Life cycle assessment needs predictive spatial modelling for biodiversity and ecosystem services

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LCA Forum, November 3rd, 2017

natural capital PROJECT

Unilever

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Shining a light on the intimate connections between people and nature

Stanford | Department of Biology

Stanford Woods Institute for the Environment

WWF

The Nature Conservancy

Institute on the Environment

University of Minnesota

Driven to Discover℠

Pollination

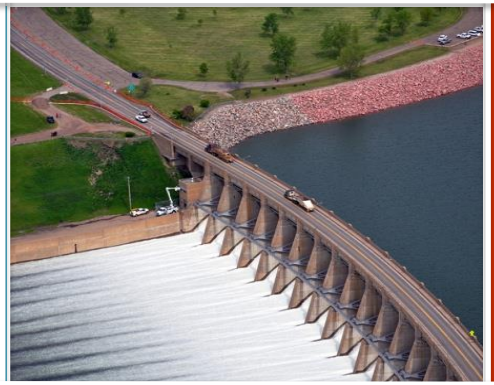
Air quality

Cultural value

Water supply

Food, fuel, fiber

Food production



Flood protection

Clean water

Mental health

Recreation

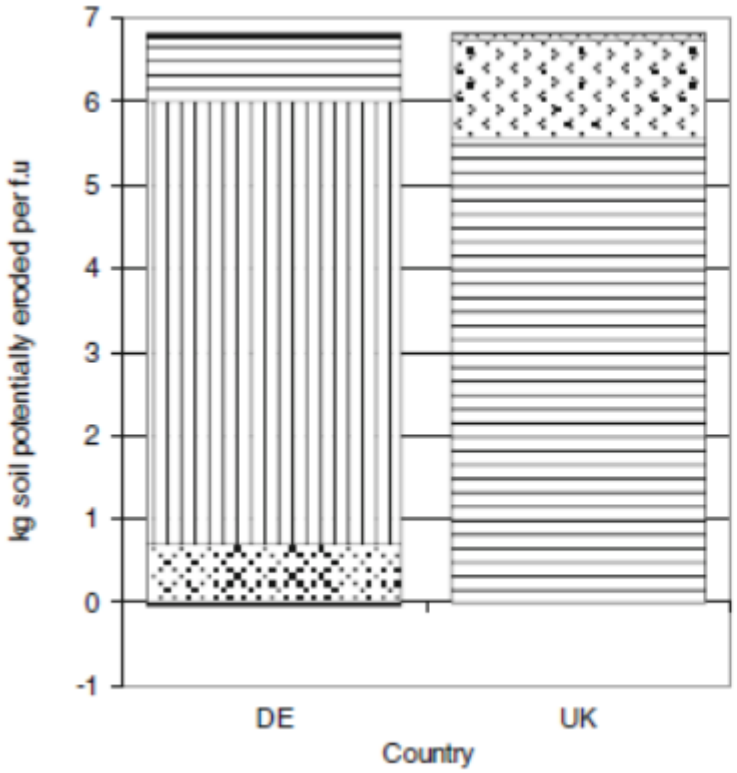
Does a commodity supply chain depend on ecosystem services?

Where are the safest sourcing regions to minimize harm to ecosystems?

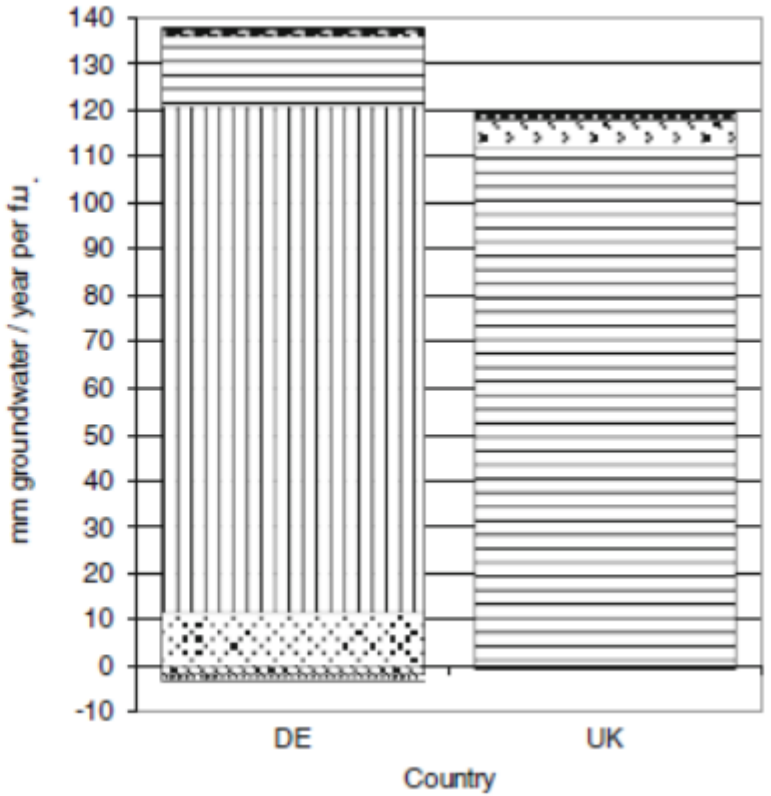
Can we enhance LCAs to better represent environmental impacts?

Life Cycle Assessment calculates product impacts

Erosion regulation potential

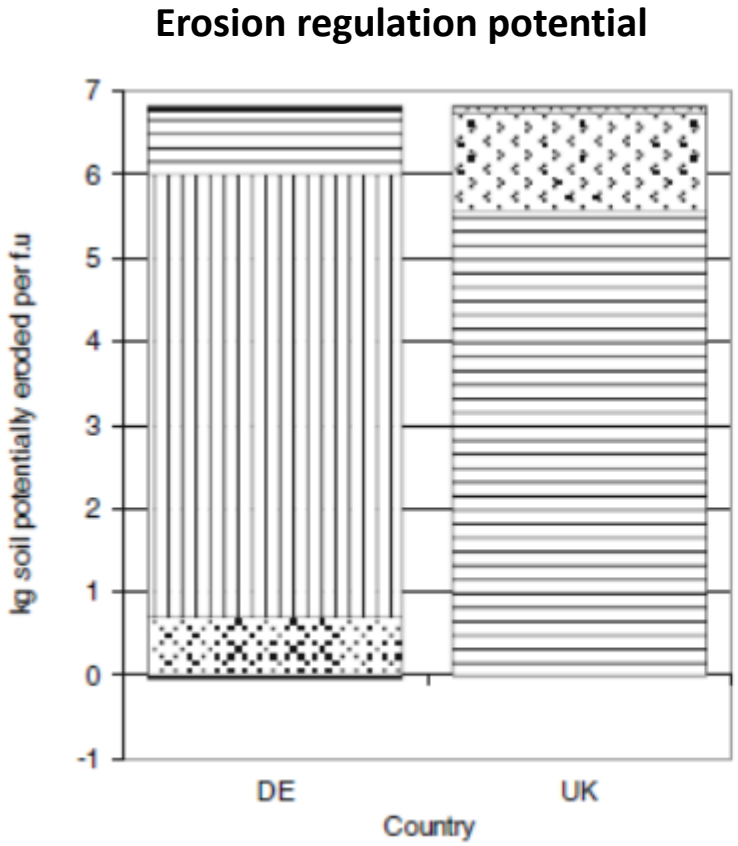


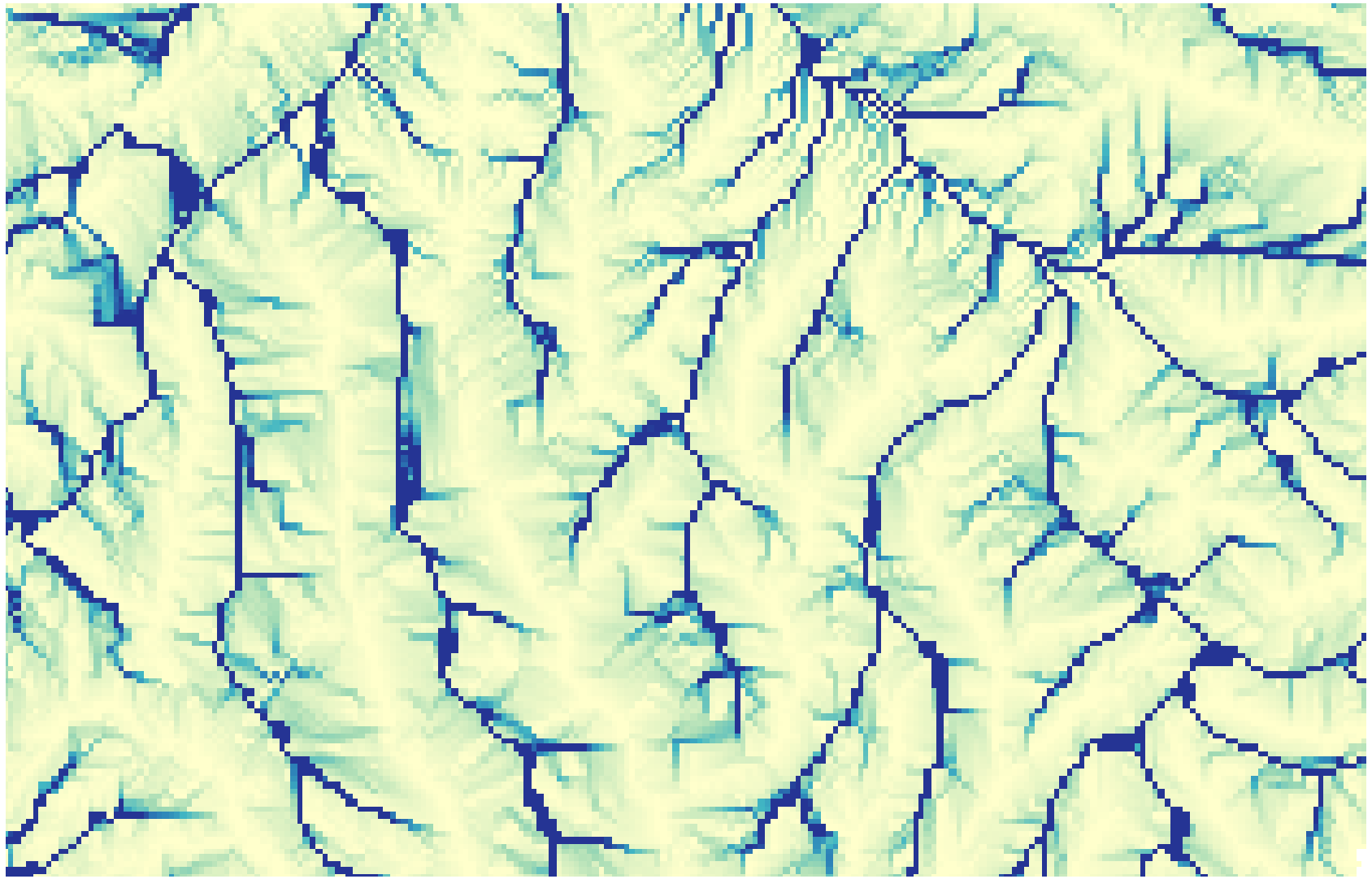
Freshwater regulation potential



Milà i Canals et al. 2013

… but LCA doesn't capture spatial context



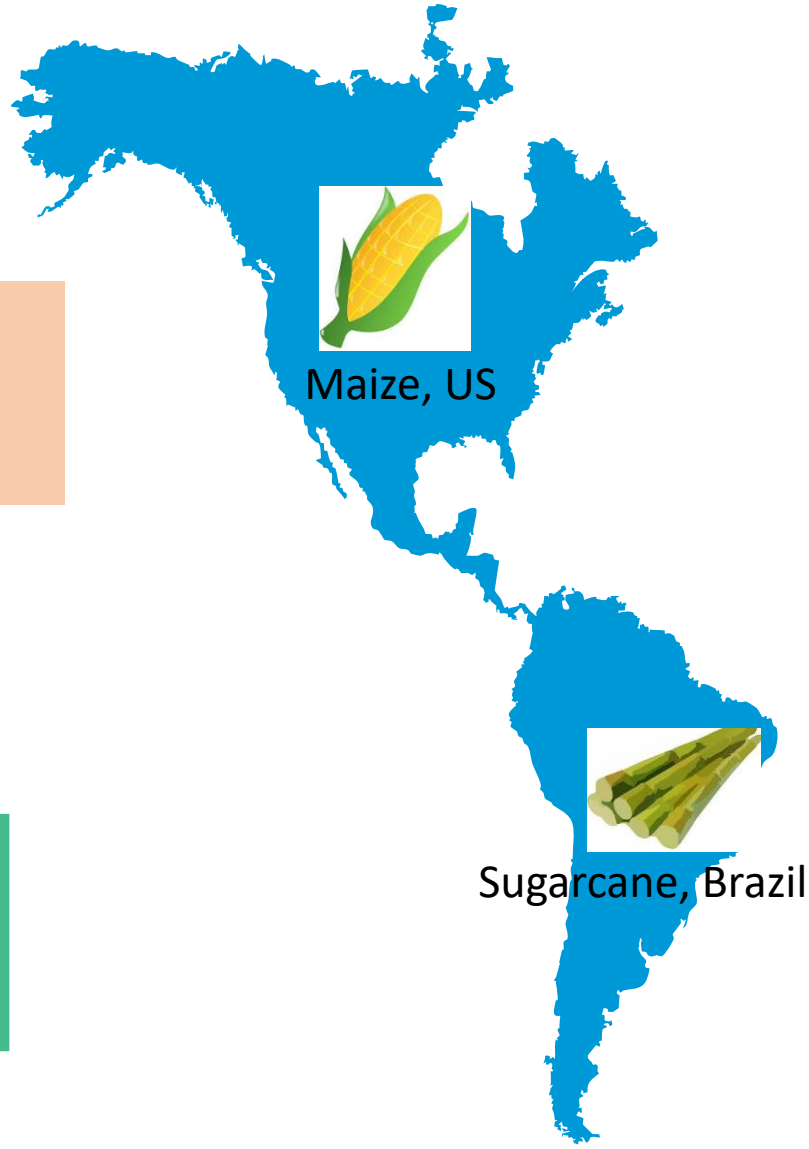


Bioplastics Use Case

“Life cycle assessment needs predictive spatial modelling for biodiversity and ecosystem services” Nature Communications 2017

BIOPLASTICS USE CASE

Which bioplastic feedstocks, grown in which locations have lower environmental impacts?



3 production volume scenarios

Biodiversity and ecosystem services:

- Water consumption
- Eutrophication potential
- Erosion regulation
- Global warming
- Biodiversity damage

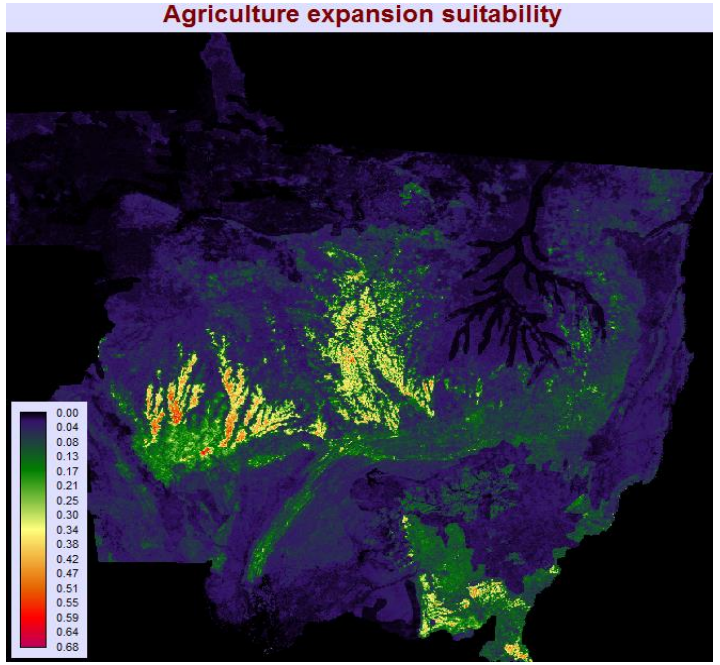
Constraints

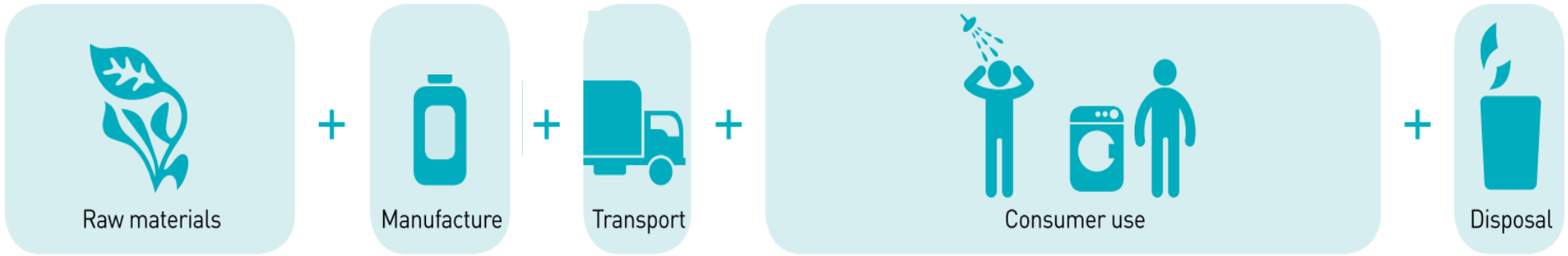
- Works with globally available data
- Works with limited land change/ES modelling expertise

- Takes account of expansion and *some* account of intensification
- Allocates expansion based on suitability of land for agriculture

Our Approach: LUCI-LCA

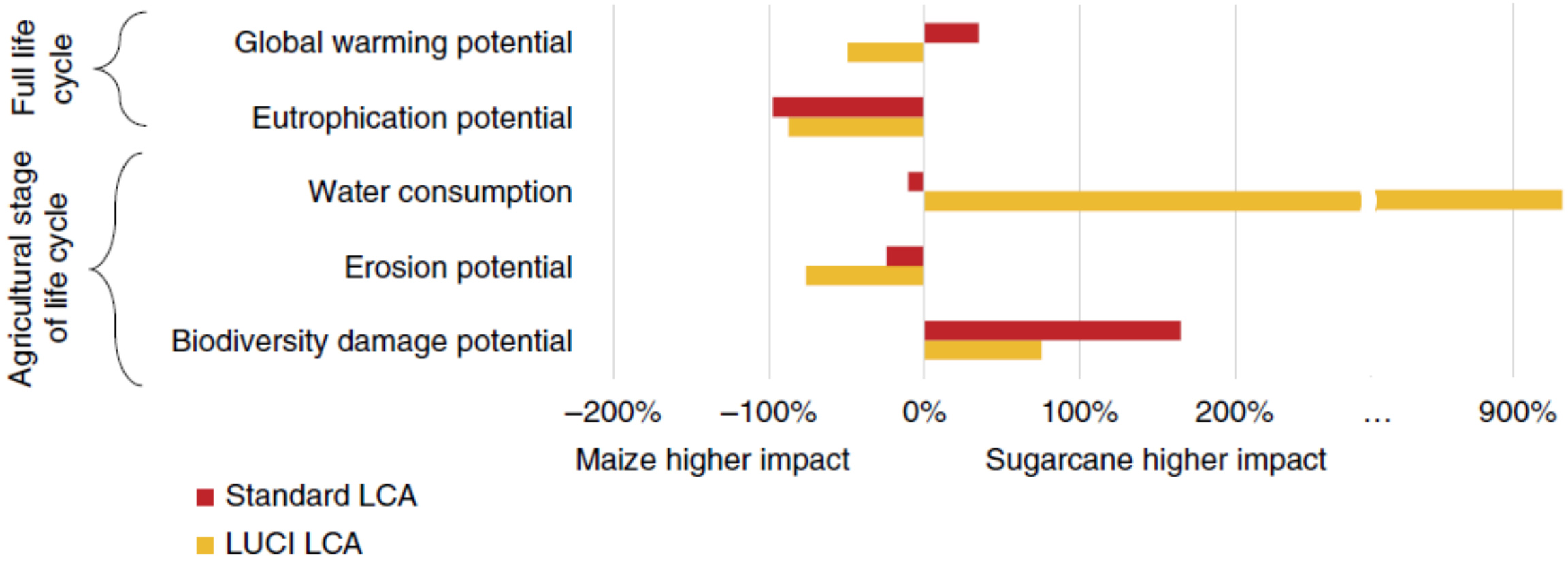
- Contextualising impacts of land use change in relation to the rest of the life cycle through LCA





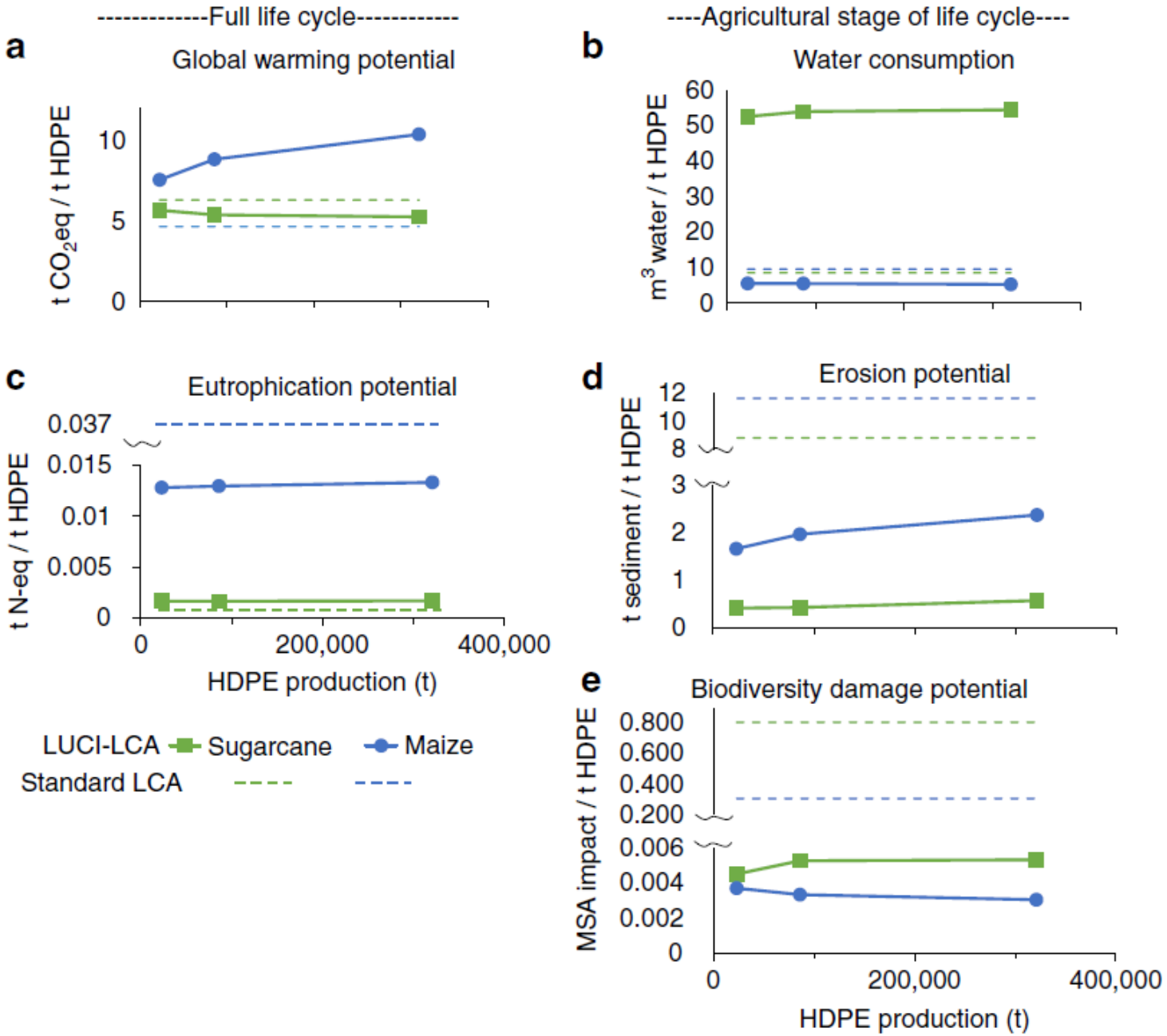
Source: Unilever Sustainable Living Plan

Take-home #1: Enhanced LCA changes sourcing decisions (Brazil vs. US)



Chaplin-Kramer et al. 2017 Nature Communications

Take-home #2: Production volume changes the impact on ecosystem services



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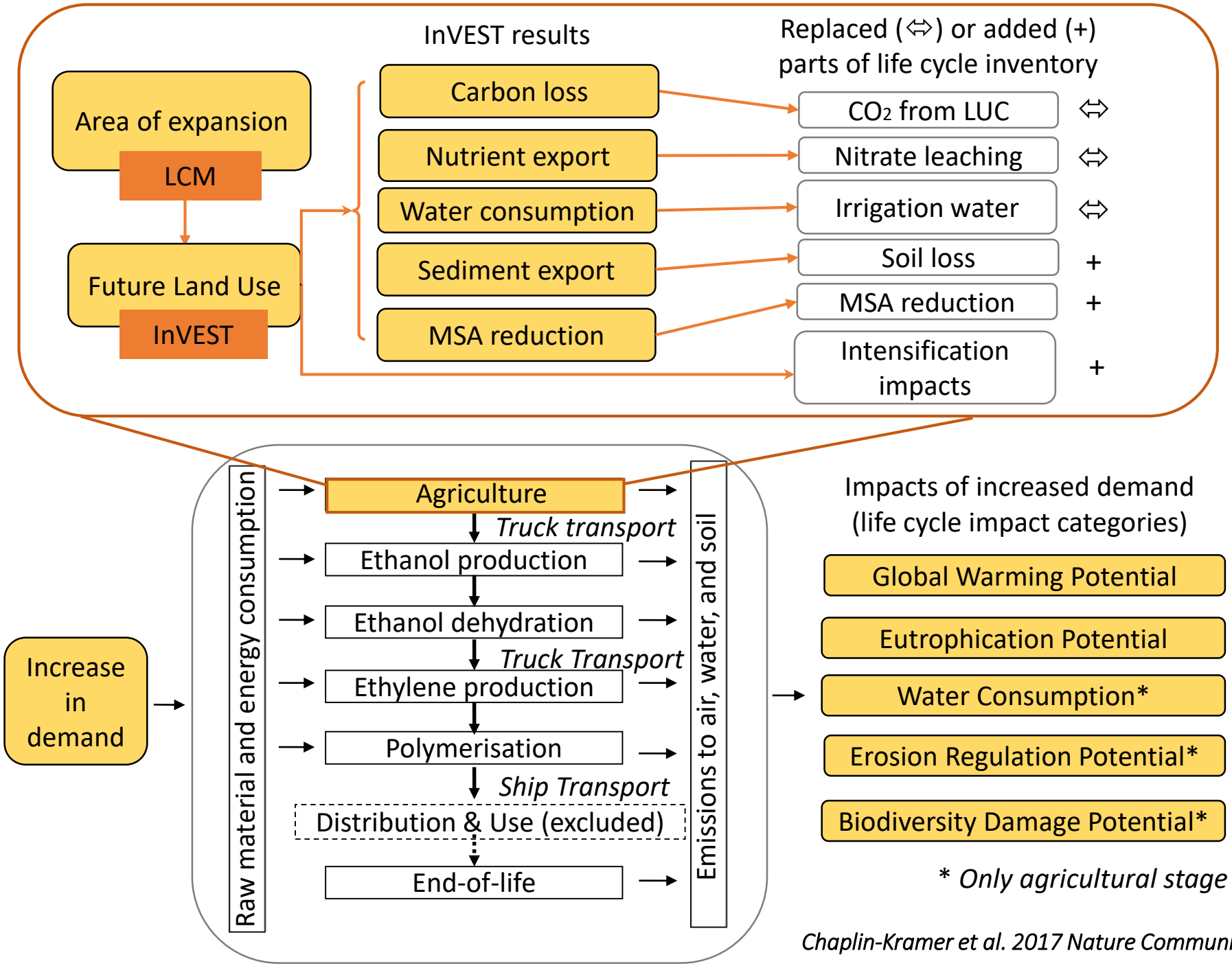
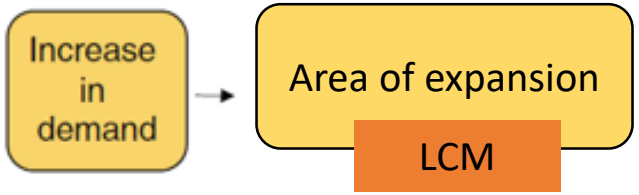
Methods

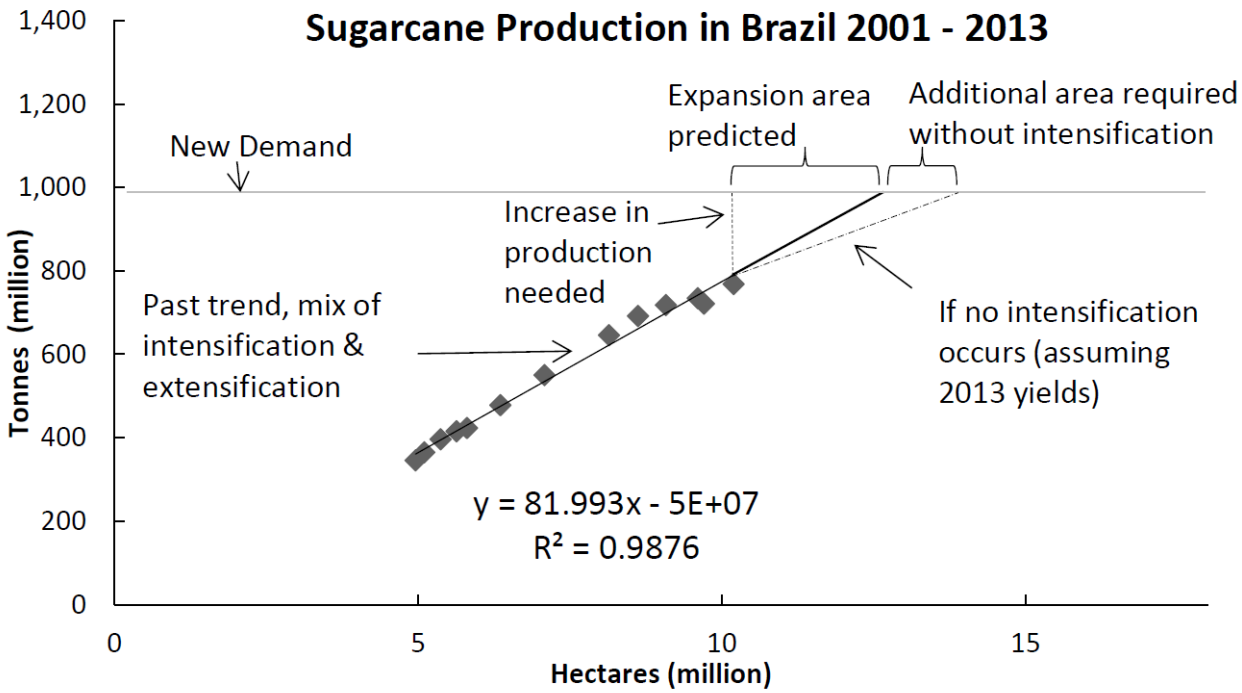
Spatially-explicit, predictive Life Cycle Assessment



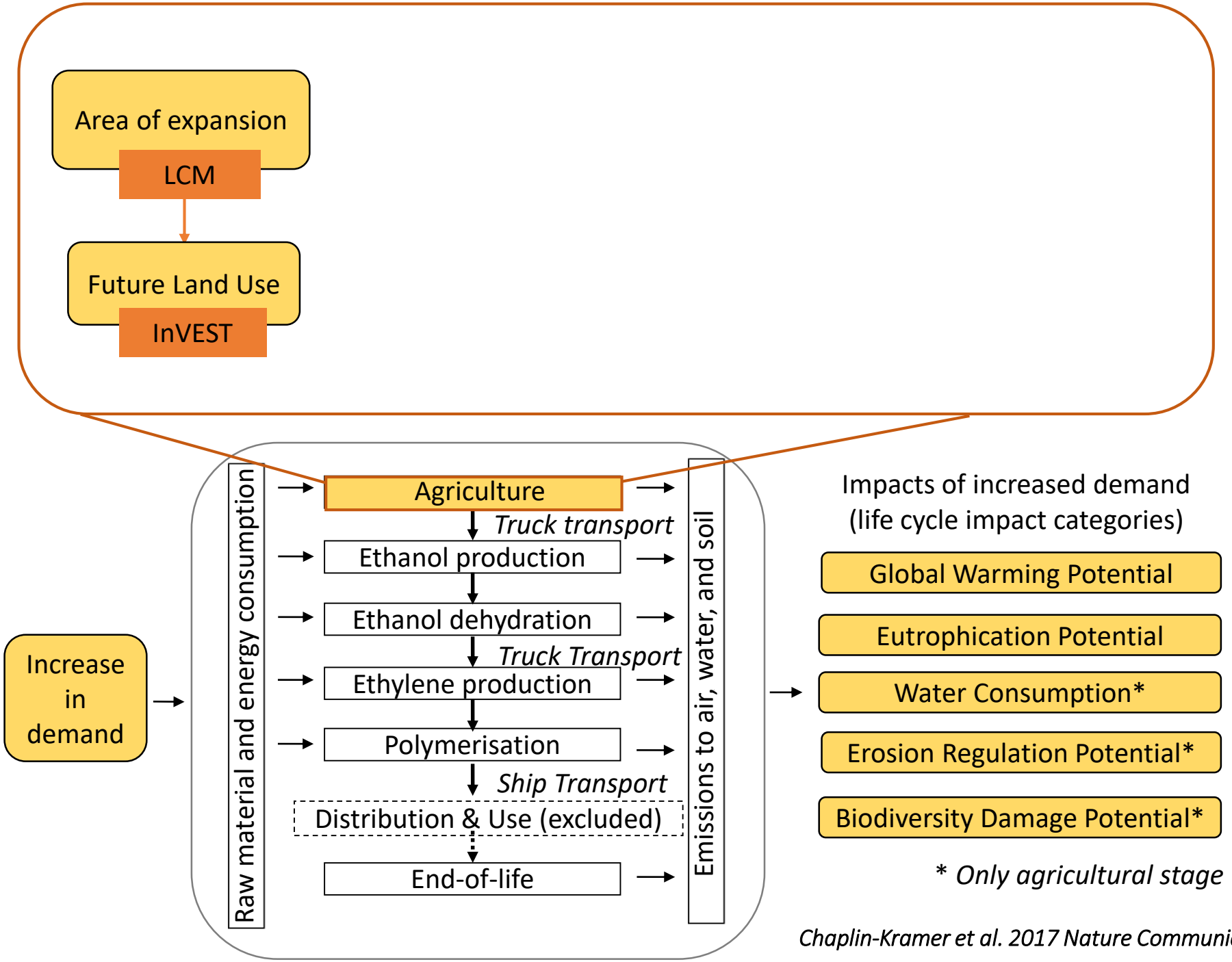
Chaplin-Kramer et al. 2017 Nature Communications



Crop	HDPE demand (T)	Conversion Factor	Crop production target (T):	Area of expansion predicted (ha):
Sugarcane	23,000	26.75	615,278	7,504
Sugarcane	86,000		2,300,603	28,059
Sugarcane	321,000		8,587,134	104,730
Maize	23,000	5		
Maize	86,000			
Maize	321,000			



Spatially-explicit, predictive Life Cycle Assessment



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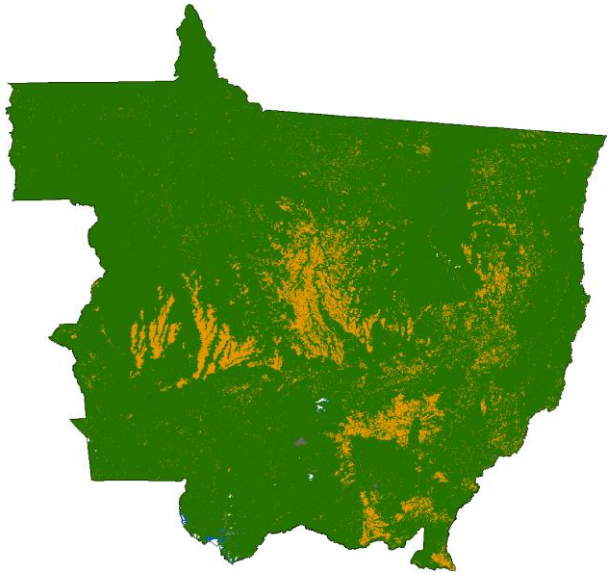
Area of expansion

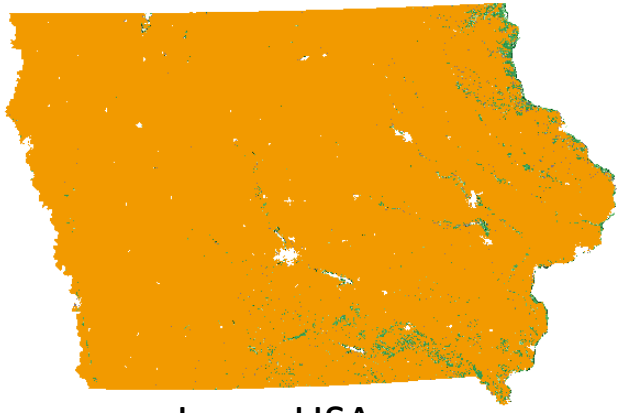
LCM

Future Land Use

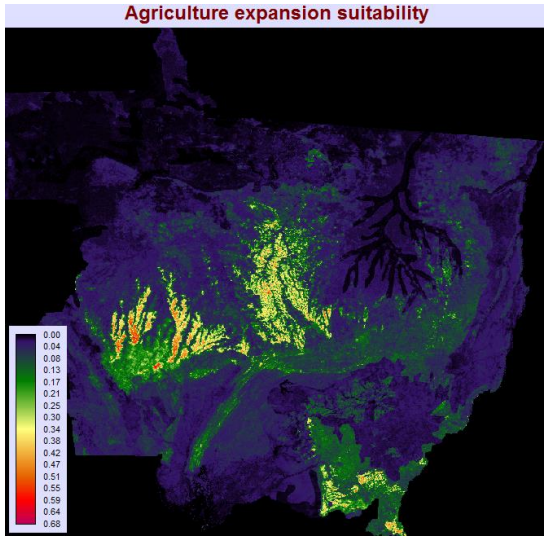
InVEST

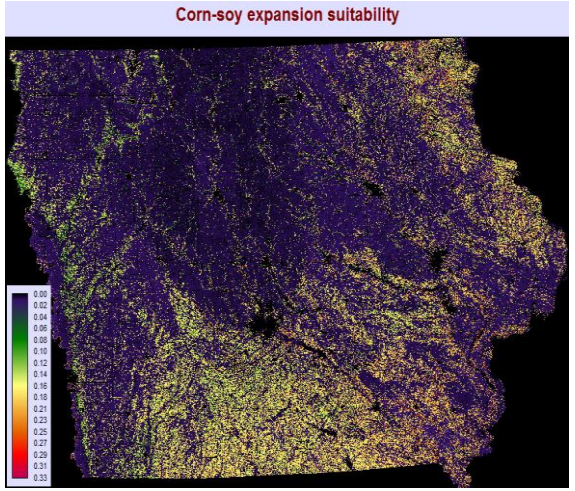


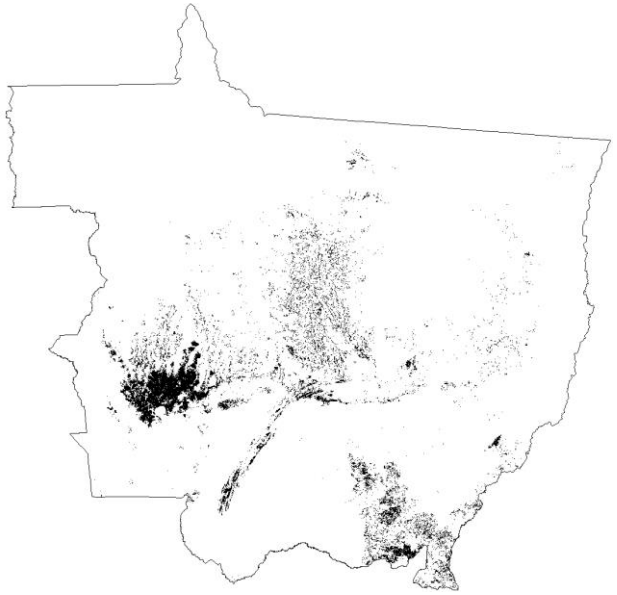
Mato Grosso, Brazil

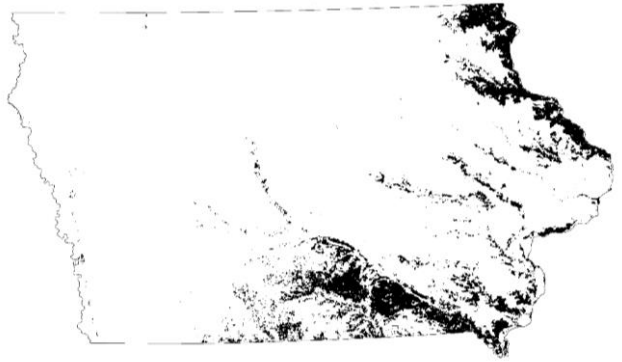


Iowa, USA





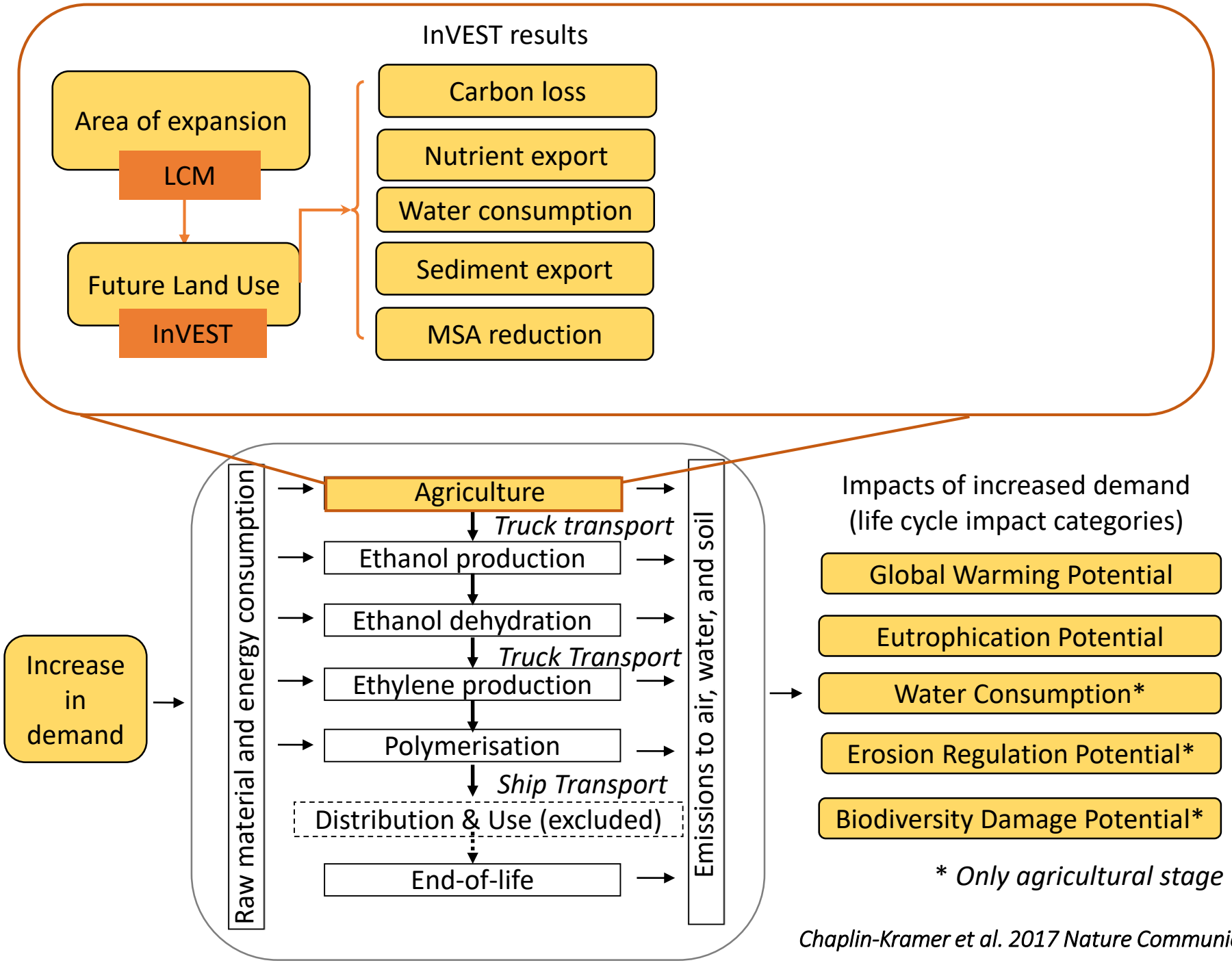




InVEST integrated valuation of ecosystem services and tradeoffs

Scenario Generator

Spatially-explicit, predictive Life Cycle Assessment



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Area of expansion

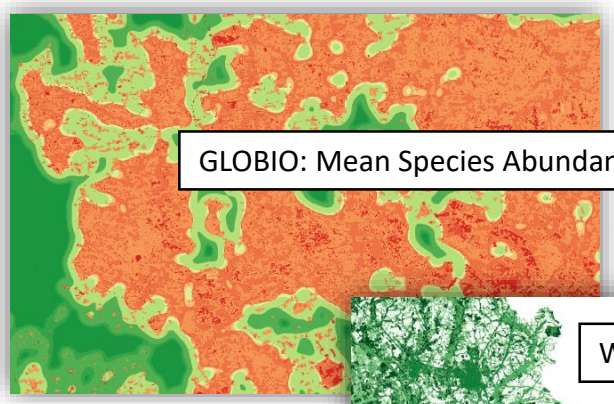
LCM

Future Land Use

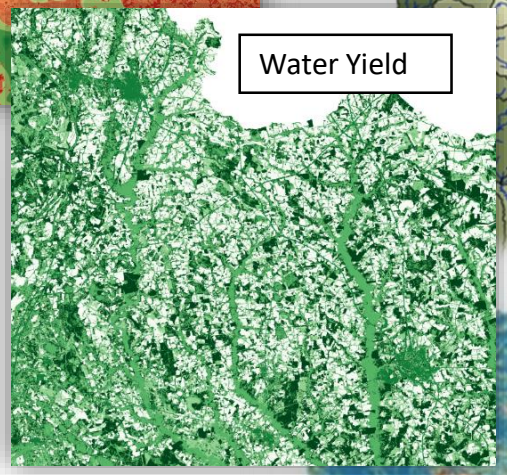
InVEST

InVEST results

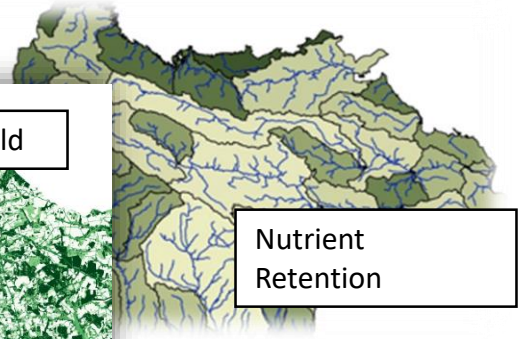
- Carbon loss
- Nutrient export
- Water consumption
- Sediment export
- MSA reduction



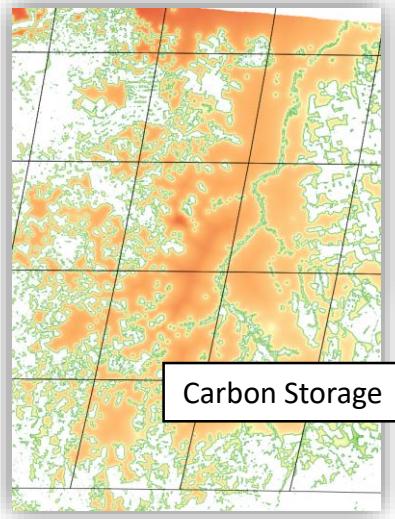
GLOBIO: Mean Species Abundance



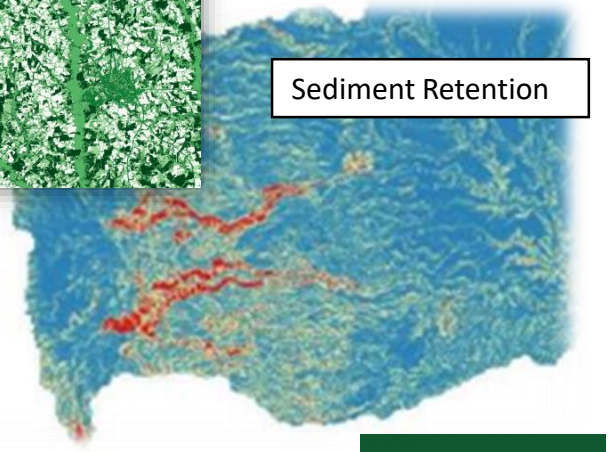
Water Yield



Nutrient Retention



Carbon Storage

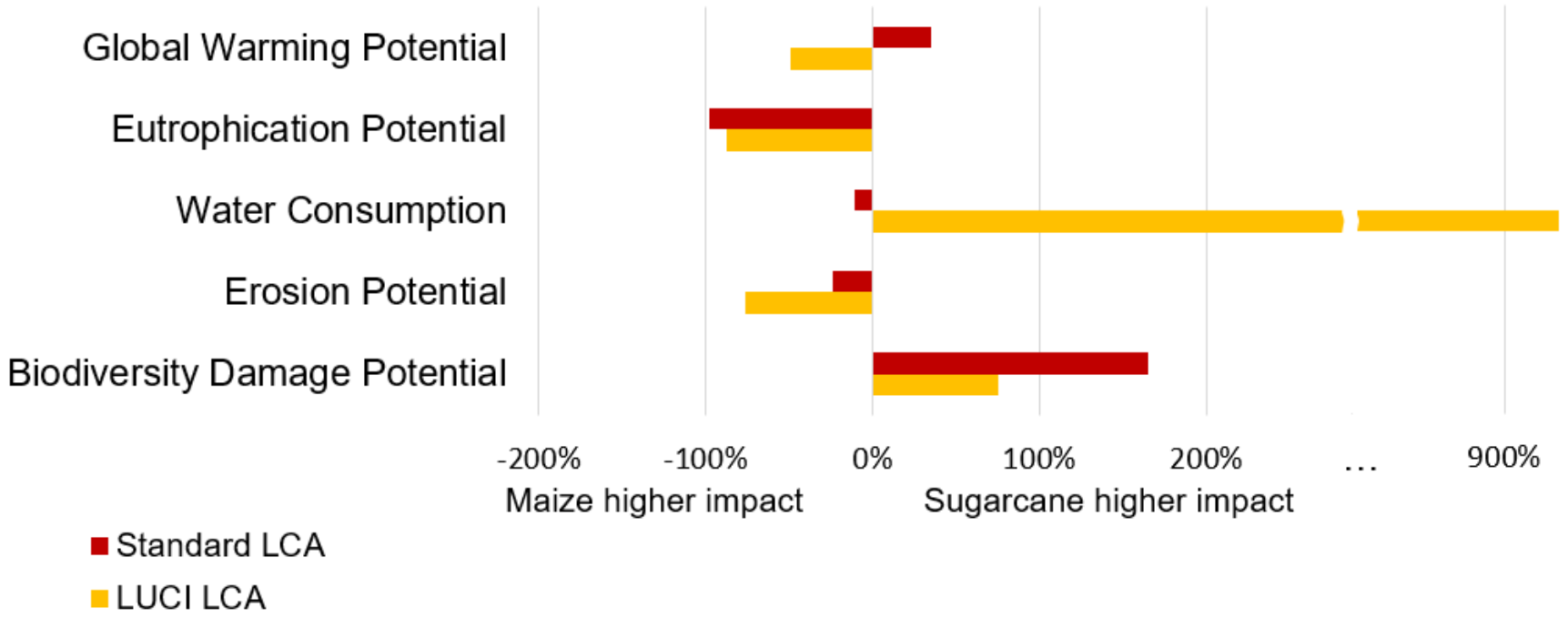


Sediment Retention

InVEST

integrated valuation of ecosystem services and tradeoffs

Spatially-explicit understanding from LUCI-LCA may change supply chain decisions



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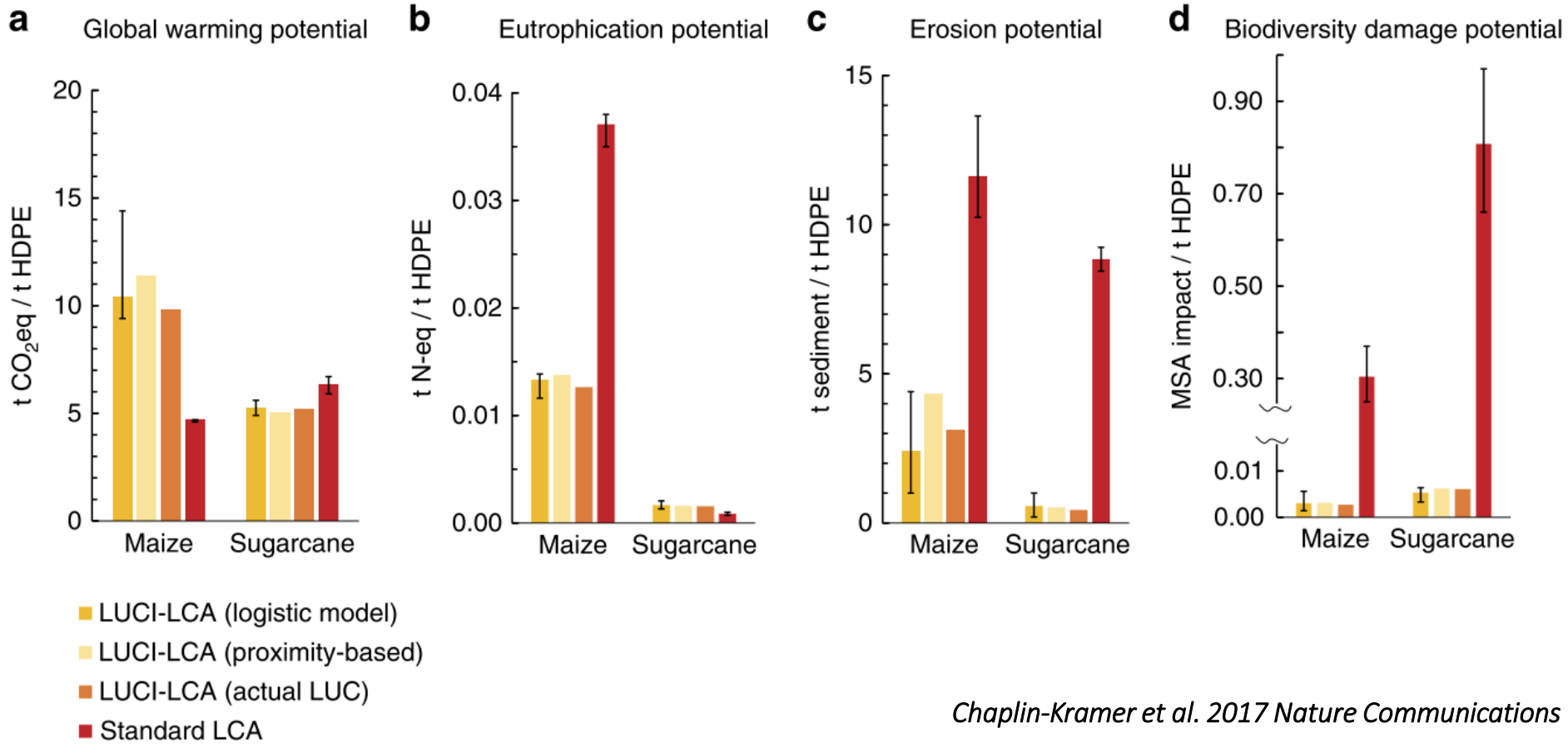
Discussion

- How confident are we in these results?
- Multi-criteria analyses: combining information from 5 services?



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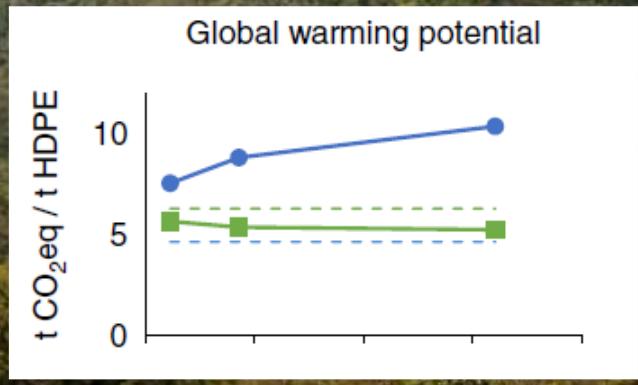
What are the biodiversity and ecosystem impacts and dependencies of increased use of bio-based materials?

InVEST integrated valuation of ecosystem services and tradeoffs

Scenario Generator

Do impacts and dependencies differ with different ambitions for production volumes?



How can we guide procurement or product development options to source commodities with lower risks?

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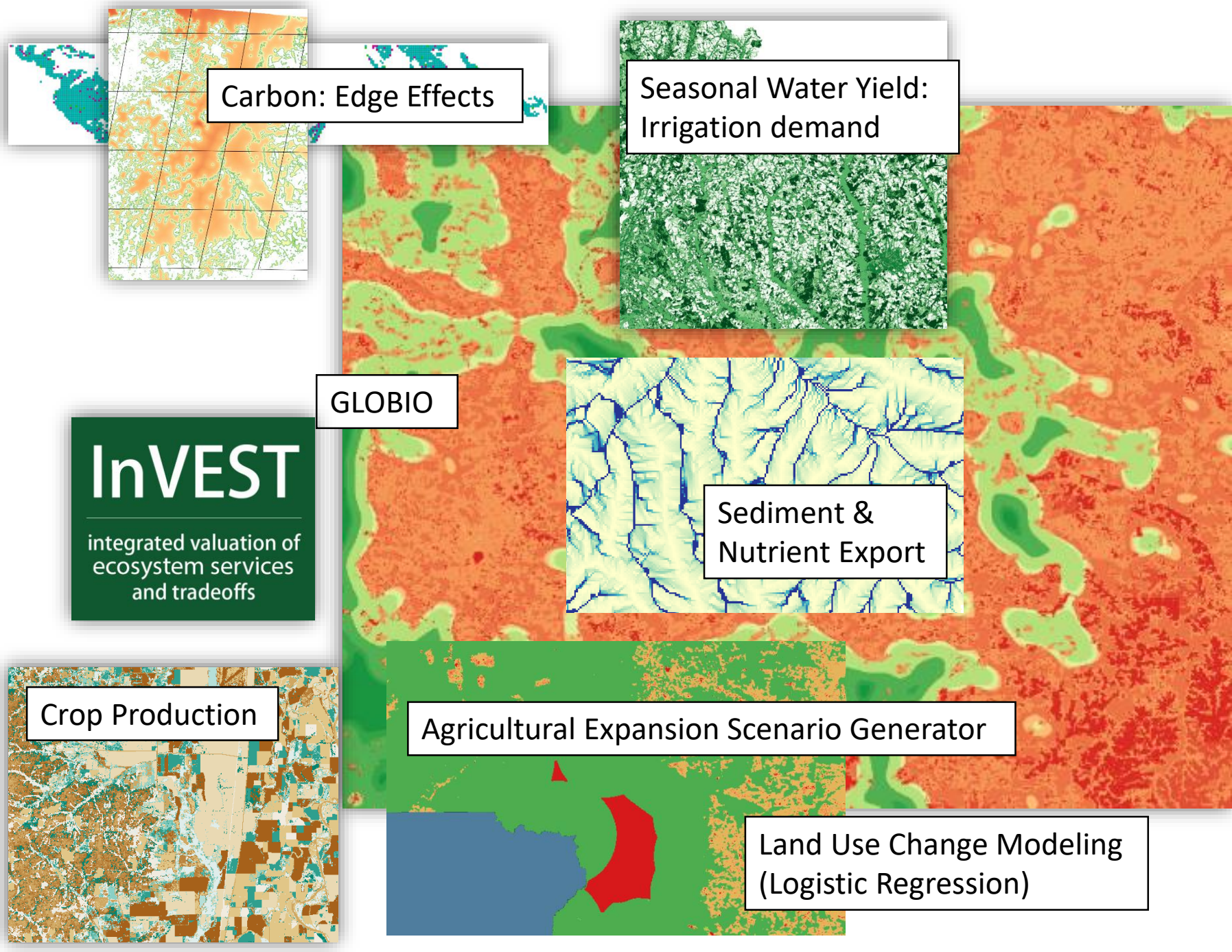
Unilever

LUCI-LCA

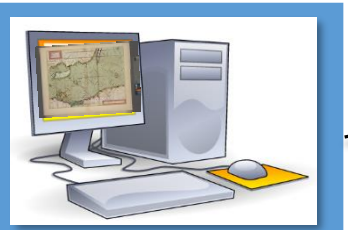
LUCI-LCA “2.0”

NatCap Software Platform: New ES Models & Tools



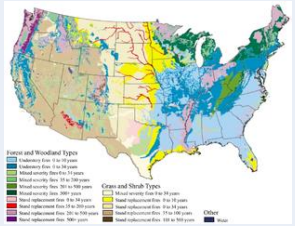
InVEST 3.3.x

Data
User provides from local computer



Scenarios
Developed by individuals/ committee

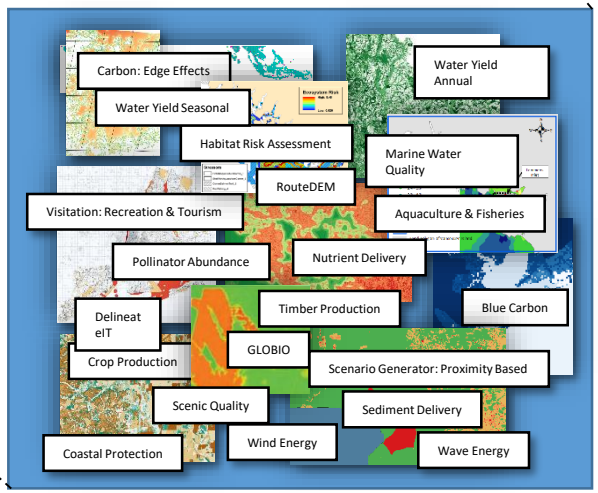
Results
Ecosystem Service Quantification



InVEST

integrated valuation of ecosystem services and tradeoffs

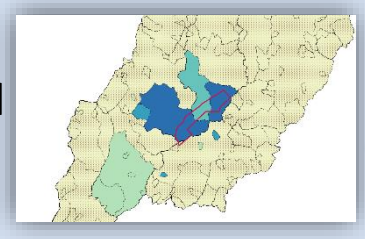
natural capital PROJECT



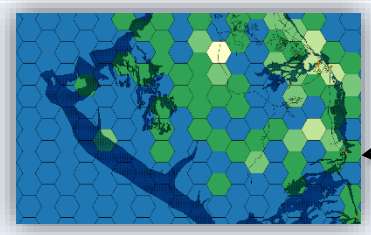
InVEST Platform

Data
Curated free global data
(or from local computer)

Potential Spatial Decisions
Expressed as constraints and preferences
(or developed by individuals/committee)

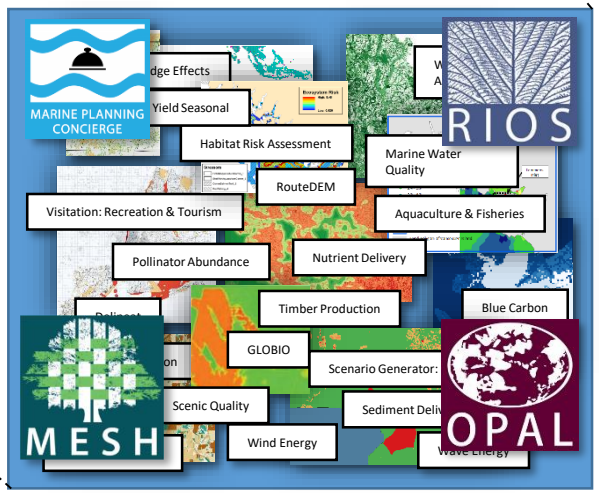


Results
Spatial Plans Guided by Mathematical Optimization (or ecosystem service quantification)



InVEST
integrated valuation of ecosystem services and tradeoffs

natural capital PROJECT



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data_tile = data_server.fetch_data_tile(aoi_bounding_box, data_id)
```

```
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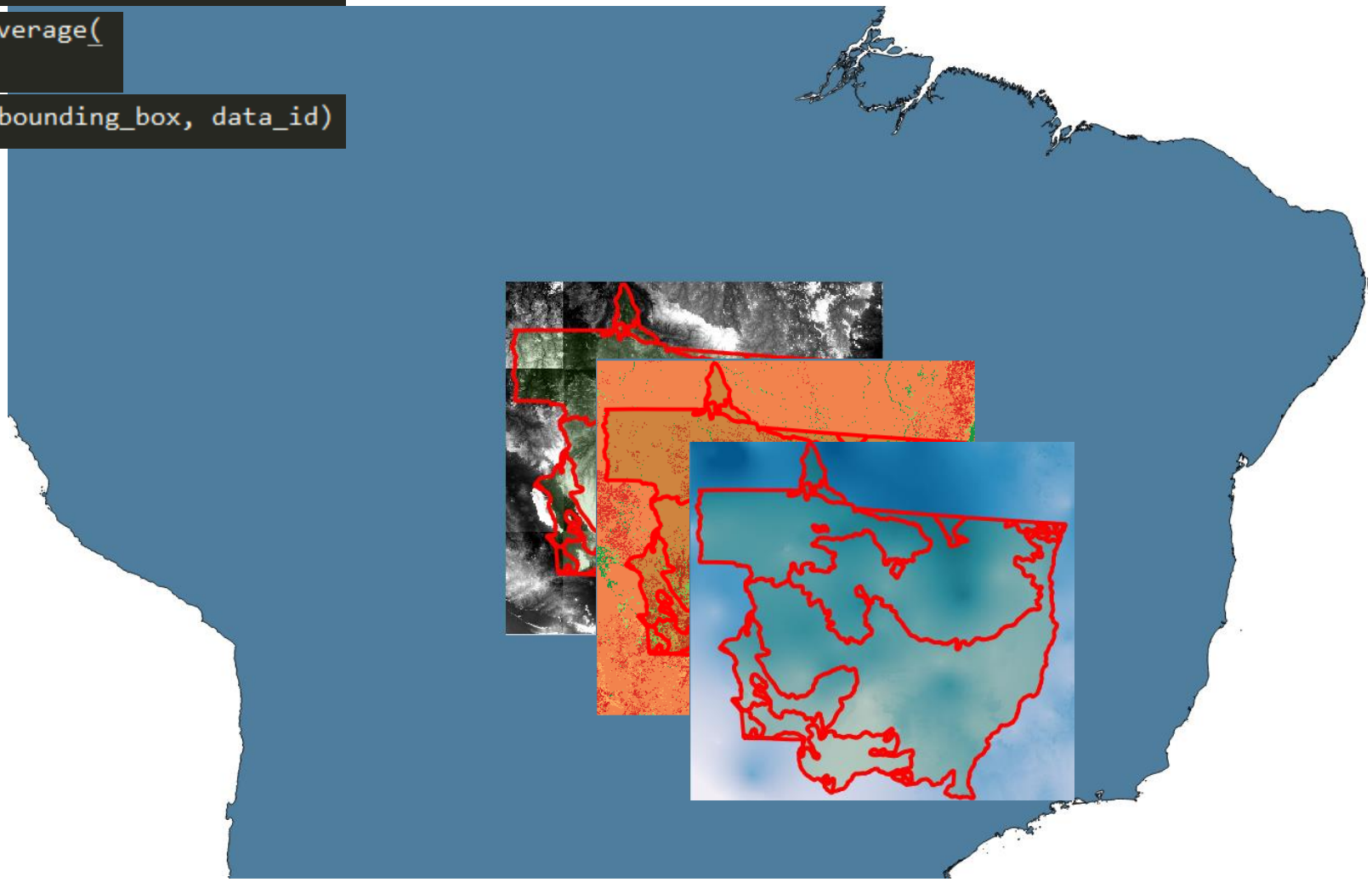
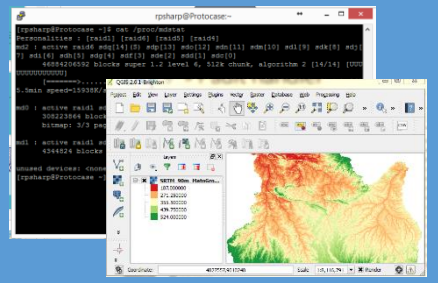
    aoi_bounding_box, ['lulc', 'precip'])
data_tile = data_server.fetch_data_tile(aoi_bounding_box, data_id)
```

NatCap Software Platform: Data Serving Preview

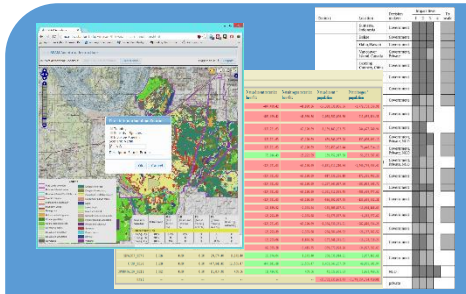


Workflow for spatial LCA approach



Preprocessing

Computation, Simulation, Quantification



Reporting, Visualization

Data aggregation, formatting, storage and selection for area of interest

Model agricultural intensification/ expansion to meet commodity demand in different regions; evaluate BES impacts of LUC resulting from sourcing decisions

- Maps of land-use change and BES impacts.
- Tables comparing impacts in different sourcing regions.
- Tools to translate change in commodity demand to likely sourcing region, changes to production, indirect effects, cumulative BES impacts.

Questions?

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Literature cited:

Milà i Canals, L., Rigarlsford, G. & Sim, S. Int J Life Cycle Assess (2013) 18: 1265.

Chaplin-Kramer, R., Sim, S., Hamel, P., Bryant, B., Noe, R., Mueller, C., … Daily, G. (2017). Life Cycle Assessment Needs Predictive, Spatial Modelling for Biodiversity and Ecosystem Services. Nature Communications, 8(15065).