

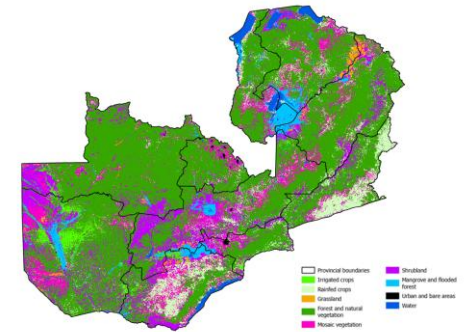
Integrated Economic-Environmental Modeling (IEEM) for Evidence-Based Public Policy and Investment Design

ZAMBIA

Onil Banerjee, PhD and Martin Cicowiez, PhD
RMGEO Consultants Inc.

April 22-25, 2025.

BASE 2020

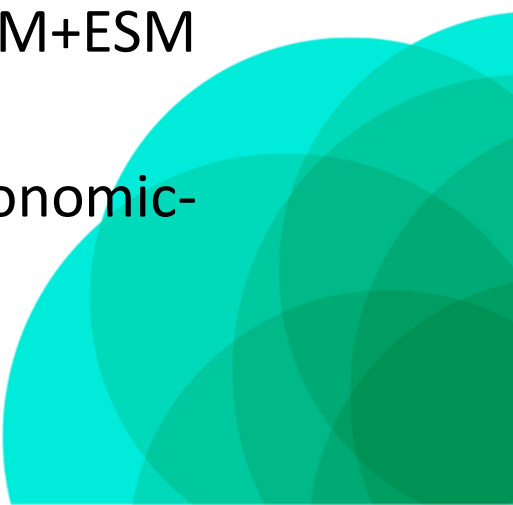




DAY ONE



WORKSHOP OBJECTIVES

1. Understand the capabilities of the Integrated Economic-Environmental Modeling (IEEM) Framework for policy and investment analysis and how to interpret results.
 2. Consolidate learning on the theoretical building blocks of IEEM analysis and gain familiarity with the practical implementation of IEEM through the ISIM interface.
 3. Understand why we link IEEM with spatial Ecosystem Services Modeling (ESM) and Land Use Land Cover (LULC) change modeling: the IEEM+ESM workflow.
 4. Know how to continue learning more about integrated economic-environmental modeling.
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PLAN FOR THE WEEK

Day one, April 22, 2025.

2:00pm-2:30pm. Opening remarks by Abdirahman Zeila Dubow. Introductions and Workshop Plan.

2:30pm-5:00pm. Overview and applications of the IEEM+ESM workflow including spatial Land Use Land Cover and Ecosystem Services Modeling for IEEM.

Day two, April 23, 2025.

9:00am-12:30pm. Review of IEEM mathematical structure and its dataset.

12:30pm. Lunch

- 2:00pm-5:00pm. ISIM Interface for IEEM. Defining policy questions for IEEM implementation.



PLAN FOR THE WEEK


Day three, April 24, 2025.

9:00am-12:30pm. Implementing policy questions in IEEM-ZMB step by step; analysis of simulation results.

12:30pm. Lunch

2:00pm-5:00pm. Implementing policy questions in IEEM-ZMB step by step; analysis of simulation results.

Day four, April 25, 2025.

- 8:00am-11:00am. Implementing policy questions in IEEM-ZMB step by step; analysis of simulation results. Wrap up and next steps. Working Paper.
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IEEM IN ZAMBIA BACKGROUND

DEVELOPMENT AND APPLICATION OF IEEM-ZMB

Phase I

- 2017-2018: Objective- Develop IEEM-ZMB and implement the model for various policy scenarios. Develop scenarios around the National Development Plan.

Phase II

- 2022: IEEM-ZMB to support the design of the Transforming Landscapes for Resilience and Development (TRALARD); Objective: Update IEEM and apply it to inform policies to promote restoration, conservation, agriculture, food security and tourism. While the original scope was multi-sectoral policy analysis, it was eventually decided that scenarios would center on the Tourism Master Plan.

Phase III

- 2022-2023: IEEM-ZMB applied to the ex-ante economic analysis of the Green, Resilient and Transformational Tourism Development (GREAT) Project; Objective: Develop IEEM+**ESM** and apply it to the ex-ante analysis of the Project.

DEVELOPMENT AND APPLICATION OF IEEM-ZMB

Phase IV: Current Phase

- Sept. 2024 to June 2025: Objective- Update IEEM-ZMB, build capacity and apply IEEM-ZMB to analysis of key strategic policy.
- Spatial analytics for TRALARD II and Emissions Reduction Program, spatial targeting.

Core tasks:

1. Build capacity through online training, virtual sessions and in-person workshop.
2. Update IEEM-ZMB database and document model and application.
3. Finalize implementation of IEEM-ZMB linked with Land Use Land Cover (LULC) change and Ecosystem Services (ES) modeling. Prepare Working Paper.



THE IEEM+ESM WORKFLOW

VALUE-ADDED OF THE IEEM APPROACH

- IEEM is a dynamic economy-wide CGE model for future-looking scenario analysis of public policy/investment. With it, we ask “What if...?” questions.

- IEEM integrates SEEA, covering market ES.
- IEEM has natural resource modules with policy relevant features.
- IEEM generates standard economic indicators relevant to Ministries of Finance and others in addition to natural capital and wealth metrics.
- IEEM is linked with a microsimulation model to estimate distributional/poverty impacts.

- IEEM is linked with spatial LULC and ES modeling (IEEM+ESM) to estimate impacts non-market ES.



NATURAL CAPITAL

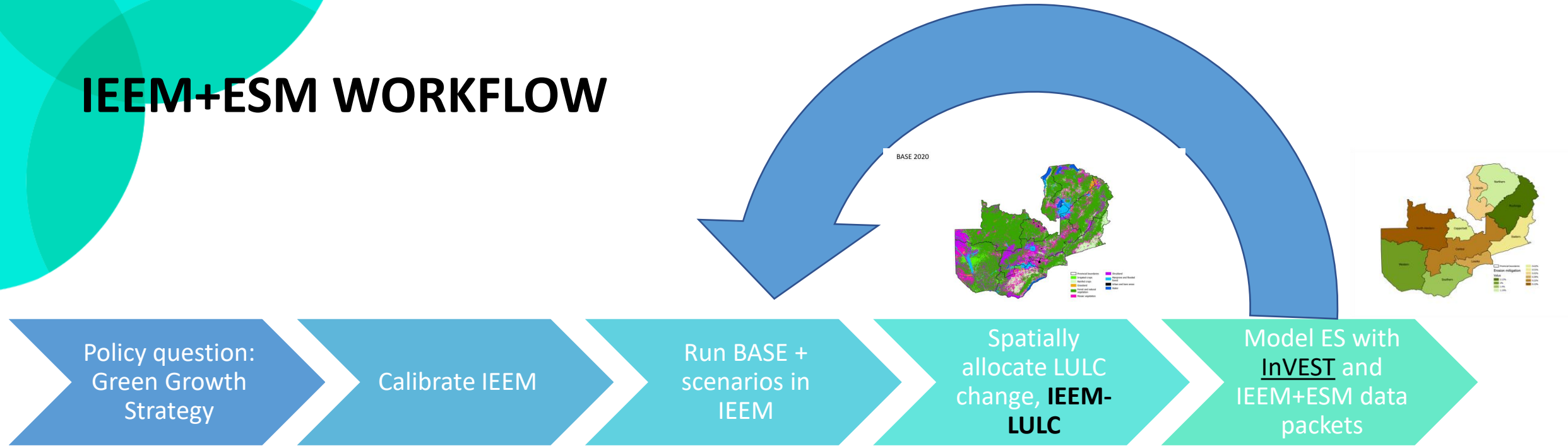


MANUFACTURED
CAPITAL



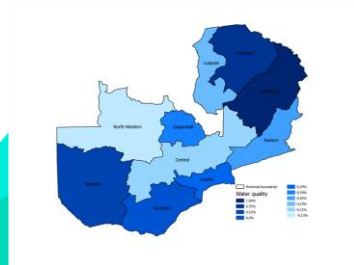
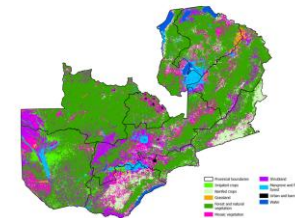
HUMAN CAPITAL

IEEM+ESM WORKFLOW



- IEEM, the LULC change model and ES models are iterated to account for agent response to changes in future ES flows.
- An economic value estimate of regulating ES is generated consistent with Zambia's System of National Accounts (tier 3 valuation methods).

COMBI 2020



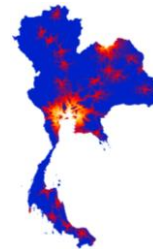
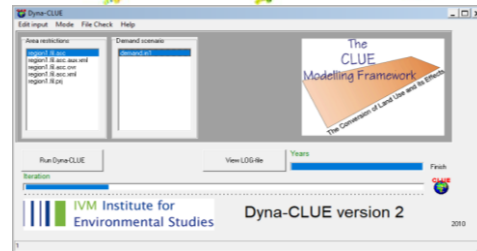
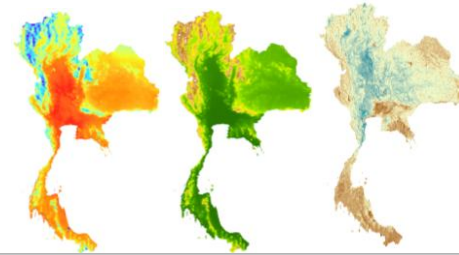
IEEM WORKFLOW

Integrated Economic-Environmental Model. This study investigates socioeconomic and environmental impacts of a business-as-usual climate change and environmental degradation counterfactual scenario versus a portfolio of climate and environmental mitigation strategies.



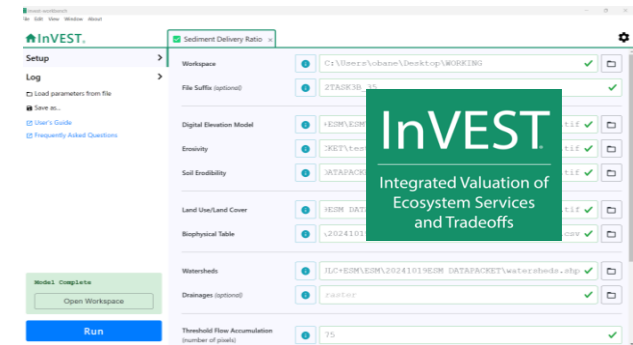
Data: Social Accounting Matrix based on Thailand's System of National Accounts, integrated economic accounts, household income and expenditure surveys and other national data sources.

Dyna-CLUE land use land cover change modeling.



Data: Biophysical (climate, topography, soils) and socioeconomic (distance to markets, infrastructure, population) geospatial data.

InVEST ecosystem service biophysical modeling of erosion mitigation, water regulation, water purification, climate regulation, crop pollination and coastal protection ecosystem services.

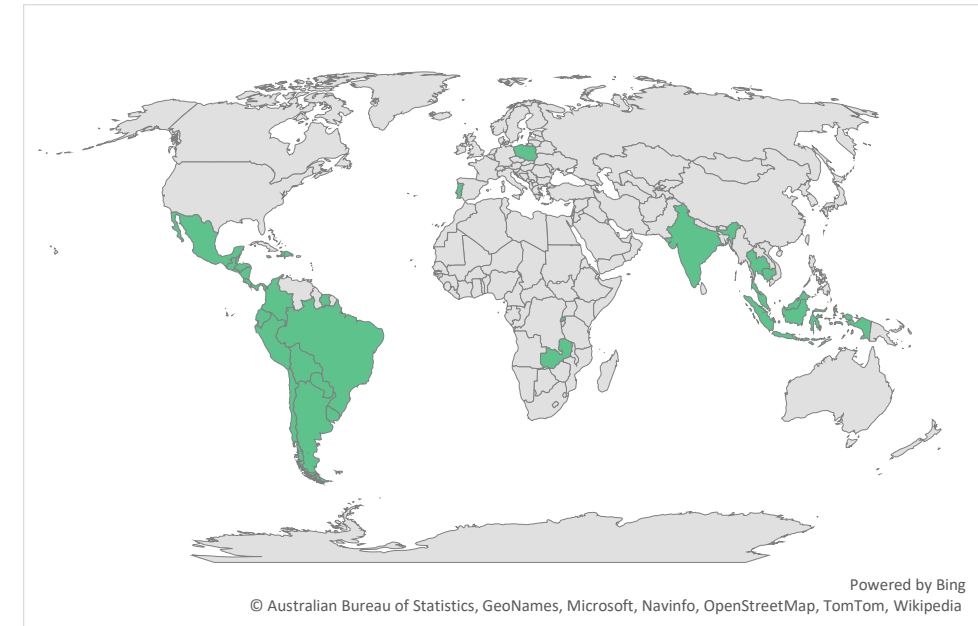


Data: land use land cover, soil characteristics and climate data.

Economic shocks calculated to account for changes in ecosystem service flows and climate change, implemented in IEEM in year $t+1$. In this study, IEEM accounts for: erosion, pollination, climate variable impact on agricultural productivity; temperature impacts on labor productivity and tourism demand; climate impacts on sea level rise. Other transmission pathways between environmental variables and the economy are available depending on the policy experiment.

PAST/PRESENT/FUTURE OF IEEM+ESM

- **IEEM's three-prong strategy:**
(1) Expand coverage of IEEM+ESM. (2) Enhance linkages between IEEM and ESM and develop heuristics. (3) Build capacity, collaborate and generate awareness and demand for integrated analysis.
- Hundreds of policy applications in collaboration with Ministries of Finance, Central Banks, line ministries; UN, IDB, WB, FAO, CI. Also used in project design.
- **OPEN IEEM Platform:** IEEM models for LAC countries, LULC model, ES datapackets, and training resources now available. **Parallel platform for countries beyond LAC.**
- Robust and timely evidence-based policy advice at lower cost. No more re-inventing the wheel: focus on innovation.



Developing IEEM Modeling Infrastructure and Capacity Around the World.

Onil Banerjee, PhD.



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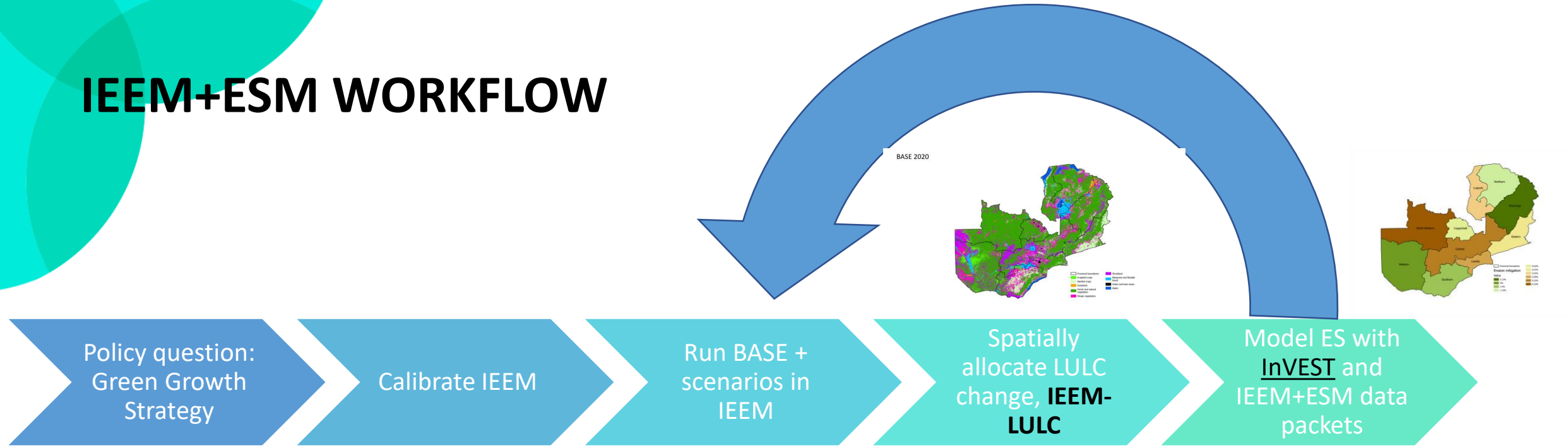
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IEEM-ZMB APPLICATION TO ZAMBIA'S GREEN GROWTH STRATEGY

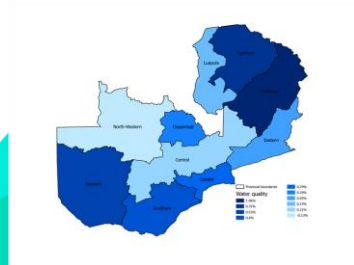
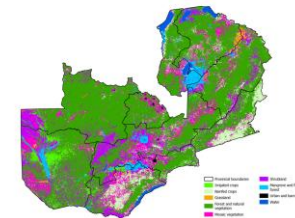
BASIS FOR WORKING PAPER

IEEM+ESM WORKFLOW



- IEEM, the LULC change model and ES models are iterated to account for agent response to changes in future ES flows.
- An economic value estimate of regulating ES is generated consistent with Zambia's System of National Accounts (tier 3 valuation methods).

COMBI 2020



SCENARIO DESIGN

Scenarios are based on key Agriculture, Forestry and Other Land Use (AFOLU) investments in Zambia's National Green Growth Strategy (2024-2030).

- **BASE:** Business-as-usual (GDP, population, deforestation) to 2050.
- **INVEST:** Investment of \$220,848,280 from 2025-2030.
- **CLIMATE:** CC impacts on land productivity, agricultural and construction labor productivity, human health and tourism (damage functions for RCP 8.5).
- **CLIMAGRI:** Implementation of climate adapted agriculture for crops (500,000 ha) and livestock (7,000 ha). Productivity: 2%; Cost: US\$31,750,000.
- **IRRIGAGRI:** Expansion of irrigated agriculture by 2,600 ha. Productivity: 50%; Cost: US\$79,800,000.
- **AFFORDEFOR:** Reduction of deforestation of 52,000 ha; 600,000 ha and 60,000 ha regenerated and reforested. Cost: US\$109,298,280.
- **INTERV:** INVEST+CLIMAGRI+IRRIGAGRI+AFFORDEFOR.
- **COMBI:** CLIMATE+INTERV.

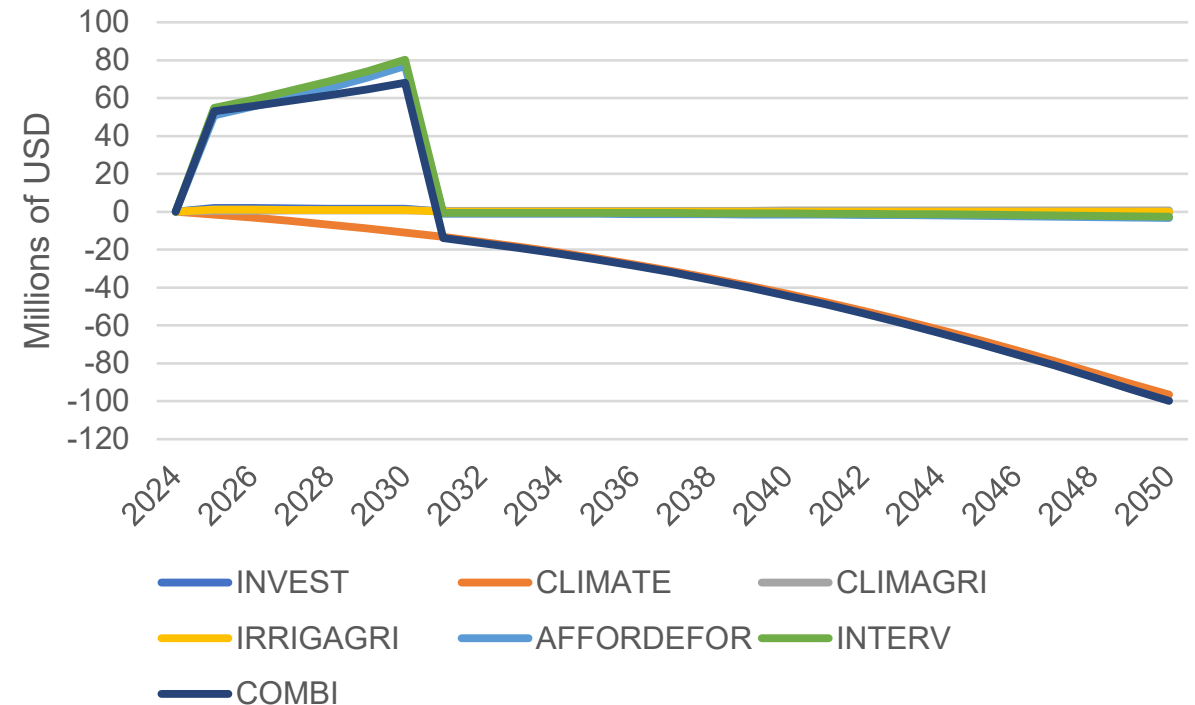
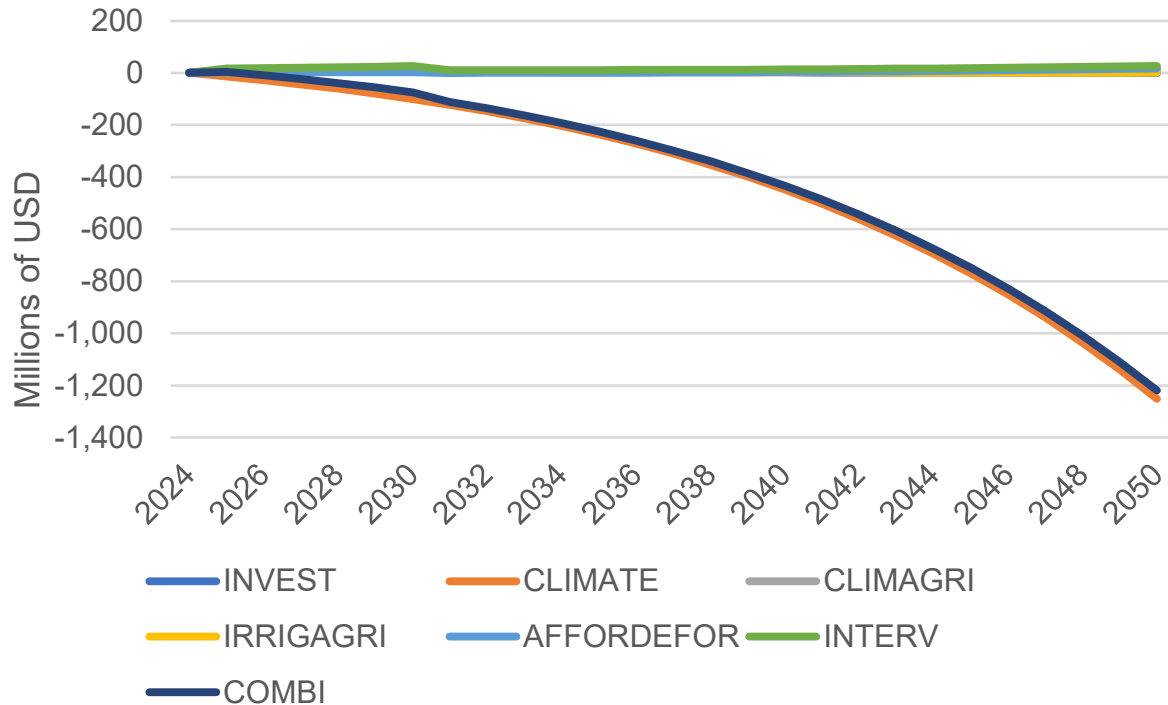
SCENARIO IMPACTS ON THE ECONOMY

Millions of USD as a difference from BASE in 2050.

	INVEST	CLIMATE	CLIMAGRI	IRRIGAGRI	AFFORDEFOR	INTERV	COMBI
GDP	0	-1,252	10	1	17	27	-1,219
Cumulative GDP	88	-11,362	158	67	127	440	-10,883
Wealth	0	-97	1	0	-3	-3	-100
Cumulative wealth	9	-1,017	15	7	344	376	-648
Private investment	-1	-187	1	0	18	18	-164
Exports	-1	-387	3	0	10	11	-373
Imports	-1	-347	2	0	9	10	-334

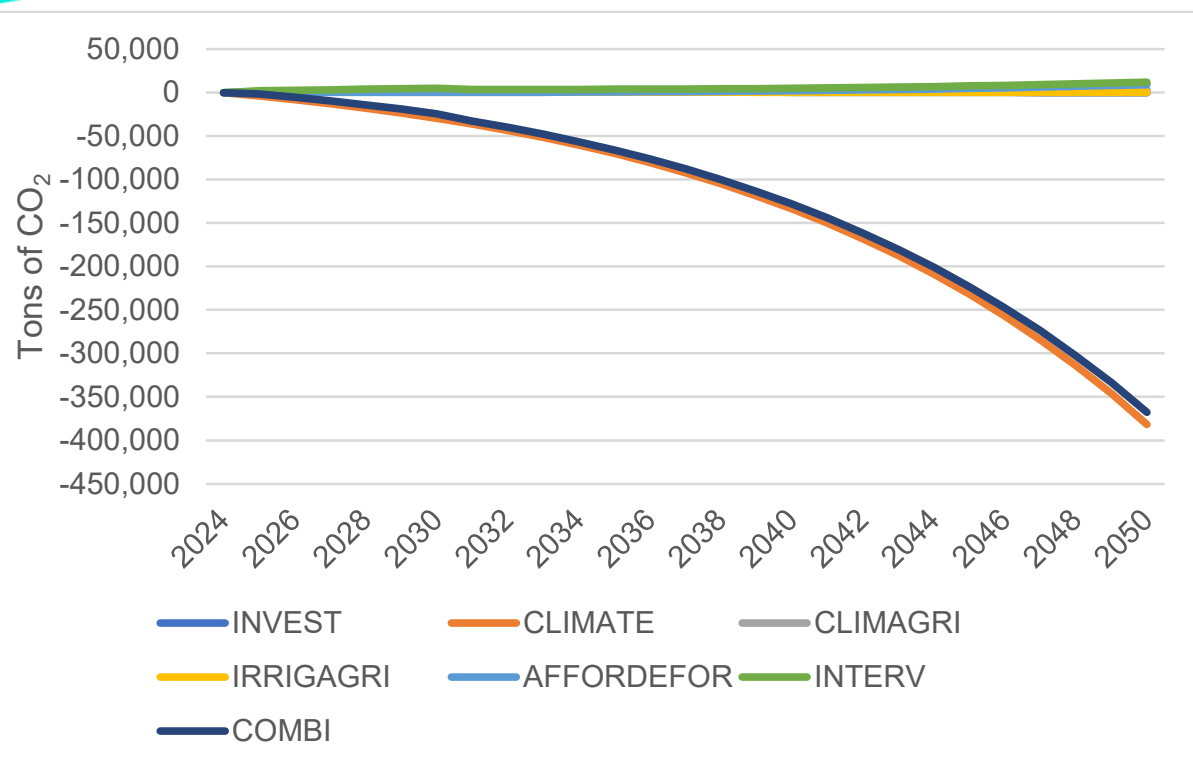
ECONOMIC IMPACTS

Trajectory of GDP (left) and wealth (right) as difference from BASE in millions of USD.



ECONOMIC IMPACTS

Scenario-driven changes on annual CO₂ emissions (left) and cumulative emissions (right); from fossil fuel combustion (not including LULC change).

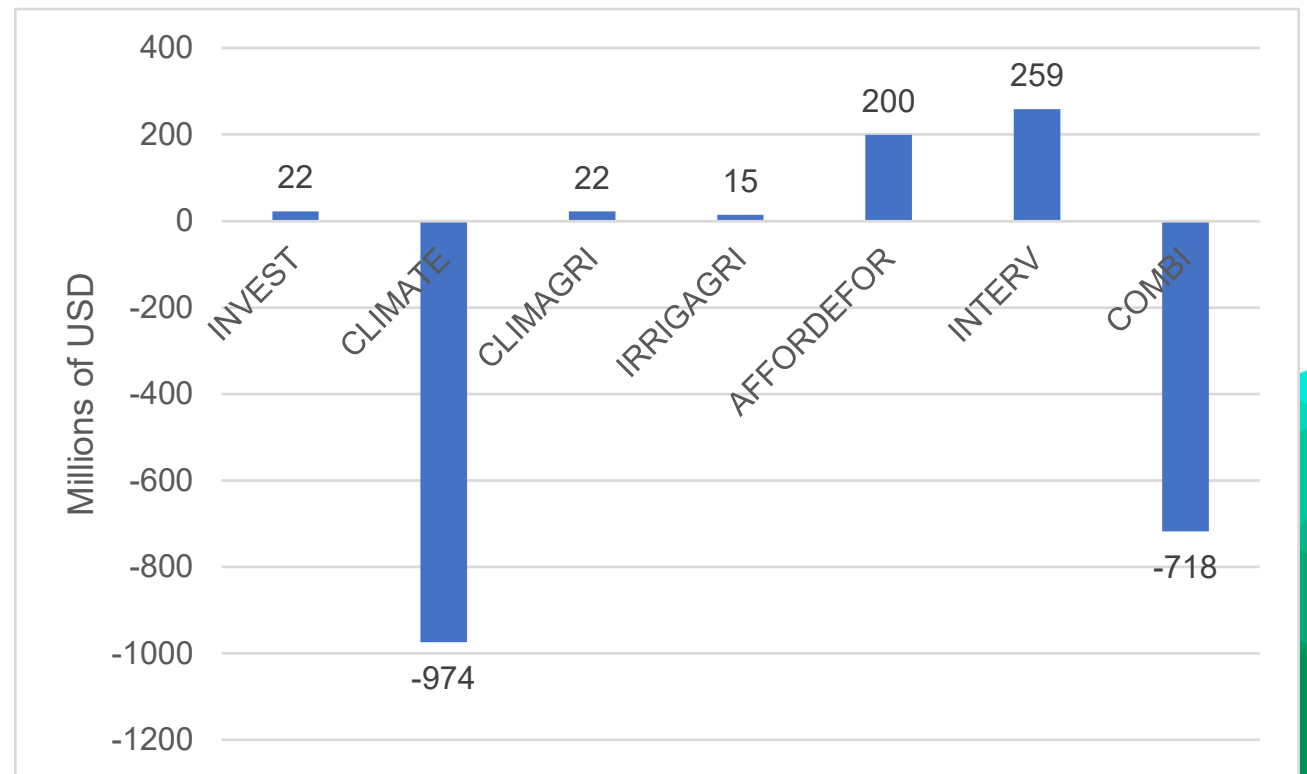


Scenario	Change in CO ₂ emissions (tons)
INVEST	17,737
CLIMATE	-3,417,179
CLIMAGRI	44,958
IRRIGAGRI	15,053
AFFORDEFOR	67,157
INTERV	144,783
COMBI	-3,260,367

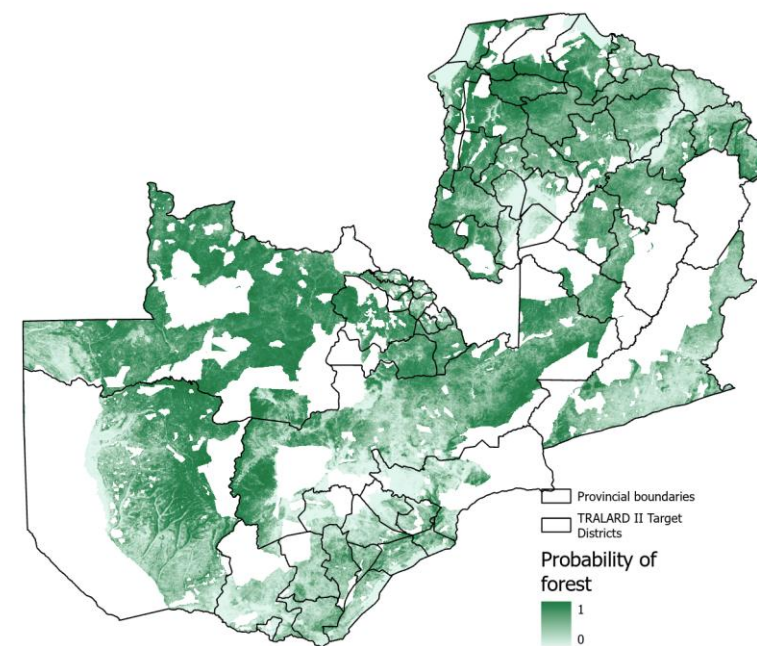
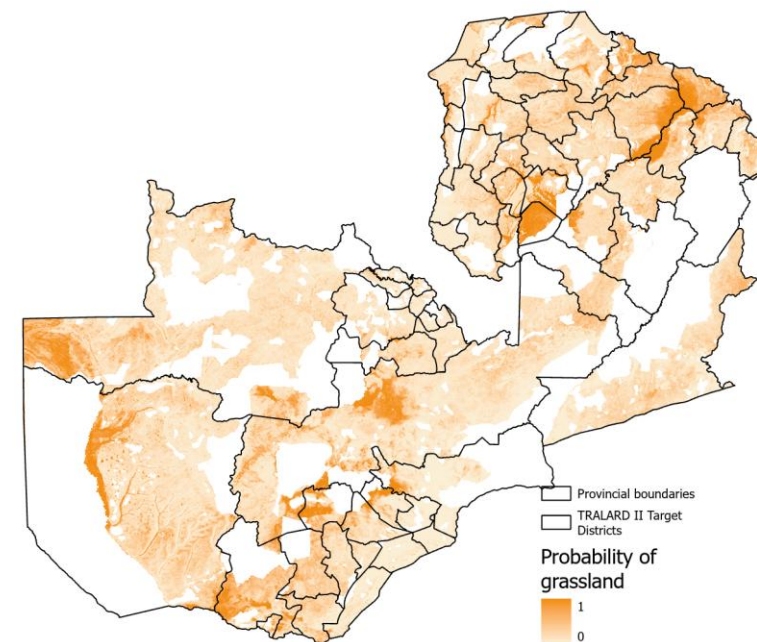
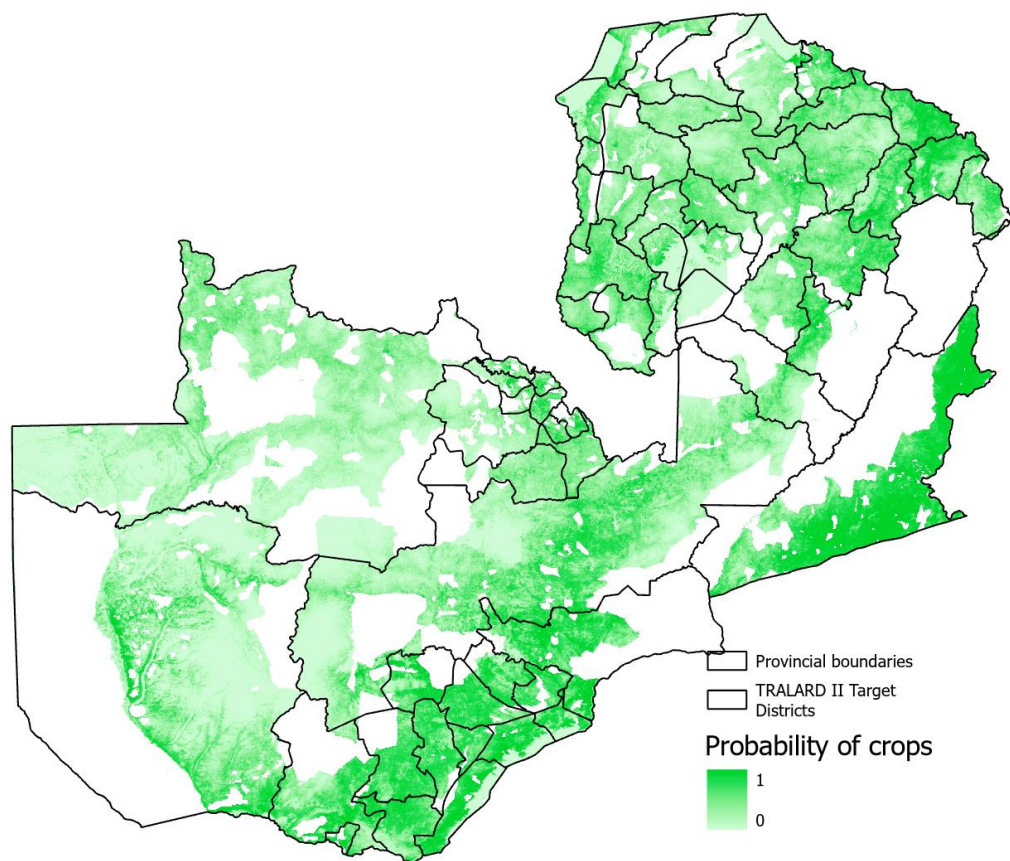
ECONOMIC IMPACTS

Scenario-driven changes in the number of poor (left) and net present value (right).

Scenario	Change in number of individuals
INVEST	-170
CLIMATE	445,070
CLIMAGRI	-3,525
IRRIGAGRI	-526
AFFORDEFOR	-27
INTERV	-4,260
COMBI	440,596

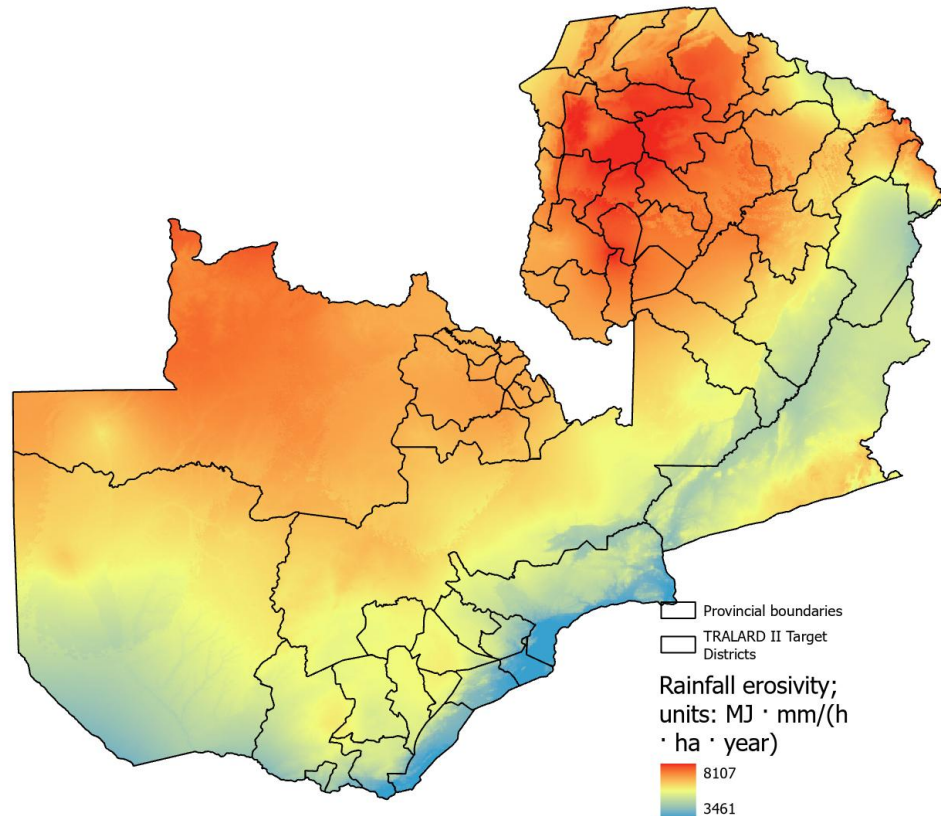


PROBABILITY OF A LAND COVER CLASS OCCURRING

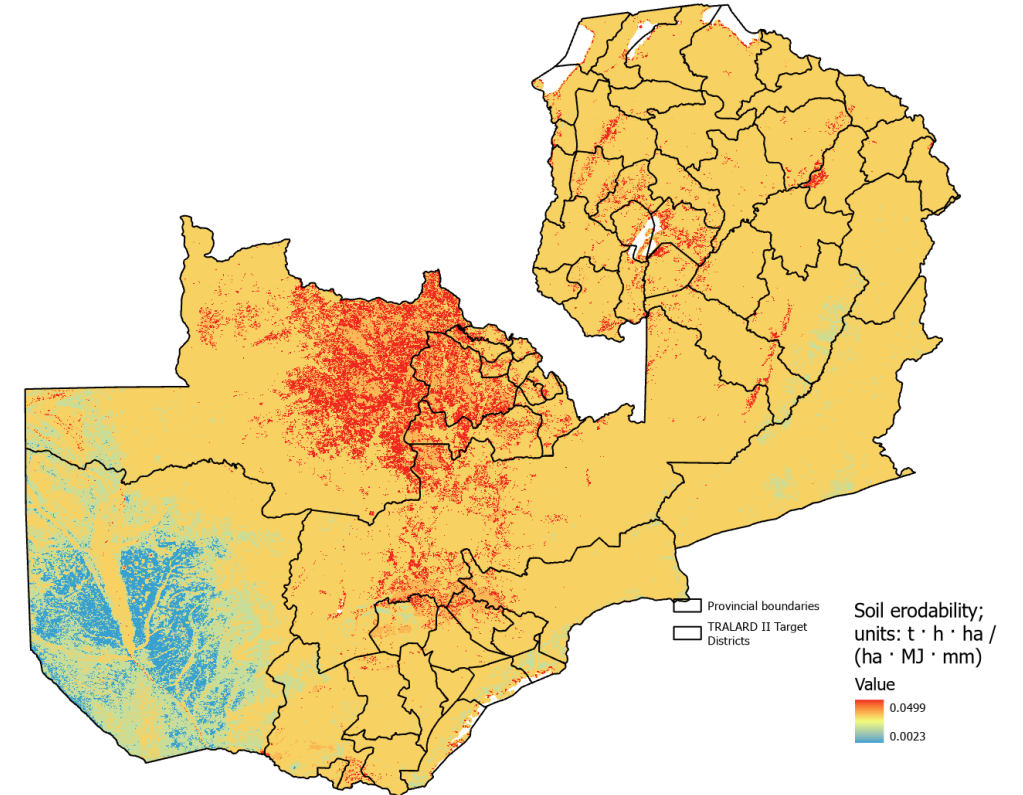


SPATIAL TARGETING

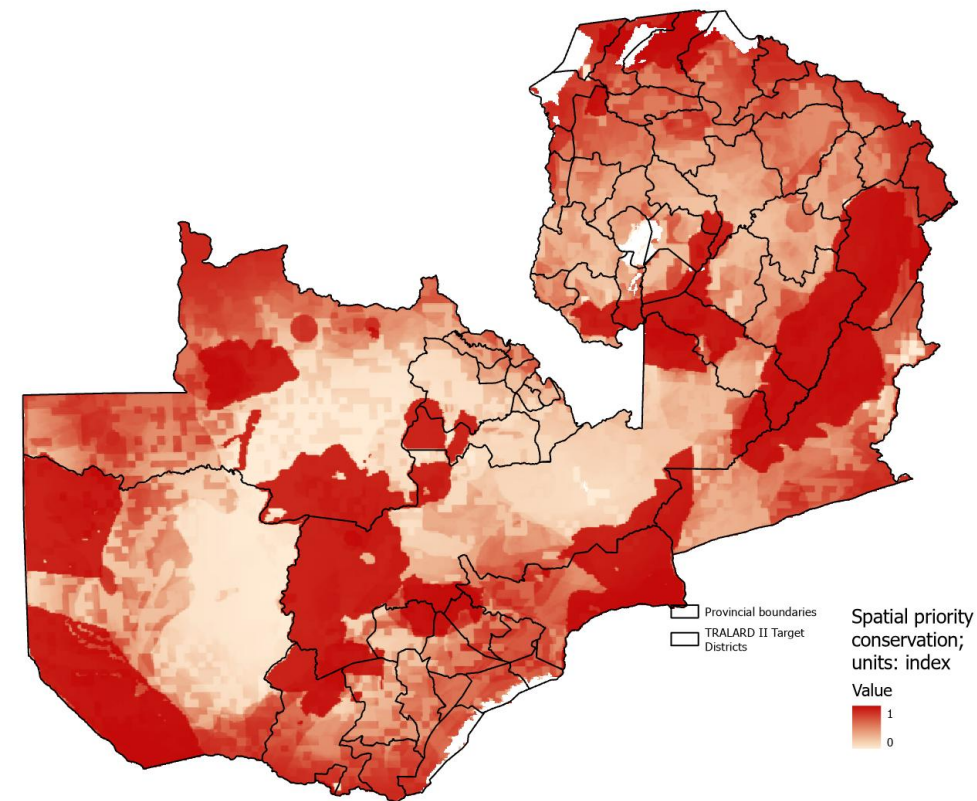
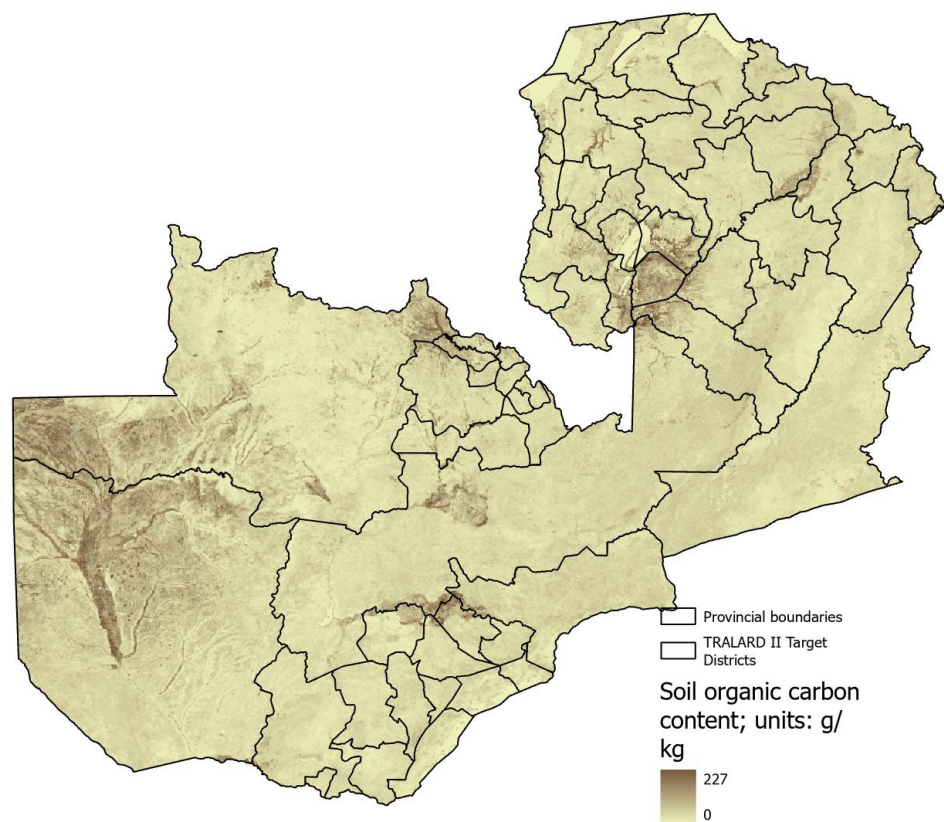
Intensity and duration of rainfall.



Susceptibility of soil particles to detachment and transport by rainfall.

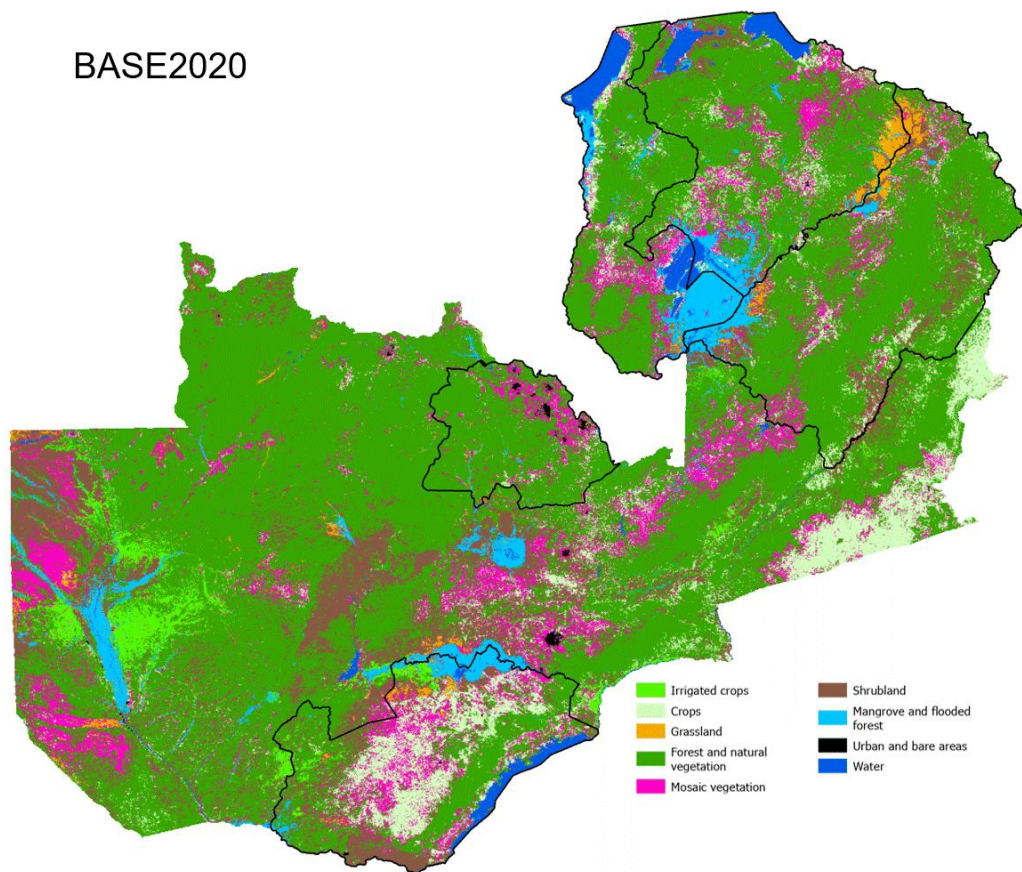


SPATIAL TARGETING

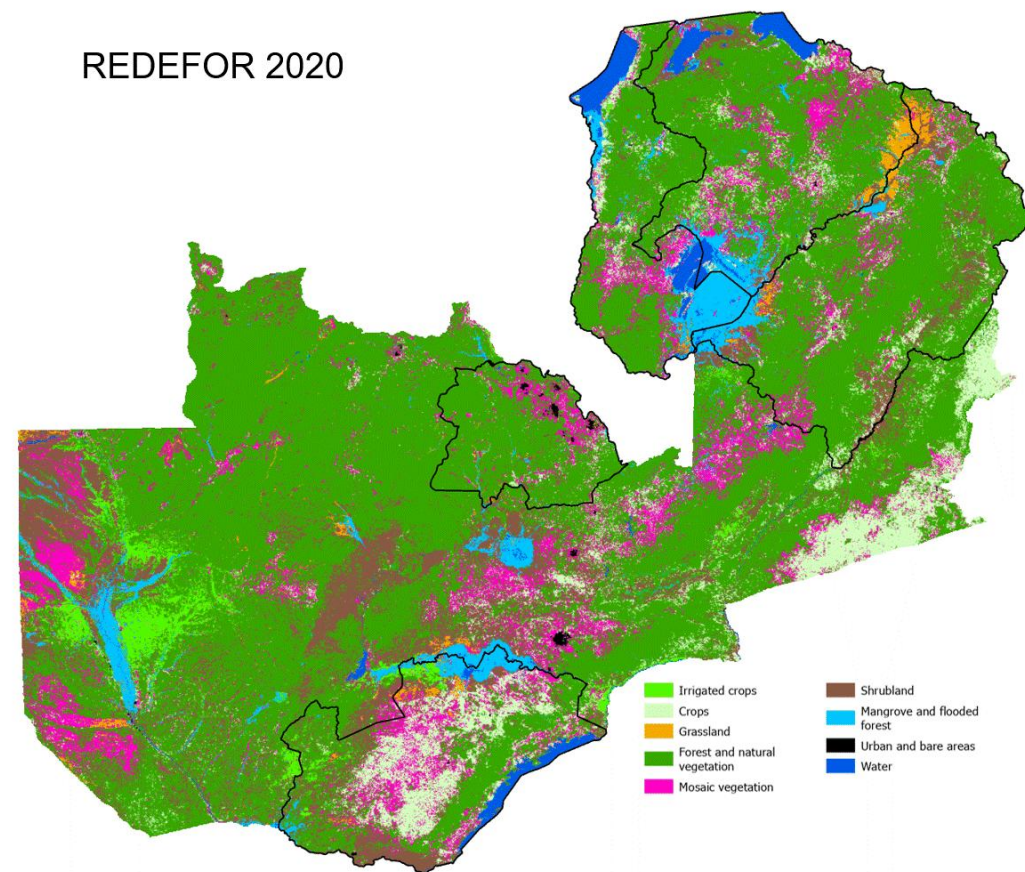


LULC RESULTS

BASE2020

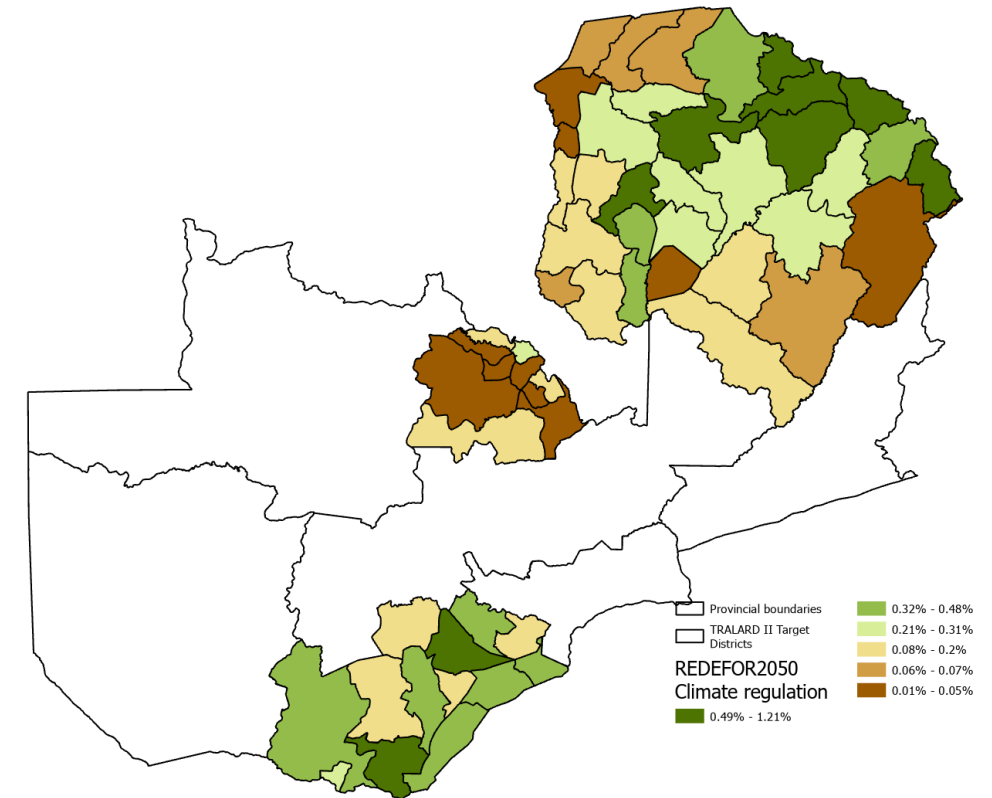
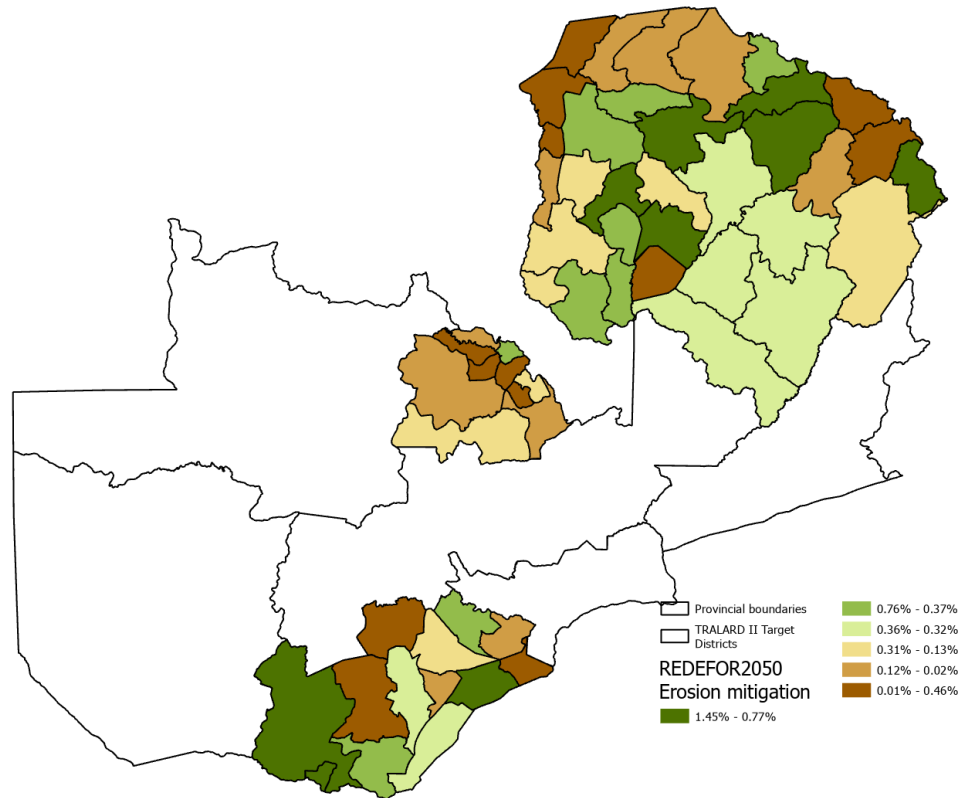


REDEFOR 2020

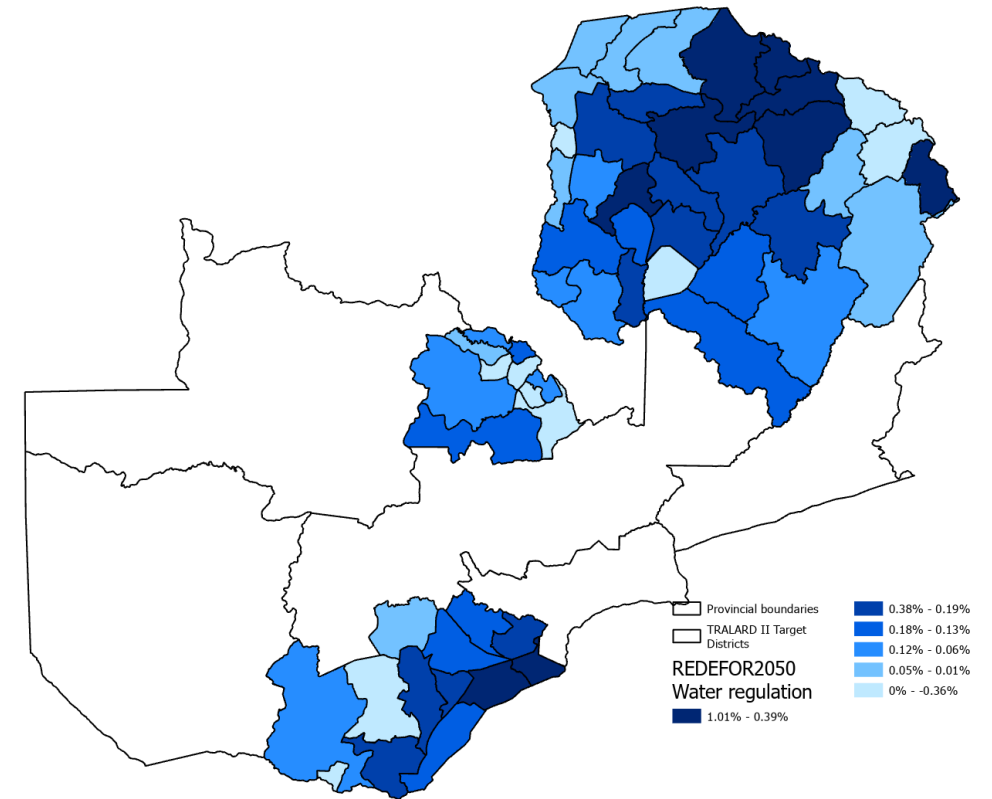
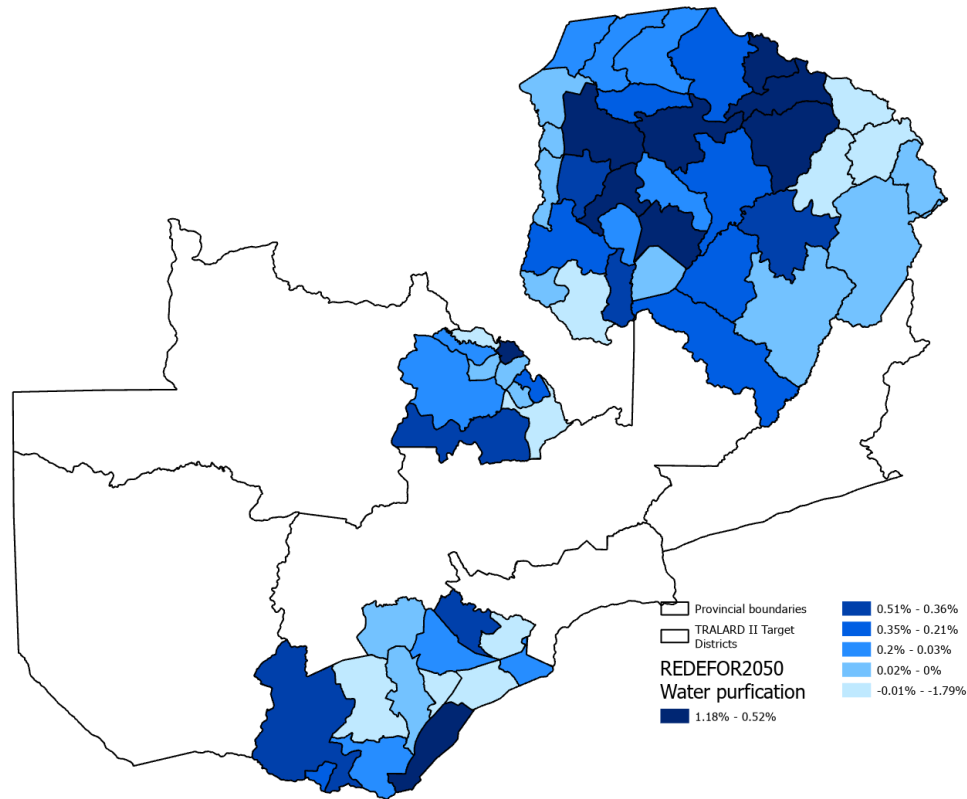


SCENARIO IMPACTS ON EROSION MITIGATION AND CLIMATE REGULATION ES

Luapula, Copperbelt, Muchinga, Northern and Southern Provinces.



SCENARIO IMPACTS ON WATER PURIFICATION AND WATER REGULATION ES



KEY FINDINGS

- The investments in Green Growth offset a small share of climate change's impact on GDP.
- Consideration of other sectoral strategies would provide clearer picture of to what degree impacts can be mitigated.
- There is significant scope in Zambia for AFOLU investments to play an important role in reducing emissions and achieving carbon neutrality. IEEM+ESM can contribute to spatial targeting of interventions to optimize outcomes across economic, environmental and social indicators.
- IEEM+ESM can be applied to assessing alternative investment portfolios for mitigating climate impacts.

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