DecLaRe: Decision support for strengthening land resilience in the face of global challenges

How modeling can assist adaptation planning: Insights from crop modeling and mental models.

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PIK

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OUTLINE

Context

Suitability modelling

Mental models

Conclusion


CONTEXT

Introduction and context

- ✓ Climate change is increasing the complexity and urgency of agricultural adaptation which are sometimes lacking(IPCC, 2022)
- ✓ Effective planning requires tools that support decision-making under uncertainty (Wise et al., 2014)
- ✓ Models to explore future scenarios and support adaptation accordingly(Antle et al., 2017)

Crop models simulate crop growth and yield under varying climate and management conditions (Jones et al., 2003)

Mental models represent how individuals or communities perceive causal relationships in their environment (Biggs et al., 2011)

Algebraic models: GAMS most used by economists

- ✓ Modelling can support supports more context-specific, inclusive, and robust adaptation strategies (Etienne et al., 2014; van Hulst et al., 2020)

What is modeling ?

Modeling is the process of creating simplified representations of real-world systems (Epstein, 2008)

“Modeling as a tool for exploring complexity”

- ✓ Used to simulate, understand, and predict system behavior under different scenarios
- ✓ Helps explore "what-if" questions in complex, uncertain environments
- ✓ Can be quantitative (e.g., crop models, economic models) or qualitative (e.g., mental models, RCTs)
- ✓ Supports decision-making, planning, adaptation,…

Impacts on agricultural production

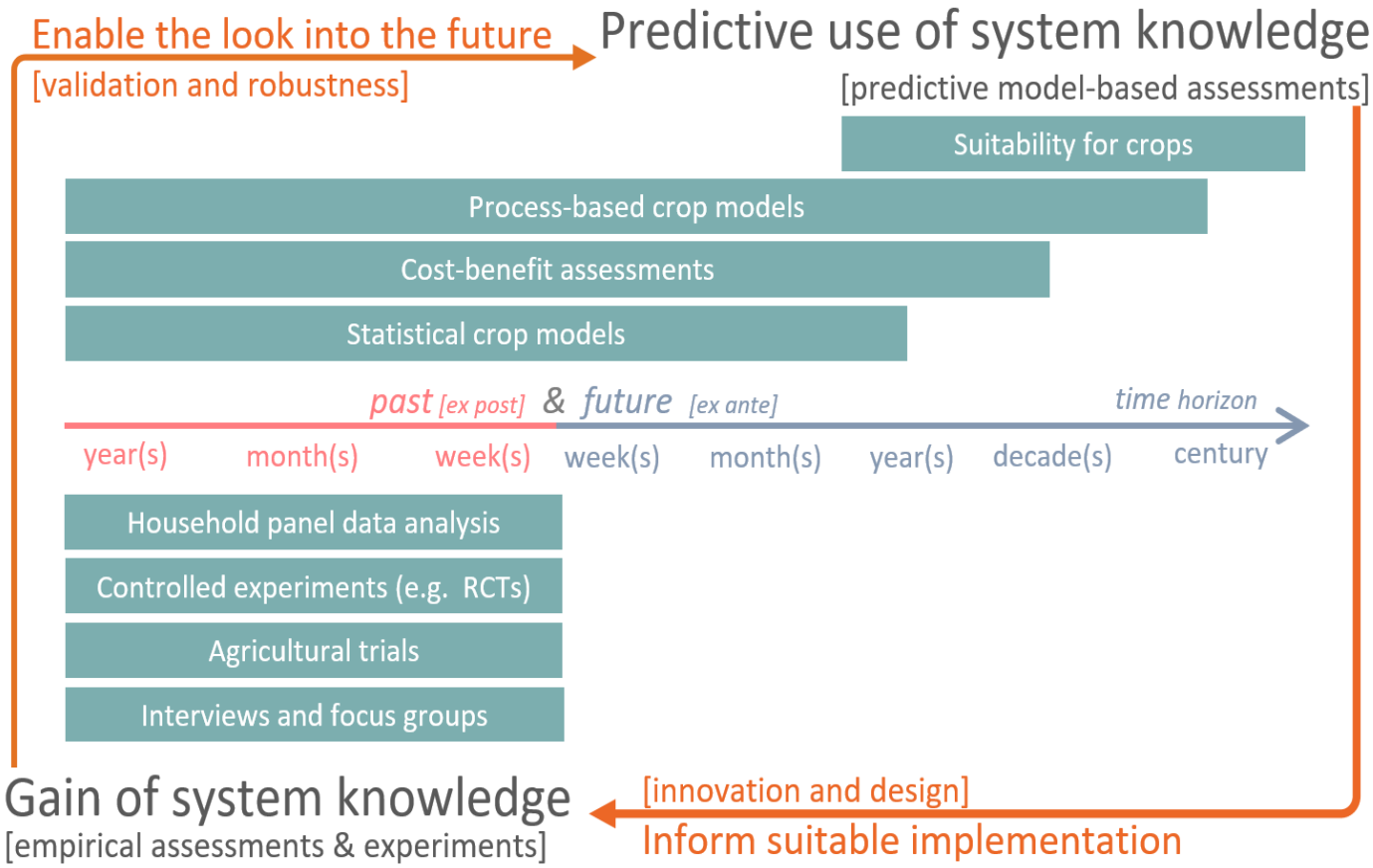
Crop models help to quantify (future) losses and shifts in production

+

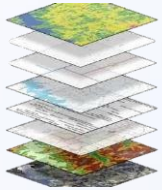
Mental models can help to identify farmers perception and preferences

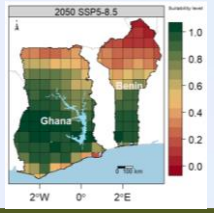
Both approaches contribute to a holistic understanding on adaptation

And test the effectiveness of adaptation measures


Enable the look into the future
[validation and robustness]
Predictive use of system knowledge
[predictive model-based assessments]
Suitability for crops
Process-based crop models
Cost-benefit assessments
Statistical crop models
past [ex post] & future [ex ante]
time horizon
year(s)
month(s)
week(s)
week(s)
month(s)
year(s)
decade(s)
century
Household panel data analysis
Controlled experiments (e.g. RCTs)
Agricultural trials
Interviews and focus groups
Gain of system knowledge
[empirical assessments & experiments]
[innovation and design]
Inform suitable implementation

Land suitability modelling





Data

Calculation based on crop requirements

Output

✓ **Data**

Climate, Soil, Management, Water availability, Ground measurements, Yield data.

✓ **Models**

Process based models, statistical models, Machine learning.

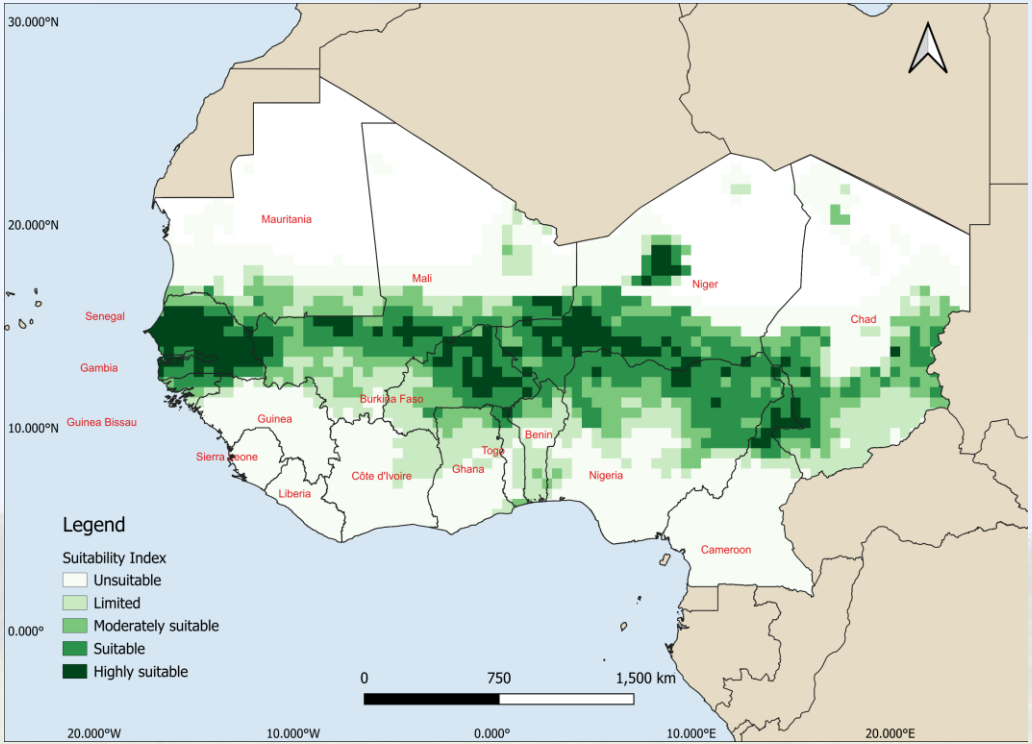
✓ **Output**

Suitability explicit maps, Yield estimation for crop, Change in suitable area under cc, Optimal planting and harvesting date.

Case of tree suitability in West Africa

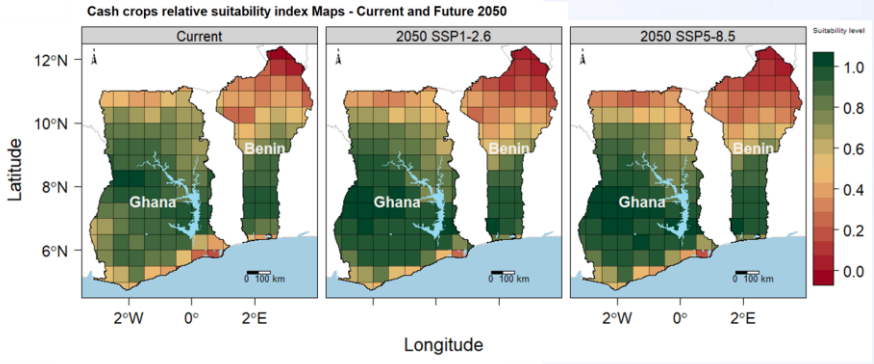
***tas : surface air temperature*

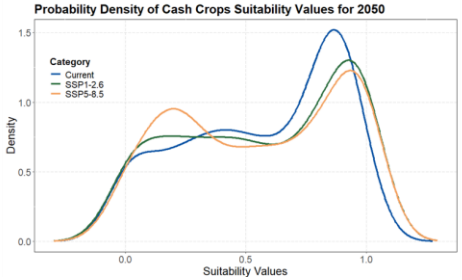
Based on consecutive dry days, consecutive wet days (max), precipitation sum, coefficient of variance for tas, mean tas, tasmax, ground water depth, soil pH.



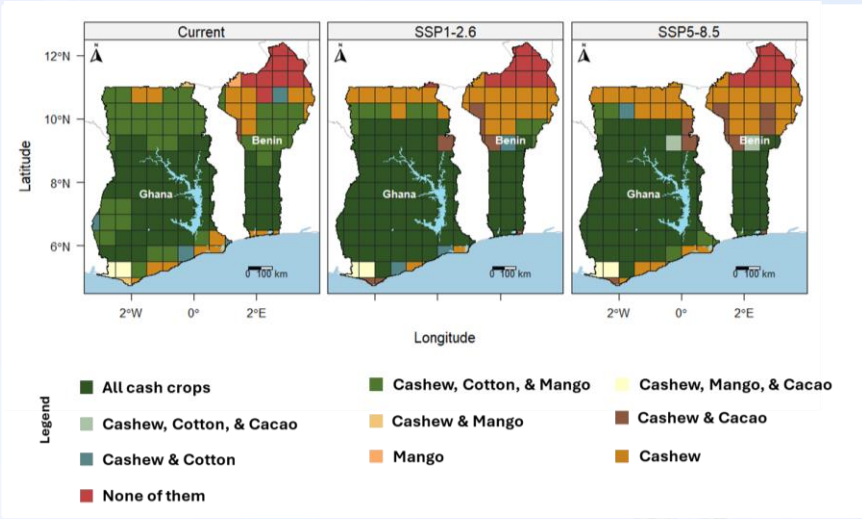
Faidherbia albida is (highly) suitable across the Sahel.

Crop modelling using Ecocrop



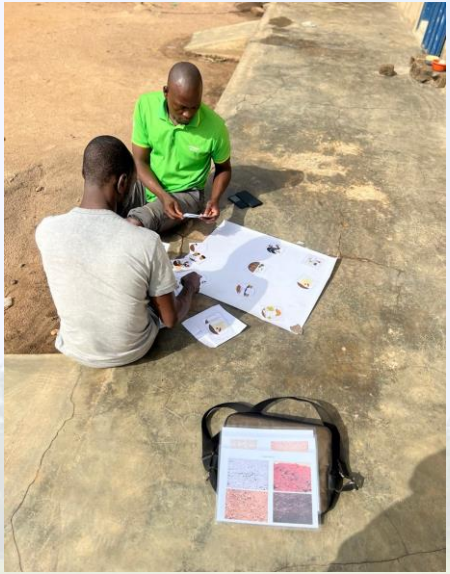


- Climate-driven shifts in suitability
- Diversification potential



- Identification of areas losing or retaining suitability
- Inform where to invest in irrigation, soil improvement, or agroforestry.
- Prevent unsuitable land use that could worsen degradation
- Explicit guidance for adaptive land use planning, crop choices, and land investment

Mental models data collection



Mental models in a nutshell

✓ **What is mental model?**

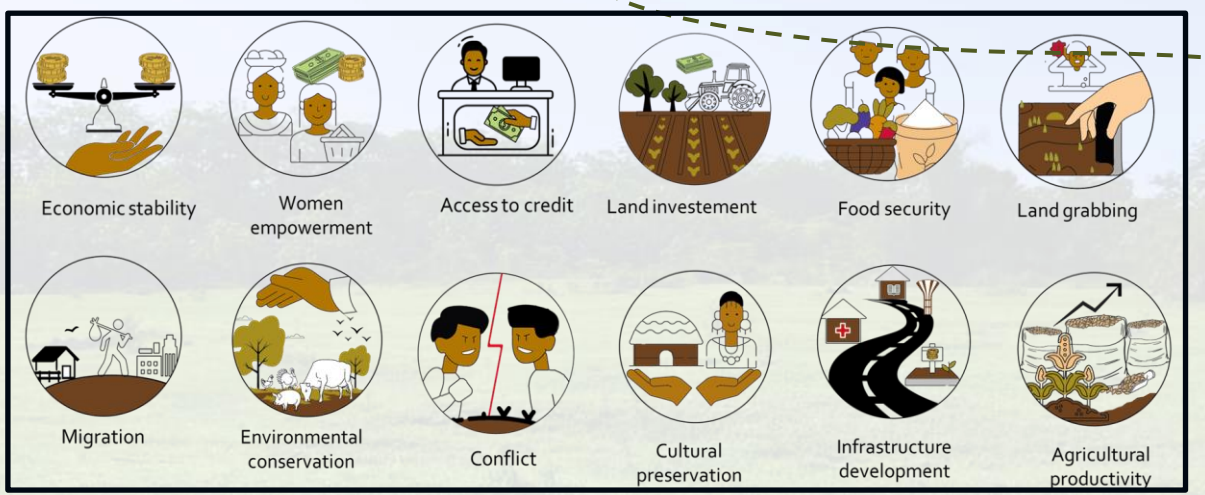
Explanation of someone's thought process about how something works in the real world. Based on an individual's experiences and describe a person's own internal understanding of the external world (Jones et al., 2011)

✓ **Application**:

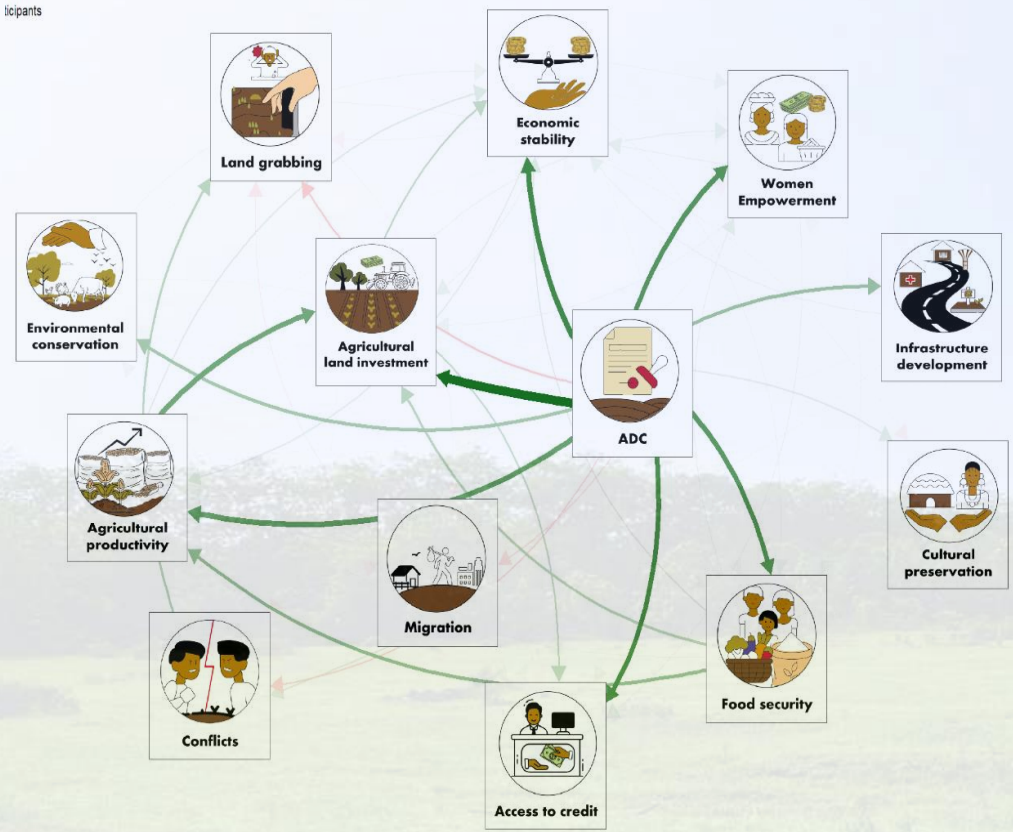
Analysis of local perceptions of land tenure security in Northen Benin, by asking : "What are the consequences (bad or good) of having an ADC ? (With weighted arrows)?"

M-Tool

The mental model mapping tool



Findings : Mean mental models



Key interpretations:

- ADC : pivotal mechanism for unlocking rural transformation through food security, land investment, credit access, infrastructure development.
- While ADC can is seen as a major positive change, institutional safeguards are needed to mitigate risks like land grabbing and social conflicts.
- Focus on short-term; long-term impacts are less explored.

Findings and contributions: Test to highlight differences

Men vs Women

Driver selected in mental model (0 = not selected, 1 =selected)	P_Value Gender
Women empowerment	0
Migration	0.004
Conflict	0.0042
Infrastructure development	0.0414
Land grabbing	0.0461
Agricultural productivity	0.115
Environmental conservation	0.1239
Cultural preservation	0.1856
Access to credit	0.3839
Food security	0.6018
Economic stability	0.772
Agric land investement	0.8523

Migrants vs non migrants

Driver selected in mental model(0 = not selected, 1 =selected)	P_Value Migration
Agric land investment	0.0026
Conflict	0.0207
Cultural preservation	0.0492
Migration	0.1357
Environmental conservation	0.2483
Access to credit	0.3679
Women empowerment	0.4212
Food security	0.4393
Agricultural productivity	0.5854
Economic stability	0.7613
Infrastucture development	0.924
Land grabbing	0.9737

- Strengthen local land governance with migrant and women representation, improved access to land rights information and dispute resolution.
- Offer flexible land rights (e.g., long-term leases) to encourage investment.
- Use local leaders to challenge negative views on women's empowerment, infrastructure development.

Conclusion

Does modelling can assist adaptation planning?

Yes, by translating complex data into actionable strategies, but its impact depends on ensuring that results are accessible and understandable to all stakeholders.

How can modelling assist adaptation planning?

🌾 Crop Modelling

Translates climate data into actionable insights
Identifies vulnerable crops, regions & future risks
Supports evidence-based decisions on crop diversification and timing.

🧠 Mental Models

Reveal local perceptions, knowledge, preferences, and priorities
Expose mismatches between scientific recommendations and local understanding
Enable co-design of adaptation strategies rooted in context

Call to action

“Let’s bridge science and societies”

“Engage with local voices, use modelling, turn climate impacts into pathways for resilient action and co-create adaptation solutions that work on the ground.”

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Thank you for your attention!

DecLaRe

Decision support for strengthening **La**nd **Re**silience in the face of global challenges