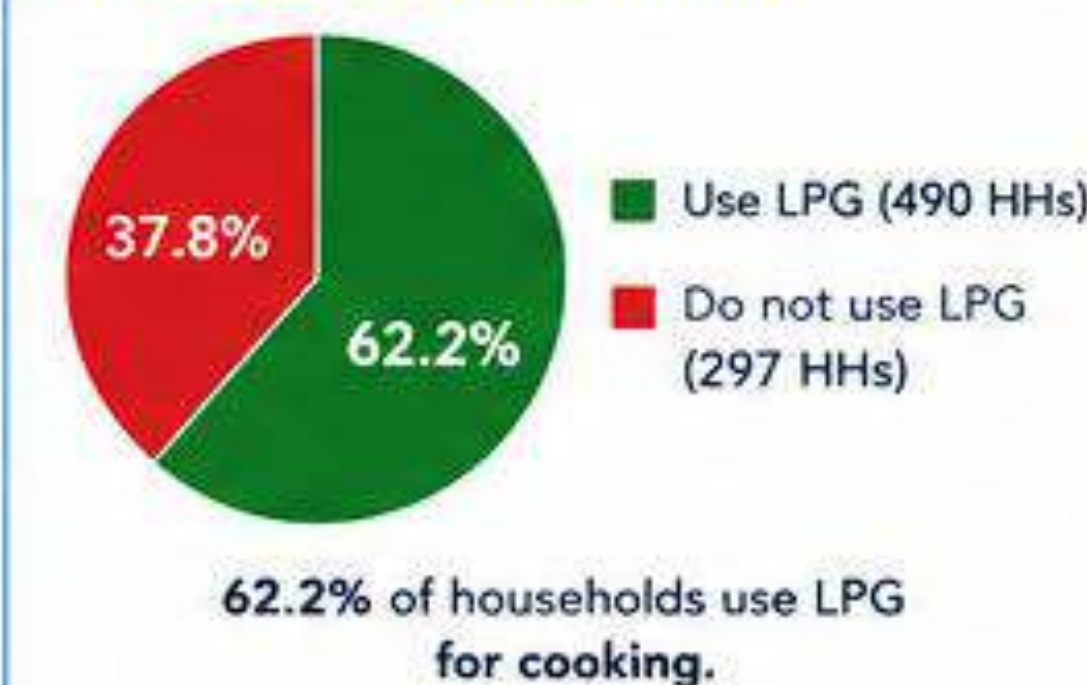
- Structured questionnaires
- Key informant interviews
- Focus group discussions
- Direct observations

Data Analysis

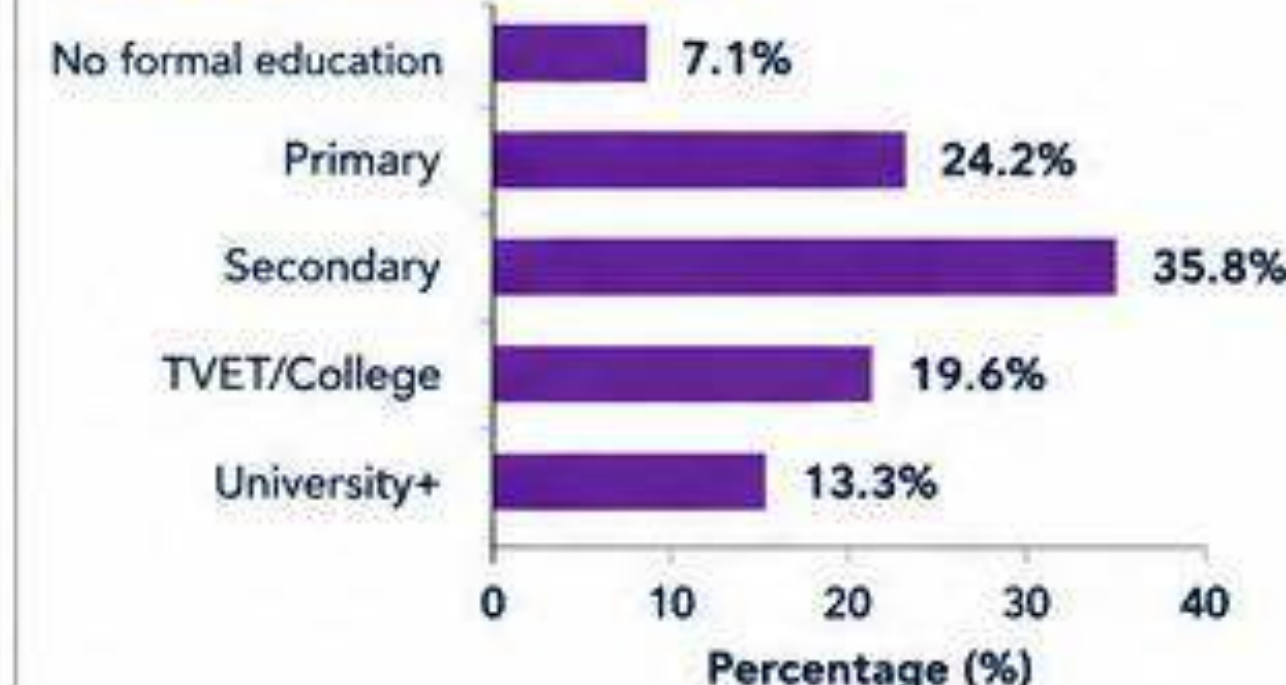
- Descriptive statistics
- Chi-square test
- Binary logistic regression
- Thematic analysis

5. HOUSEHOLD CHARACTERISTICS (N = 787)

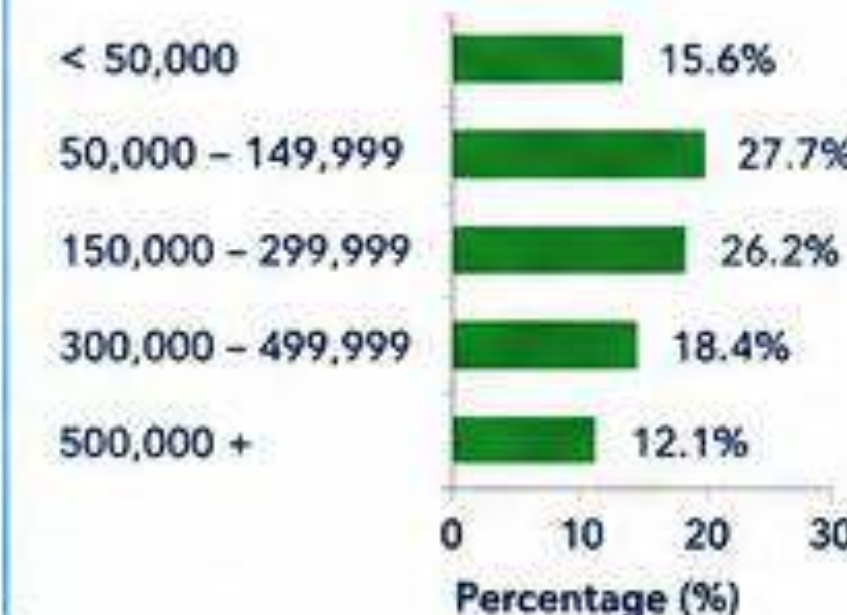
5.1 LPG ADOPTION STATUS



5.2 EDUCATION LEVEL



5.3 INCOME LEVEL (RWF)



5.4 EMPLOYMENT STATUS



5.5 HOUSEHOLD SIZE



5.6 ACCESS TO ELECTRICITY



5.7 ACCESS TO CREDIT



6. FACTORS INFLUENCING LPG ADOPTION

6.1 CHI-SQUARE TEST RESULTS

Factor	Chi-Square (χ^2)	df	p-value	Association
Education Level	42.315	4	0.000	Significant
Income Level	51.782	4	0.000	Significant
Employment Status	18.467	4	0.001	Significant
Access to Electricity	14.632	4	0.000	Significant

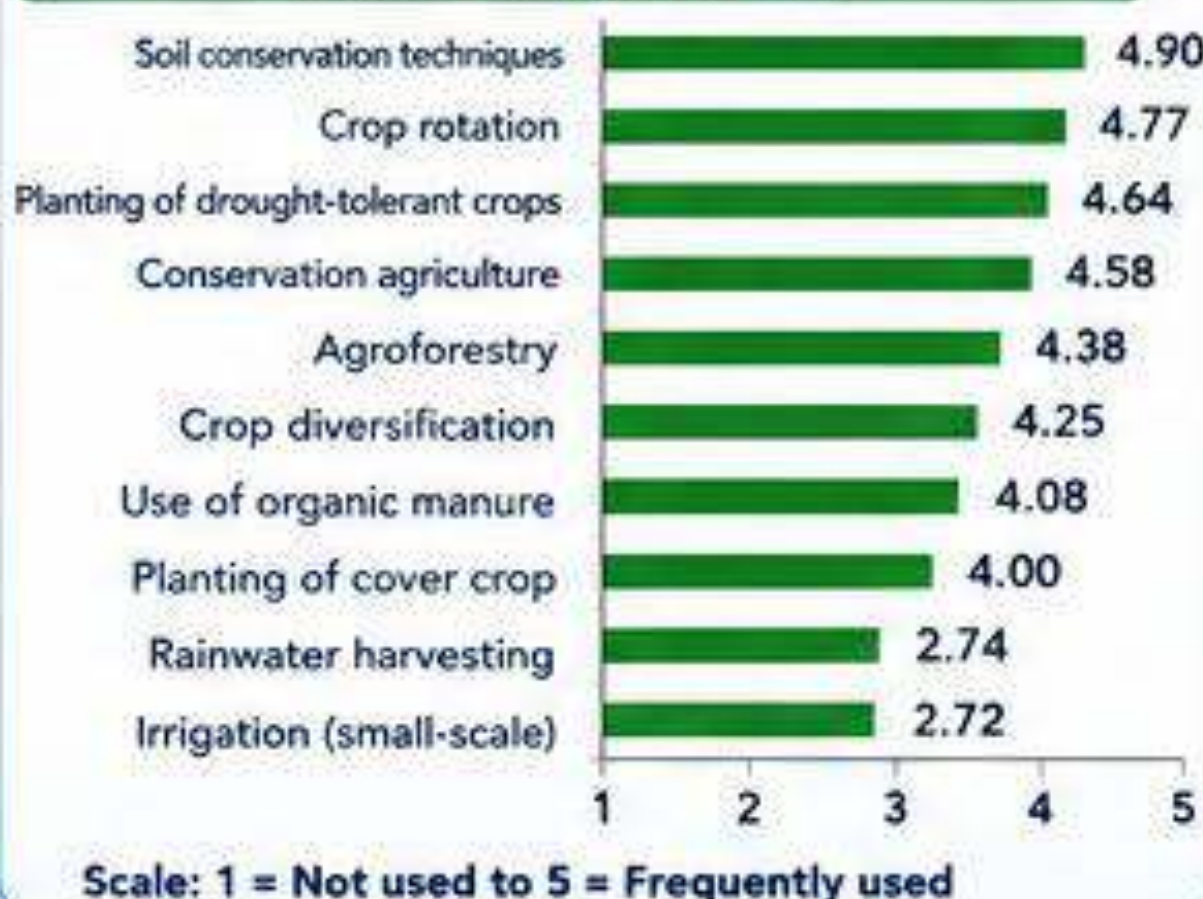
6.2 BINARY LOGISTIC REGRESSION

Factor	B	Exp(B)	p-value	Effect
Income	0.843	2.23	0.000	+
Education	0.621	1.86	0.000	+
Household size	-0.215	0.81	0.003	-
Electricity access	1.102	3.01	0.000	+
Constant	-2.145	-	0.000	-

6.3 KEY INSIGHTS

- Higher income and education increase the likelihood of LPG adoption.
- Larger household size reduces the likelihood of adoption.
- Access to electricity strongly encourages LPG adoption.
- Fuel stacking still observed; full transition not yet achieved.

6.4 COMMON CSA PRACTICES ADOPTED (Mean Scores out of 5)



7. POLICY IMPLICATIONS & RECOMMENDATIONS



FINANCIAL SUPPORT

Provide targeted subsidies, PAYG systems and micro-credit for LPG adoption.



EXPAND SUPPLY NETWORK

Increase LPG distribution points and ensure reliable supply chains.



AWARENESS & BEHAVIOR CHANGE

Intensify education on benefits, safety and correct LPG usage.



strategies.



TARGET VULNERABLE HOUSEHOLDS

Focus on large families, low-income households and women.

9. LIMITATIONS OF THE STUDY

- Cross-sectional design limits causal inference.
- Restricted to two sectors; results may not generalize.
- Self-reported data may be affected by recall or reporting bias.
- Future studies should use longitudinal and mixed-method designs.

10. FUTURE RESEARCH DIRECTIONS

- Examine digital extension platforms in promoting LPG adoption.
- Investigate gender-specific barriers to clean cooking transitions.
- Conduct longitudinal studies on sustained LPG use and fuel stacking behavior.
- Assess effectiveness of subsidies, financing mechanisms and market innovations.

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