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Research Centre for the Management of Agricultural and Environmental Risks

Proyecto PRISMA: resiliencia frente a las sequías y seguridad alimentaria en los sistemas pastorales deÁfrica Occidental

IP: Eva Iglesias

Madrid, June 5th 2026

I. Seguros indexados

Colaboradores: RBM, Acción Contral el Hambre, UC3M (Á. Escribano), UC Davis (M. Carter), U. Maryland (E. Lichtenberg), U. Miguel Hernández (M. Brugarolas) y CREDA (Z. Kallas), UPM

II. Alimentos para el ganado y riesgo de aflatoxinas

Colaboradores: Instituto de investigaciones agrarias y medioambientales de Burkina Faso (INERA), U. Abdou Moumouni de Níger, Instituto de Economía Rural e Investigación en Ciencias Agrarias de Mali (IER), U. Landmark de Nigeria, Complejo de Ciencia y Tecnología de Abuya (SHEDA), U. de Lleida, UPM

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Enhancing drought resilience: An index insurance scheme for West African pastoralists?

Enrique Estefania-Salazar & Eva Iglesias

Joint work with Michael Carter and Alvaro Escribano

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3 How to improve the quality of Index Insurance?

4 A Regional Livestock Index Insurance model in West Africa

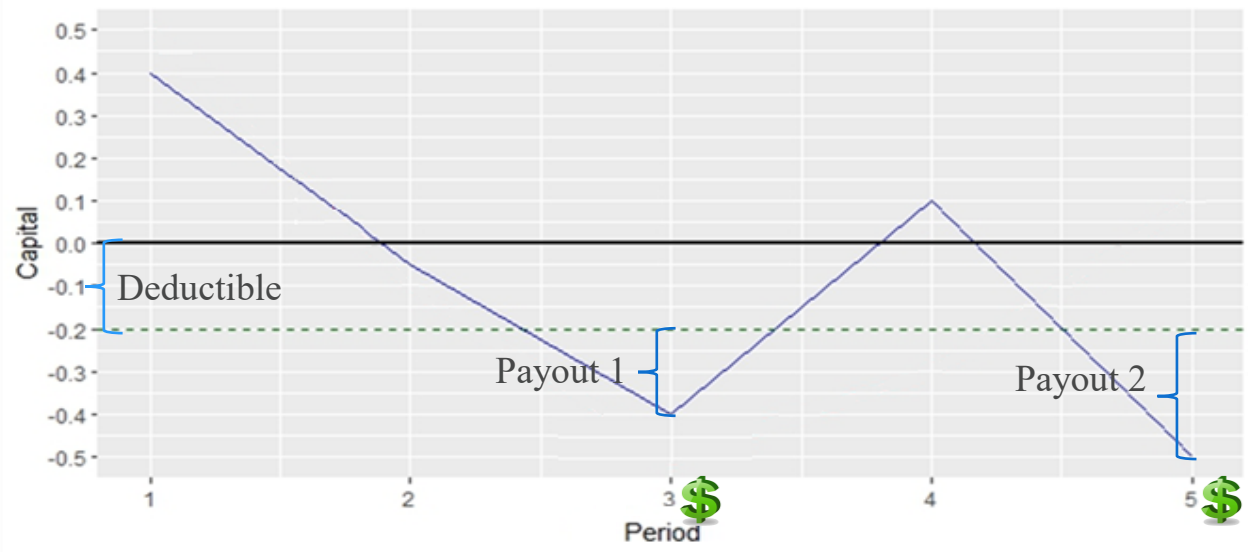
5 Conclusions and Future Research

I. Introduction

- Droughts rank among the most severe natural hazards in sub-Saharan Africa, with frequency and intensity increasing in recent decades (Kpenekuu et al., 2024).
- Drought episodes account for nearly 70% of the variability in livestock productivity (Stanimirova et al., 2019).
- Despite the critical role of pastoral systems in West African economies and household welfare, this region presents a significant research gap in index-based insurance (Adeyinka et al., 2022).
- The benefits of Index-Based Livestock Insurance (IBLI), including positive impacts on food security and poverty reduction, are well documented across low-income countries.
- Yet successful programs remain scarce and adoption rates persistently low (Cole & Xiong, 2017; Jensen et al., 2016).

I. Introduction

- Insurance enables farmers to make **riskier/more profitable decisions** and mitigate the economic impact of drought.
- Index-based insurance is an **innovative risk management tool** promoted by the World Bank and other organizations that aims to transform the traditional insurance system.
- **Compensation is calculated based on the difference between expected losses and an average index** that is objectively observable, measurable, and cannot be manipulated.
- **The index and individual losses must be correlated** (e.g., precipitation or vegetation indices).



II. Objectives

To design and evaluate the first regional index-based insurance scheme for rangelands in West Africa.

- **Estefania-Salazar, E. & Iglesias, E. (2026). Enhancing drought resilience: An index insurance scheme for West African pastoralists. Climate Risk Management, 52, 100808. https://doi.org/10.1016/j.crm.2026.100808**

To develop and evaluate a methodology to enhance the quality of index-based insurance products by reducing basis risk.

- **Estefania-Salazar, E., Carter, M. R., Iglesias, E., & Escribano, Á. (R&R). Breaking Boundaries: Lower Tail Dependence Can Triple the Economic Value of Index Insurance for Rural Households. Journal of Development Economics**
- Estefania-Salazar, E., & Iglesias, E. (2024). Enhancing spatio-temporal environmental analyses: A machine learning superpixel-based approach. *Heliyon*, *10*(14), e34711. https://doi.org/10.1016/j.heliyon.2024.e34711

To assess the phenological parameters in West Africa and determine climate change trends

- Estefania-Salazar, E., & Iglesias, E. (2025). Assessing vegetation phenology dynamics in West African rangelands: Implications for livestock sustainability and transhumance. *Ecological Informatics*, *88*, 103138. https://doi.org/10.1016/j.ecoinf.2025.103138

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III. How to improve the quality of index insurance?

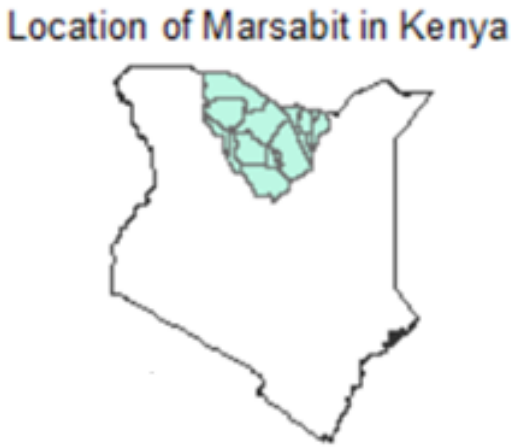
Introduction

- Basis risk can be decomposed in 2 components.
  - *Design basis risk*: The index fails to capture actual losses.
  - *Idiosyncratic or spatial basis risk*: Individual losses deviate from the average losses of the surrounding area.
- Most existing literature has focused on generating indices that better predict losses, while idiosyncratic or spatial basis risk has received comparatively little attention.
- Research contribution**: Can we enhance insurance quality by replacing administrative zones with optimally designed zones?**

III. How to improve the quality of index insurance?

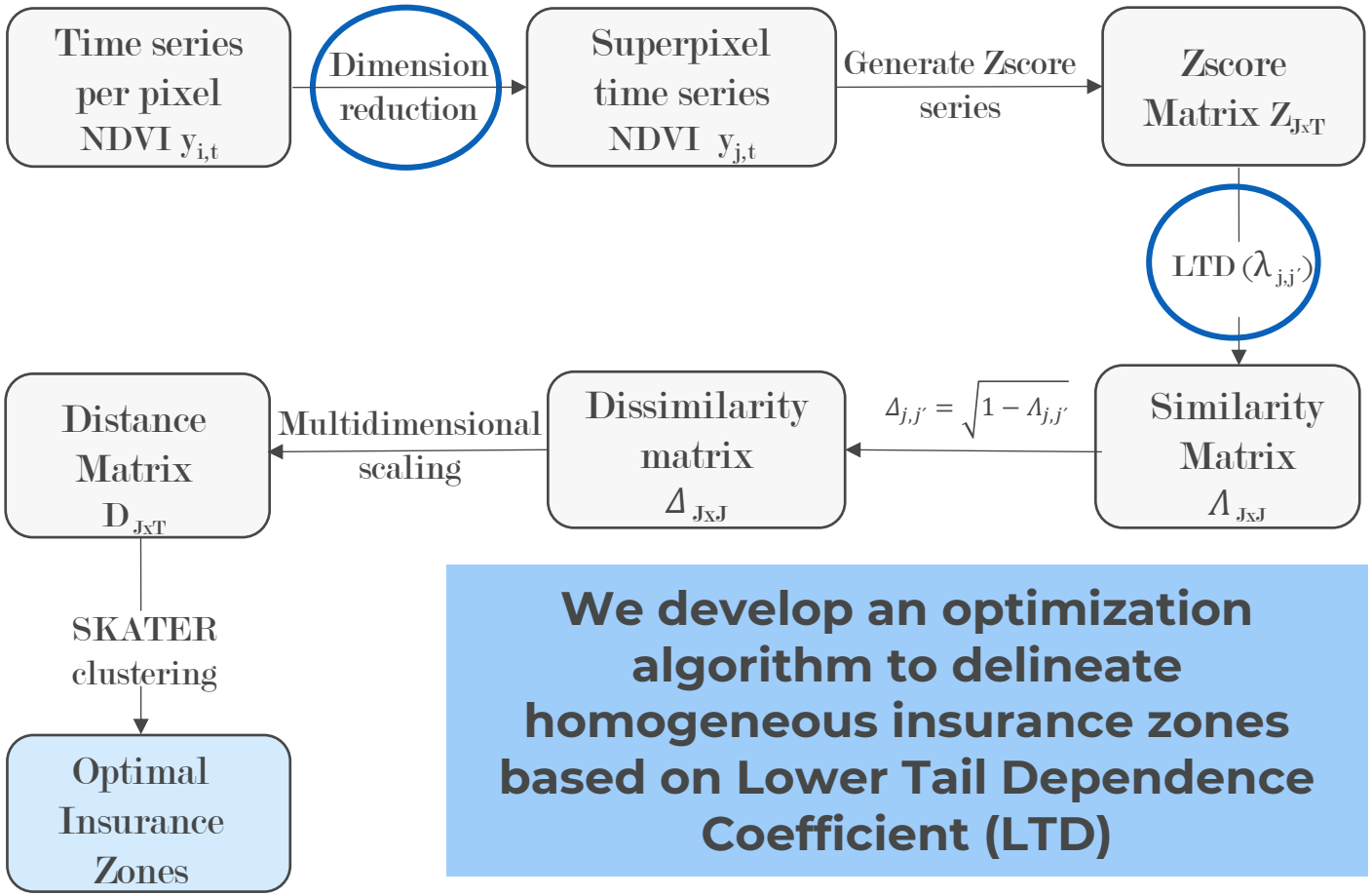
Case study

- Marsabit, Northern Kenya
- The Index-Based Livestock Insurance (IBLI) program, operational since 2011, provides compensation payments for drought-induced livestock mortality
- Mortality predictions, and subsequent payouts, are estimated based on seasonal deviations of NDVI from its long-term mean



III. How to improve the quality of index insurance?

Methodology



We develop an optimization algorithm to delineate homogeneous insurance zones based on Lower Tail Dependence Coefficient (LTD)

III. How to improve the quality of index insurance?

Methodology

We use the Relative Insurance Benefit (RIB) to measure the welfare gain of an index-based scheme relative to that of a perfect insurance scheme (Kenduiywo et al., 2021).

Utility with no insurance

$$V^n = \int v(y) f_y dy \approx \frac{1}{T}\sum_{t=1}^{T} v(y_t)$$

Utility with insurance

$$V^s = \frac{1}{T}\sum_{t=1}^{T} v\left(y_t - \pi_z + I(x_{zt})\right)$$

s: Imperfect Insurance (IBLI)
p: Perfect Insurace
n: No Insurance

$$CE = U^{-1}(V) \longrightarrow RIB^s = \frac{C^s - C^n}{C^p - C^n}$$

V: Utility
C: Certainty equivalent
t: Period (t=1,….T)
y: Economic yield
π: Insurance premium
I: Indemnity

RIB=1 → Perfect Insurance

0<RIB<1→ Imperfect Insurance

RIB<0→ No insurance

III. How to improve the quality of index insurance?

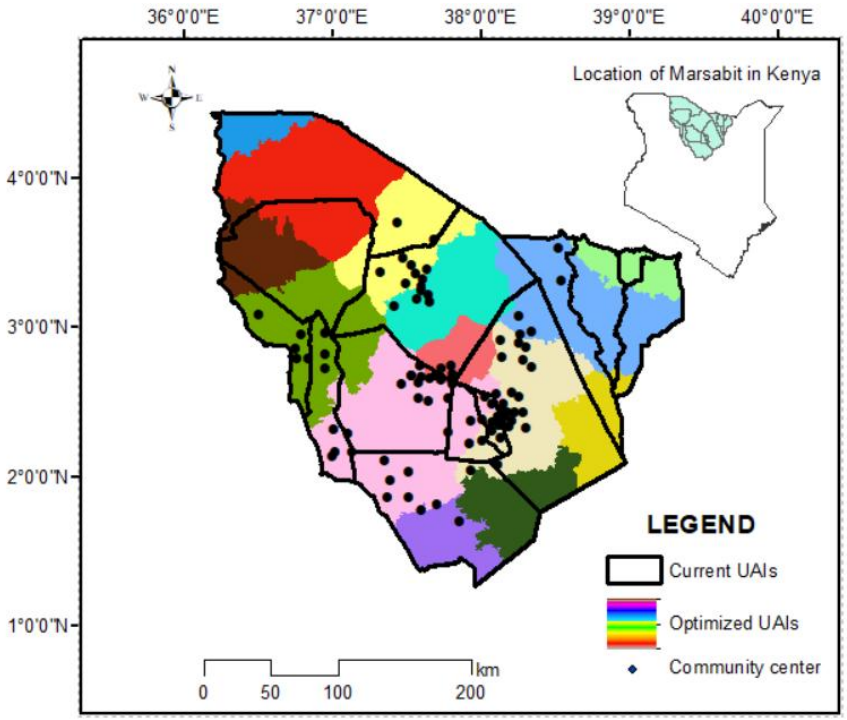
Methodology

- We simulate IBLI payouts in Marsabit under both current and optimized zones.
- Validation: Seasonal livestock mortality data from 903 households across 13 seasons (2008–2015).
- The current scheme comprises 14 insurance zones (Wards) based on ethnic boundaries; for comparability, we also derive 14 optimized zones.
- The algorithm is flexible: changing the number of zones, is an additional strategy to reduce basis risk.

III. How to improve the quality of index insurance?

Results

Current Insurance Areas (delineated in black) and Optimal Insurance Areas (in color)



III. How to improve the quality of index insurance?

Results: Insurance quality under optimized zones (RIB)

Drought severity →

RIB under Current versus Optimized UAI's

UAI Scheme		*z*-score Trigger Level (Indemnity Probability) -0.5 (0.309)	-0.7 (0.242)	-0.9 (0.184)	-1.0 (0.159)	-1.1 (0.136)	-1.3 (0.097)	-1.5 (0.067)
Ward-based	RIB	0.240	0.241	0.188	0.116	0.092	0.047	0.005
LTDM	RIB	0.383	0.384	0.383	0.358	0.287	0.160	0.098
	% Gain	59.6	59.3	103.7	208.6	212	240.4	1860.0
Correlation-based	RIB	0.345	0.344	0.343	0.340	0.16	0.041	0.000
	% Gain	43.8	42.7	82.4	193.1	182.6	-12.8	-100.0

59.3% improvement in RIB (current trigger)

Improvement increases for more severe droughts: >200%

Insurance zones defined using LTDC outperform those derived from a correlation-based approach.

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A Regional IBLI Model in West Africa

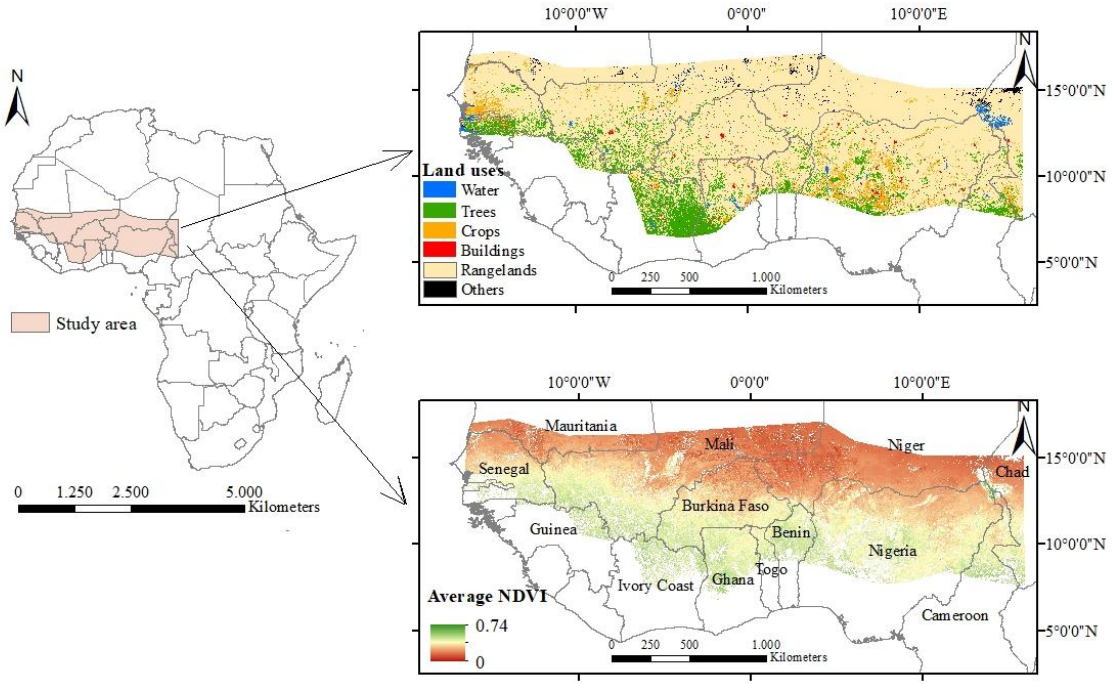
Introduction

- Only sovereign insurance (ARC) and few local pilots (Senegal 2023, Nigeria)
- 70–90% of cattle are transhumant → requires cross-border coverage
- Despite facing some of the most acute drought adaptation needs, West Africa remains a critically understudied region in index insurance.
- Contribution: first regional livestock index insurance designed for West Africa (12 countries), minimizing basis risk and assessing the benefits of regional cooperation.

A Regional IBLI Model in West Africa

Case study

West Africa: 2.9M km^2 grazing lands



A Regional IBLI Model in West Africa

Methodology

1. Phenological characterization

- Determine the insurable period (threshold method)
- Identify climate trends (STL decomposition)

2. Index Validation

- Fixed-effects linear model to assess how NDVI relates to biomass availability
- Pastoral Early Warning System (AAH, 2025): 188 "sentinel agents" providing weekly qualitative data since 2016

3. Developing the actuarial model

- Delineation of optimal insurance zones
- Survey to 1,735 herders across Senegal, Mali, Niger, and Burkina Faso: Estimation of the loss/payout function = f(Z-Score)

A Regional IBLI Model in West Africa

Methodology

4. A Regional Approach to Risk Pooling

- Systemic risk is assessed following the Value at Risk (VaR) approach
  Buffer Fund: $BF = \mathbb{P}(\sum_{i=1}^{n} w_i[I_i - \pi_i] \geq \mathrm{l}) = 1 - \lambda$
  Buffer Load: $BL = BF \cdot r/n$
- A copula methodology (vine copulas) is applied to estimate long-run spatial dependence, and a Monte Carlo simulation is carried out to determine the VaR

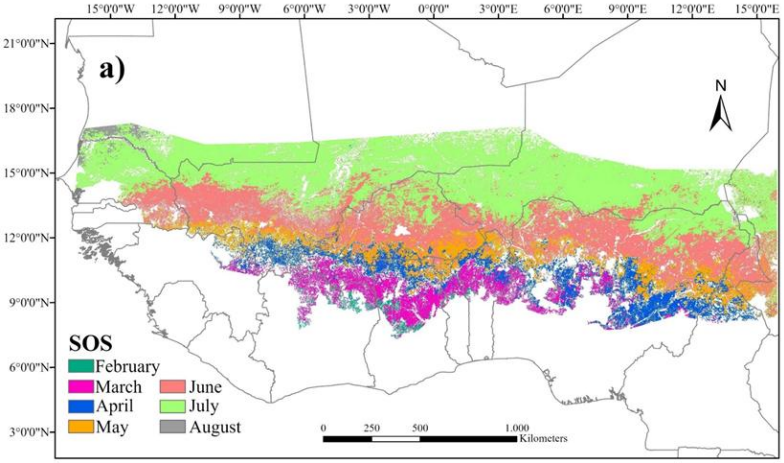
5. Evaluation of Index-Based Insurance Quality

- Product quality is assessed using the Relative Insurance Benefit (RIB) $RIB = \frac{C^s - C^n}{C^p - C^n}$
- Simulation of different scenarios (Regional Approach, Loading Factor, Subsidies)

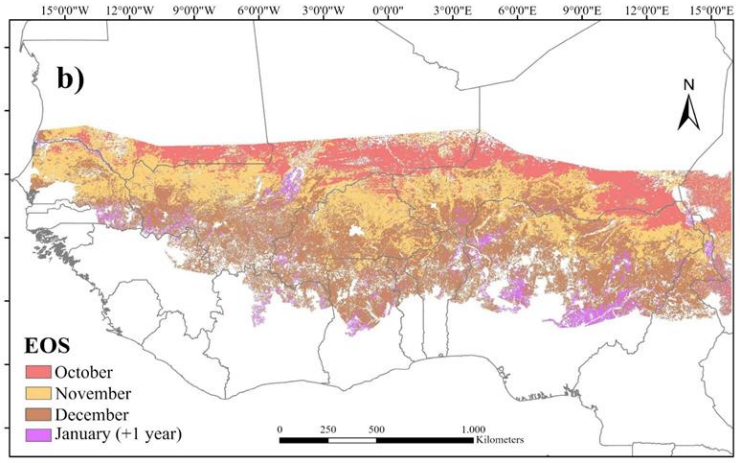
A Regional IBLI Model in West Africa

Results: The insurance period

Start of season (SOS)



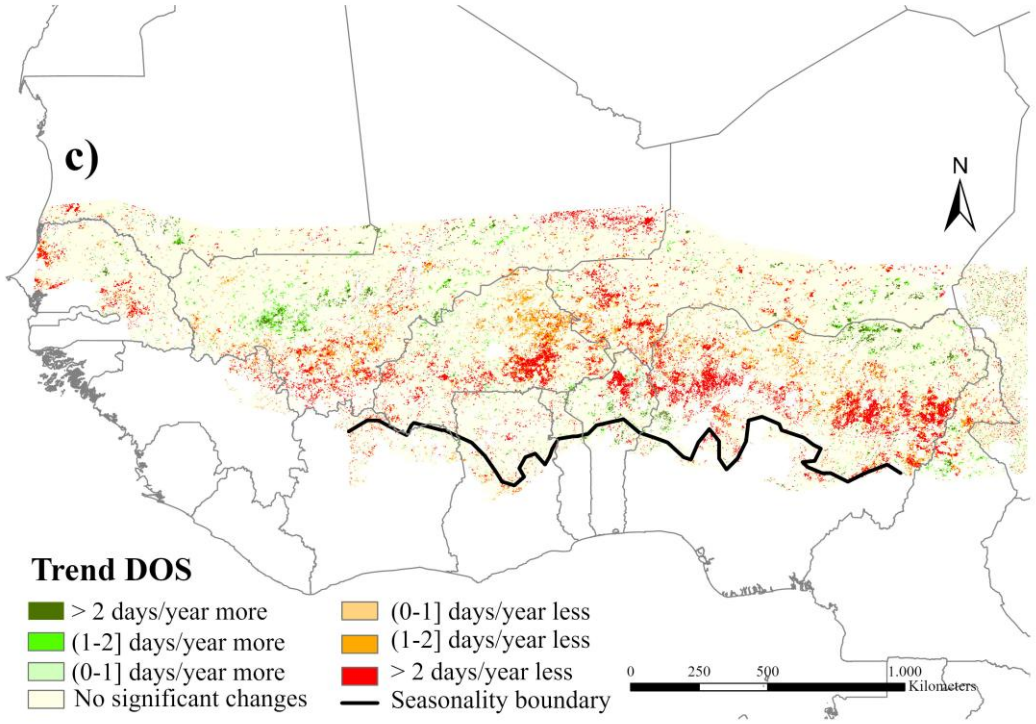
Endo of season (EOS)



- High complementarity of pastoral systems in the region
- Transhumance is an efficient strategy for the use of natural resources
- A mapping tool for a multi-zonal insurance scheme adapted to transhumance

A Regional IBLI Model in West Africa

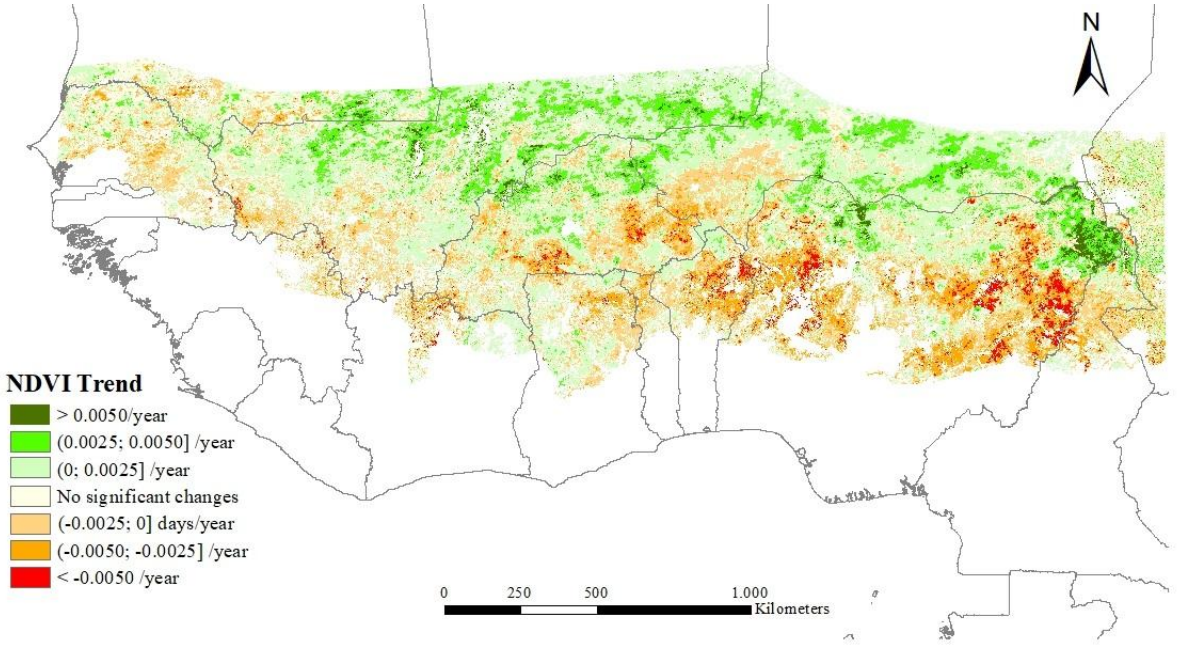
Results: Trends in season length



Wet season shortening across the region poses major challenges for transhumance strategies.

A Regional IBLI Model in West Africa

Results: NDVI (annual biomass)



Biomass gains in the north contrast with losses in the south, which hosts the most productive pastoral areas.

A Regional IBLI Model in West Africa

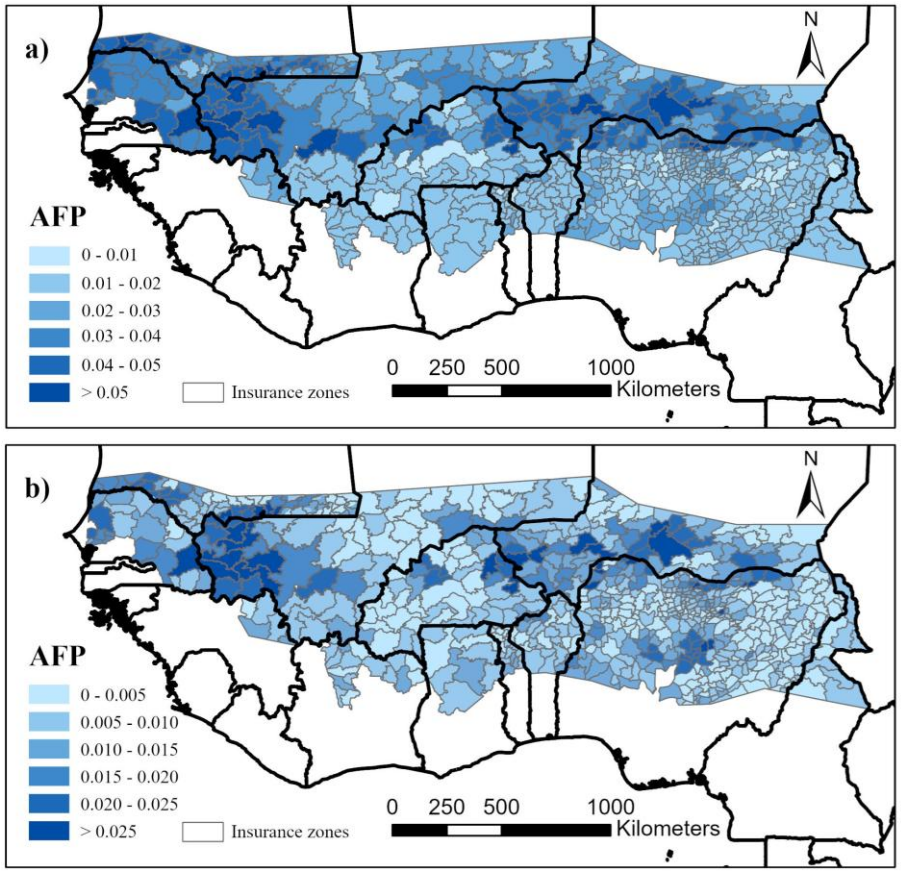
Results: NDVI validation

	Yearly score	Monthly score	Monthly score
$Z\text{-score}_t$	0.121***	0.540***	0.561***
	(0.038)	(0.001)	(0.001)
$Z\text{-score}_{t-1}$			-0.035
			(0.070)
n	2934	2885	2885
Adjusted R^2	0.469	0.373	0.373

- Values consistent with those reported in other index insurance programs.
- Values consistent with those reported in other index insurance programs

A Regional IBLI Model in West Africa

Results: Actuarial Model – Actuarial Fair Premium (AFP)



Moderate drought
AFP=2.6% of the insured value (3.4% in Sahel and 1.6% in Sudan)

Severe drought:
AFP=1.0% of the insured value (1.2% in Sahel y 0.7% in Sudan)

A Regional IBLI Model in West Africa

Results: Actuarial Model vs Field survey

Field Survey results show that:

- 72% willing to purchase index insurance; 17% possibly interested.
- Mean WTP = 1% of insured value.
- Premium subsidies essential in the initial phase.
- Awareness workshops and outreach initiatives are needed.

A Regional IBLI Model in West Africa

Results: Actuarial Model– Loading Factor

	Trigger level -0.7				Trigger level -1.3				TLU (M)
1-Ruin probability	**0.999**	**0.990**	**0.950**	**0.900**	**0.999**	**0.990**	**0.950**	**0.900**	
By country	0.163	0.107	0.060	0.036	0.100	0.064	0.033	0.019	
Burkina Faso	0.113	0.074	0.045	0.027	0.062	0.044	0.022	0.014	9.328
Benin	0.177	0.112	0.051	0.028	0.149	0.083	0.039	0.017	2.400
Ivory Coast	0.157	0.093	0.053	0.032	0.084	0.053	0.032	0.016	1.968
Cameroon	0.127	0.070	0.040	0.023	0.069	0.035	0.018	0.011	10.691
Ghana	0.176	0.106	0.052	0.032	0.093	0.066	0.033	0.017	3.128
Guinea	0.260	0.195	0.086	0.041	0.132	0.075	0.032	0.019	7.006
Mali	0.172	0.119	0.063	0.040	0.101	0.075	0.044	0.025	15.093
Mauritania	0.303	0.210	0.103	0.061	0.133	0.093	0.048	0.026	3.242
Niger	0.223	0.150	0.094	0.058	0.174	0.110	0.048	0.029	15.362
Nigeria	0.081	0.059	0.038	0.025	0.050	0.035	0.022	0.015	28.706
Senegal	0.388	0.186	0.099	0.065	0.234	0.119	0.056	0.031	4.105
Togo	0.137	0.085	0.043	0.029	0.086	0.051	0.023	0.014	1.122
Regional	0.101	0.071	0.042	0.029	0.072	0.049	0.031	0.017	102.150

- Commercial Premium = Fair Premium + Loading Factor
- Reserve funds under a regional pool approach are lower than for individual countries.
- 2 to 3 times lower for most countries.

A Regional IBLI Model in West Africa

Results: Actuarial Model – Insurance quality

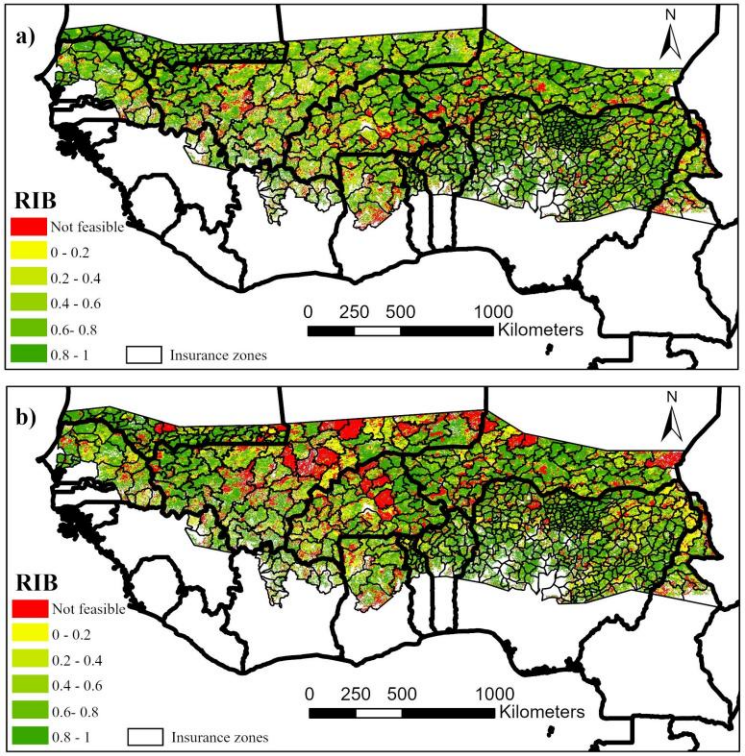
- 2 activation levels (z-score = −0.7 and −1.3)
- Actuarial premium without loading factor

Moderate drought:

- 89% of the territory with positive RIB Mean RIB = 0.60

Severe drought:

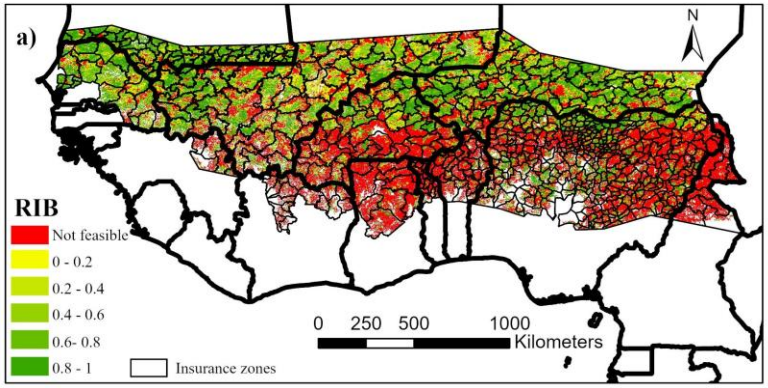
- 79% of the territory with positive RIB
- RIB Identification of low-performance zones (e.g., increasing the number of zones)



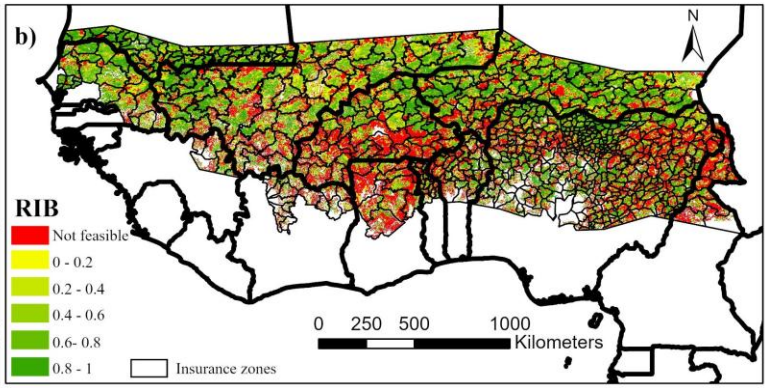
A Regional IBLI Model in West Africa

Results: Actuarial model– Insurance quality

AFP with LF: without pool



AFP with LF: with pool

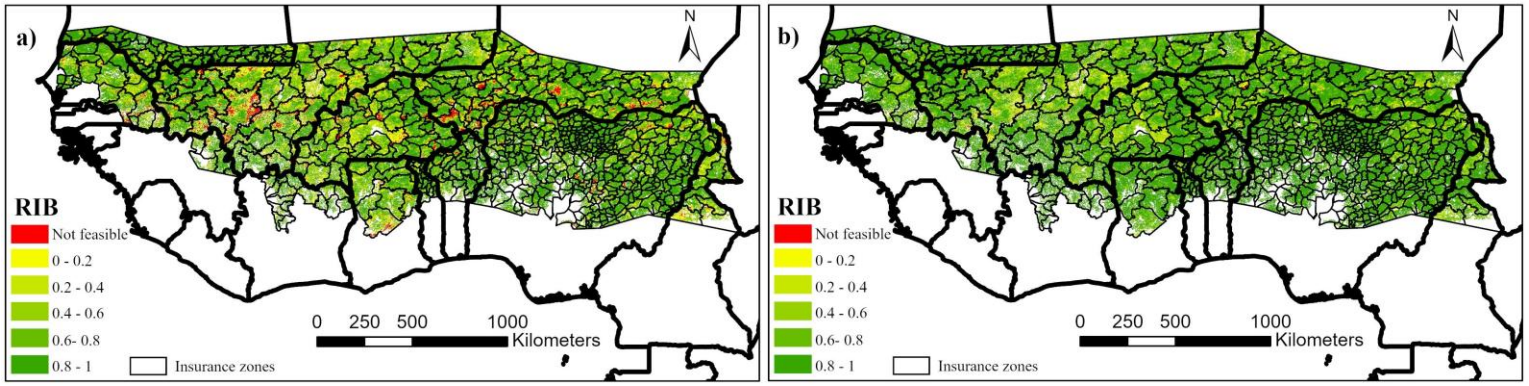


- Commercial Premium = Fair Premium + Loading Factor
- The loading factor reflects the cost of maintaining reserves to cover extreme events.
- 45% of the territory shows a positive RIB without pooling, rising to 55% with pooling.

A Regional IBLI Model in West Africa

Results: Actuarial Model with loading factor and subsidies

25% subsidy on the loaded premium



- **Moderate drought (z-score = −0.7):**

99% of the area with positive RIB — Mean RIB = 0.66

- **Severe drought (z-score = −1.3):**

95% of the area with positive RIB — Mean RIB = 0.67

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Conclusions

- The Optimal Insurance Zone methodology **improves insurance quality**. It has already been adopted in Kenya's insurance Company (Takaful).
- This study designs the **first regional index-based drought insurance for pastoral systems in West Africa** — one of the most climate-vulnerable and least-studied regions in the world.
- An extensive **survey** was conducted with **1,735 pastoralists** across Senegal, Mali, Burkina Faso, and Nigeria.
- The **regional approach** enhances risk **diversification**, reducing insurers' reserve requirements and, consequently, commercial premiums.
- This **improves donor spending efficiency**, as lower commercial premiums require less subsidies.
- Regional cooperation would facilitate respect for transhumance rights, enhancing sustainability — a double dividend.
- **Supporting** the development of **pilot programs** is essential to refine and adapt insurance conditions to local needs.

Future research

Development of a pilot RCT for IBLI

- **Randomized controlled trials** (RCTs) as the primary methodology for evaluating and scaling up an index-based insurance program to enhance climate resilience
  1. **Local validation** of indices
  2. Development of an **anticipatory index insurance** product within a regional risk management framework
  3. **Adaptation** to local needs with a gender-sensitive approach
  4. **Design** and **testing**:
     - Conditional IBLI on the implementation of regenerative practices
     - Blended IBLI with feed vouchers
     - Standard IBLI

Publications

- Estefania-Salazar, E. & Iglesias, E. (2026). Enhancing drought resilience: An index insurance scheme for West African pastoralists. Climate Risk Management, 52, 100808. https://doi.org/10.1016/j.crm.2026.100808
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Thank you for your attention

Questions and comments are welcome

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