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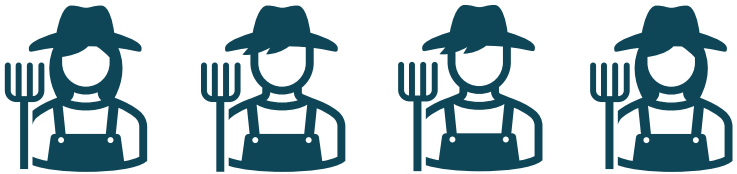
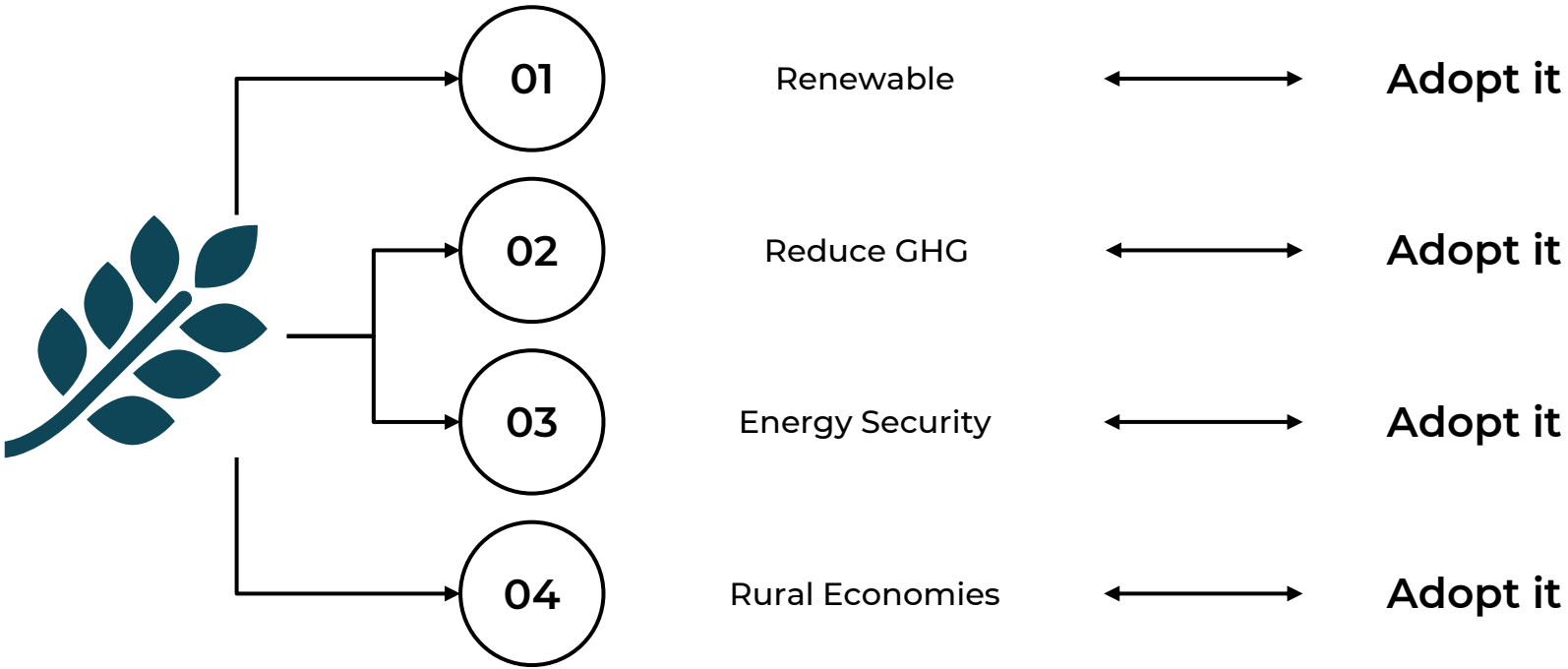
Coupling Agent-based Model with Territorial LCA to Support Agricultural Land Use Planning

Presenter: Tianran DING
Institute: Luxembourg Institute of Science and Technology
IE Day 2024 November 21



Bioenergy is the new trend



One Possibility of Adopting Bioenergy Crop

Policy

Yes

Carbon neutral
Replace fossil fuel

I don’t know technology…
Is it really profitable?

No

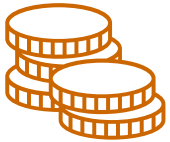
Farmer

Incentives motivation

Policy

Yes

Carbon neutral
Replace fossil fuel

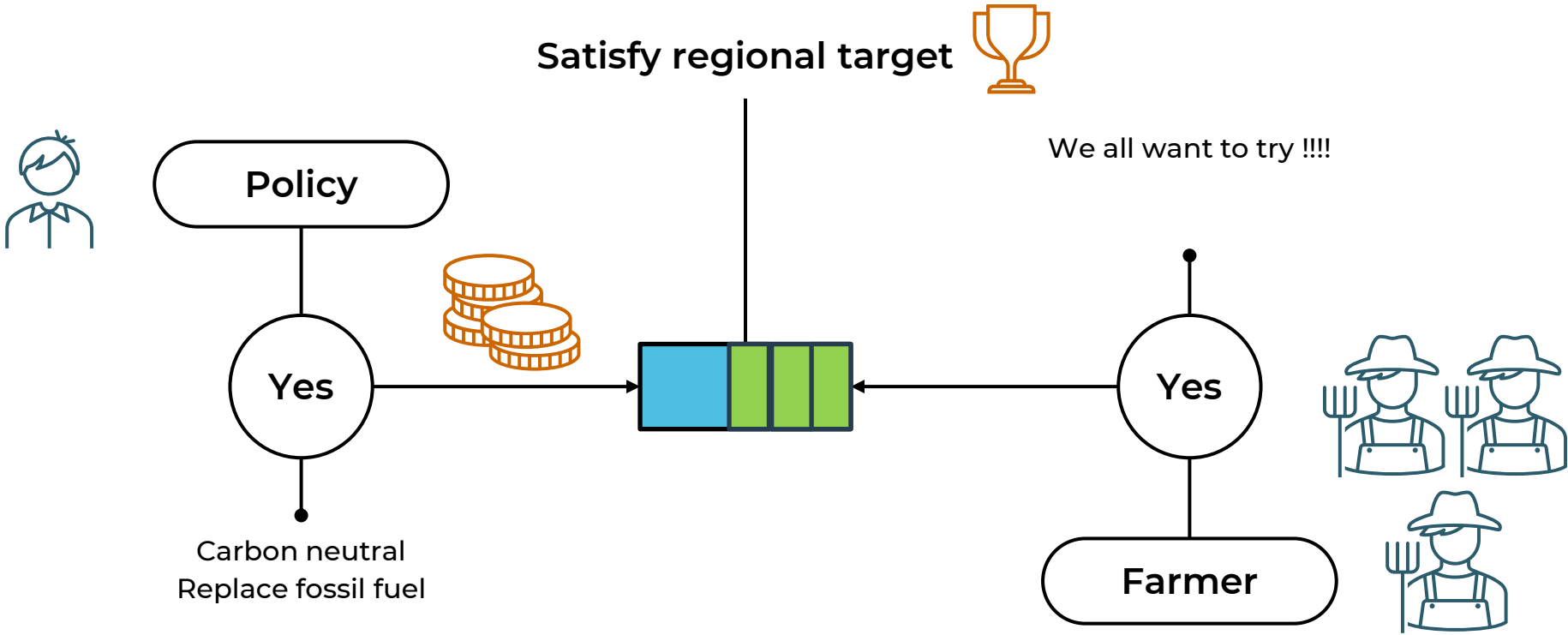


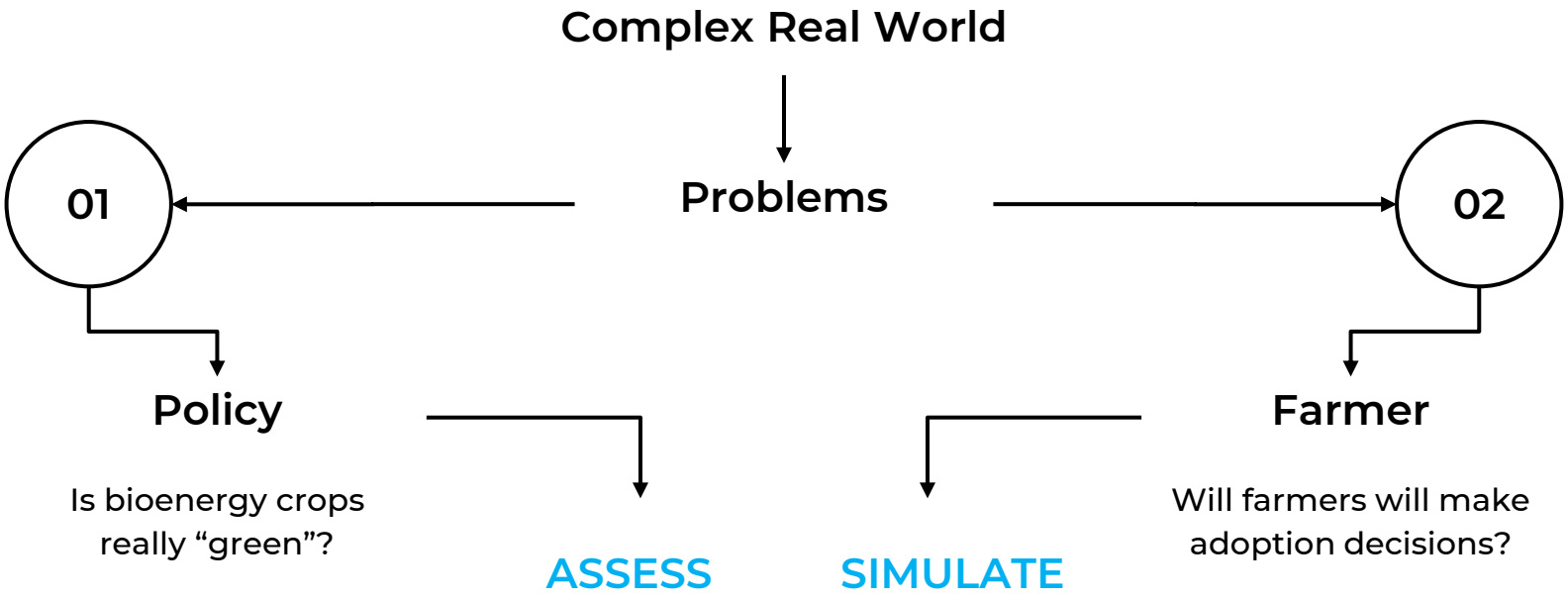
I don’t know technology…
BUT, I will try this year

Yes

Farmer

One IDEAL scenario




Complex Real World
Problems
01
02
Policy
Is bioenergy crops really “green”?
Farmer
Will farmers will make adoption decisions?
ASSESS
SIMULATE

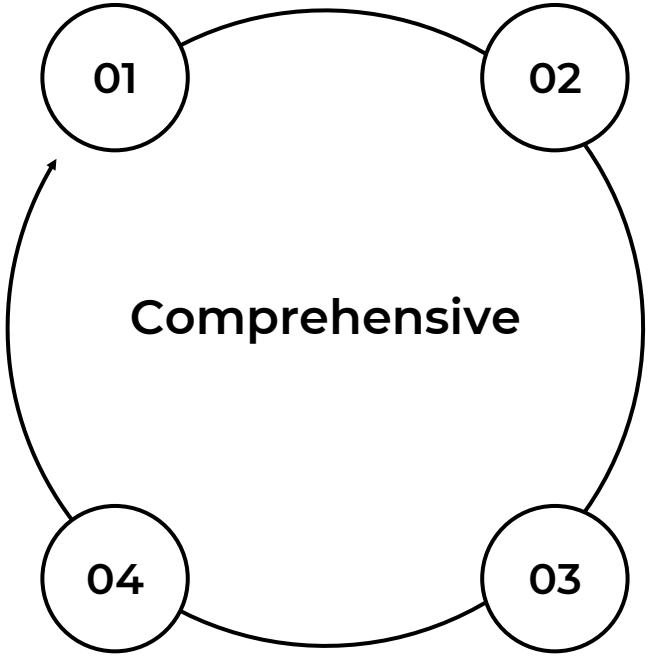
Assessment

Territorial level

Overall impacts

Life cycle

Crops’ full life cycle



Spatial specific

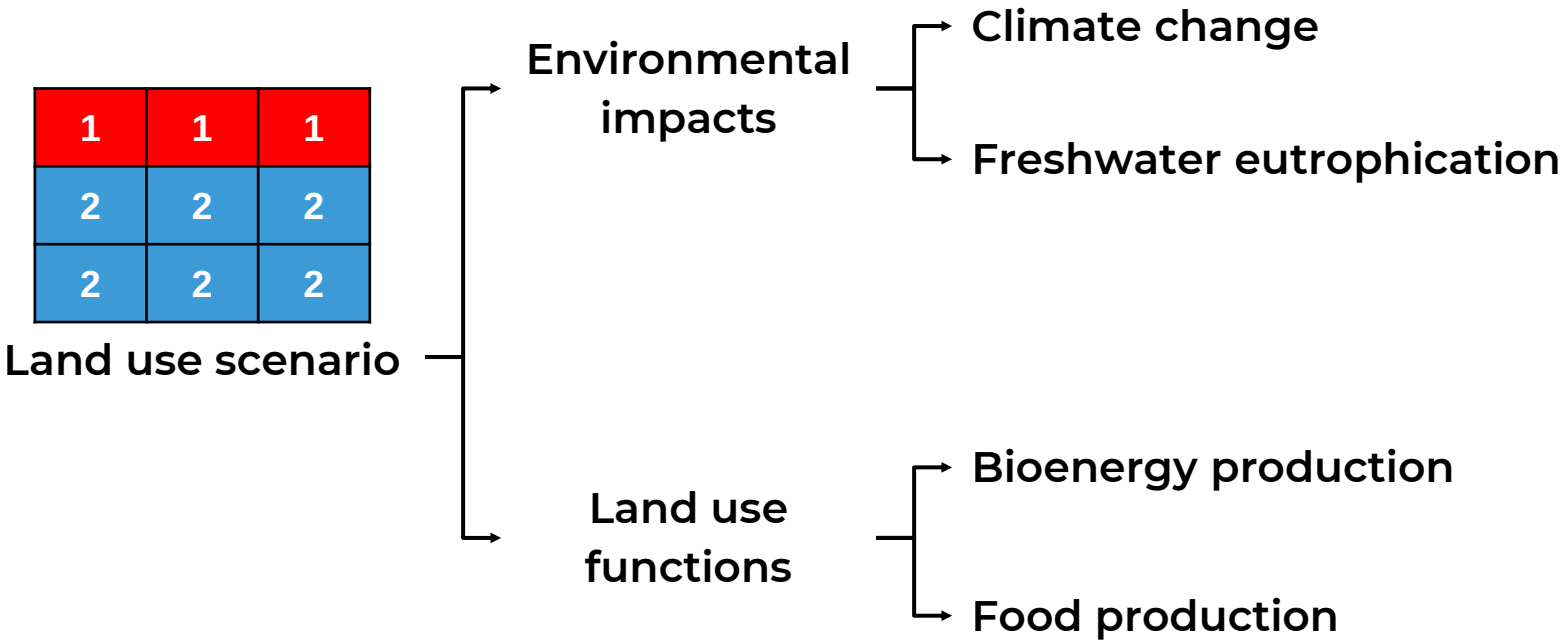
Location matters

Multi-criteria

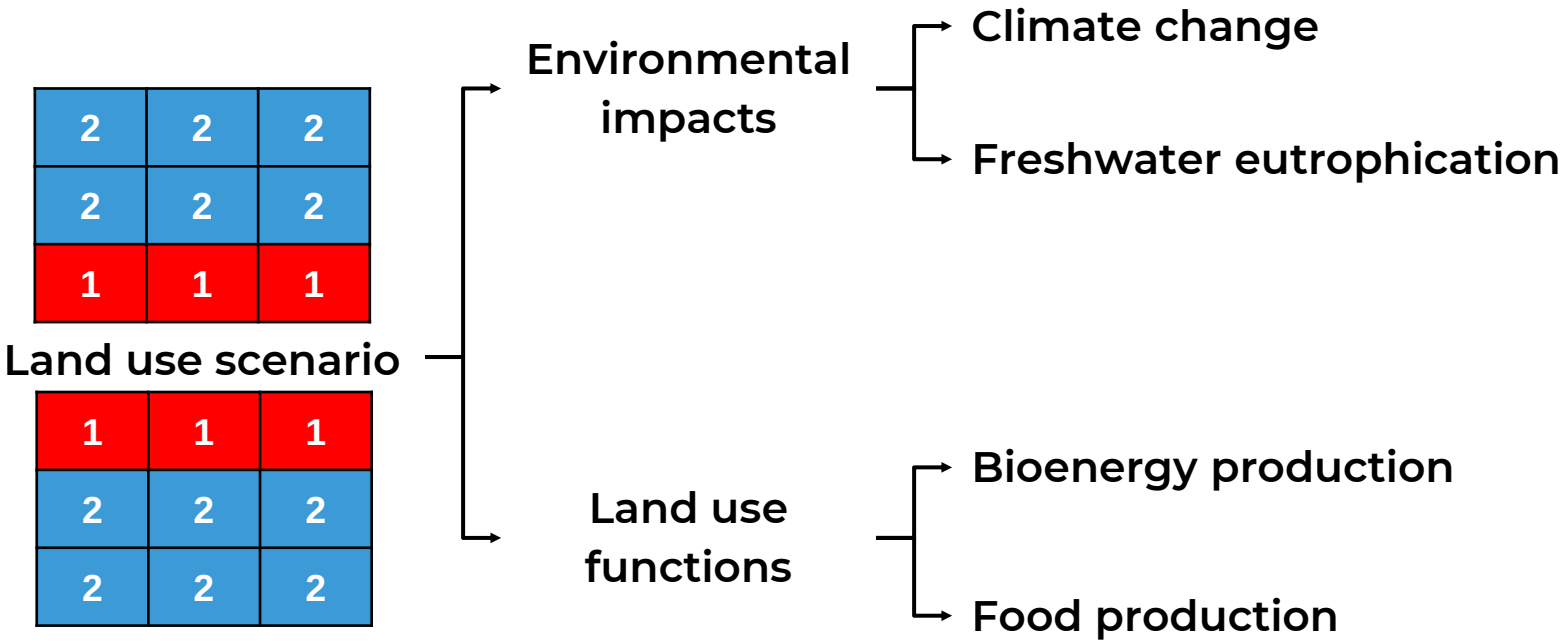
Climate change,
Eutrophication

Loiseau et al., 2013

Territorial Life Cycle Assessment

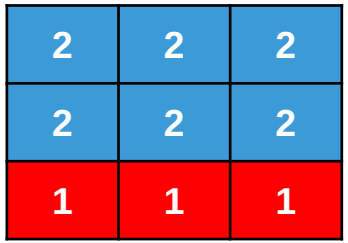


Territorial Life Cycle Assessment



Nitschelm et al., 2016

Spatial Territorial Life Cycle Assessment



Land use scenario

Environmental impacts

Spatial Climate change

Spatial Freshwater eutrophication

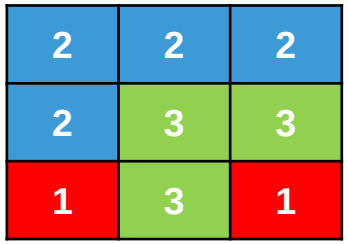
Land use functions

Spatial Bioenergy production

Spatial Food production

Geographical Information System (GIS)

Spatial Territorial Life Cycle Assessment



Land use scenario

Environmental impacts

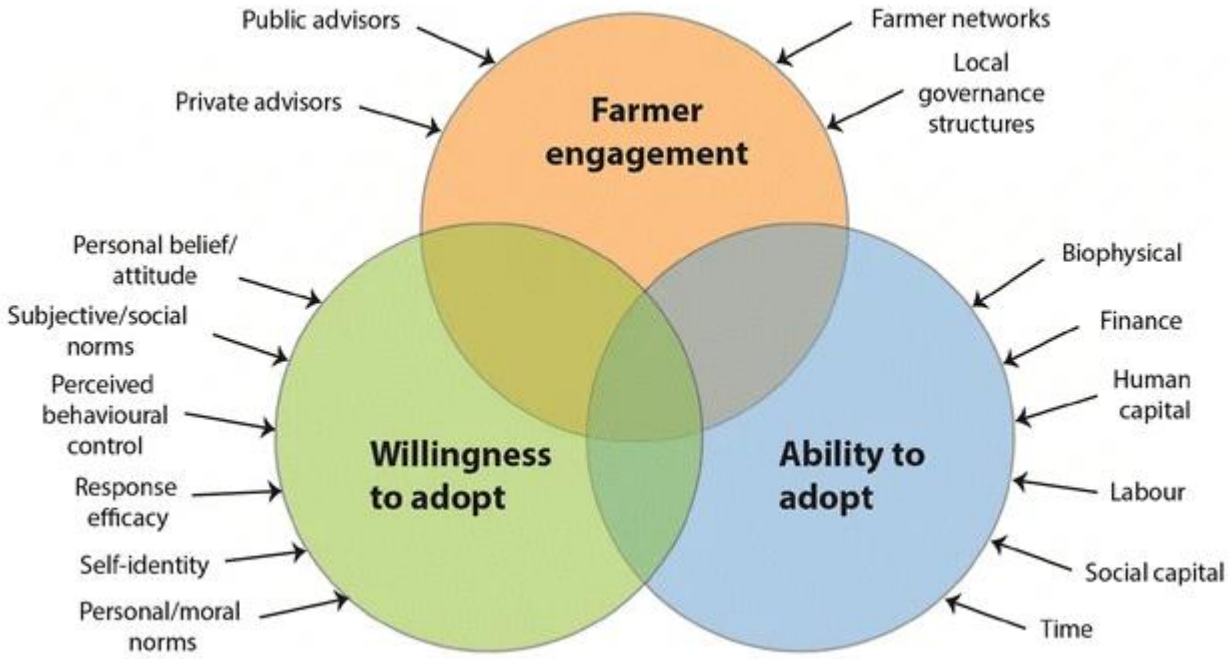
- Spatial Climate change
- Spatial Freshwater eutrophication

Land use functions

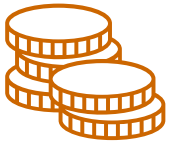
- Spatial Bioenergy production
- Spatial Food production

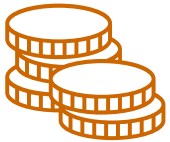
Mills et al., 2016

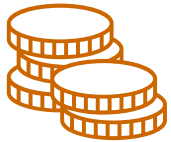
Factors influencing farmer decision-making



Agent Based Modeling







Time 0

2	2	2
2	2	2
1	1	1

Land use scenario

Time 1

2	2	2
2	3	2
1	1	1

Land use scenario

Time 2

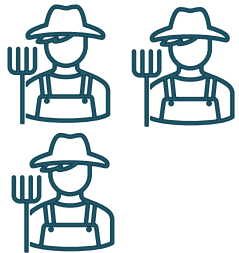
2	2	2
2	3	3
1	1	1

Land use scenario

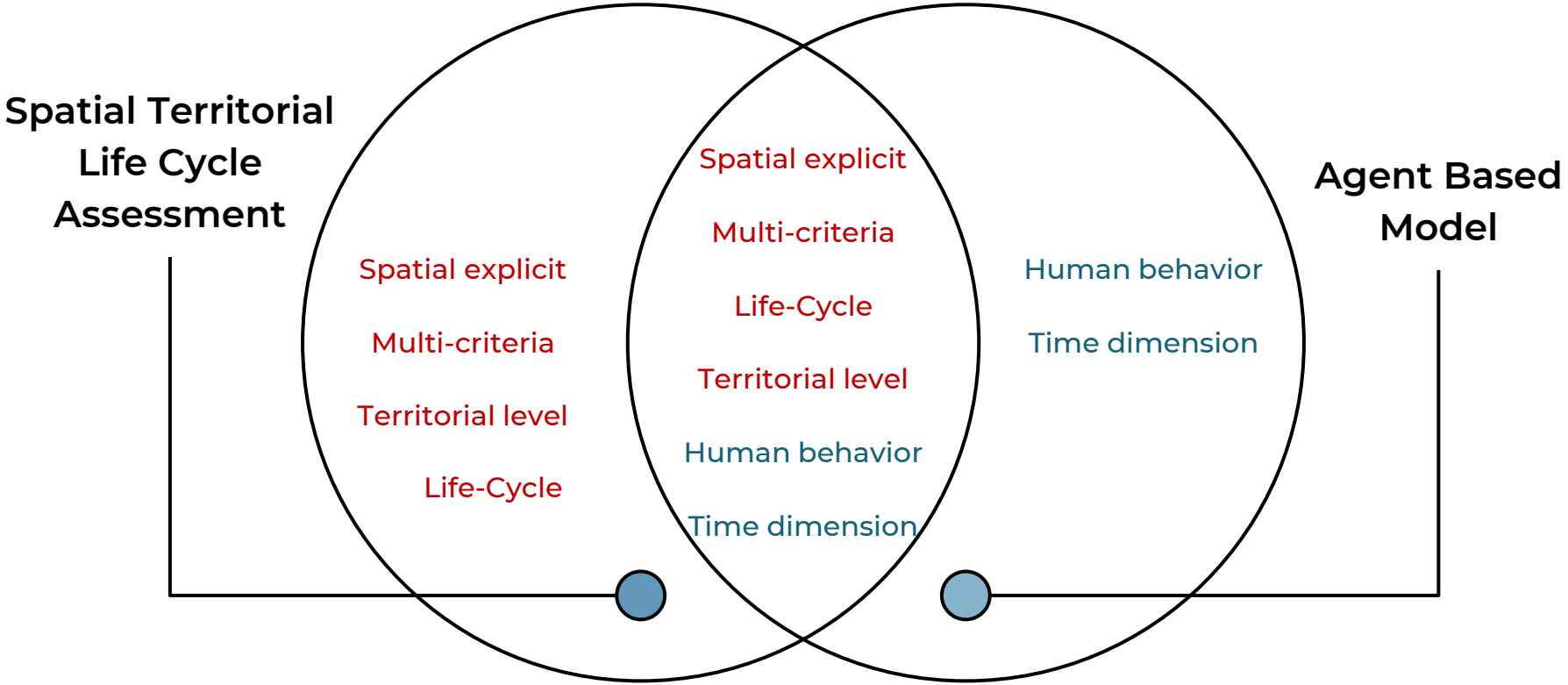
Time 3

2	2	2
2	3	3
1	3	1

Land use scenario

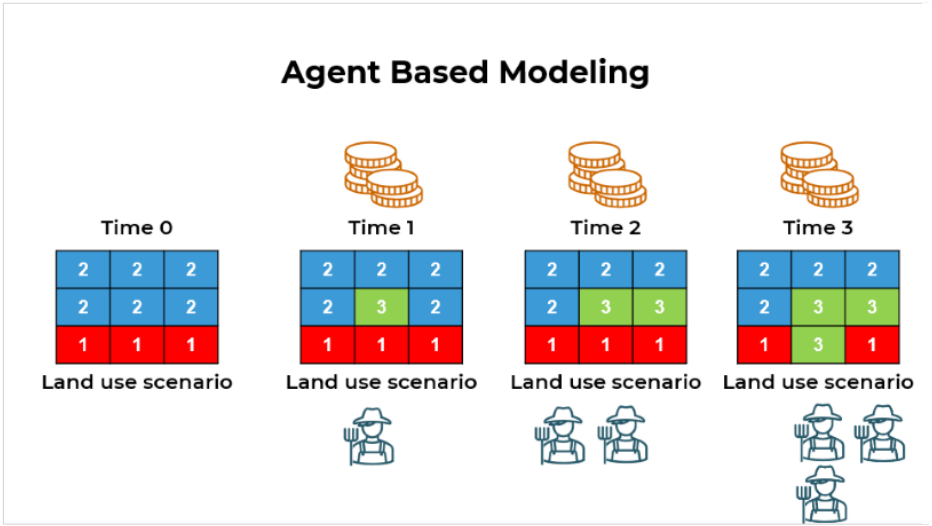


Linking Assessment with Simulation



Ding et al., 2023

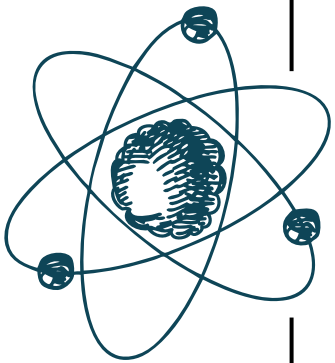
Framework



Spatial Territorial LCA

- Environmental impacts
  - Spatial Climate change
  - Spatial Freshwater eutrophication
- Land use functions
  - Spatial Bioenergy production
  - Spatial Food production

Spatial Territorial Life Cycle Assessment (LCA) – Agent Based (ABM)



01	Goal and scope	⟷	STLCA
02	Spatial specific inventory	⟷	ABM STLCA
03	Spatial specific impact assessment	⟷	STLCA
04	Interpretation	⟷	STLCA

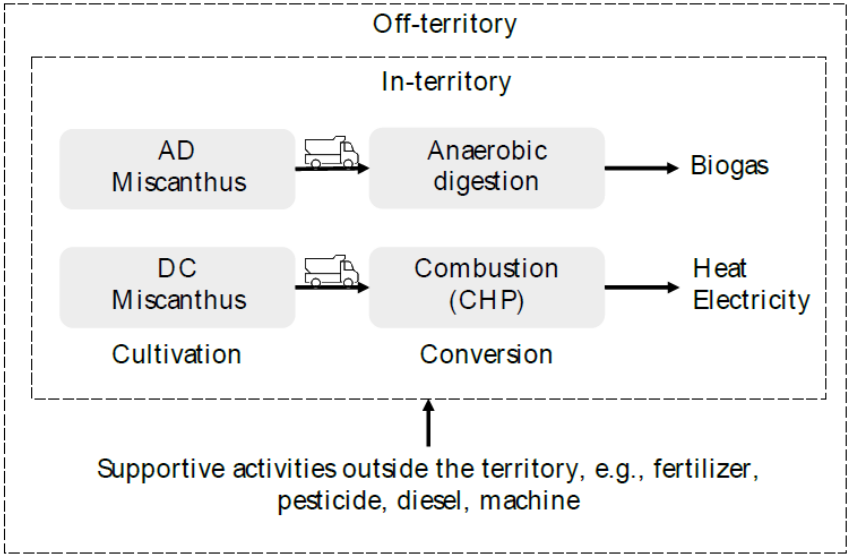
CASE STUDY

Managing for one year the agricultural territory that is currently occupied for animal production in the Walloon region (112 Kha), to produce various agricultural products.

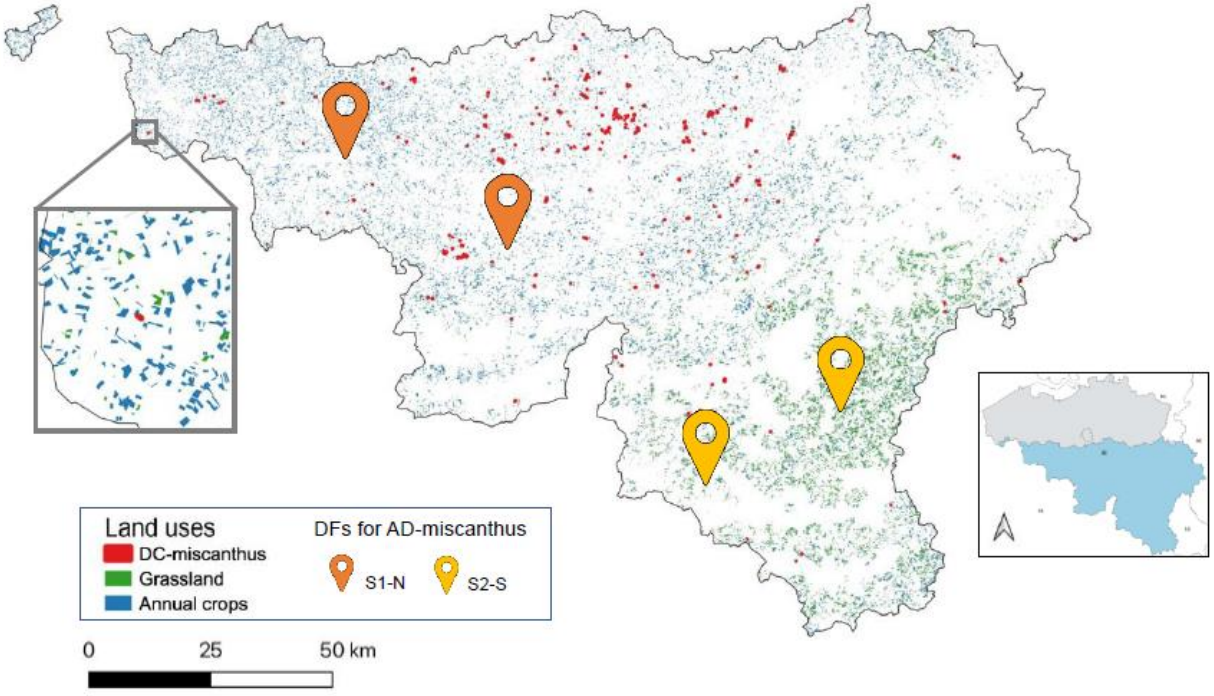
https://www.ft.com/content/e452383c-ee35-11e8-89c8-d36339d835c0

CASE STUDY

Managing for one year the agricultural territory that is currently occupied for animal production in the Walloon region (112 Kha), to produce various agricultural products.



Assumed Demonstration Farms & Subsidies



Assume adopters will be provided with subsidies over simulation time

Farmers' decision

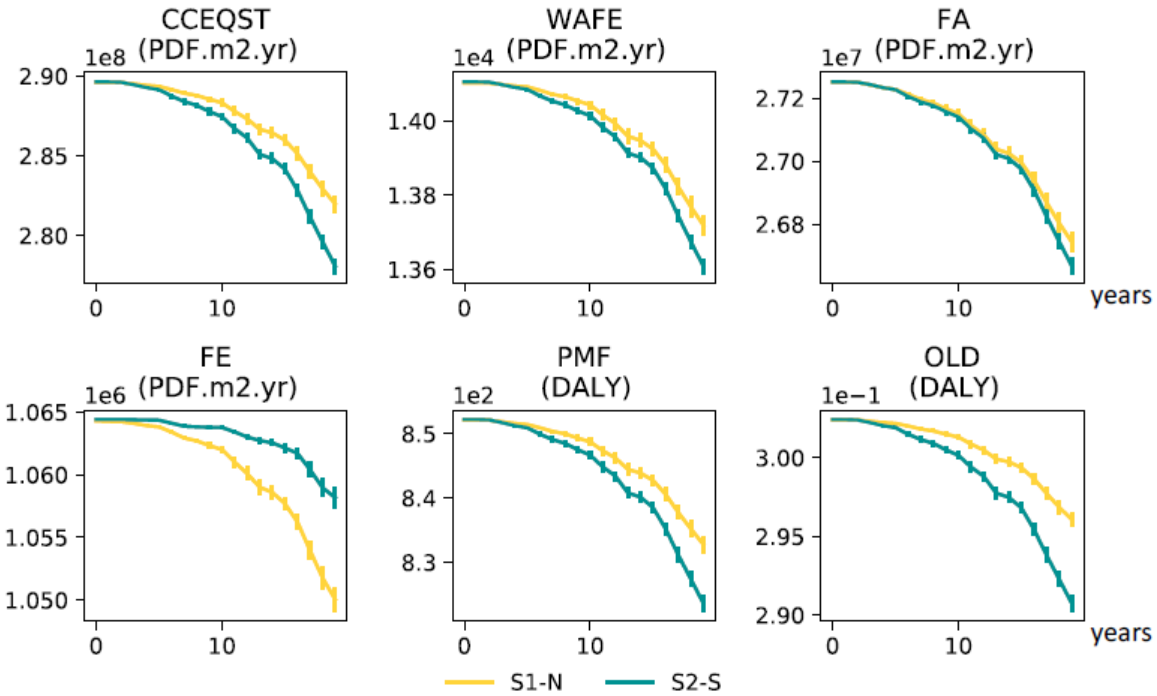
Potential profit
Neighbor profit
Own current profit

Farm size
Bigger farm, less risk aversion

Familiarity to bioenergy crops
Higher if closer to neighbor adopters

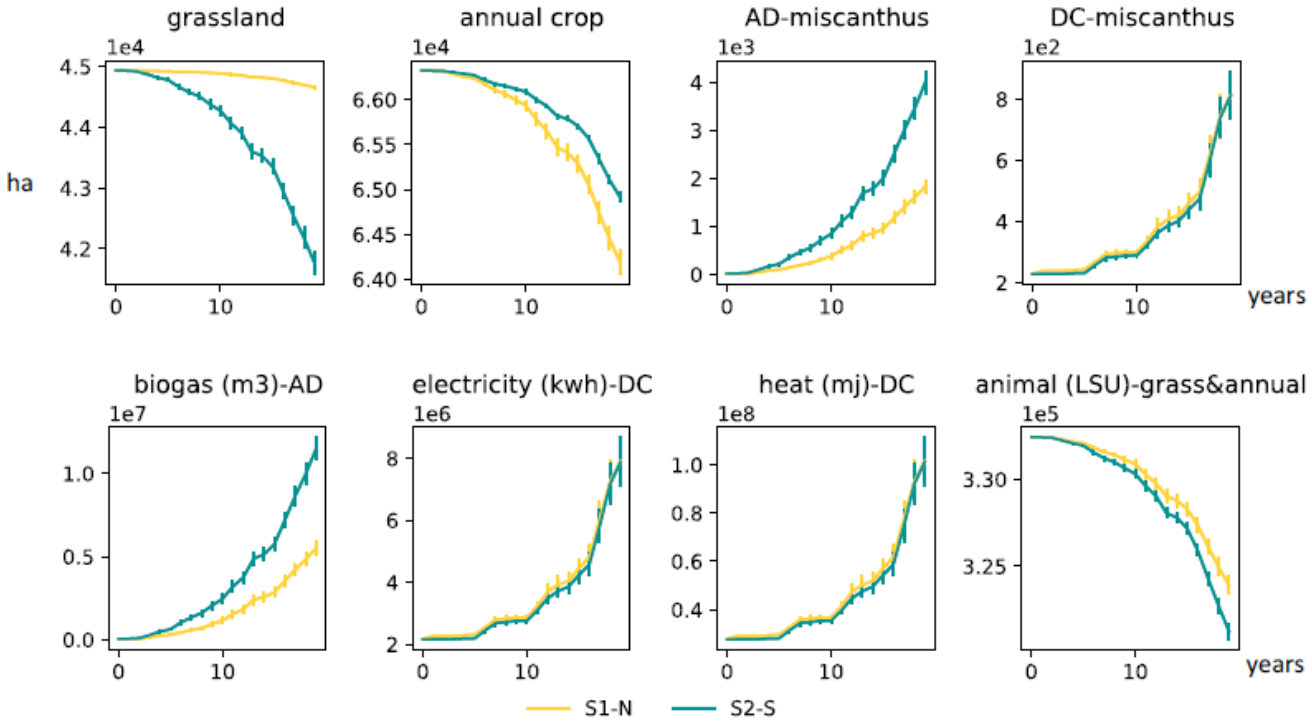
Probability to adopt

Simulated & Assessed Environmental Impacts



Different initial locations for demonstration farms would lead to different dynamic impacts at the territorial level.

Simulated & Assessed Land Use Functions



Different initial locations for demonstration farms would lead to different dynamic land use functions at the territorial level.

Decision support for land use planning

Where to locate demonstration farm?

How much incentives needs to be considered to reach the bioenergy target?

Need social science, local survey data to back up

Thanks!

Do you have any questions?

tianran.ding@list.lu

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Coupling agent-based modeling with territorial LCA to support agricultural land-use planning

Tianran Ding *, Wouter M.J. Achten **

Institute for Environmental Management and Land-use Planning, Université Libre de Bruxelles (ULB), Av. F.D. Roosevelt 50, 1050, Brussels, Belgium

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ABSTRACT

Life cycle assessment (LCA) is applied to assess large-scale systems supporting policymaking. However, most LCA studies focused on evaluating the impacts of policies and strategic planning on a static basis ignoring the dynamic nature of the territory in which the policies are implemented. This study aims to develop a dynamic territorial LCA approach, linking agent-based modeling (ABM) with the territorial LCA approach. ABM is a widely used tool to simulate dynamic emerging systems considering human factors, and the territorial LCA is a recently developed approach featuring assessing multi-functional territories. To prove the concept, the framework of the dynamic territorial LCA was implemented in a case study of promoting bioenergy crops in an agricultural territory of the