



Representing Human Agency in Land Use Models



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Methods and approaches to modelling the Anthropocene

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Highlights

- Socio-ecological system dynamics of the Anthropocene require novel modelling approaches.
- Models need to capture emergent properties, regime shifts and feedbacks between system components.

Human decision making and responses are essential components of Anthropocene

Including and representing human behavior

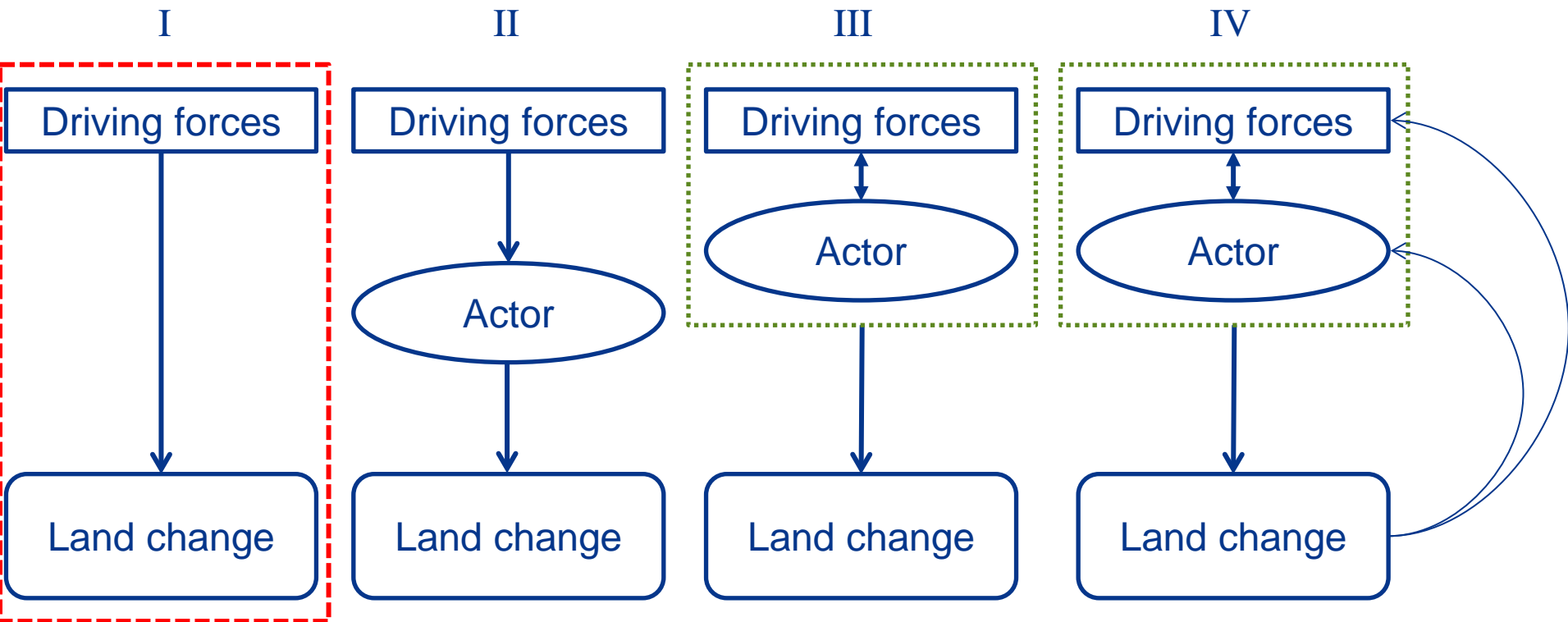
....many uncertainties in the abiotic and biotic system remain....

....But, human systems are in integrated models often much more poorly represented as compared to biophysical processes.....

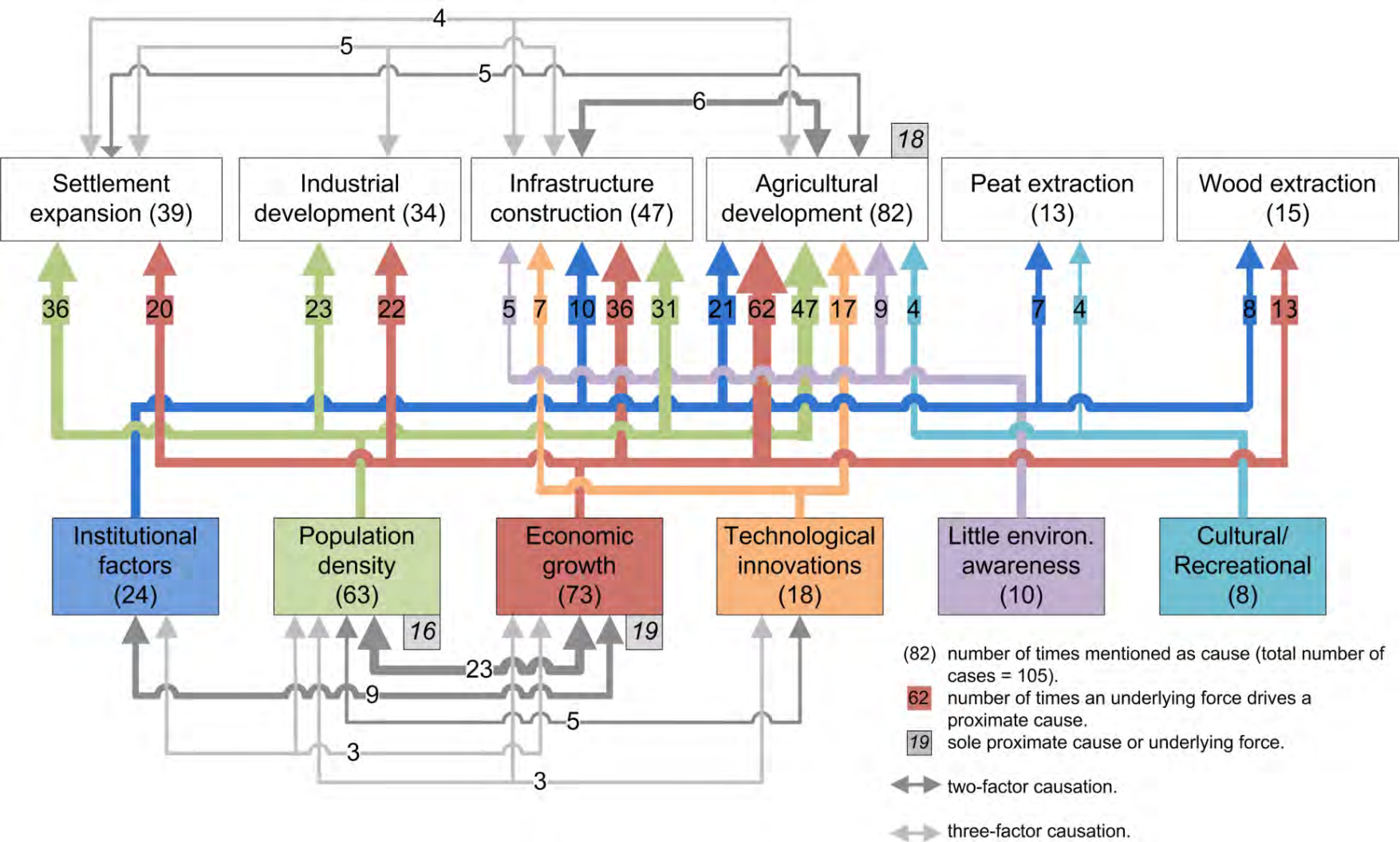
....while humans are the main driver of environmental change...



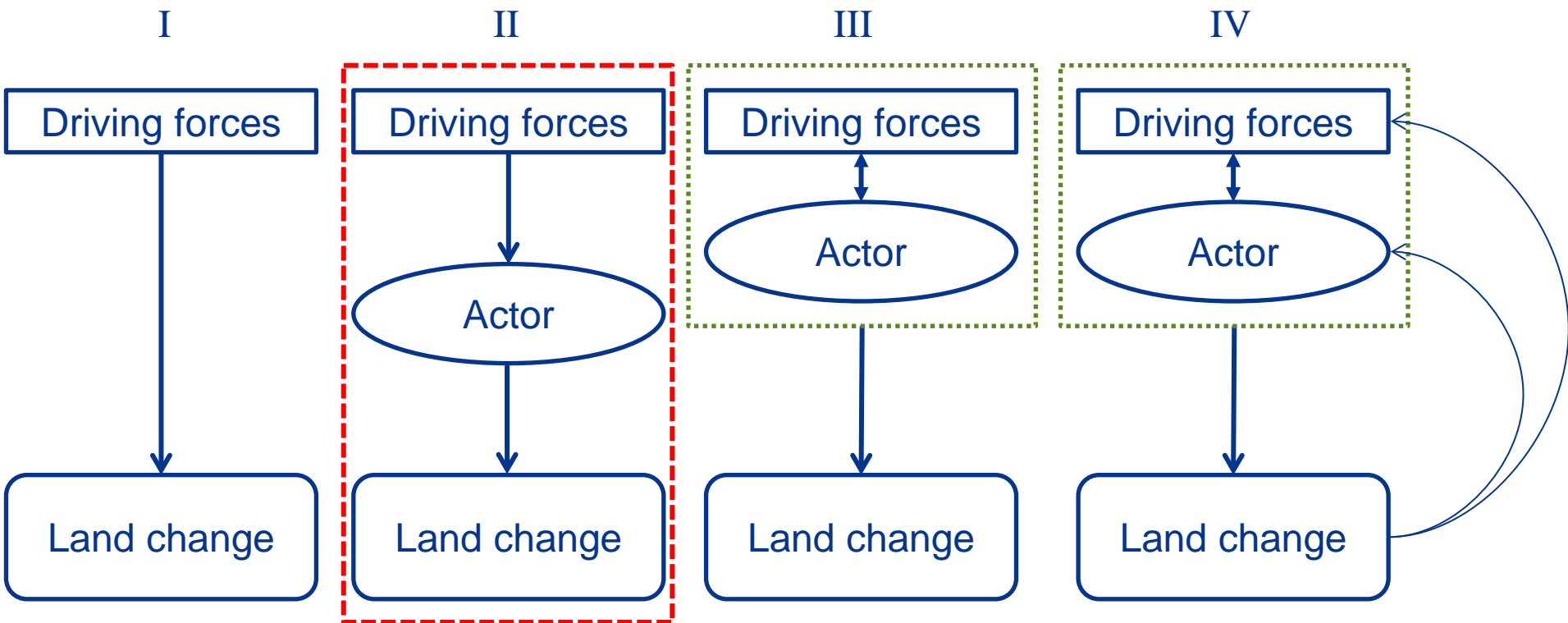
Conceptualisations of land systems drivers

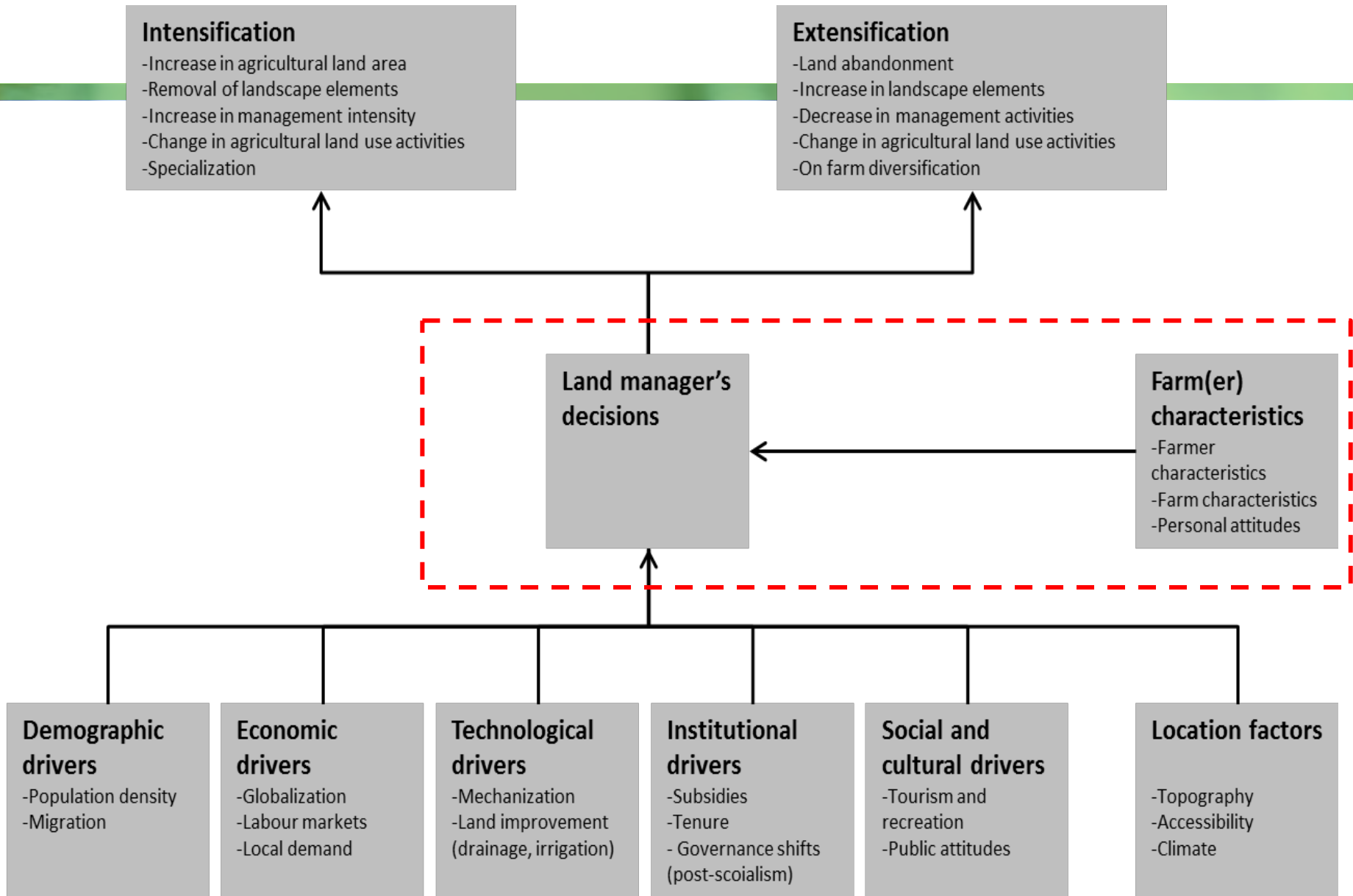


'Classical' synthesis: count of most important drivers



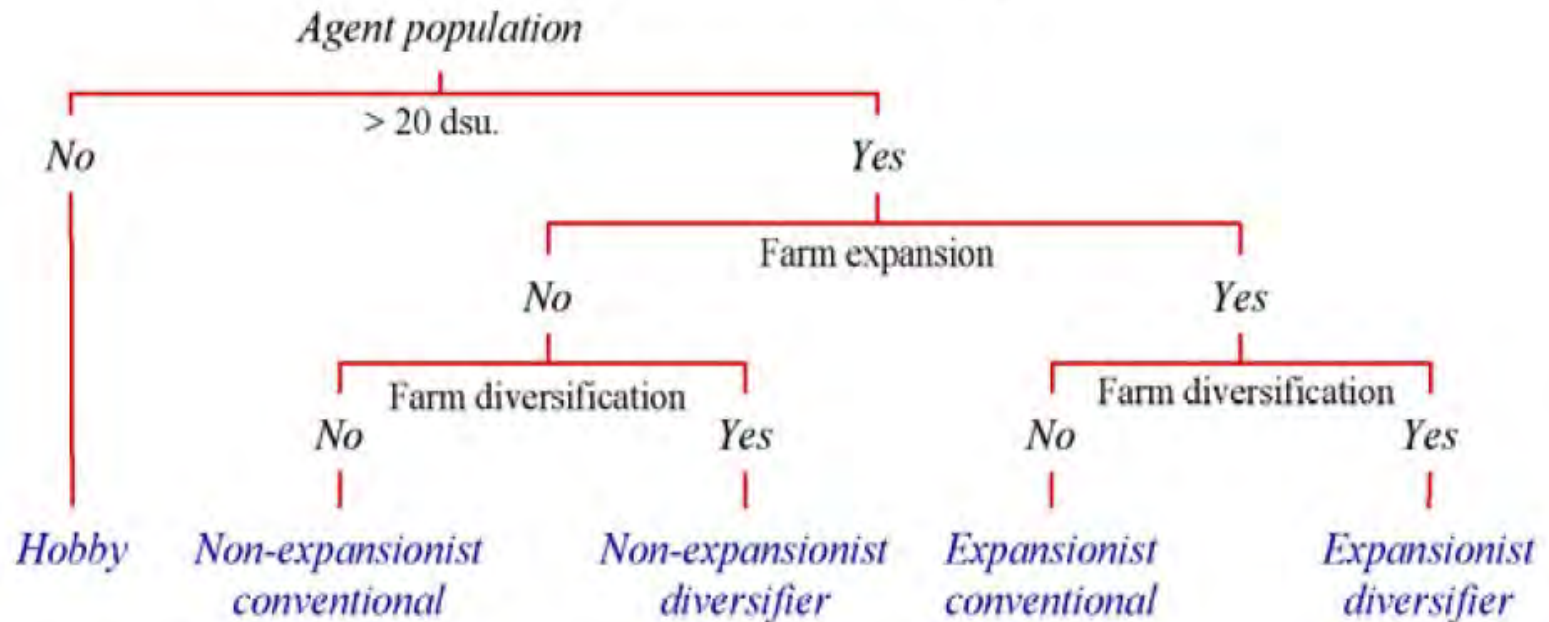
Conceptualisations of land systems drivers





Agent typology

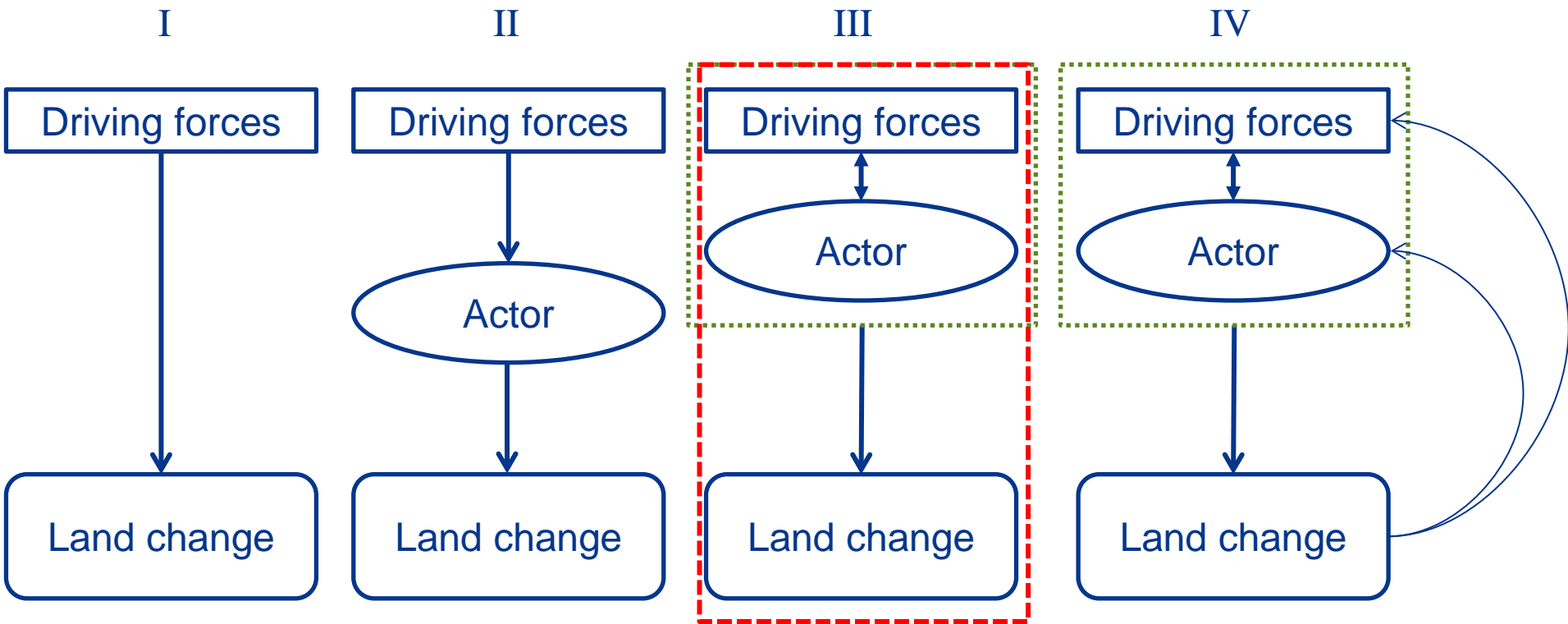
Agent typology



Agent type parameterization: production strategies

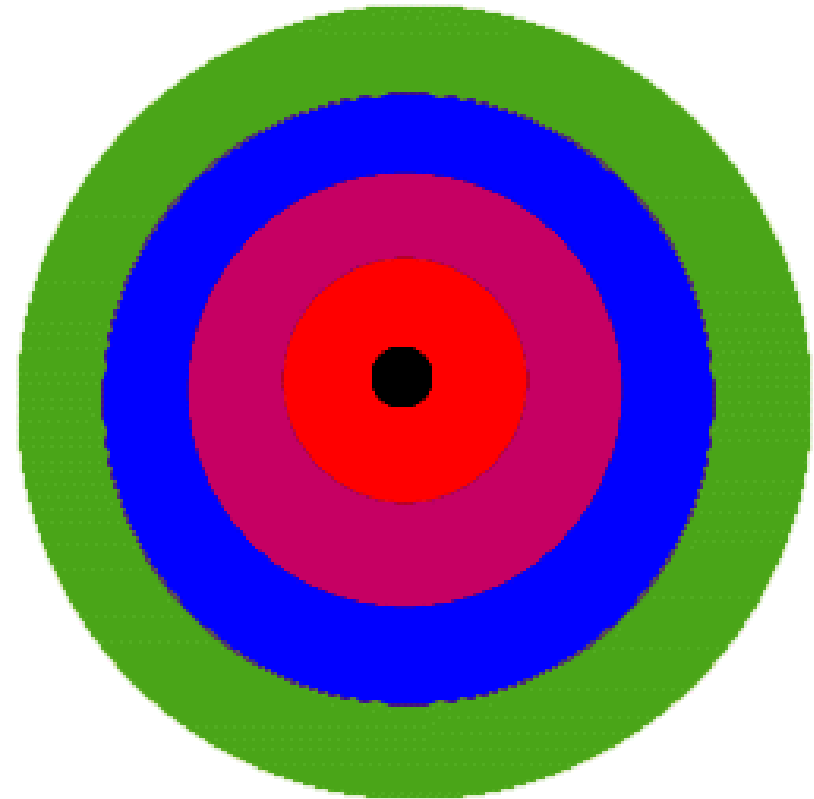
Agent type	Stop farming	Increase production	Decrease production	Diversify farm practices	Compensation schemes	Tourism and recreation
Hobby farm	+	-	+	-	-	+
Non-expansionist conventional	+	-	+	+/-	+/-	+
Non-expansionist diversifier	+	-	+	+	+	+
Expansionist conventional	-	+	-	-	-	-
Expansionist diversifier	-	+	-	+	+	+

Conceptualisations of land systems drivers



the Von Thünen model

- Economic theory:
 - People optimize profit
 - Land rent is determined by the market price, land quality and transport costs
 - Land use is therefore determined by market conditions and the distance to the market



Central City

Intensive Farming/Dairying
Forest

Extensive Field Crops

Ranching/Animal Products

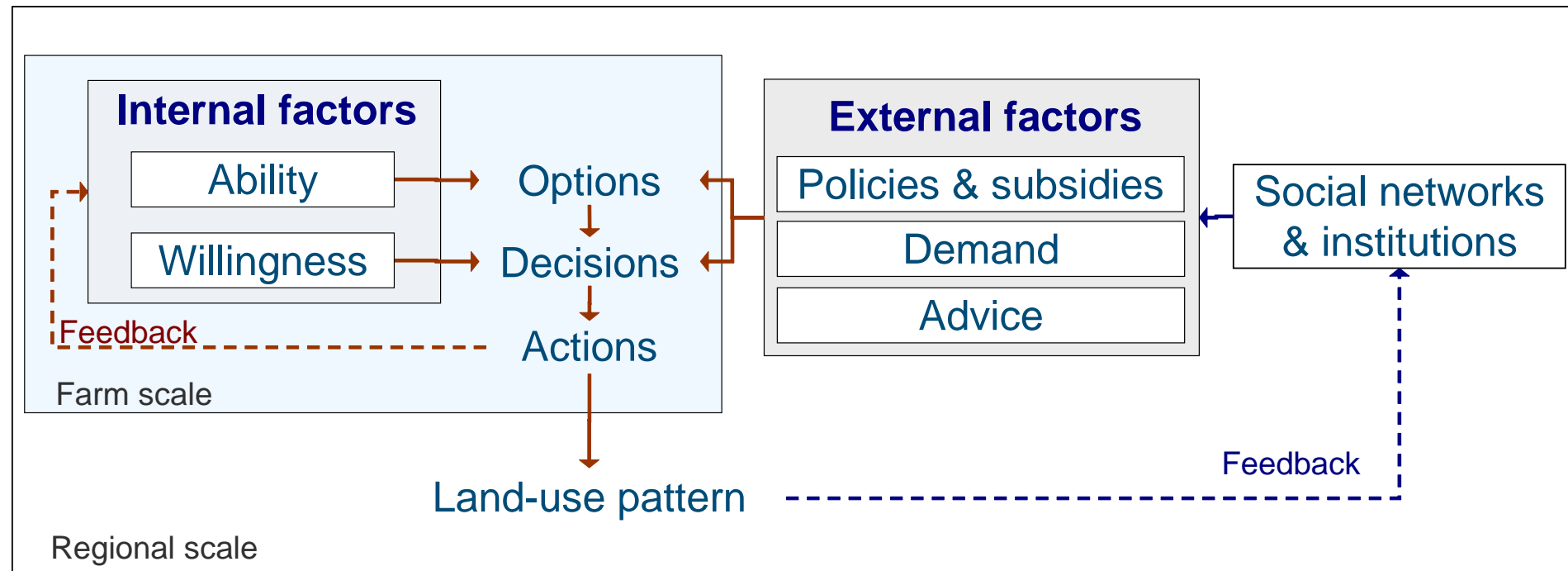
Matt T. Rosenberg, 1997



Implementation of decision making in models

- Hierarchical allocation: allocating 'highest land rent' locations to specific land uses following a hierarchy (urban > agriculture > grassland/forest > rest/nature)
- Equilibrium/partial equilibrium/optimization approaches optimizing total land rent (competition amongst land uses)
- Rule-based allocation (often using land rent based rules or cost-benefit analysis)

Agents' decision-making



Agent-objectives influencing land use decisions

Environmental objectives

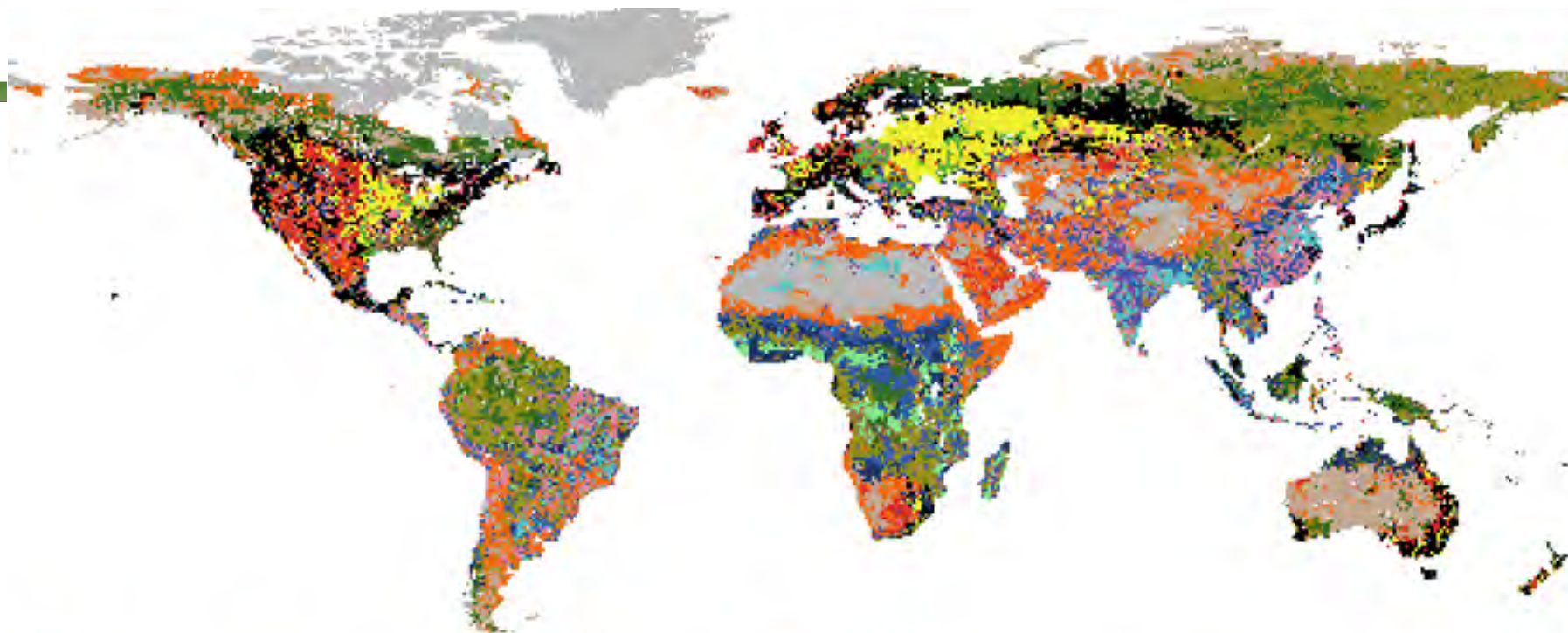
Self-realization objectives

Economic objectives

Security objectives

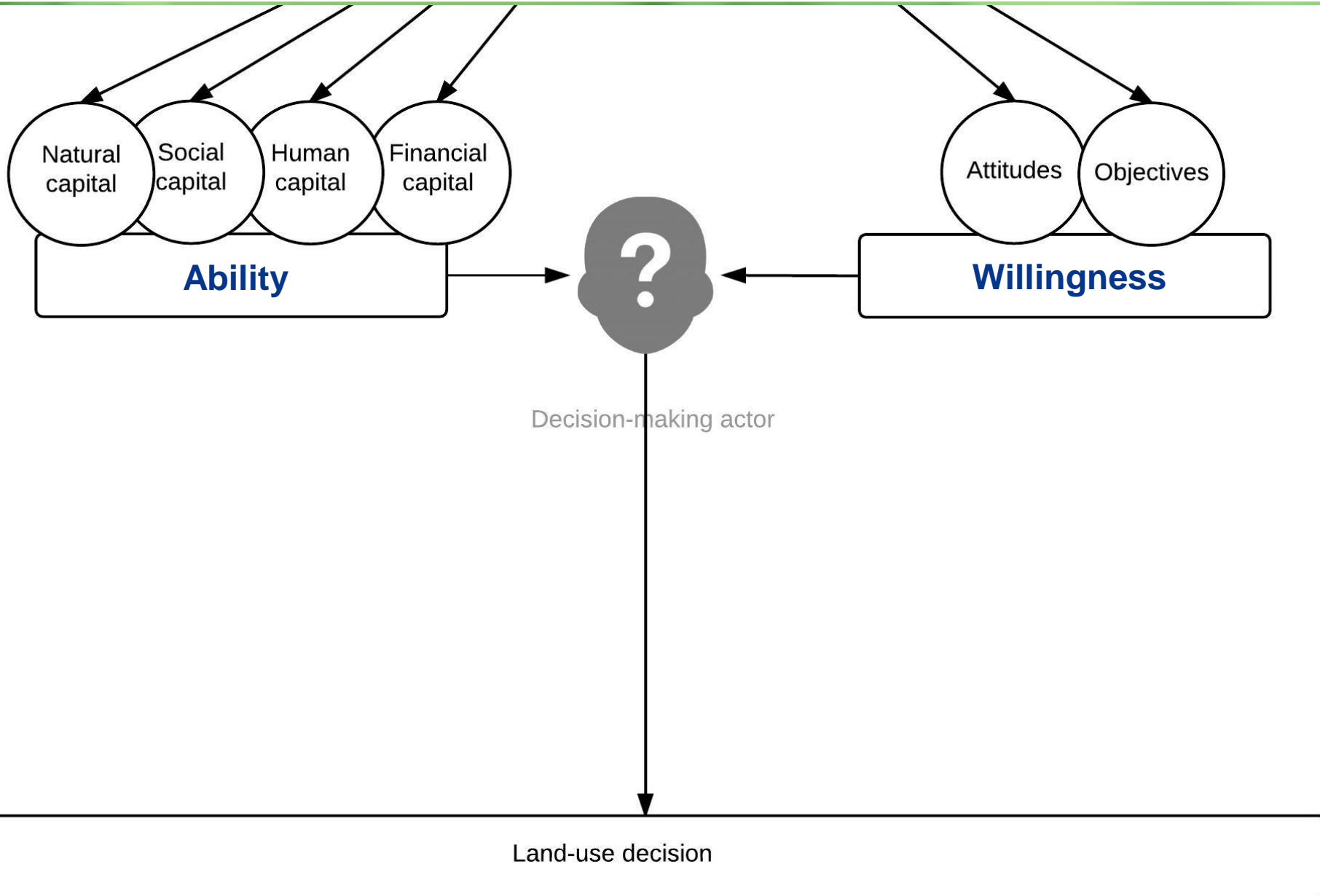
Prestige objectives

	Security objective	Environmental objective	Economic objective	Prestige objective	Self-realization objective	Mode: constraints*	Mode: trade-off factors*	Gross domestic product (US \$)	Upfront capital index	Social power rank
Lifestyle land owner	0	0.7	0.3	0	1	[4 1]	[2]	40000	3	5
Western small-scale primary-sector family enterprise	0	0.2	0.8	0	0	[]	[1 2]	100000	3	4
Western large-scale primary-sector family enterprise	0	0.1	0.9	0	0	[]	[1 2]	300000	4	3
Western very-large-scale primary-sector enterprise	0	0	1	0	0	[]	[2]	1000000	4	2
Tolerated traditionalist	1	1	0	0	0	[0 1]	[2]	5000	2	8
Oppressed traditionalist	1	0.2	0.2	0	0	[0]	[1 2]	3500	1	9
Surviver	1	0.2	0.2	0	0	[0]	[1 2]	3500	2	10
Uprooted survivor	1	0	0.5	0	0	[0]	[2]	3500	1	11
Traditional diversifier	1	0.3	0.5	0	0	[0]	[1 2]	10000	2	7
Traditional medium-poverty family enterprise	0.8	0.2	0.5	0	0	[0]	[1 2]	15000	2	6
Commercial mega company	0	0	1	0	0	[0]	[2]	10000000	4	1
Latifundio enterprise	0.5	0	0.2	1	0	[3]	[2]	500000	3	3
Gaicho enterprise	0.5	0	0.5	0.5	0	[0]	[2 3]	15000	2	7
European colonist smallholder	0.5	0.4	0.5	0	0	[0 1]	[1 2]	15000	2	6
Collective worker household	1	0	0.5	0	0	[]	[2]	10000	4	10
Transformed collective	0.5	0	0.5	0	0	[0]	[1 2]	1000000	4	3
Artificial medium-poverty family enterprise	0.5	0	0.5	0	0	[0]	[2]	20000	2	8
Poor self-sufficient	0.5	0.5	0	0	0	[0 1]	[2]	10000	0	8

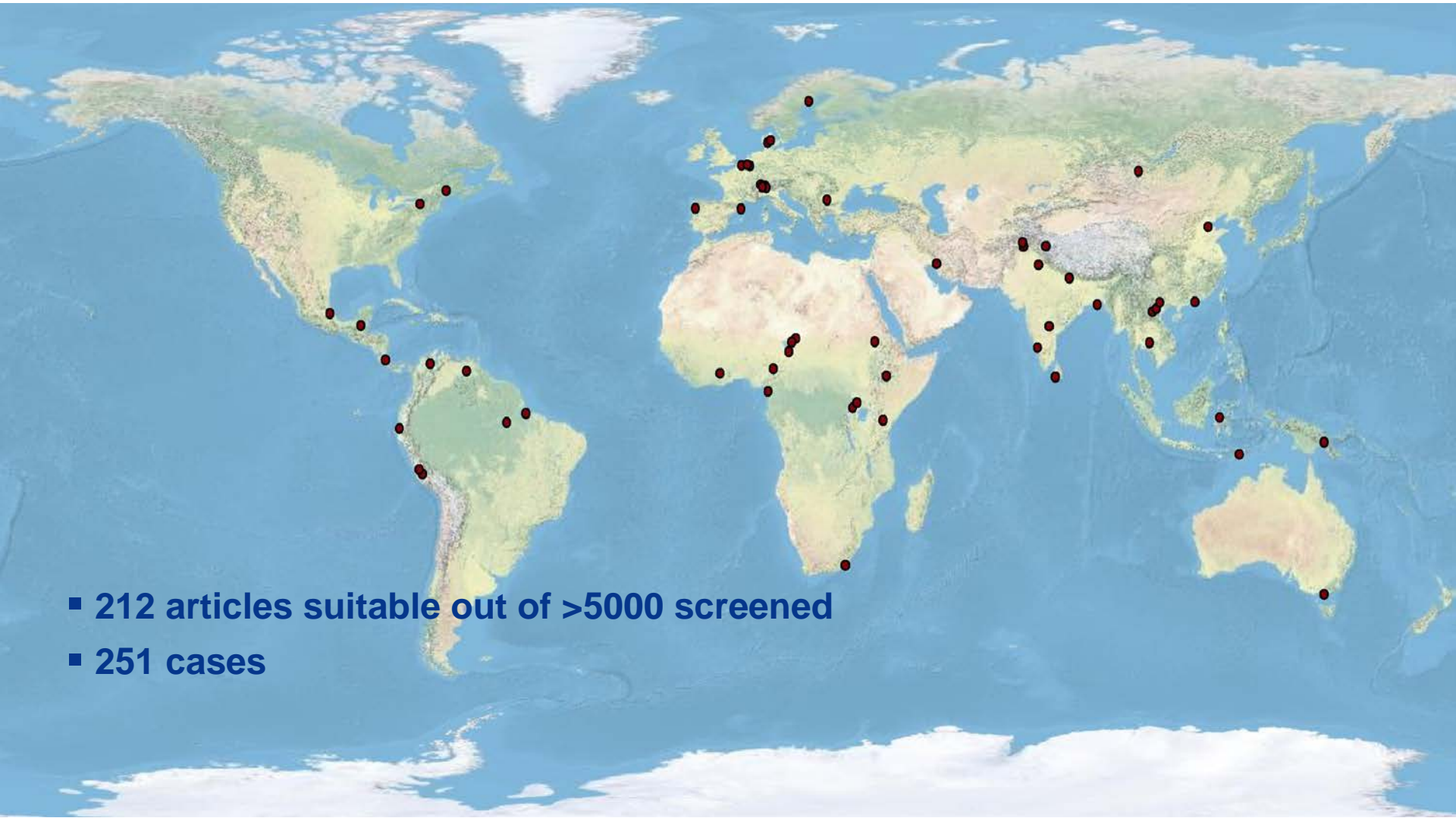


- | | |
|--|---|
| Shifting cultivation | Machinery-based commercial monocultures |
| Semi-permanent cultivation system | High-tech commercial monocultures |
| Permanent subsistence rainfed cultivation | Smallholder mixed tree-crop plantations |
| Permanent subsistence mixed farming | Forest gardens |
| Permanent cash-crop low-input rainfed cultivation | Indigenous natural forest management |
| Permanent subsistence wet-rice farming | Commercial tree-crop plantation monocultures |
| Commercial wet-rice farming | Selective logging |
| Subsistence non-rice irrigation | Clear-cutting |
| Nomadic herding | Modern sustainable forest management |
| Permanent grassland-based livestock system | Hobby agriculture |
| Western family-based mixed farming | |

Meta-analysis of land use decision making



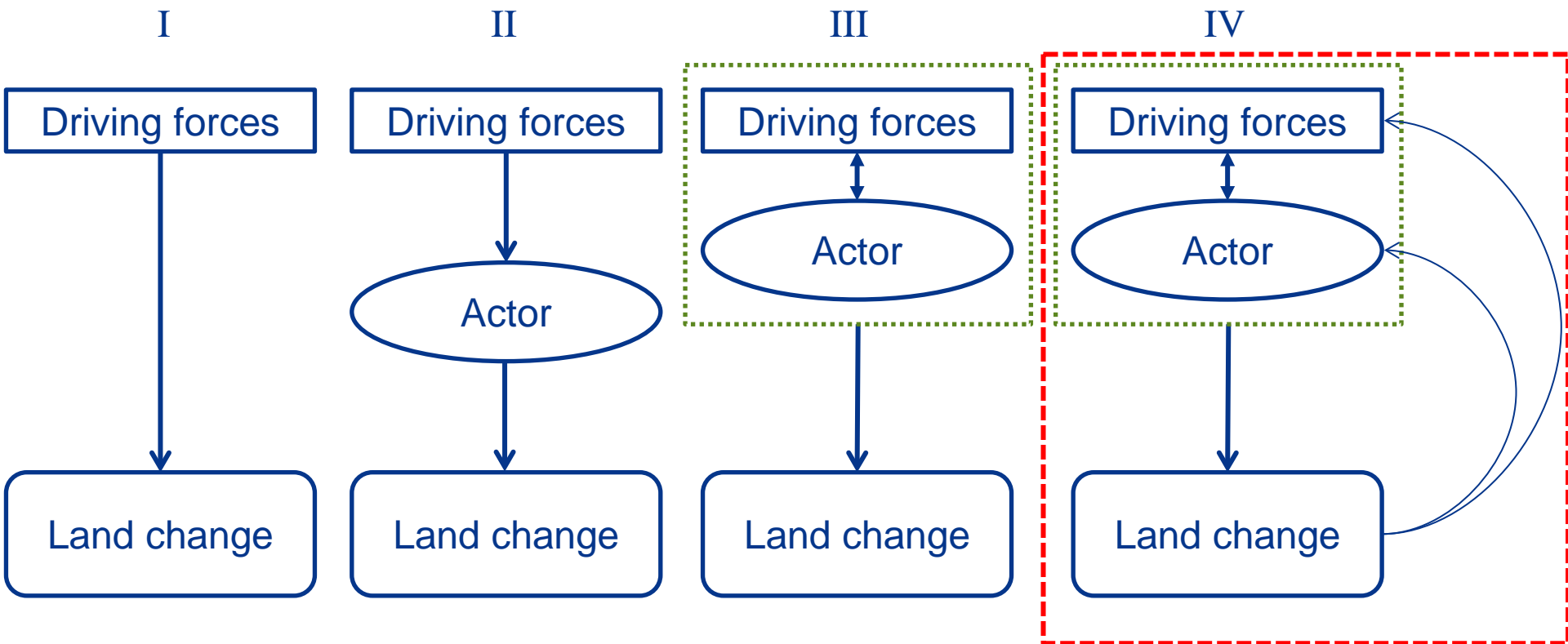
Meta-analysis of land use decision making



- 212 articles suitable out of >5000 screened
- 251 cases

Cluster	Objective	Attitude	Ability
Cluster 1	Livelihood security, moderate economic growth	High biospheric values, progressive	High land tenure security, social safety nets
Cluster 2	Lifestyle, environment and economic	High environmental values, progressive, law obedient	High financial, natural and social capital
Cluster 3	Economic, environment and social prestige	Progressive, law obedient	Highest financial, natural and social capital
Cluster 4	Economic and livelihood security	progressive	Moderate financial capital, land size, land tenure security
Cluster 5	Livelihood security and economic	Progressive, biospheric values	Low financial and natural capital, high social capital
Cluster 6	Survival	Conservative	Lowest financial, natural and social capital

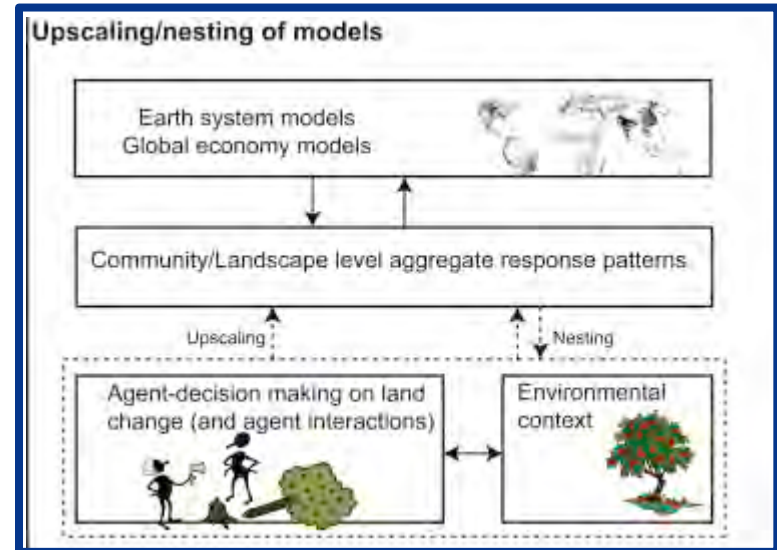
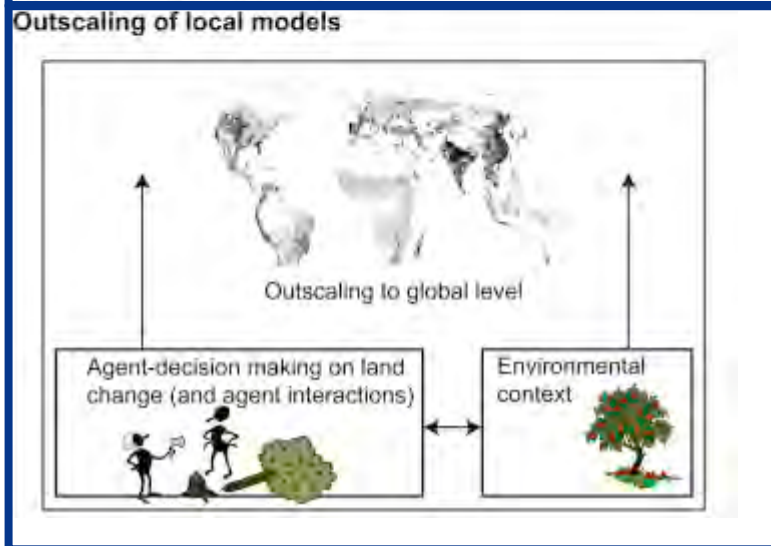
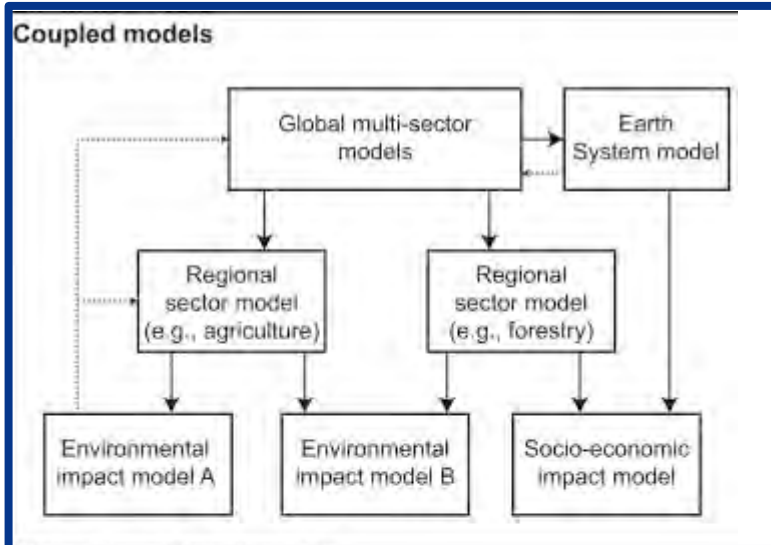
Conceptualisations of land systems drivers



Feedbacks

- Adaptation and mitigation strategies to environmental change
 - Telecoupling (feedbacks across a distance/scales: markets, governance, people, conflict)
 - Learning and developing (innovation, scale enlargement) towards different decision making strategies
- ➔ Behavior and land use decision making are not static and constant as our models assume...
- ➔ The rules of the game are changing....

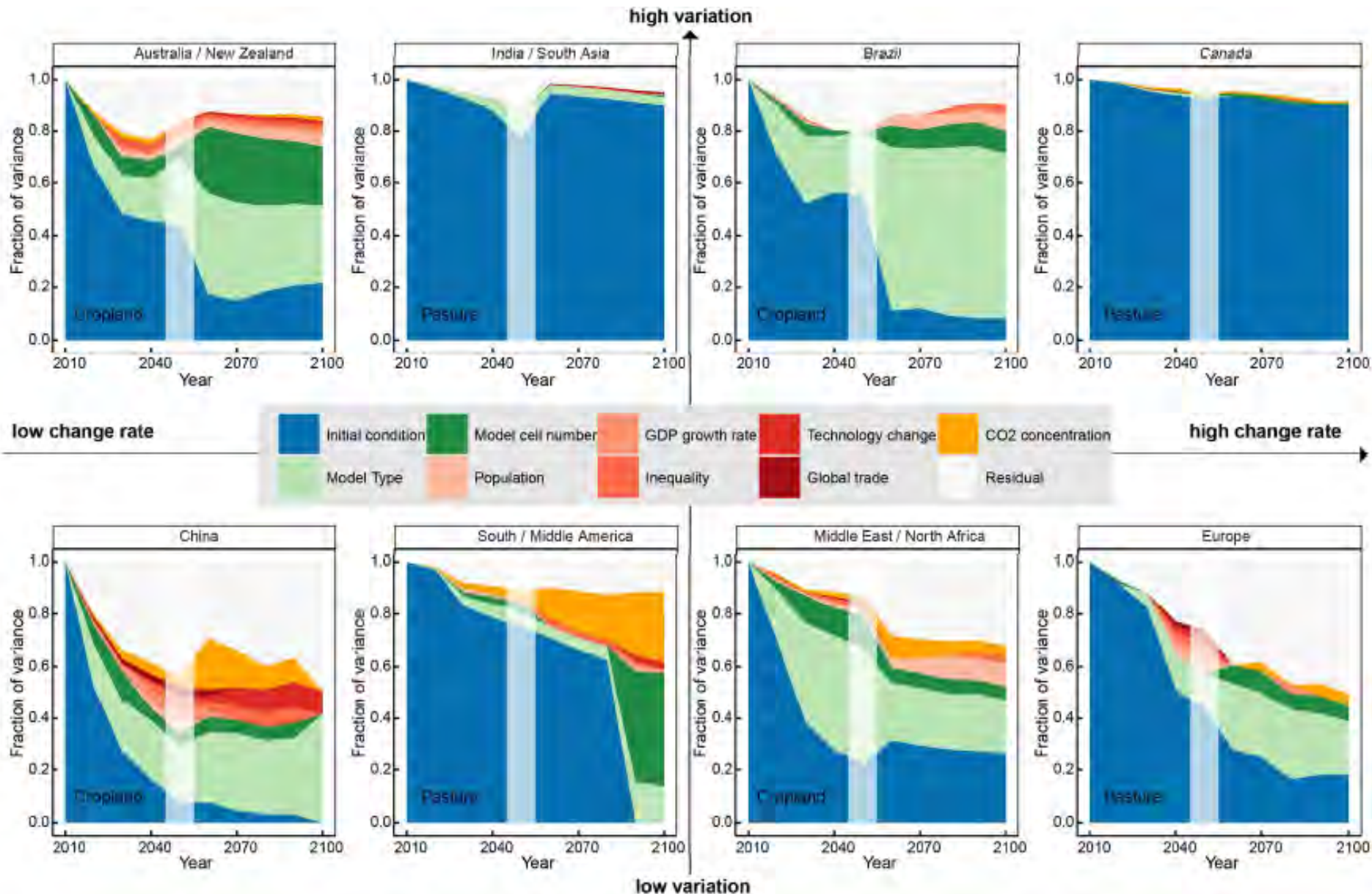
Representing multi-scale interactions and feedbacks



The future of land use modelling

- High uncertainties inherent to modelling socio-ecological processes
- Similarities between current assessment models in representation of human dimensions are likely to underestimate the real uncertainty

Decomposition of variation



The future of land use modelling

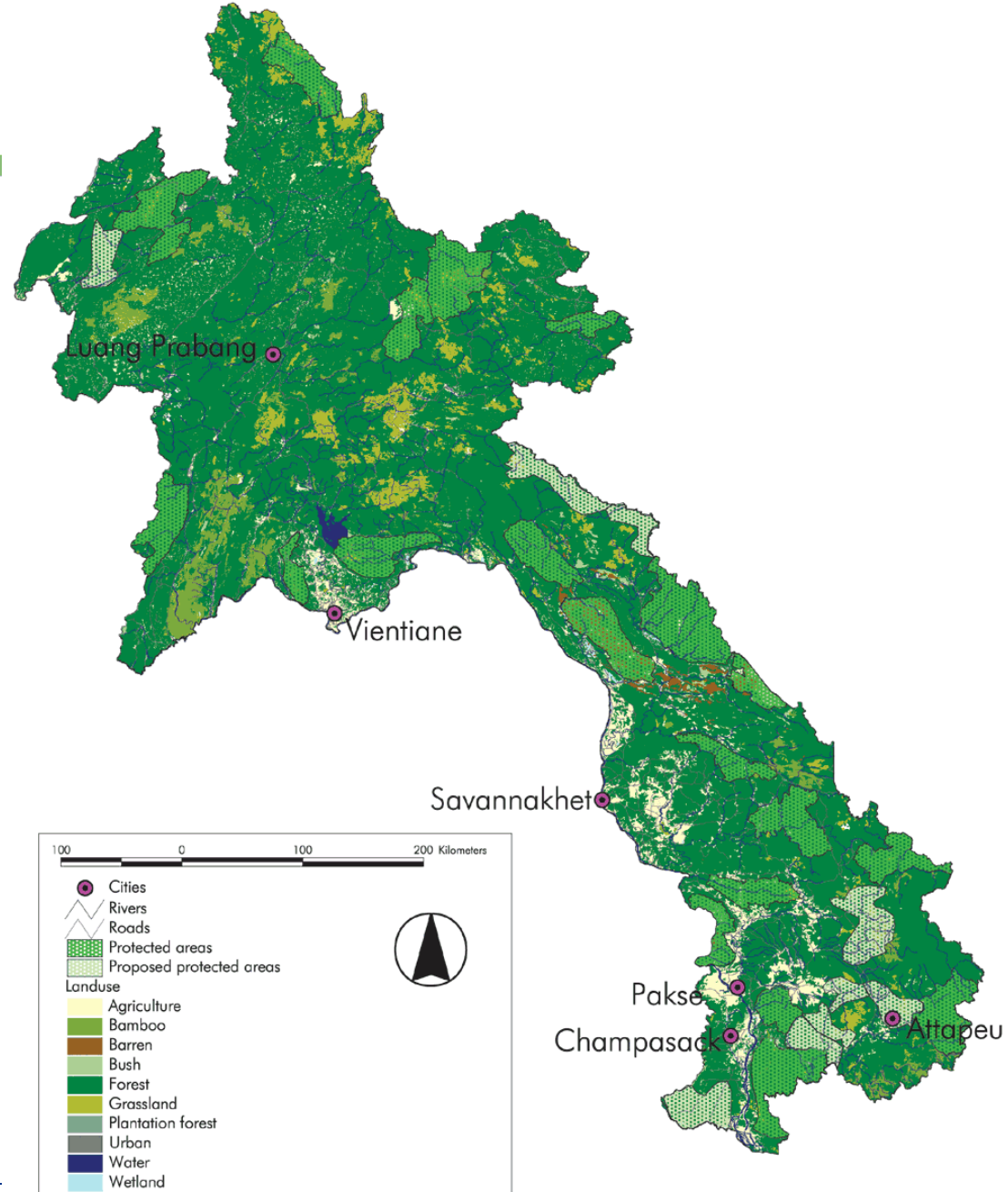
- High uncertainties inherent to modelling socio-ecological processes
- Similarities between current assessment models in representation of human dimensions are likely to underestimate the real uncertainty
- Alternative ways of representing human dimensions in land use modelling is critical
- Agent-based modelling is NOT the only way forward (as many agent-based models start resembling pixel-based models)

The future of land use modelling

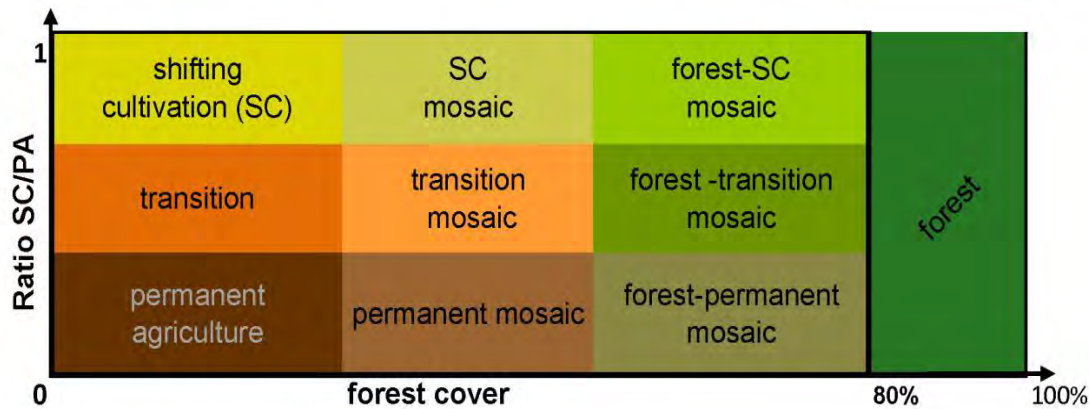
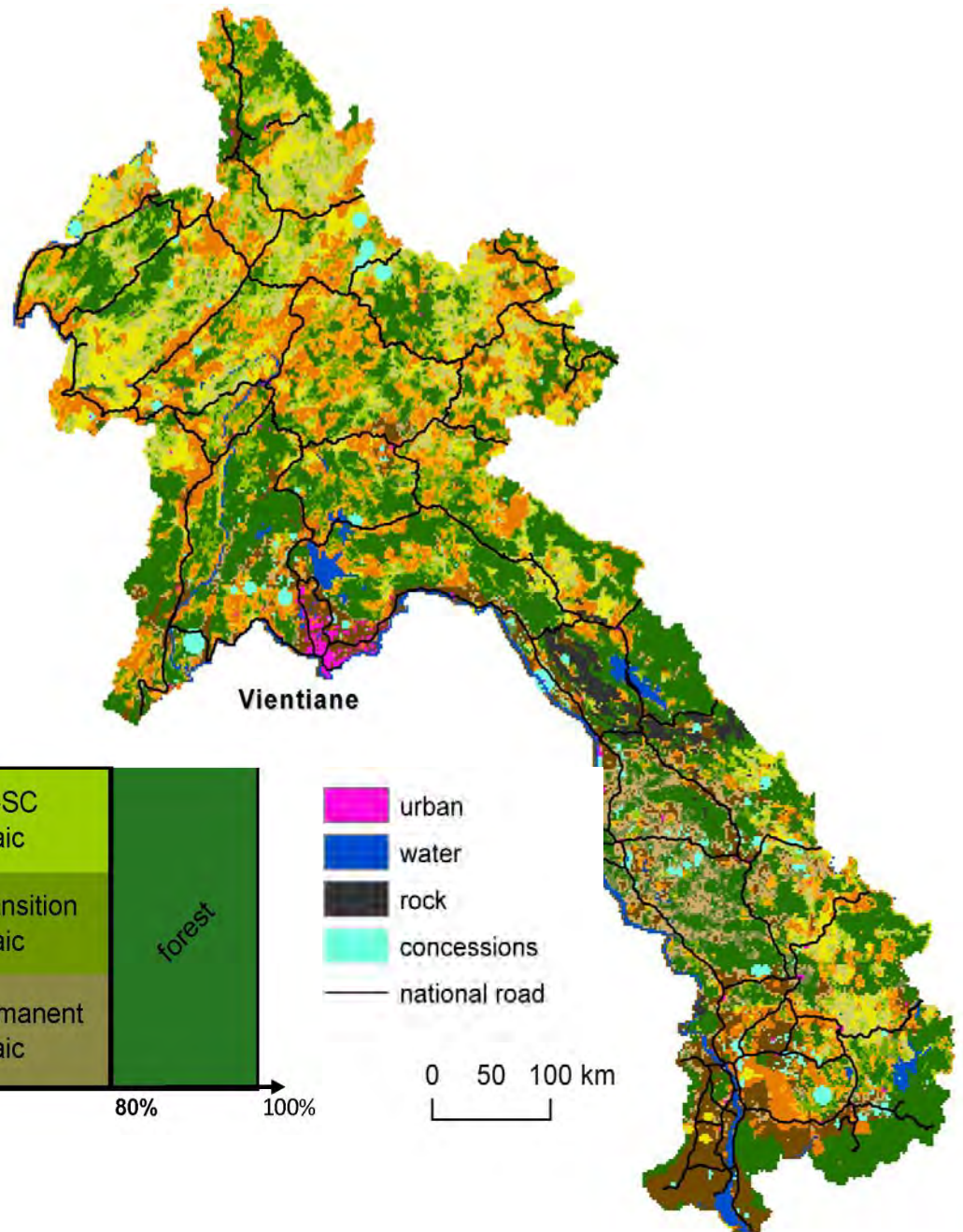
Ways forward:

- empirical work in 'measuring' and 'characterizing' land use decision making to underpin model algorithms
- move away from: one size fits all, vary decision making in space and time (adapt model rules 'on the go')
- new land use representations in large scale models
accounting for land management: a land systems approach

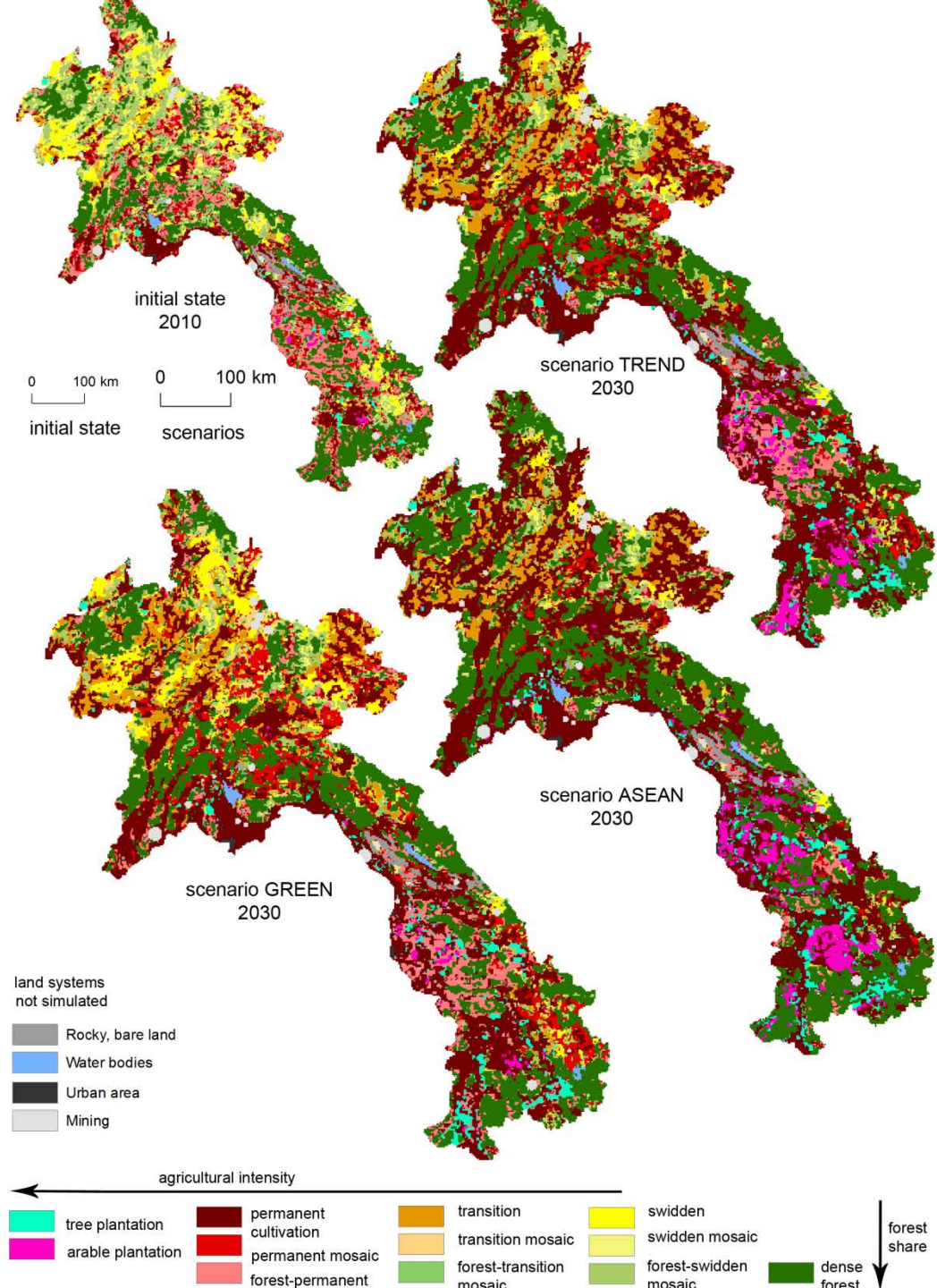
Land cover map of Laos



Results



Regime shifts in land systems and landscapes



What does it take?

- Respect the variation in land use models (move away from a fixed set of IPCC IAM models and MIP type of exercises that lead to convergence of models)
- Bring modelers and case-study scientists together:
 - SIMPLIFY THE COMPLEXITY OF THE REAL WORLD
 - REPRESENT THE DIVERSITY OF THE REAL WORLD
- Invest in model building rather than in model application

