

Federal Research Institute
for Forest, Snow and Landscape
Switzerland



Interdisciplinary approaches to *Land Use Change allocation*

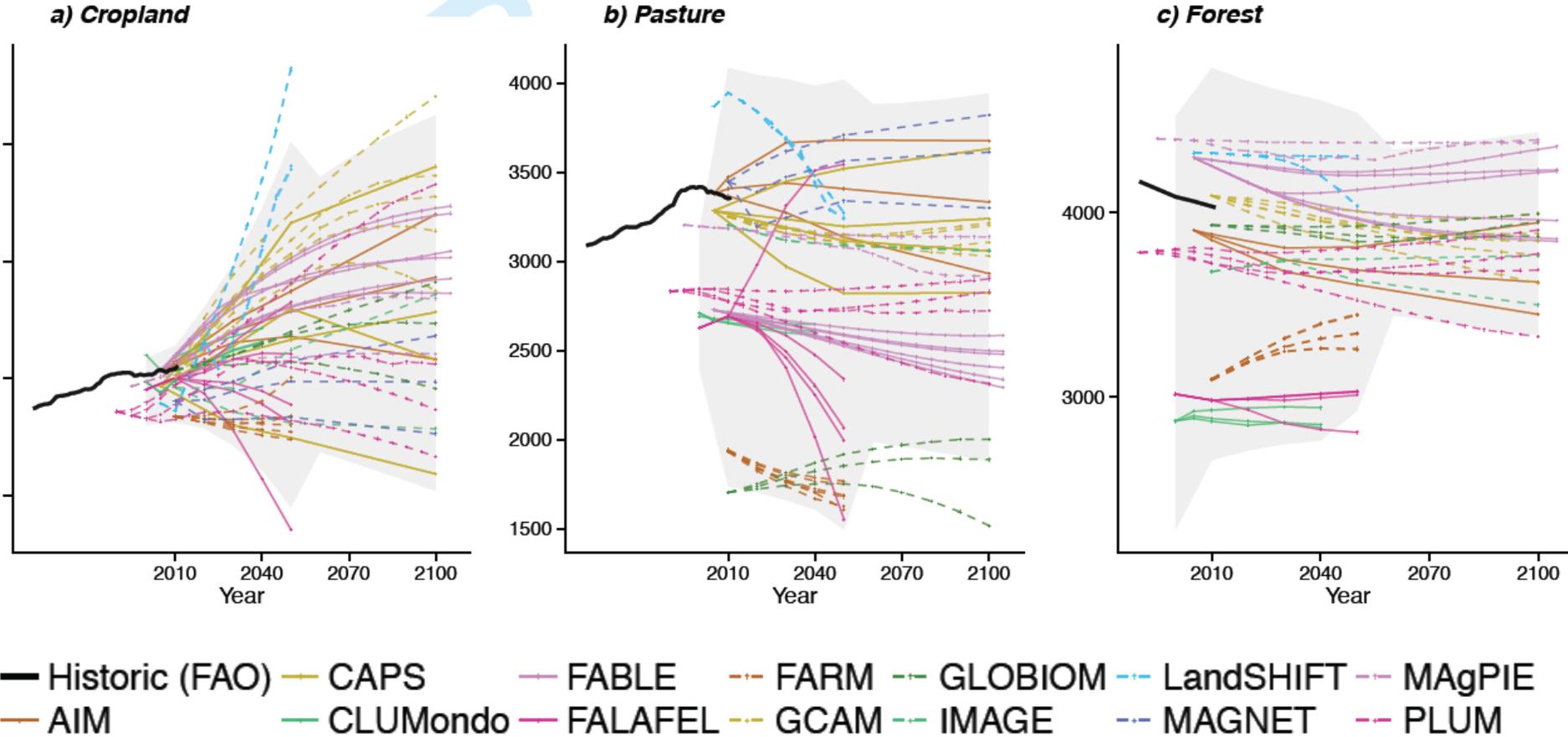
 IVM Institute for
Environmental Studies

Peter Verburg

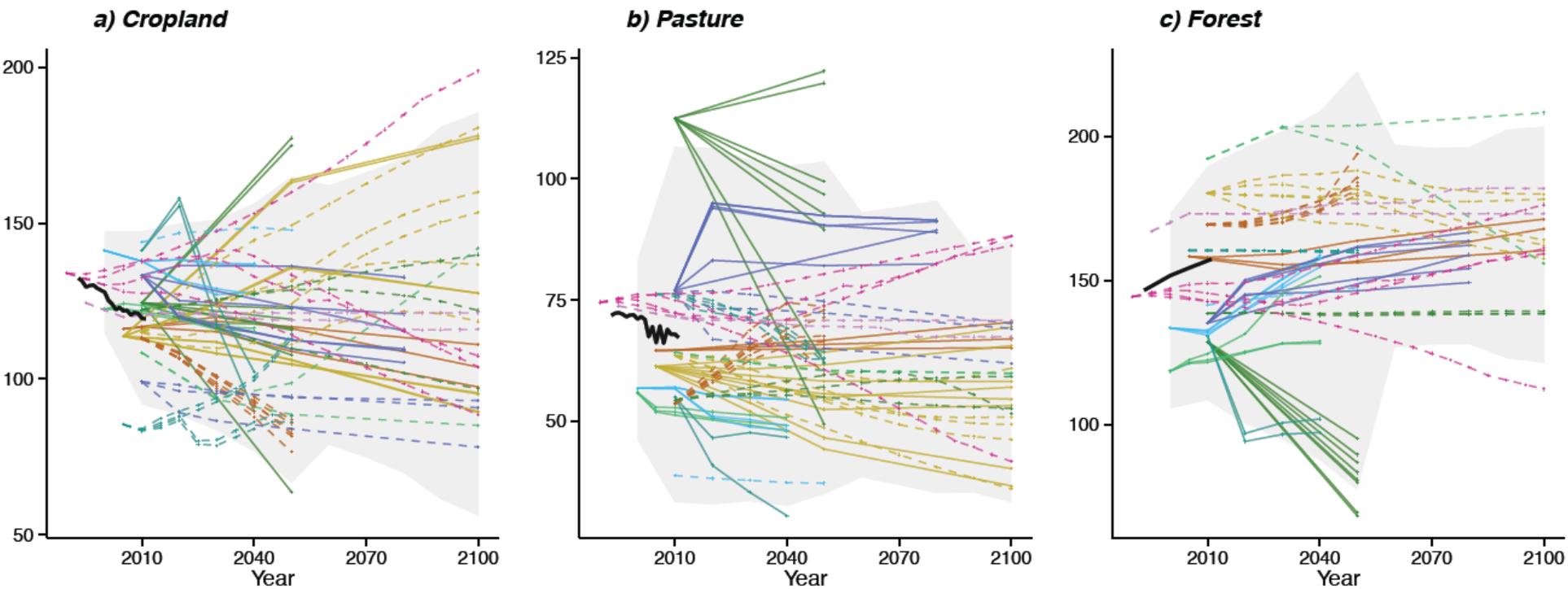
What's wrong with most/all land use models?

- Highly uncertain (*but uncertainty is a key characteristic of Socio-Ecological systems*)
- Focus on land cover (a 'symptom') rather than on Socio-Ecological System changes
- Do not account for multiple functions of land use beyond food/energy production
- Use oversimplistic, uniform, behavioral assumptions

Comparison of global land use models: global

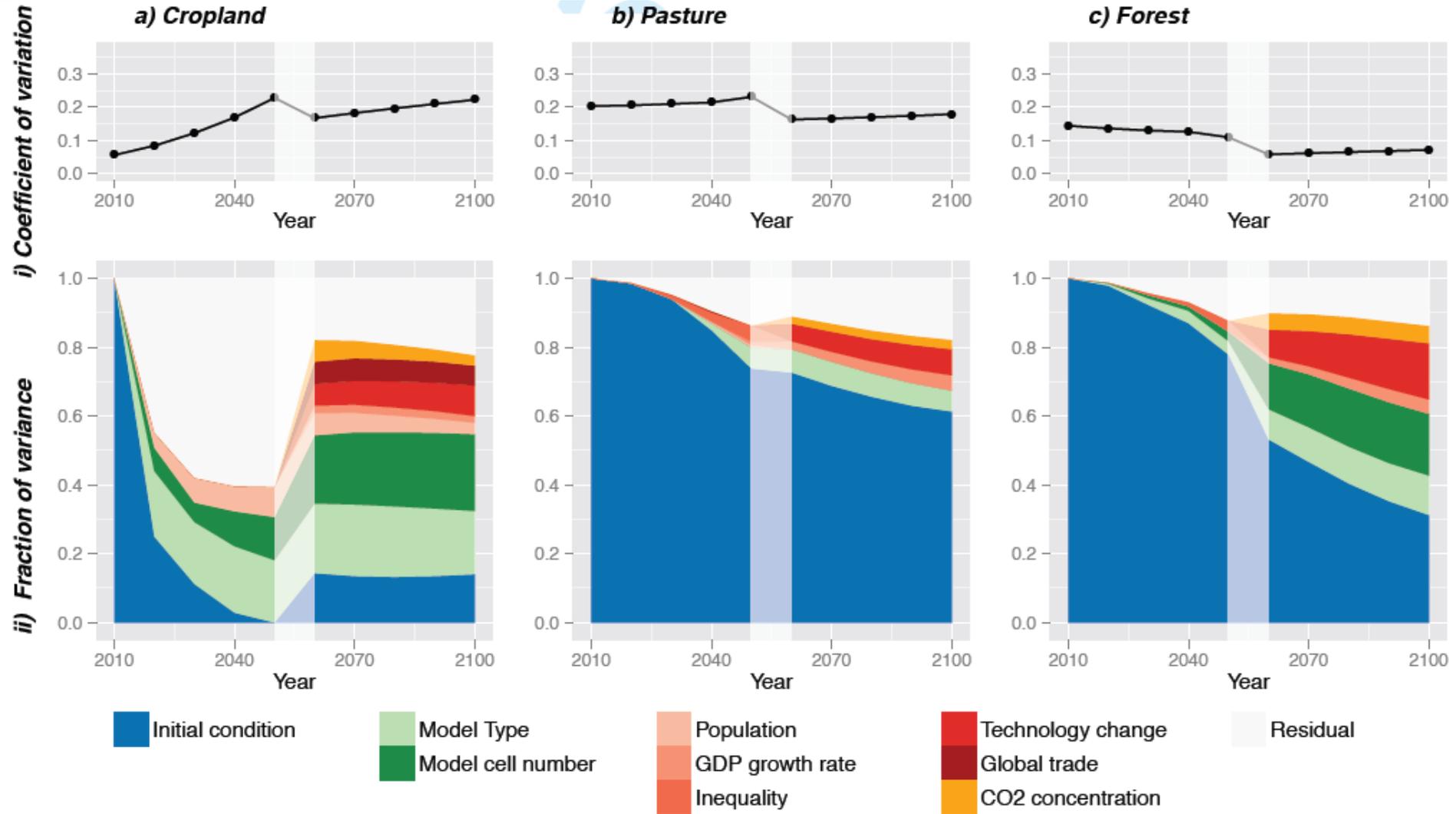


Comparison of global land use models: Europe

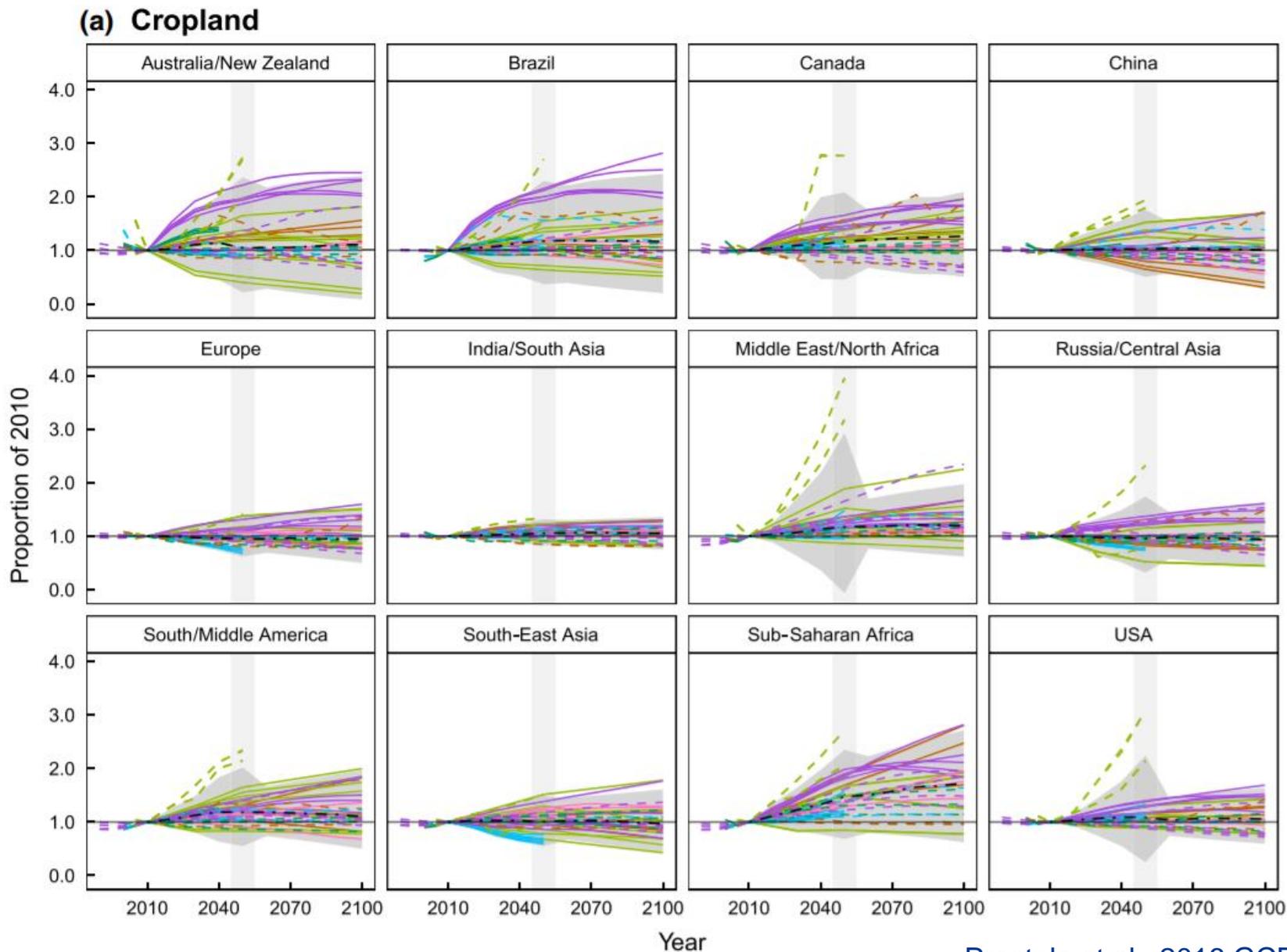


— Historic (FAO) — CAPS — CLUMondo — DynaCLUE — FARM — GLOBIOM — LUISA — MAGNET — PLUM
 — AIM — CLIMSAVE-IAP — CRAFTY — EcoChange — GCAM — IMAGE — LandSHIFT — MagPIE

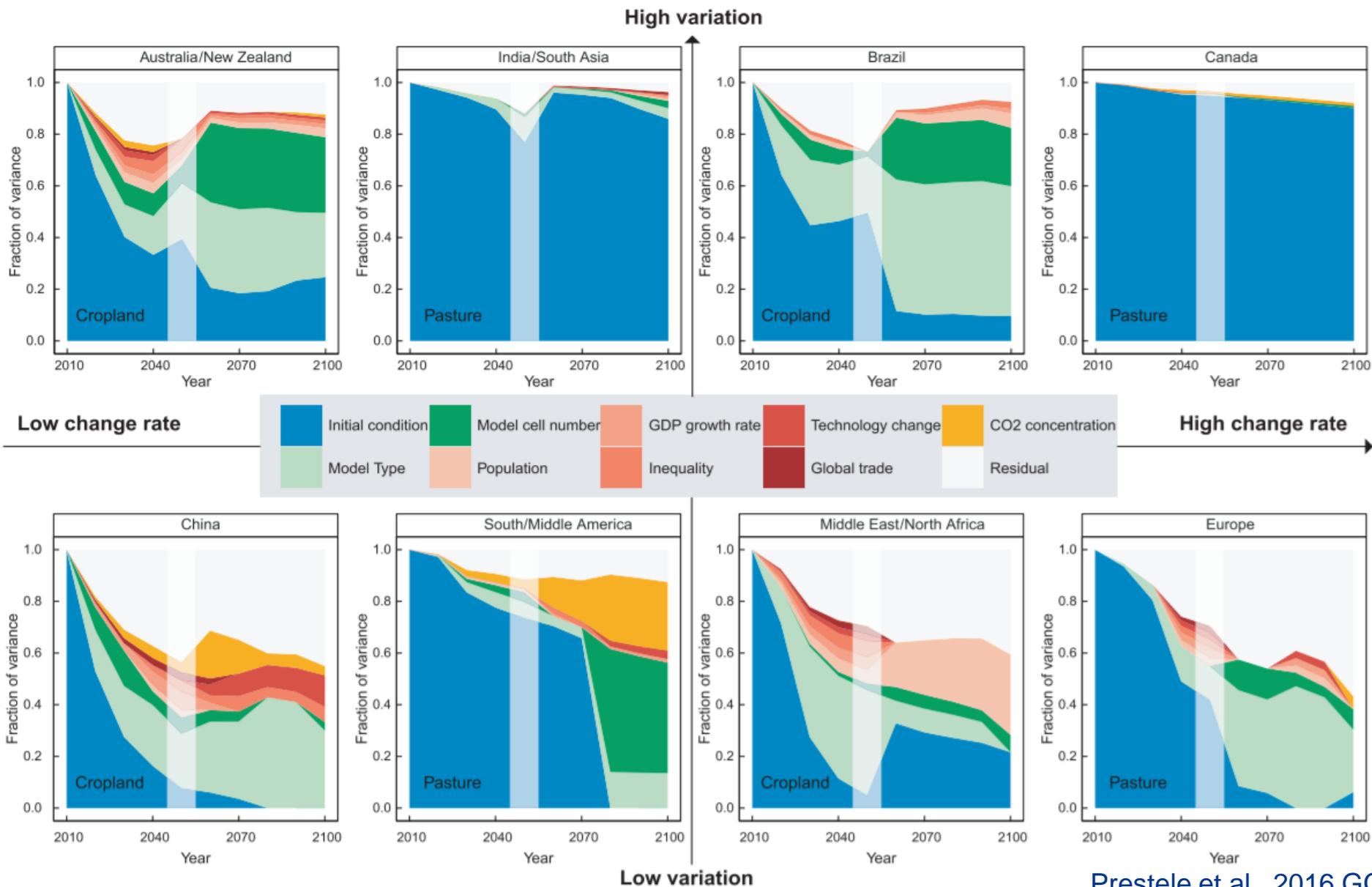
Partitioning op variance: Global



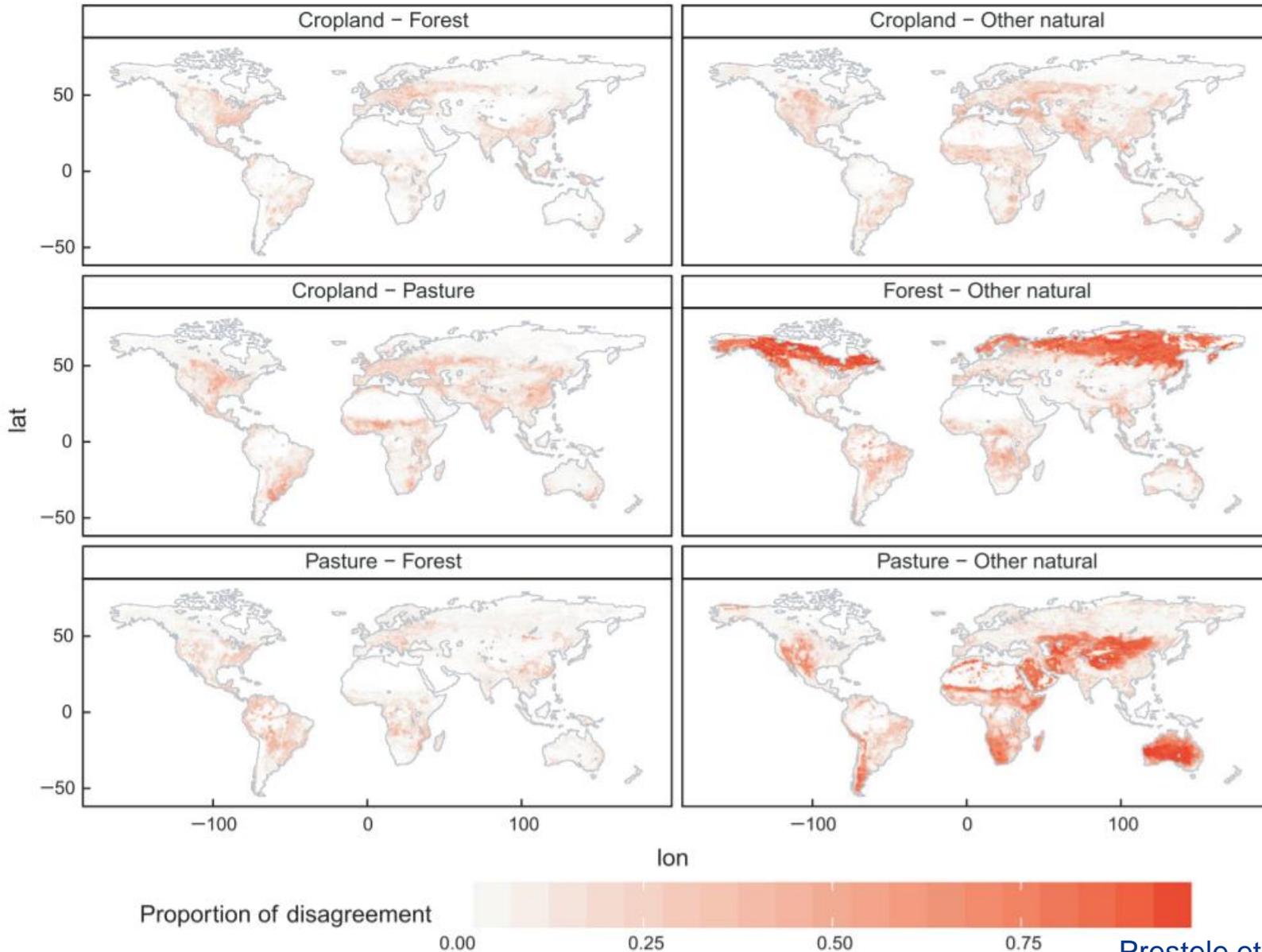
Regional differences



Sources of uncertainty vary by region



Hotspots of spatial allocation disagreement



Progress towards improvement.....

Classical approach

- 1 rule set for allocation
- expert-based allocation rules
- hierarchical allocation
- land cover only
- pixel-based
- biophysical focusses

CLUMondo approach

- -regionally differentiated rule sets
- -empirically derived rules
- -full competition
- -land systems approach
- -patch-based/neighborhood rules
- -decision-making/behavioural focus

Progress towards improvement.....

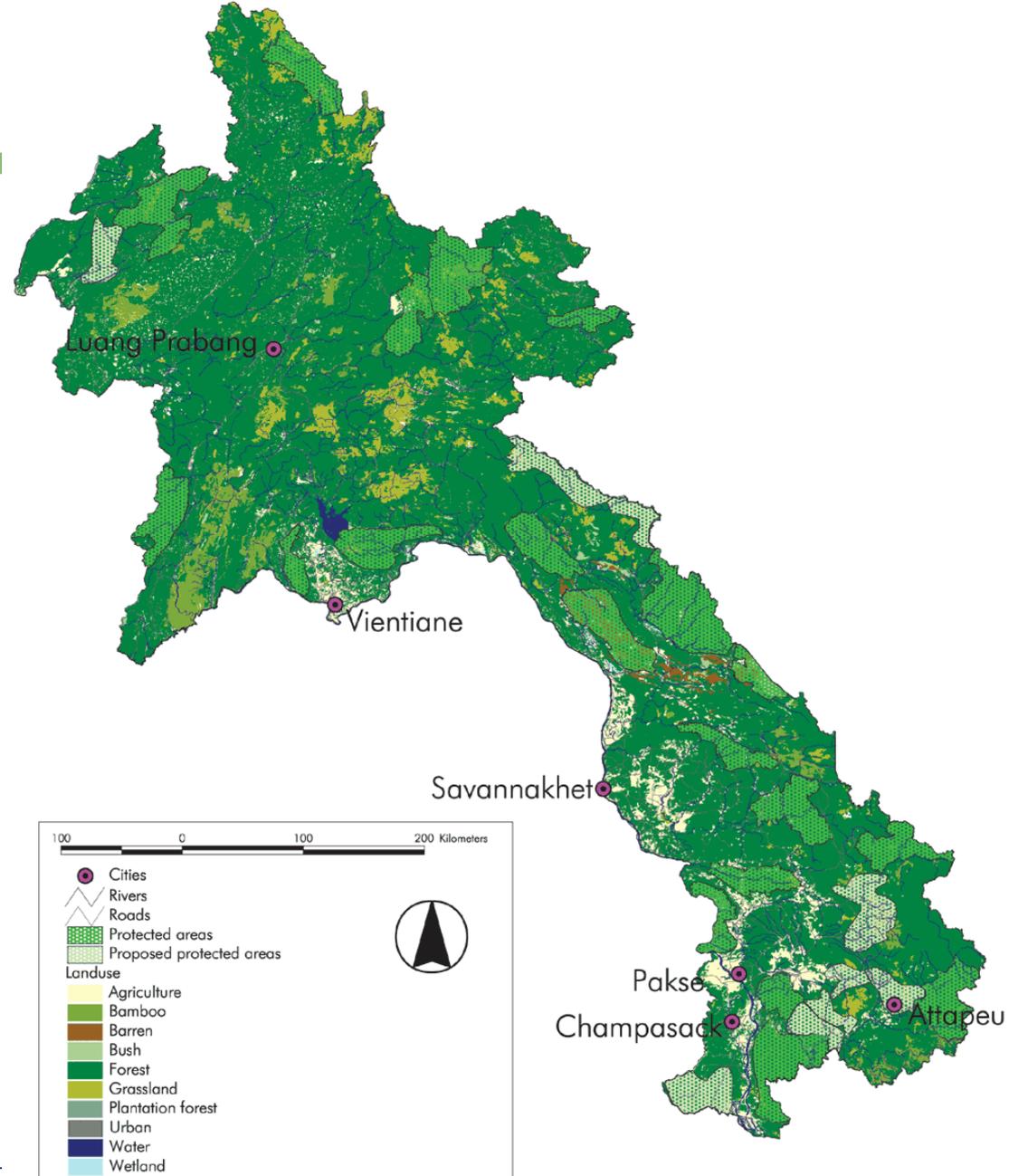
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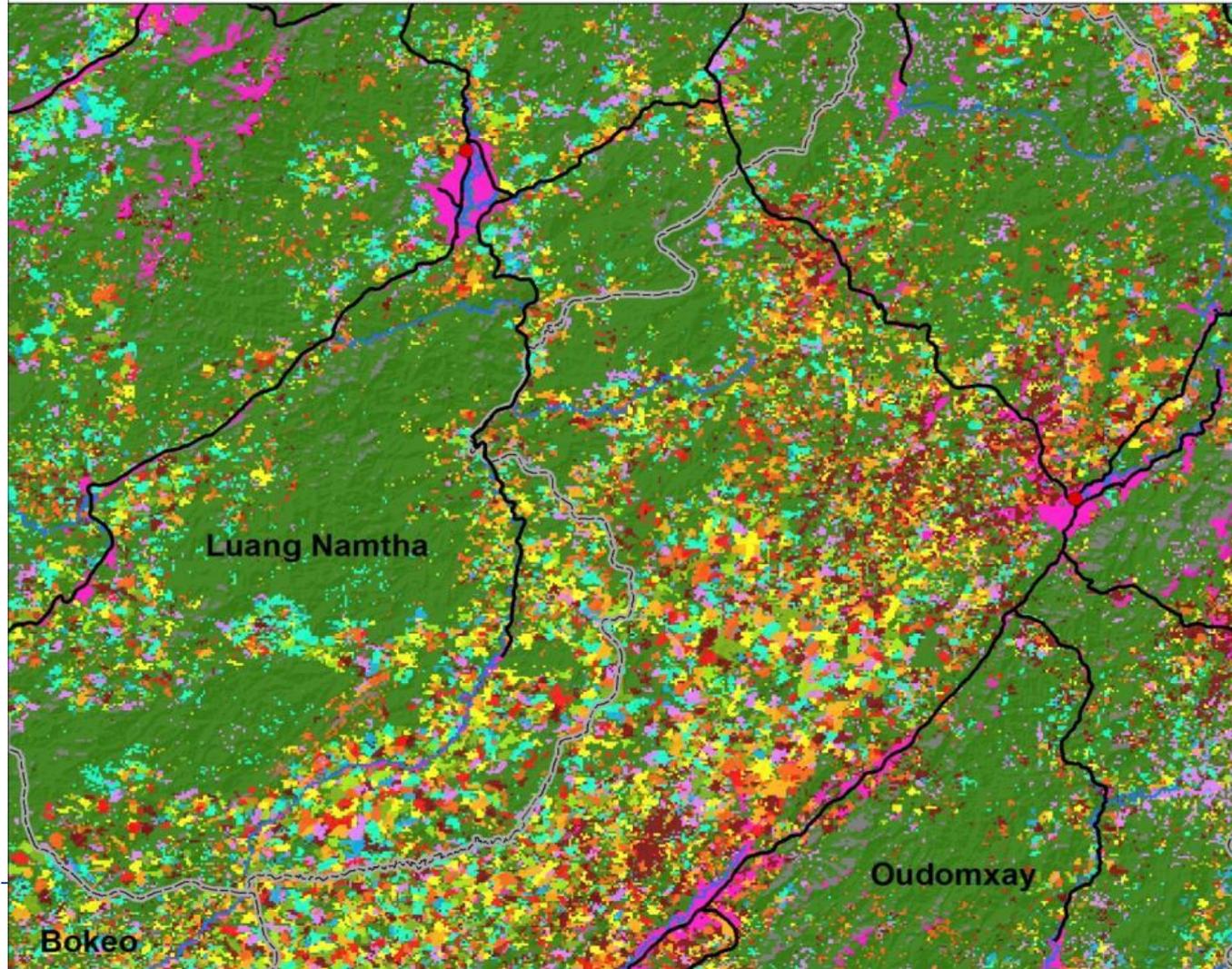
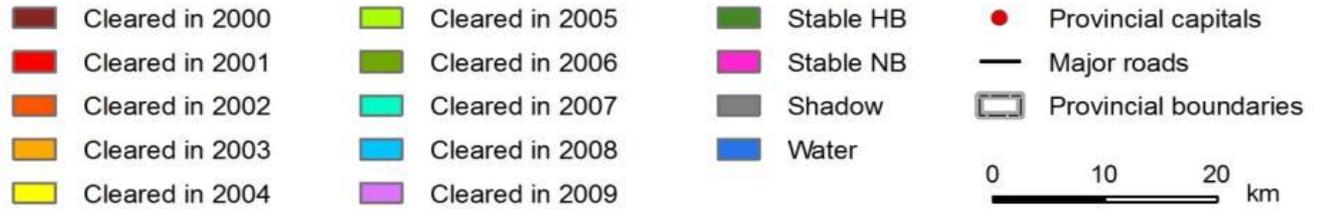
Land cover map of Laos



Shifting cultivation

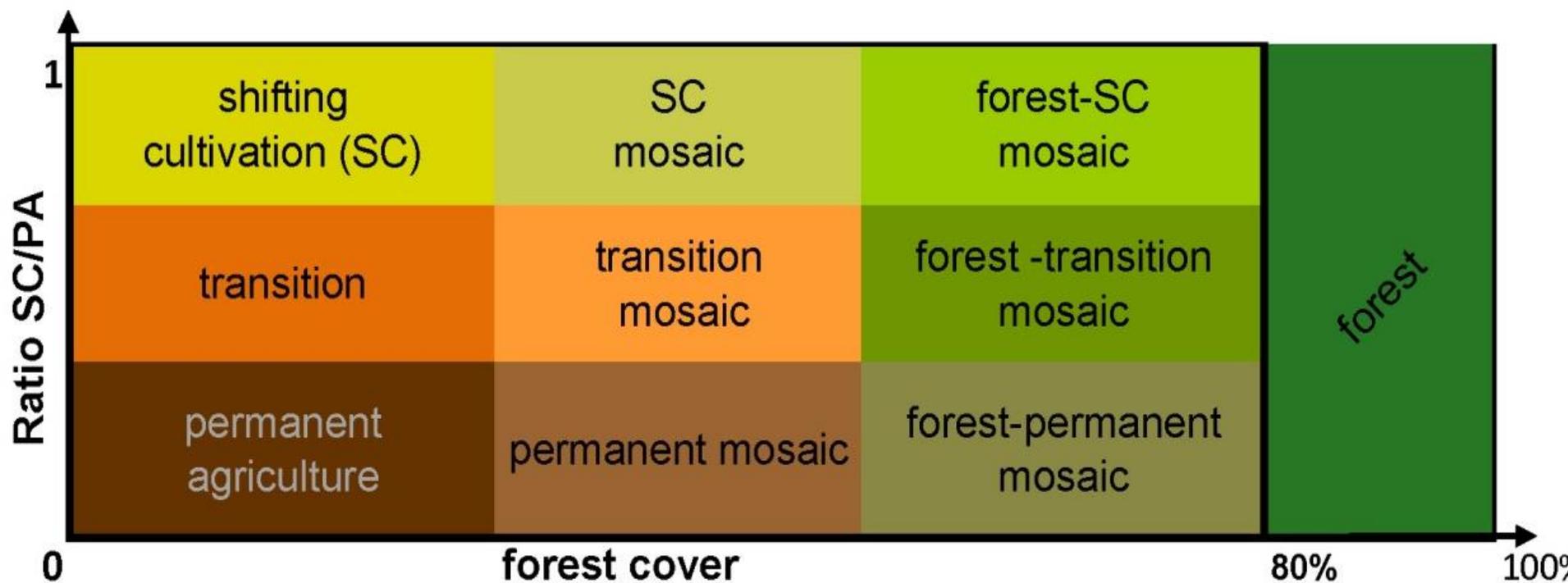
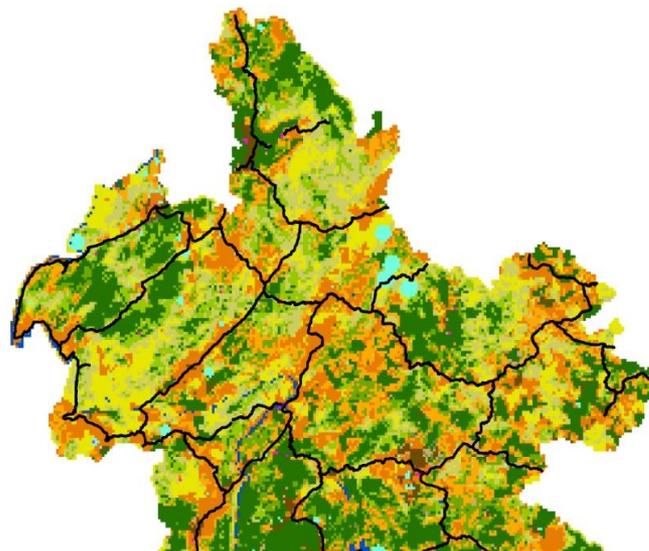


Classification of land cover change trajectories using MODIS EVI time series data

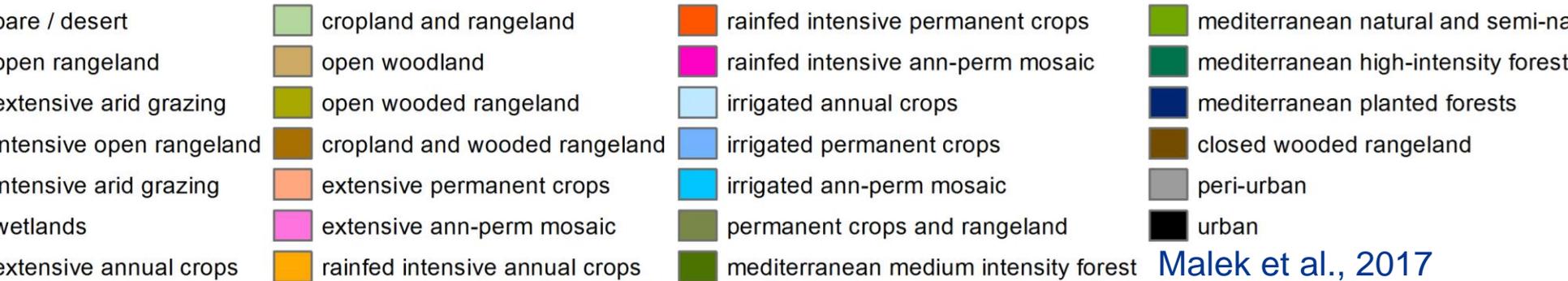
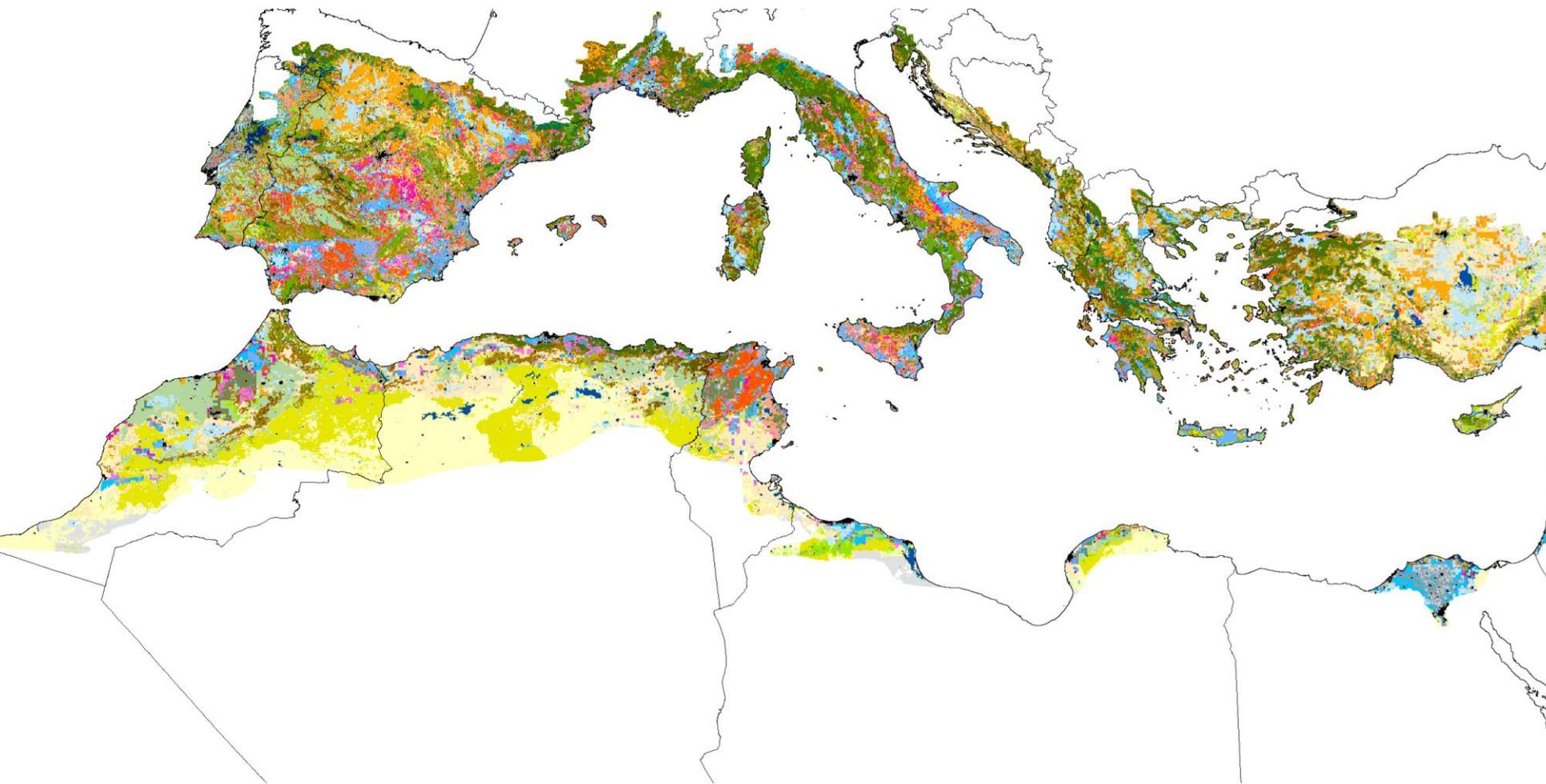


K. Hurni , et al. 2012 (fc)

Results





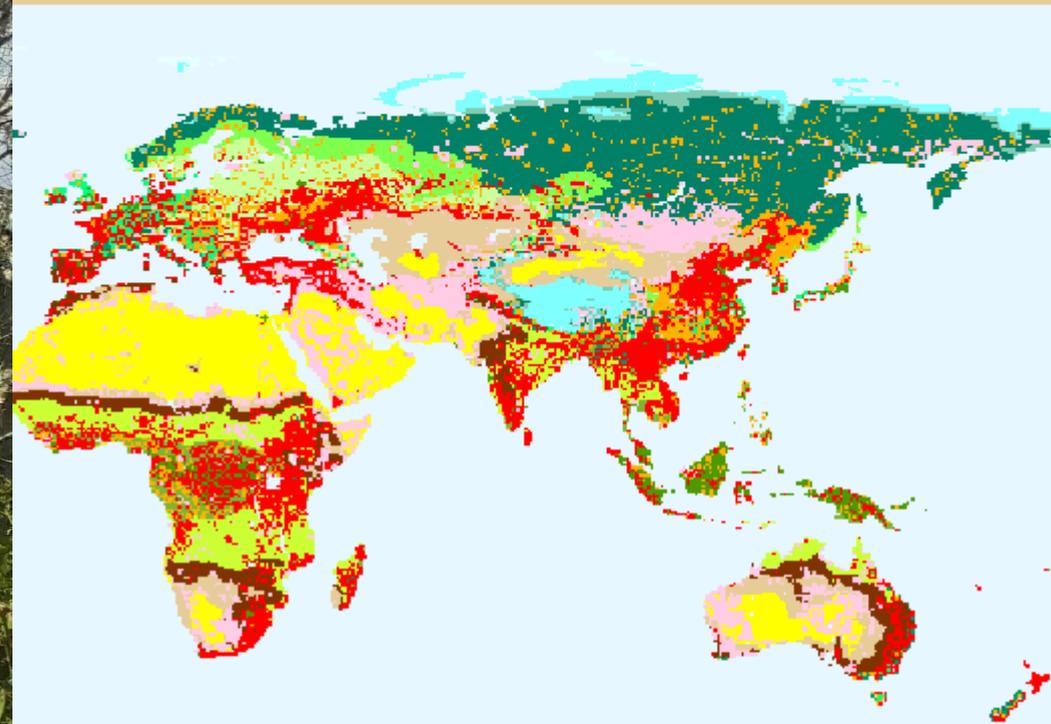


Malek et al., 2017





er - 2090 - B1



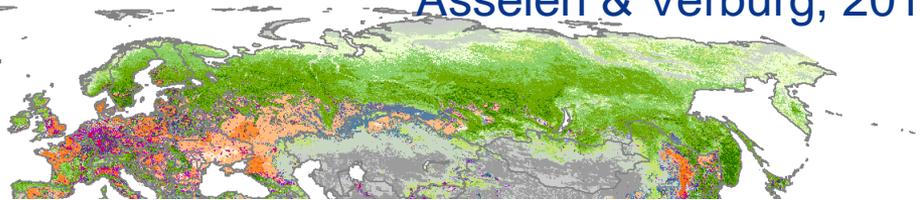
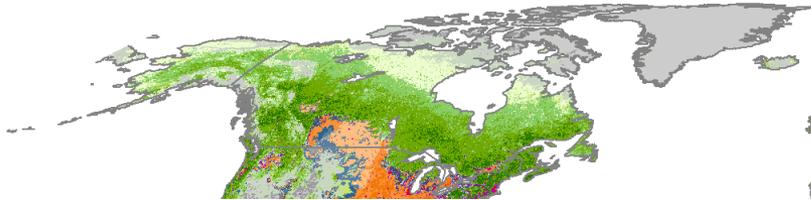
M: Time Control

Time 2090

Navigation buttons: Play, Stop, Previous, Next, Home, End, Stop, and a right arrow button.

- Warm mixed forest
- Grassland/Steppe
- Hot desert
- Scrubland
- Savanna
- Tropical woodland
- Tropical forest





Cropland Systems

-  Cropland; extensive with few livestock
-  Cropland; extensive with bovines, goats & sheep
-  Cropland; extensive with pigs & poultry
-  Cropland; medium intensive with few livestock
-  Cropland; medium intensive with bovines, goats & sheep
-  Cropland; medium intensive with pigs & poultry
-  Cropland; intensive with few livestock
-  Cropland; intensive with bovines, goats & sheep
-  Cropland; intensive with pigs & poultry

Mosaic cropland and grassland systems

-  Mosaic cropland and grassland with bovines, goats & sheep
-  Mosaic cropland and grassland with pigs & poultry
-  Mosaic cropland (extensive) and grassland with few livestock
-  Mosaic cropland (medium intensive) and grassland with few livestock
-  Mosaic cropland (intensive) and grassland with few livestock

Mosaic cropland and forest systems

-  Mosaic cropland and forest with pigs & poultry
-  Mosaic cropland (extensive) and forest with few livestock
-  Mosaic cropland (medium intensive) and forest with few livestock
-  Mosaic cropland (intensive) and forest with few livestock



Eckert IV projection.

Cropland Systems

-  Cropland; extensive with few livestock
-  Cropland; extensive with bovines, goats & sheep
-  Cropland; extensive with pigs & poultry
-  Cropland; medium intensive with few livestock
-  Cropland; medium intensive with bovines, goats & sheep
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- Mosaic cropland (intensive) and forest with few livestock

Forest systems

-  Dense forest
-  Open forest with few livestock
-  Open forest with pigs & poultry

Mosaic (semi-)natural systems

-  Mosaic grassland and forest
-  Mosaic grassland and bare

Grassland systems

-  Natural grassland
-  Grassland with few livestock
-  Grassland with bovines, goats & sheep

Bare systems

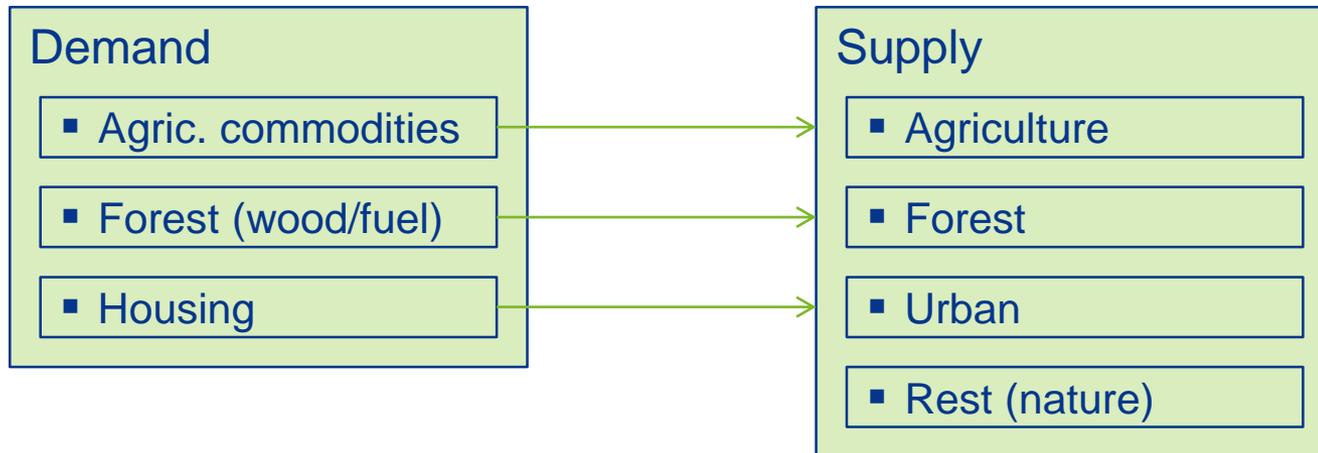
-  Bare
-  Bare with few livestock

Settlement systems

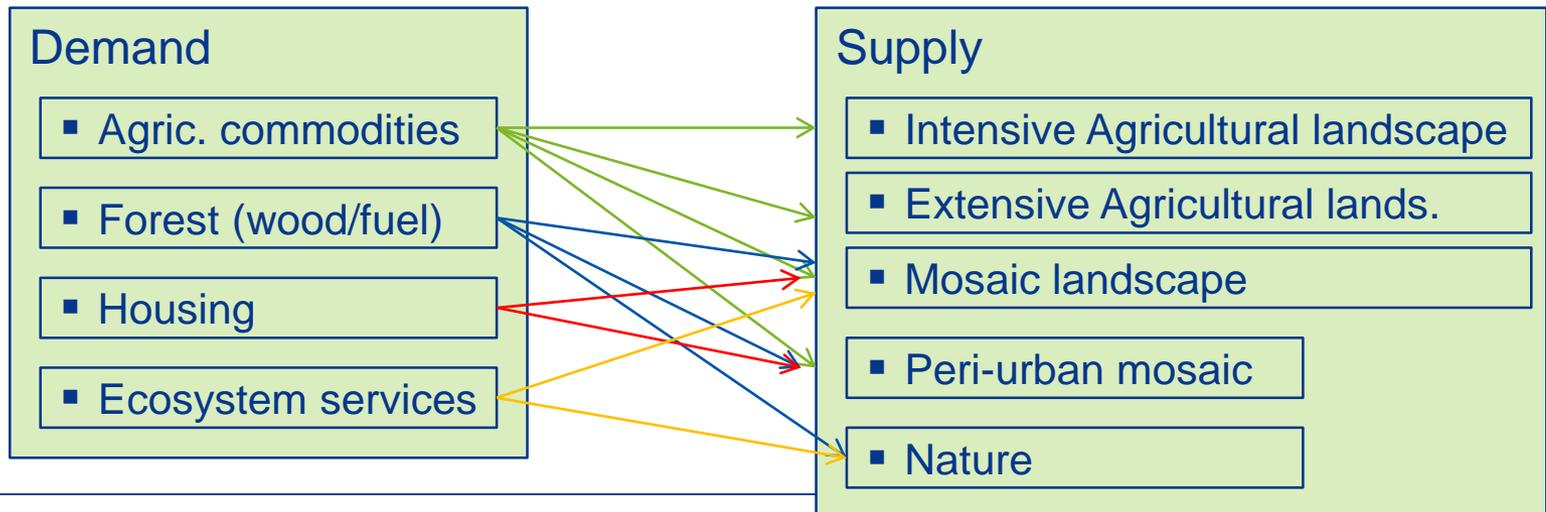
-  Peri-urban and villages
-  Urban

CLUMondo model

traditional



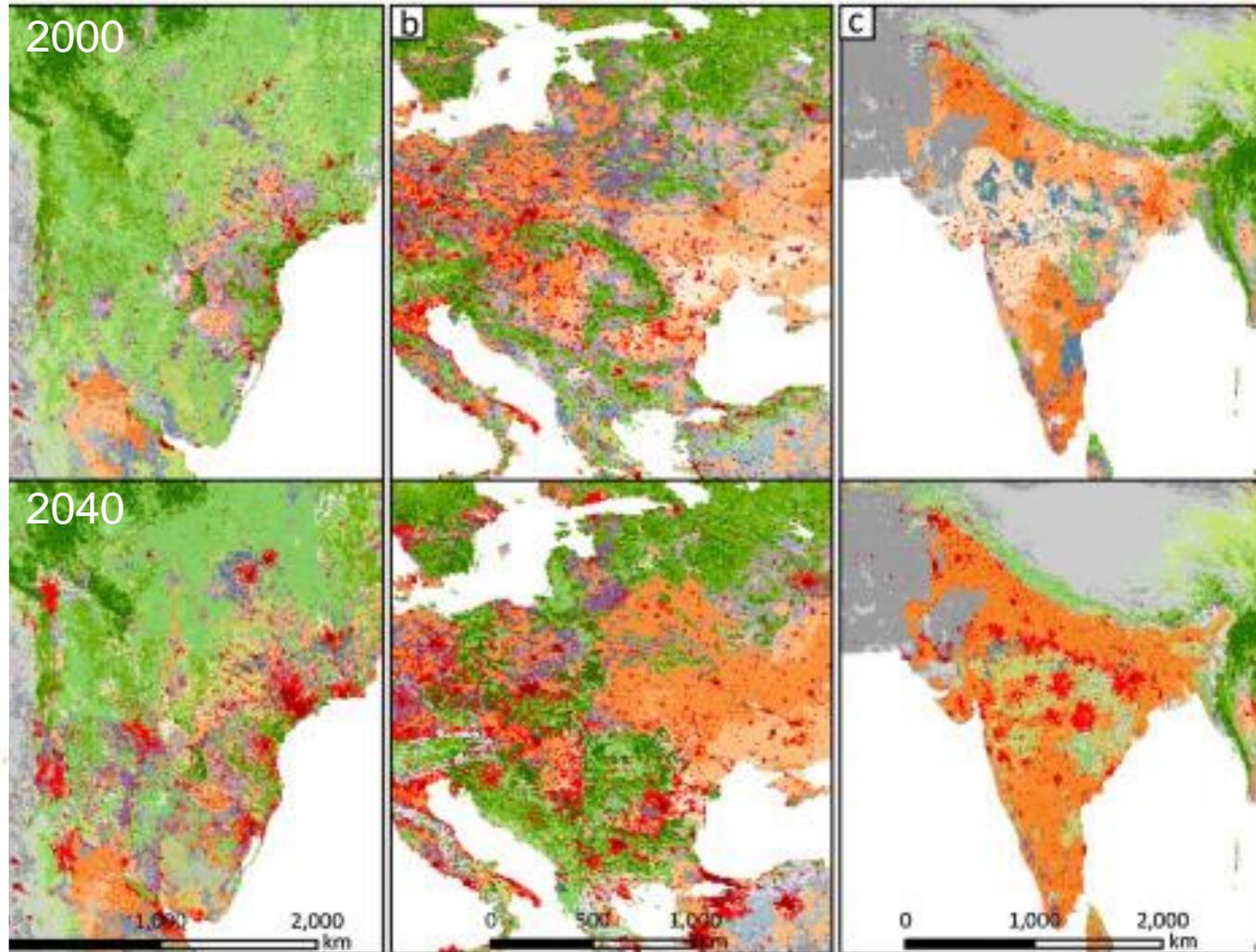
CLUMondo



Simulation results

Land Systems

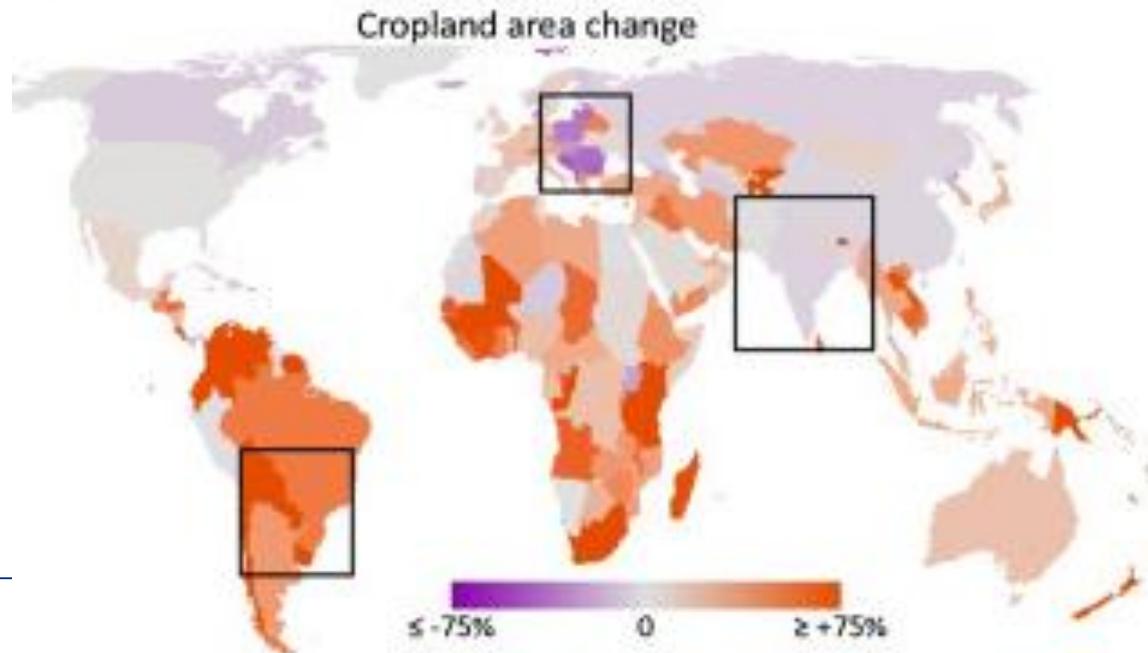
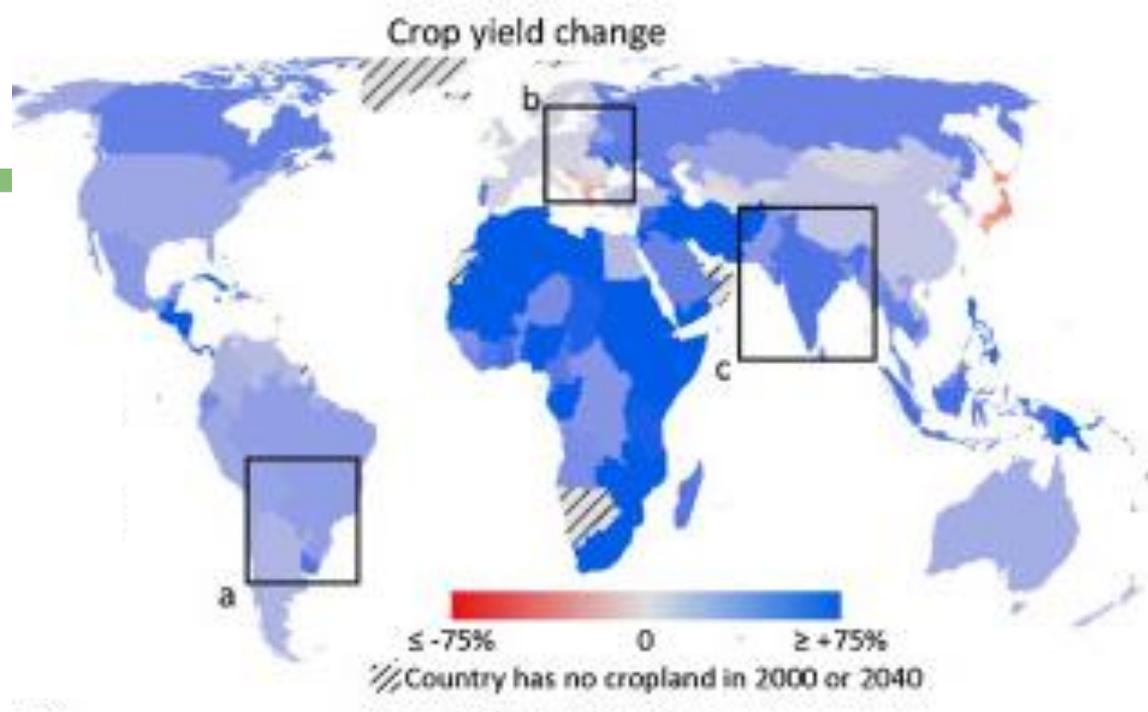
- Cropland ext.; few livestock
- Cropland ext.; bovines, goats & sheep
- Cropland med. int.; few livestock
- Cropland med. int.; bovines, goats & sheep
- Cropland int.; few livestock
- Cropland int.; bovines, goats & sheep
- Mosaic cropland & grassland; bovines, goats & sheep
- Mosaic cropland ext. & grassland; few livestock
- Mosaic cropland med. int. & grassland; few livestock
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- Mosaic cropland ext. & forest; few livestock
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- Dense forest
- Open forest; few livestock
- Mosaic grassland & forest
- Mosaic grassland & bare
- Natural grassland
- Grassland; few livestock
- Grassland; bovines, goats & sheep
- Bare
- Bare; few livestock
- Peri-urban & villages
- Urban



Simulation results

Based on FAO agricultural outlook

2000-2040



Progress towards improvement.....

Classical approach

- 1 rule set for allocation
- expert-based allocation rules
- hierarchical allocation
- land cover only
- >***sectoral demands***
- pixel-based
- biophysical focusses

CLUMondo approach

- -regionally differentiated rule sets
- -empirically derived rules
- -full competition
- -land systems approach
- >**ecosystem service/goods targets**
- -patch-based/neighborhood rules
- -decision-making/behavioural focus

Land for.....

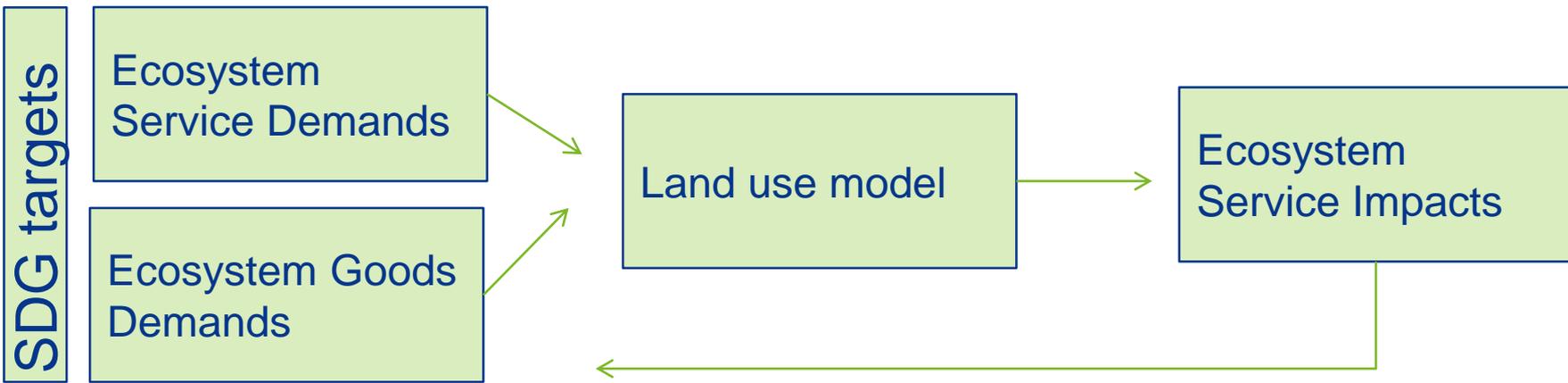
- Climate mitigation
- Biodiversity conservation
- Recreation
- Economic development
- Food security
- Green urban space
- Parking space
- Infrastructure
- Speculation



Classical representation



CLUMondo representation



Scenario

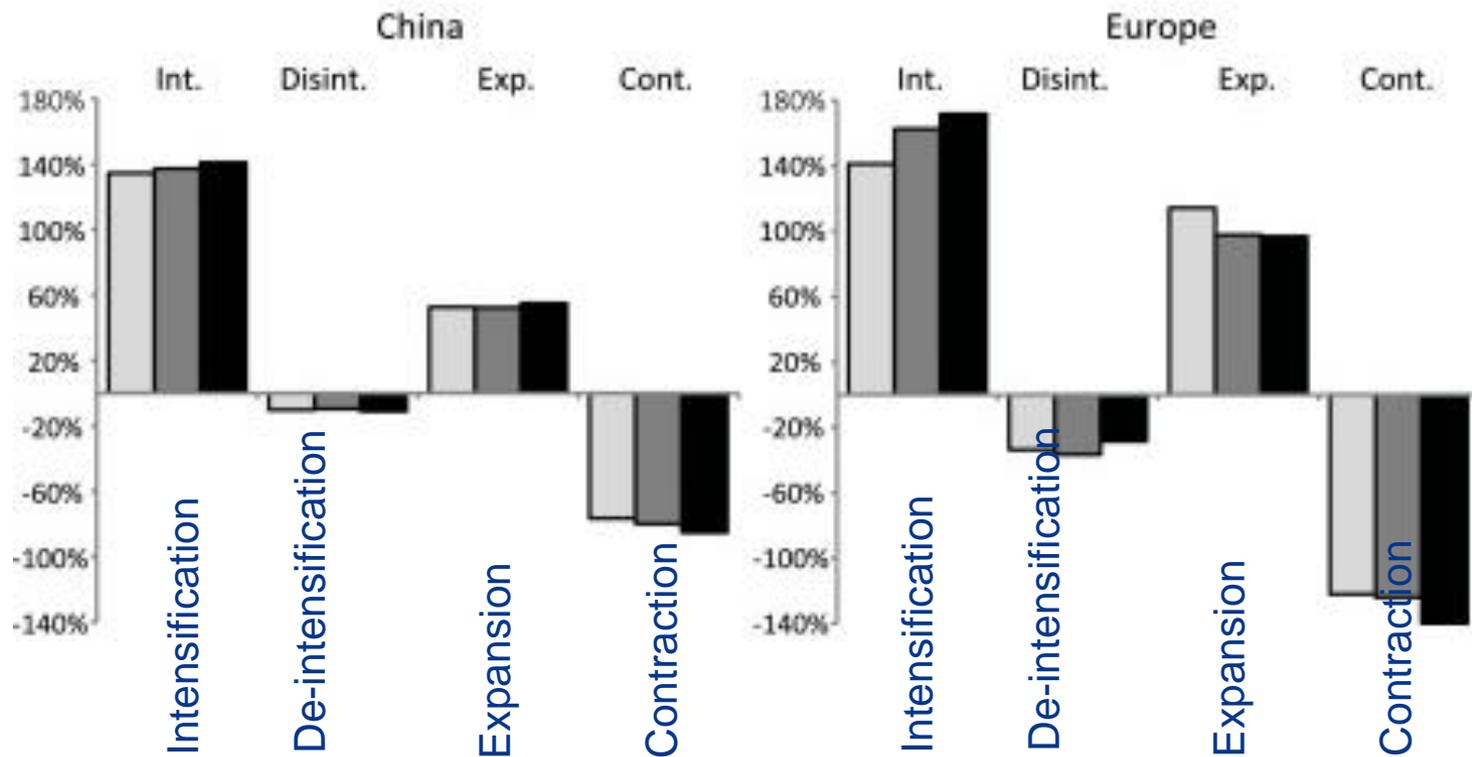
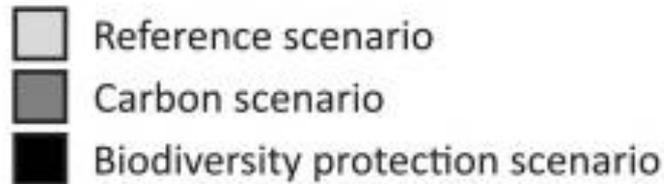
- 1) Carbon: Ambition of 'no net loss' of carbon sequestered in vegetation (below and above ground) per world-region



- 2) Biodiversity: Implementation of national targets for (conserved) natural area based on Aichi target



Results: agriculture



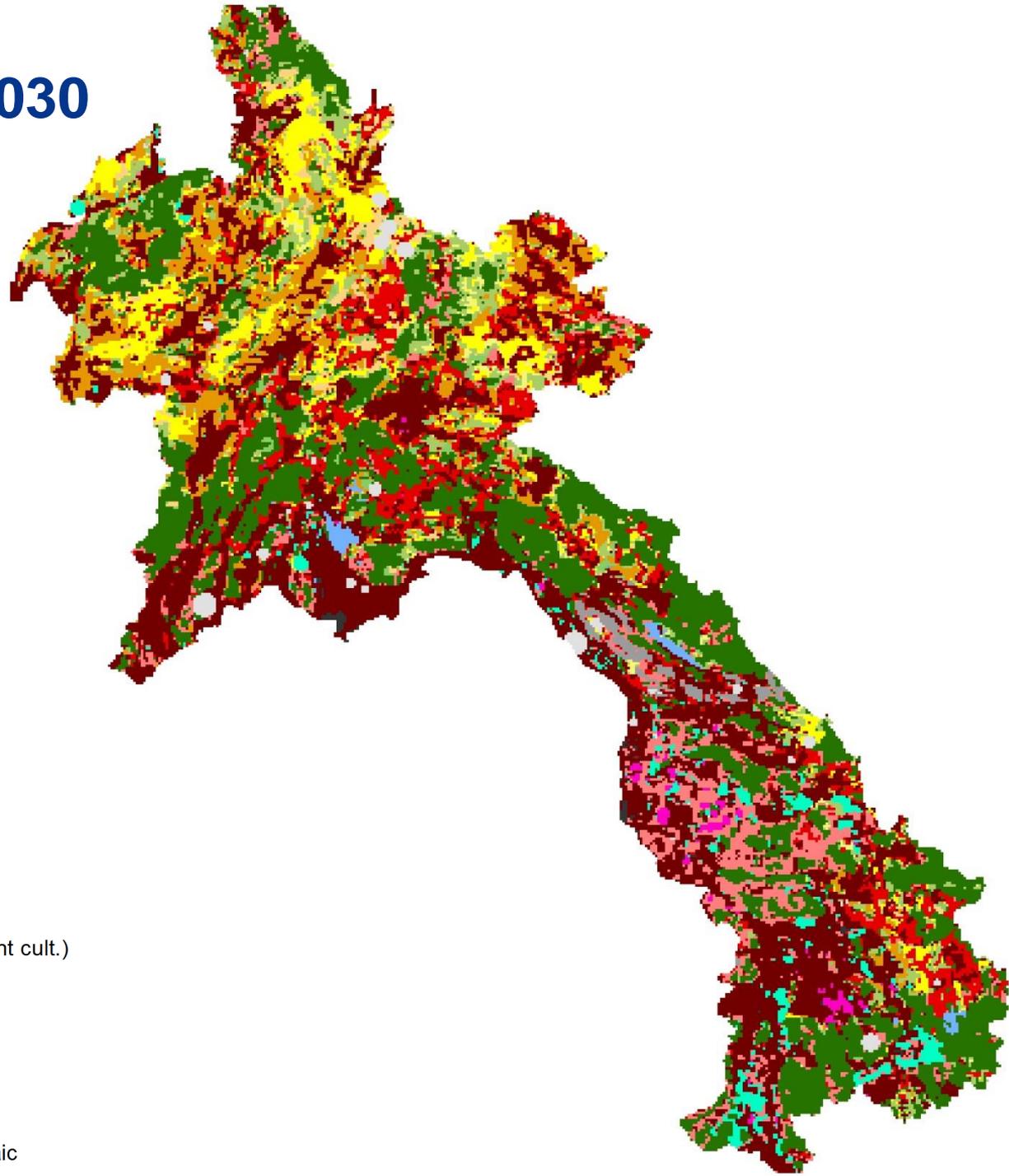
Ecosystem service demands in scenarios

Relative demand in 2030 as compared to 2010.

Scenario	Built-up area	Staple crops	Arable cash crops	Tree cash crops	Biodiversity conservation	Cultural services
TREND	223%	130%	236%	190%	n.a.	n.a.
ASEAN	223%	123%	269%	242%	8% increase of dense forest	n.a.
GREEN	223%	130%	180%	180%	Max. 18% decrease of forest cover (total of dense forest and forest mosaic land systems)	Maintenance of minimally 50% of the 2010 area of traditional shifting cultivation land systems

Laos: 2010-2030

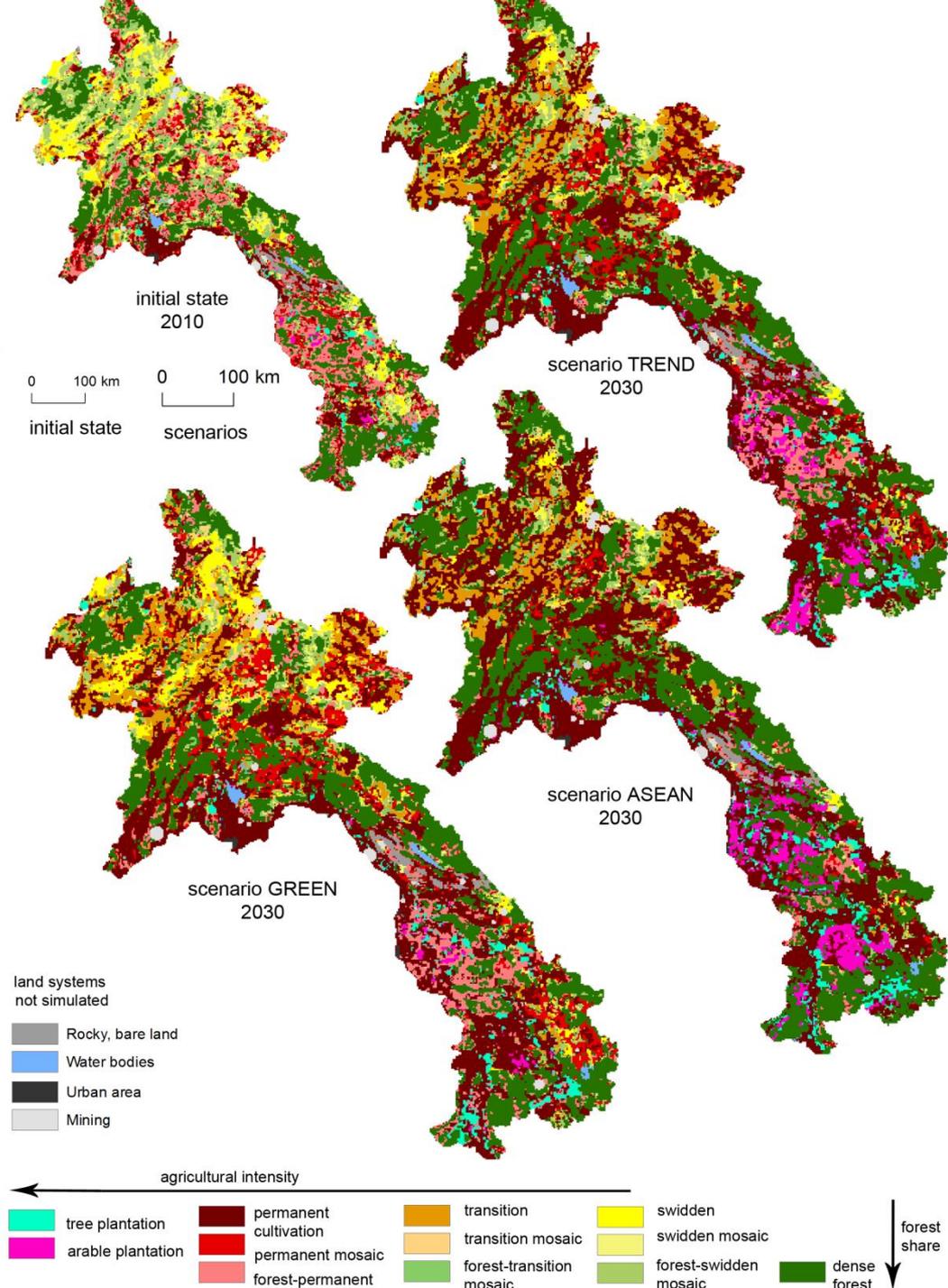
2010
Trend
Asean
Green



Legend - Land Systems

- Rocky, bare land
- Water bodies
- Urban area
- Mining
- Tree plantations
- Arable plantations
- Dense forest
- Permanent cultivation
- Permanent mosaic
- Forest- permanent mosaic
- Transition (shifting + permanent cult.)
- Transition mosaic
- Forest-transition mosaic
- Shifting cultivation
- Shifting cultivation mosaic
- Forest-shifting cultivation mosaic

Regime shifts in land systems and landscapes



Progress towards improvement.....

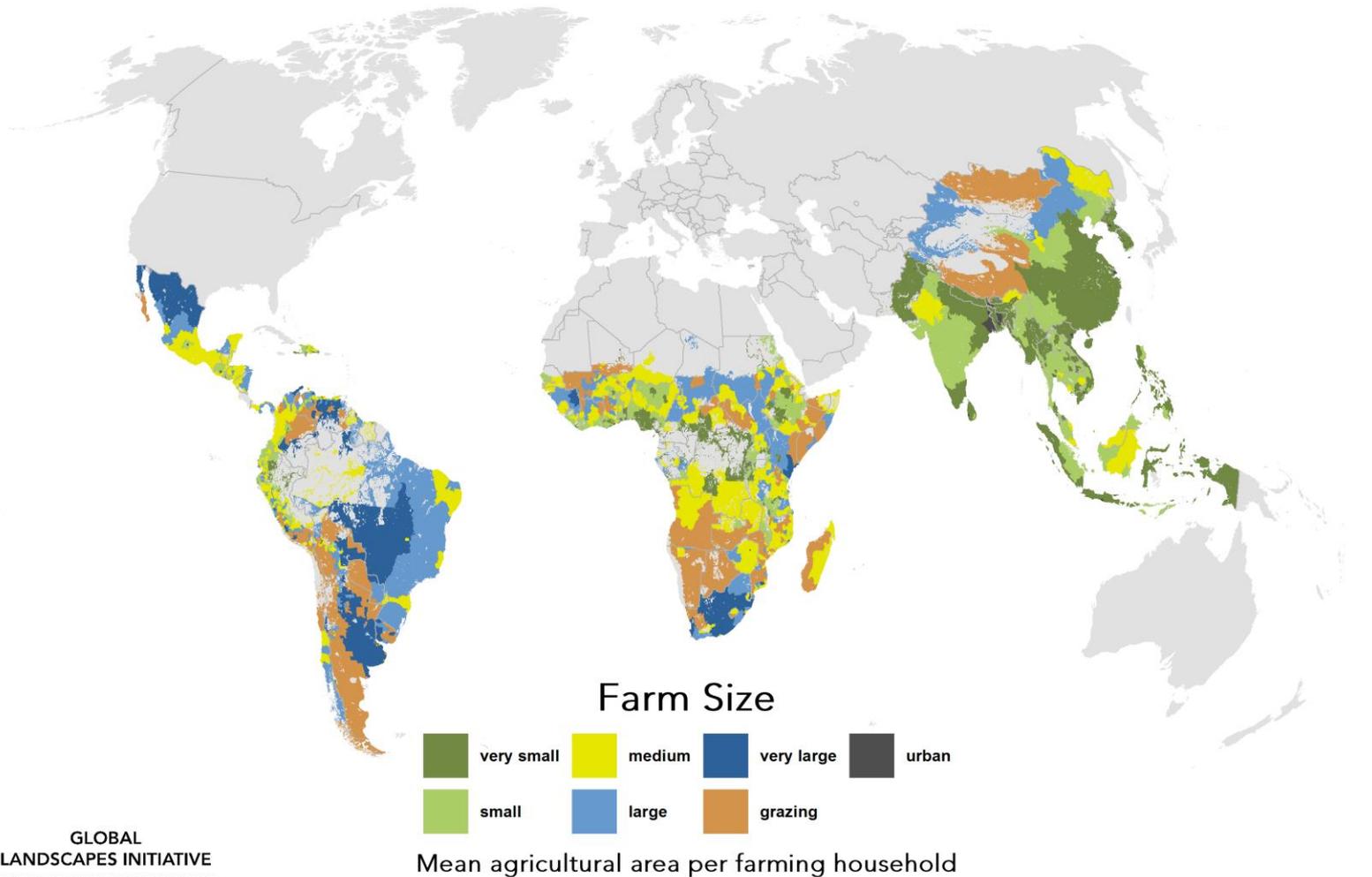
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Pixel-based approach assumes small farms



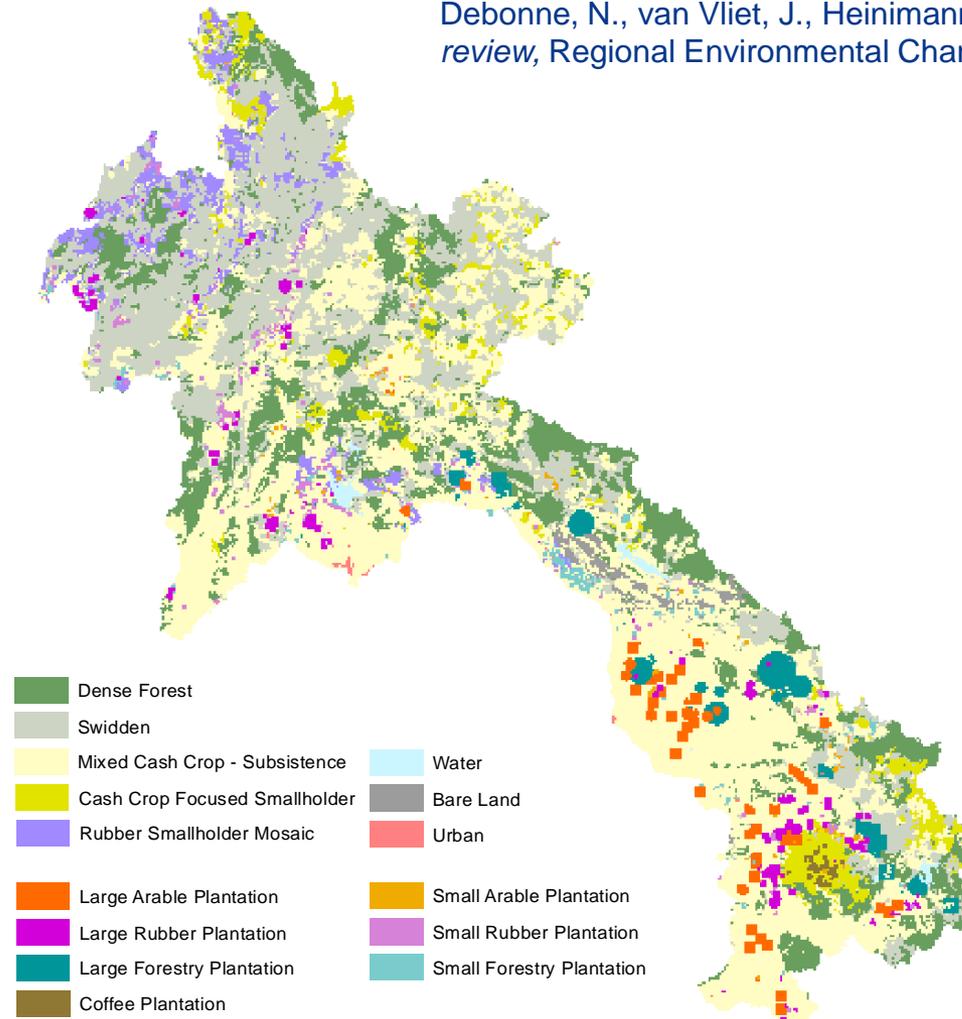




REPRESENTING LARGE-SCALE LAND ACQUISITIONS IN LAND USE CHANGE SCENARIOS FOR THE LAO PDR

Debonne, N., van Vliet, J., Heinemann, A. and Verburg, P.H. *in review*, Regional Environmental Change

No LSLA Policy



Progress towards improvement.....

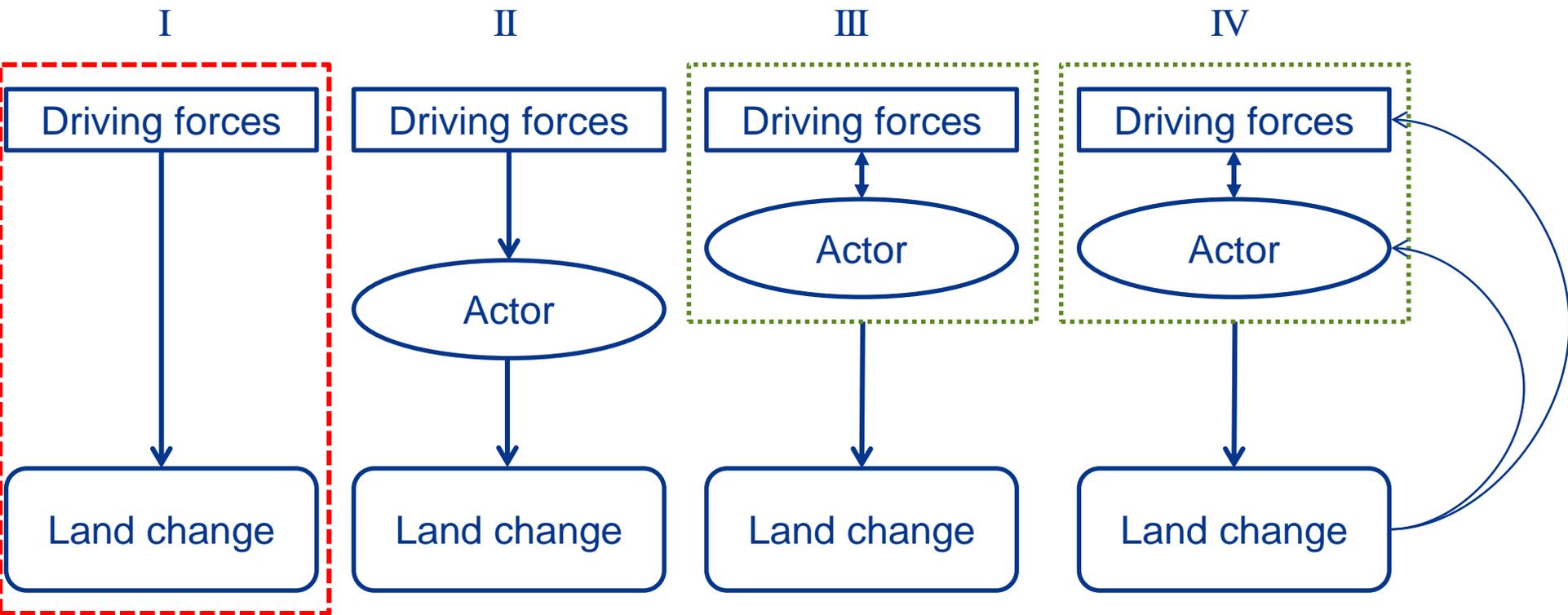
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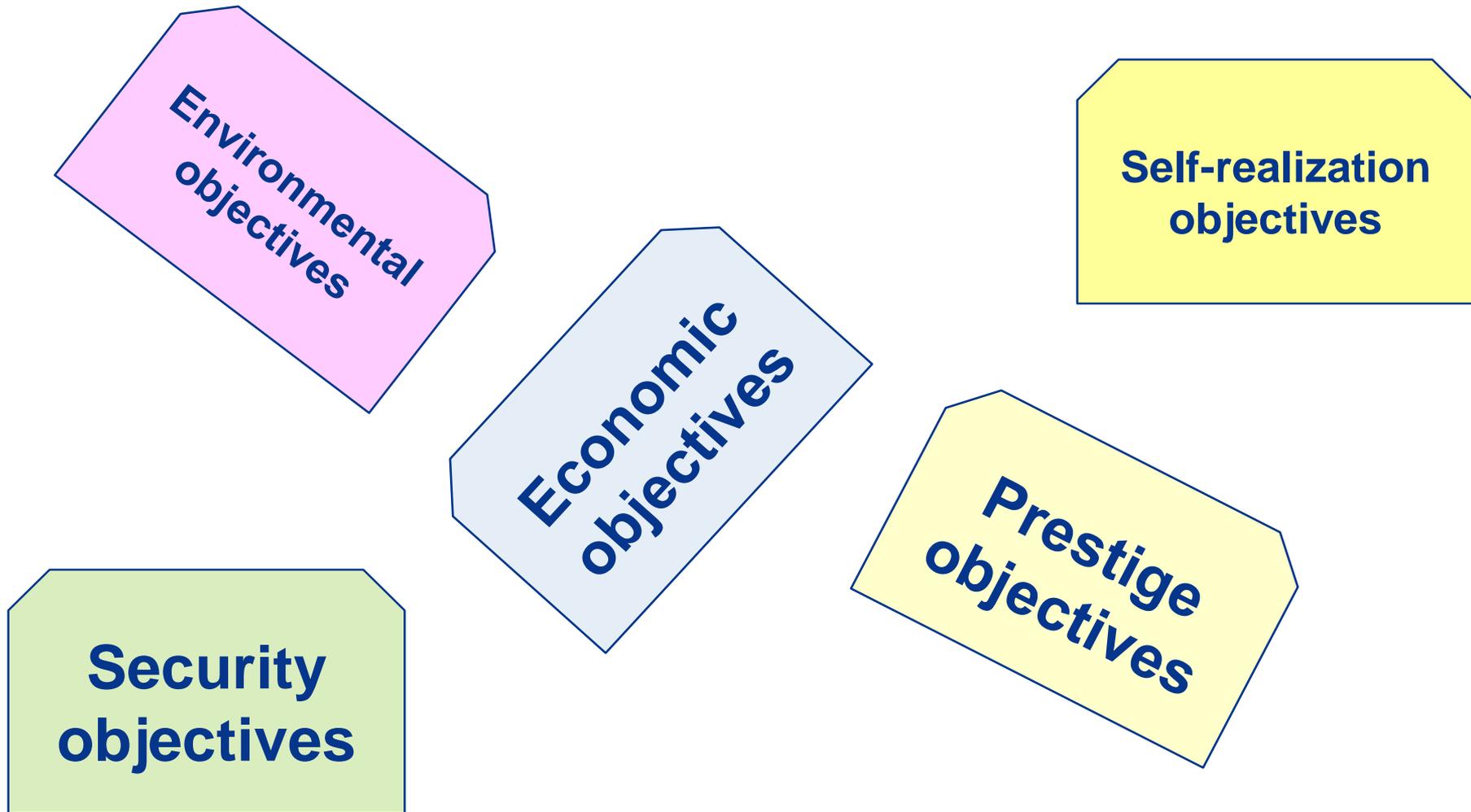
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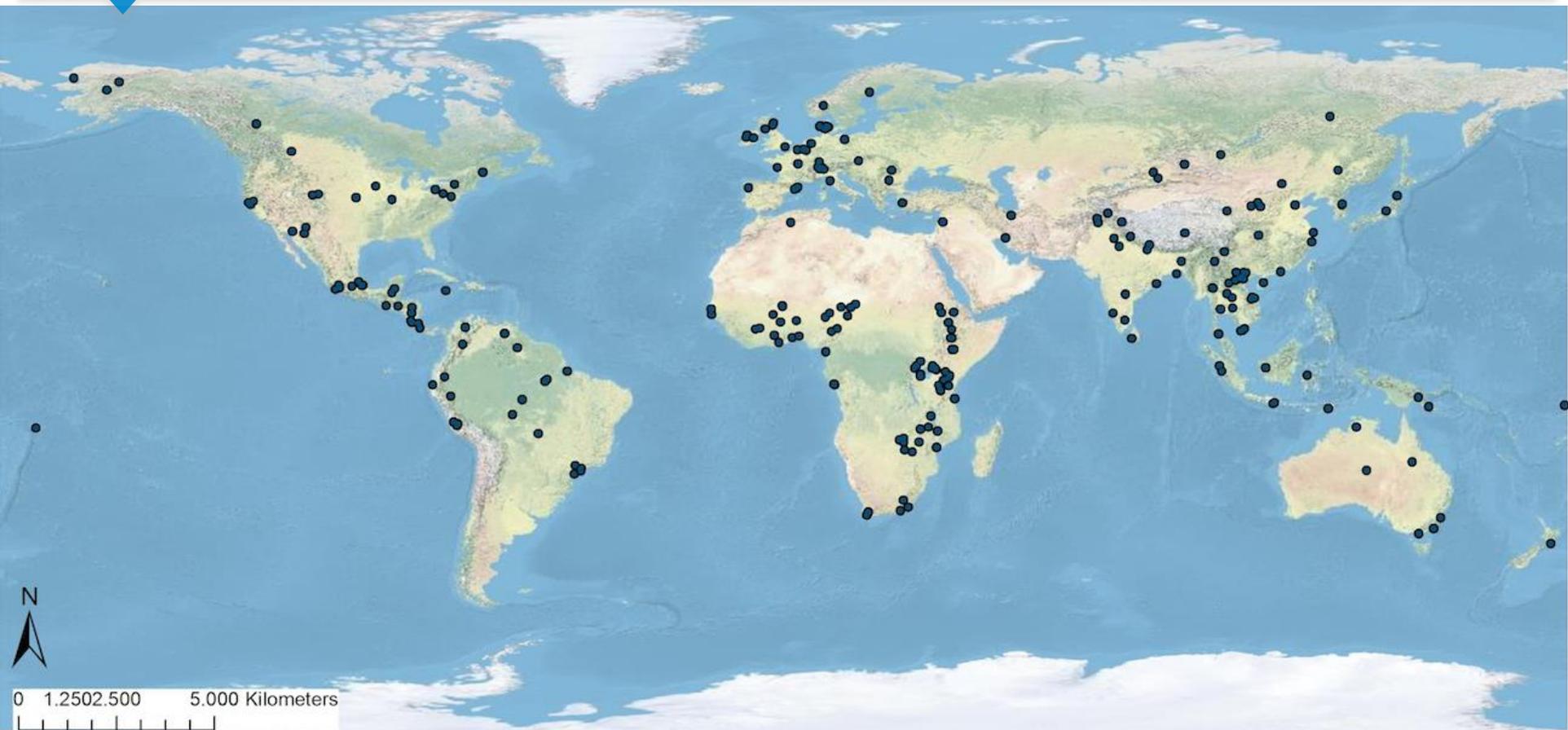
Conceptualisations of land systems drivers



Agent-objectives influencing land use decisions



CASE STUDY LOCATIONS

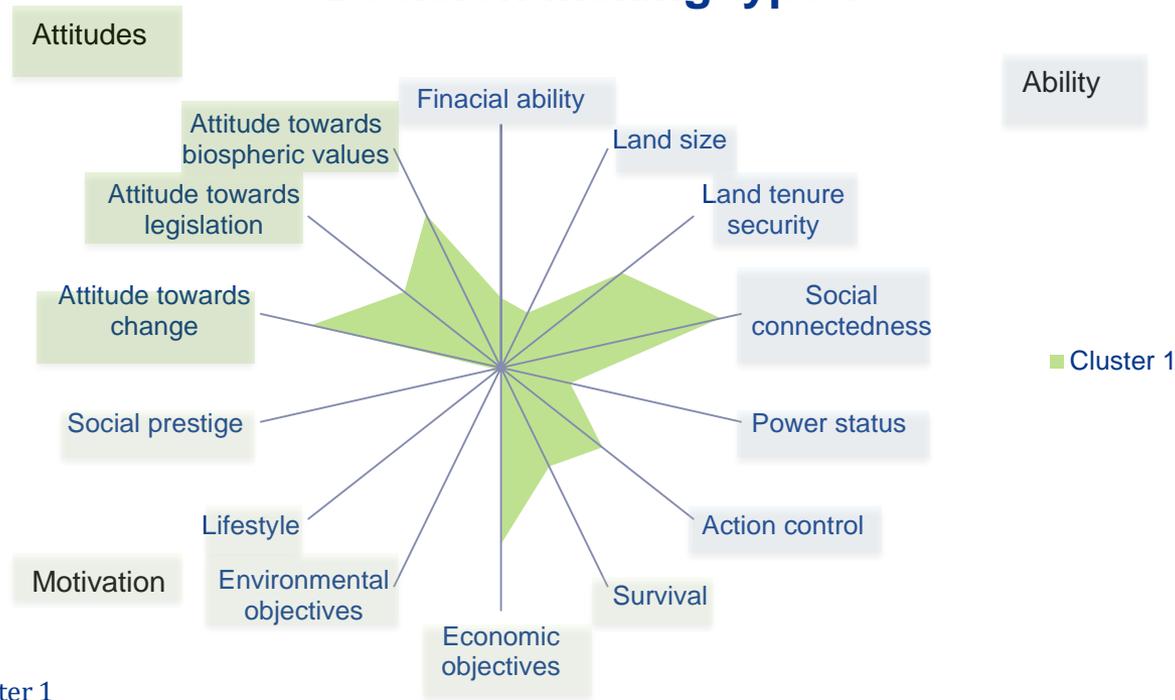


RESULTS: OVERALL DECISION-MAKING

Objective	Frequency	Low impact on decision-making	Moderate impact on decision making	High impact on decision-making
Survival	69%	10%	21%	38%
Economic	68%	17%	25%	26%
Environmental	15%	10%	4%	1%
Lifestyle	14%	7%	6%	1%
Social Prestige	5%	4%	0.5%	0.5%

RESULTS: TYPOLOGY OF DECISION-MAKING

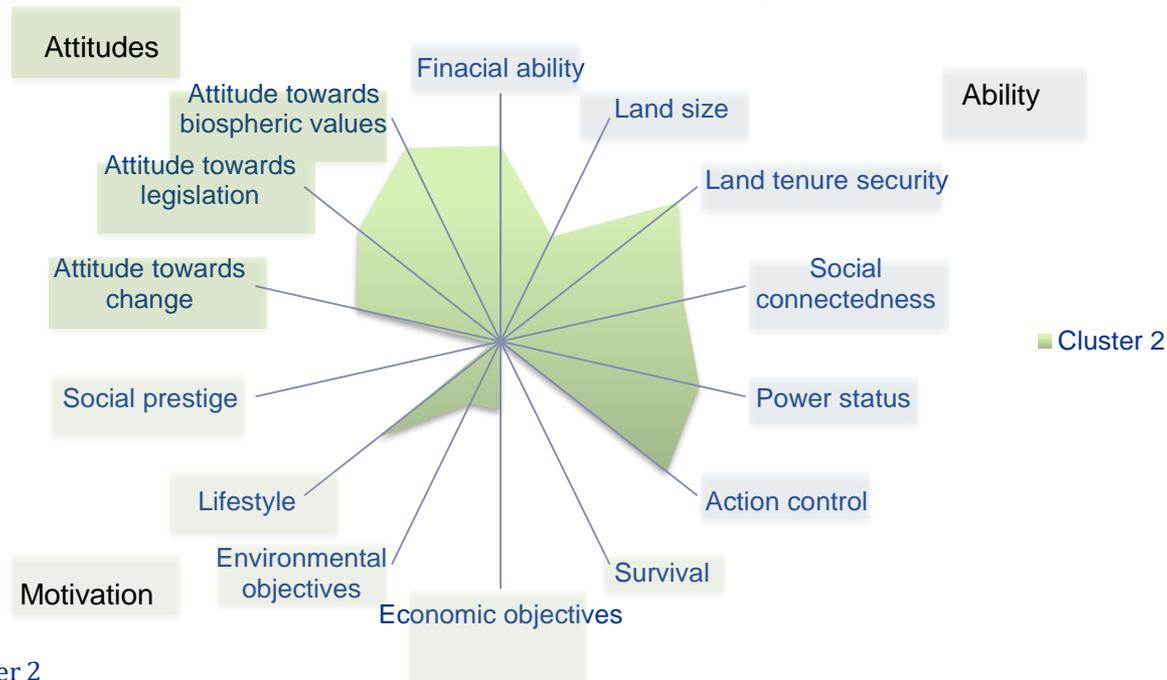
Decision-making type 1



	Cluster 1
Main motivation	Economic and to lesser extent survival
Attitudes	Low adherence to rules
Ability	Poor, small land size, medium land tenure security
Social	Highly connected, low power, low autonomy

RESULTS: TYPOLOGY OF DECISION-MAKING

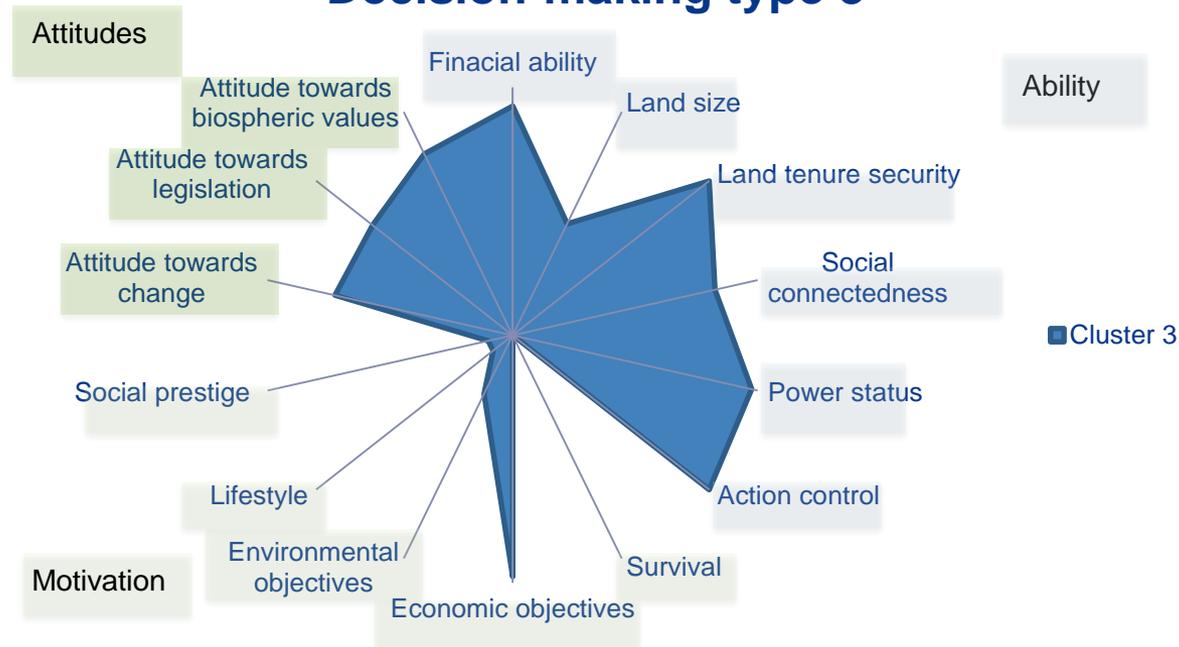
Decision-making type 2



	Cluster 2
Main motivation	Lifestyle, low environment and economic
Attitudes	Highest biospheric values
Ability	Rich actor, high land size, highest land tenure security
Social	High power and autonomy

RESULTS: TYPOLOGY OF DECISION-MAKING

Decision-making type 3



Cluster 3

Main
motivation
Attitudes
Ability
Social

Economic, highest social prestige (though low)
High biospheric attitudes
Richest actor, high land size, highest land tenure security
Highest power, highest autonomy

RESULTS: TYPOLOGY OF DECISION-MAKING

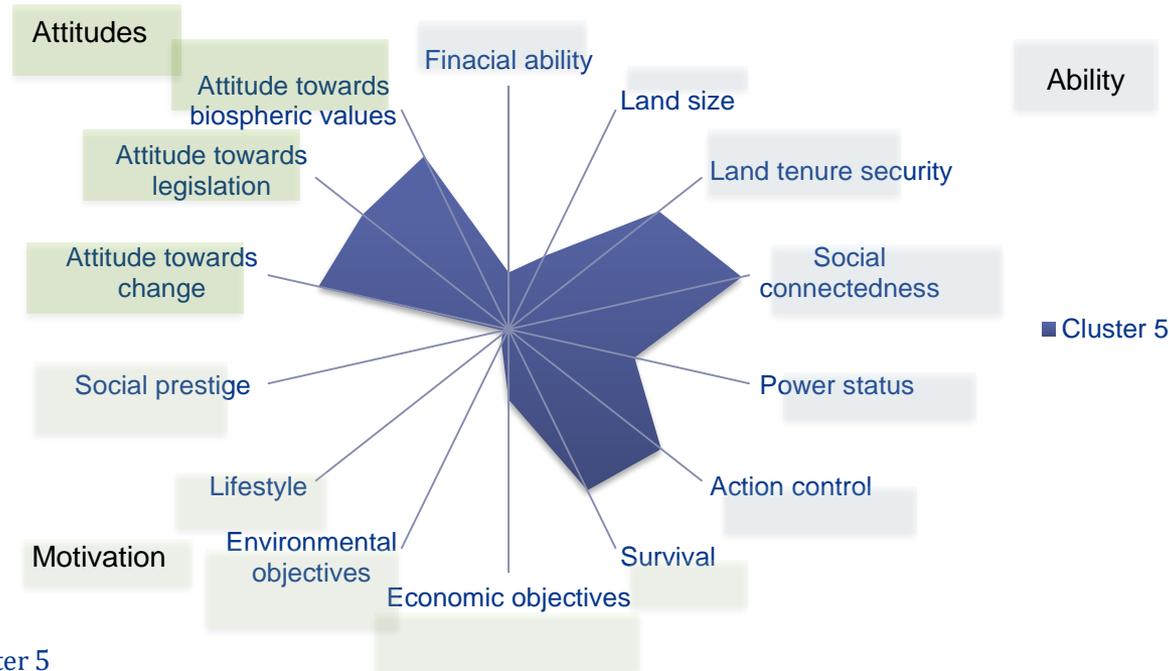
Decision-making type 4



	Cluster 4
Main motivation	Economic
Attitudes	Most progressive, highest adherence towards rules
Ability	Not poor, but not rich, highest land size, medium land tenure security
Social	Well connected, moderate power and autonomy

RESULTS: TYPOLOGY OF DECISION-MAKING

Decision-making type 5

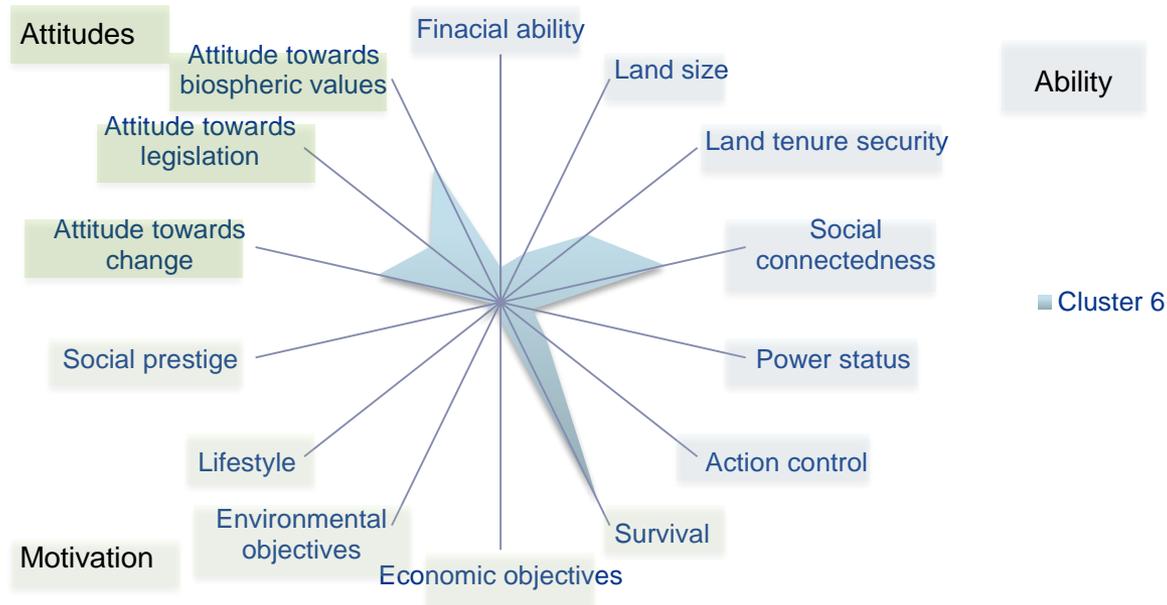


Cluster 5

Main motivation	High Survival, lesser extent economic
Attitudes	Progressive, high adherence to rules, high biospheric values
Ability	Poor, low land size, high land tenure security
Social	Best socially connected, low power, high autonomy

RESULTS: TYPOLOGY OF DECISION-MAKING

Decision-making type 6



	Cluster 6
Main motivation	Highest survival
Attitudes	Lowest adherence to rules, lowest attitude towards changes, high biospheric values
Ability	Poorest actor, lowest land tenure security
Social	Good connected, lowest power, lowest autonomy



Conclusions

- ***Location matters*** for impacts, leakage and displacement effects
- ***Spatial uncertainty*** of land use models is very high
- Progress:
 - >>from land cover to land system representations
 - >>from pixels to land management scales
 - >>from sectoral demands to ecosystem goods/services
 - >>from biophysical suitability to behaviour



Thank you!
www.environmentalgeography.nl