Nachhaltige Landnutzung – Wie regional-skalige Forschungsprojekte Antworten auf globale Fragen geben können

Ralf Seppelt, 6.12.2013 KBU Fachtagung

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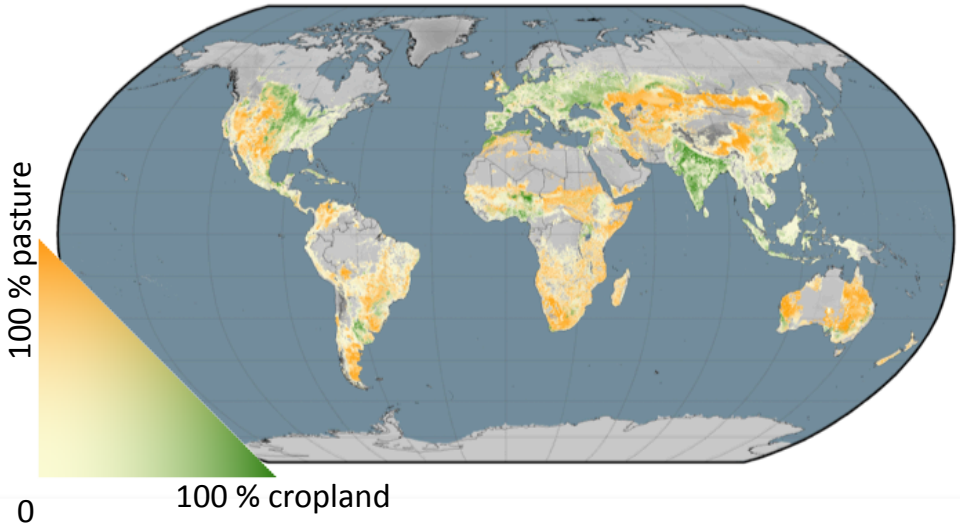
Sustainable Land Management

Sustainablility, with respect to land use:

Organize land use in a way, that

- human needs are satisfied
- given the environmental conditions and
- so that economy does not set impulses for off-setting external effects

Achive productivity, while maintaing biodiversity...



Land use Foley et al (2005, Science)

- Agriculture (14%)
- Pasture, meadows (26%)
- Infrastructure (0,5%)
- Forests (35%)
- Protection sites (11%)

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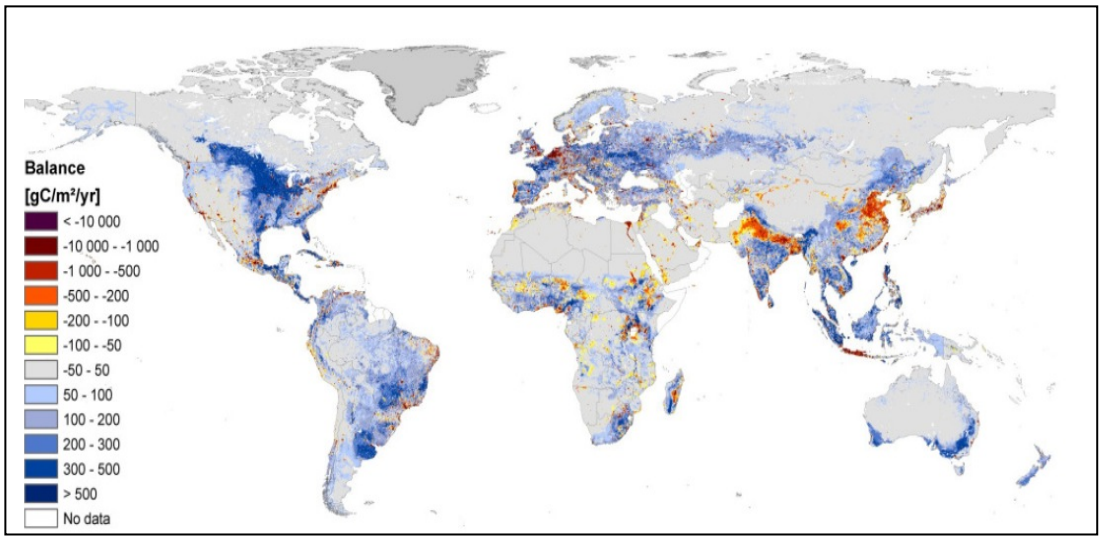
Harvesting our Earth (HANPP)



Human NPP Appropriation

- 15.6 Pg C/yr or 23.8% of potential net primary productivity
- 53% harvest,
- 40% land-use-induced productivity changes,
- 7% by human-induced fire

Haberl et al. (2007, PNAS)

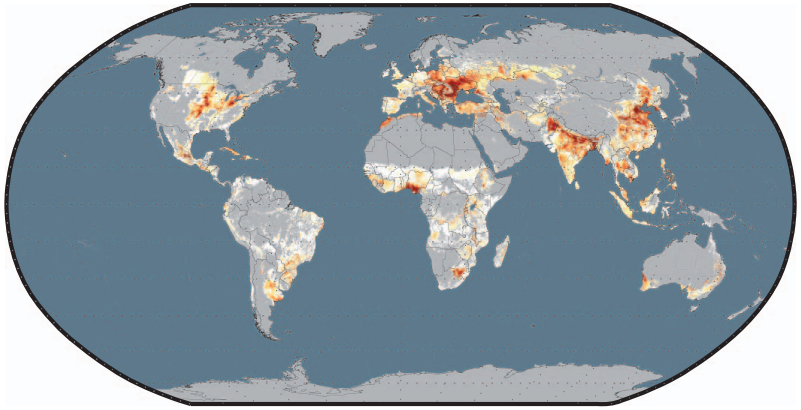
Agriculture (1961-1999)

- 12% increase in cropland
- 10% rise in permanent pasture
- Increase of 106% of overall food crop yield per unit area
- 97% rise in the area of land under irrigation,
- 638%, 203%, and 854% increase, in the use of fertilizers

Green, (2005, Science)

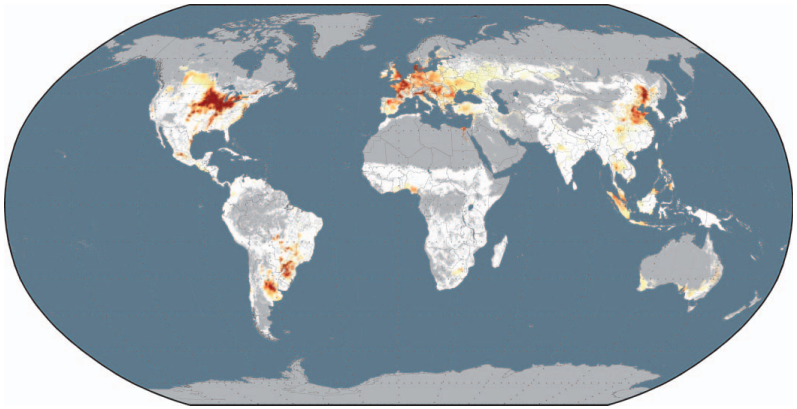
„Solutions for a cultivated planet“

- Stop expanding agriculture
- Close yield gaps
- Increase agricultural resource efficiency
- Increase food delivery by shifting diets and reducing waste



New calories from closing yield gaps for staple crops
($\times 10^6$ kcal per hectare)

0 0.5 1 1.5 2 2.5 3 3.5 4 4.5 5



Potential diet gap calories
($\times 10^6$ kcal per hectare)

0 0.5 1 1.5 2 2.5 3 3.5 4 4.5 5

Foley et al (2011, Science)

Global food security and biodiversity

- **Global food security is not directly linked to global food production**
  - Food production from smallholder farms is the backbone of global food security
  - Global food production is sufficient, but not available to the hungry
  - Food usage is inefficient – one third is wasted and one third fed to livestock
  - The EU '10% biofuel directive' causes increased food prices and contributes to rainforest destruction
  - Land grabbing and speculation on food commodities jeopardizes food security
- **Increasing yields need not translate into biodiversity loss**
- **Agroecological intensification sustains ecosystem services, while minimizing environmental costs and maintaining functional biodiversity**
  - Wildlife-friendly farming sustains cultural ecosystem services
  - Conventional intensification causes often overlooked environmental costs
  - The role of agrobiodiversity and associated ecosystem services

Tscharntke et al. (2012, Biol.Cons.)

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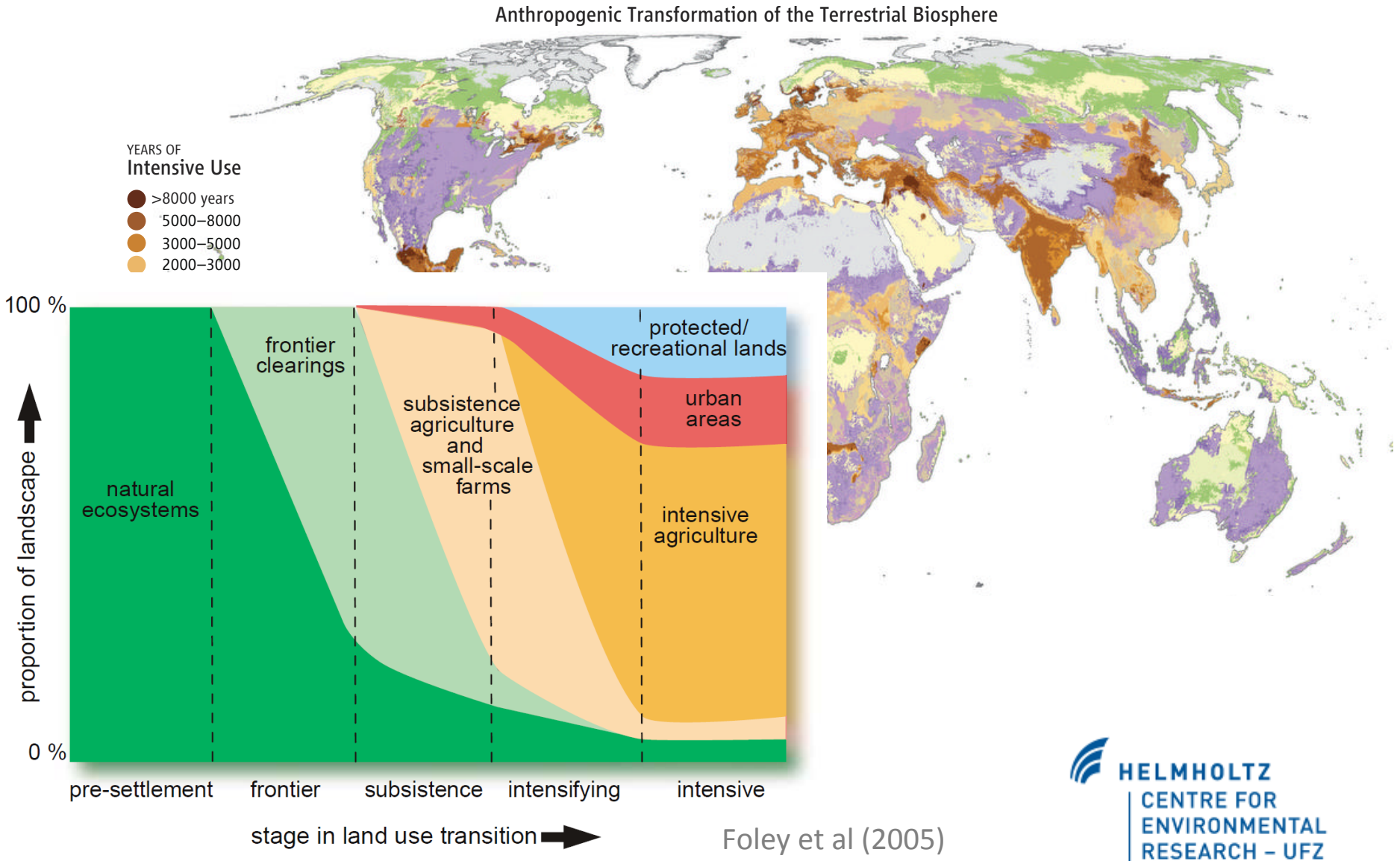
Global Land Use Change



Foley et al (2005)

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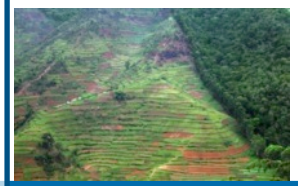
Consistant global scenarios

Global quotas		**Policy Scenario 1:** No global biofuel quotas		No quotas
Higher		**Policy Scenario 2:** Dairy/meat consumption		Lower
No expansion, historical yields		**Policy Scenario 3:** Expansion of agricultural land		Expansion, increase in productivity
No expansion, historical yields		**Policy Scenario 4:** Expansion of agricultural land; not into protected areas		Expansion, increase in productivity
Scenario Higher pressure on land	**Baseline scenario: Business as might be usual** Current legislation (tariffs, quotas, RCP 8.5)			**Scenario Lower pressure on land**

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Integrated gobal Agro-Environmental Models

Climate Scenarios
Soil
Topography
Crop-Suitability
Sowing Dates
Multiple Cropping
Irrigation

PROMET

Global Dynamic
Crop- Growth Model
(hourly , 1 km)

coupling

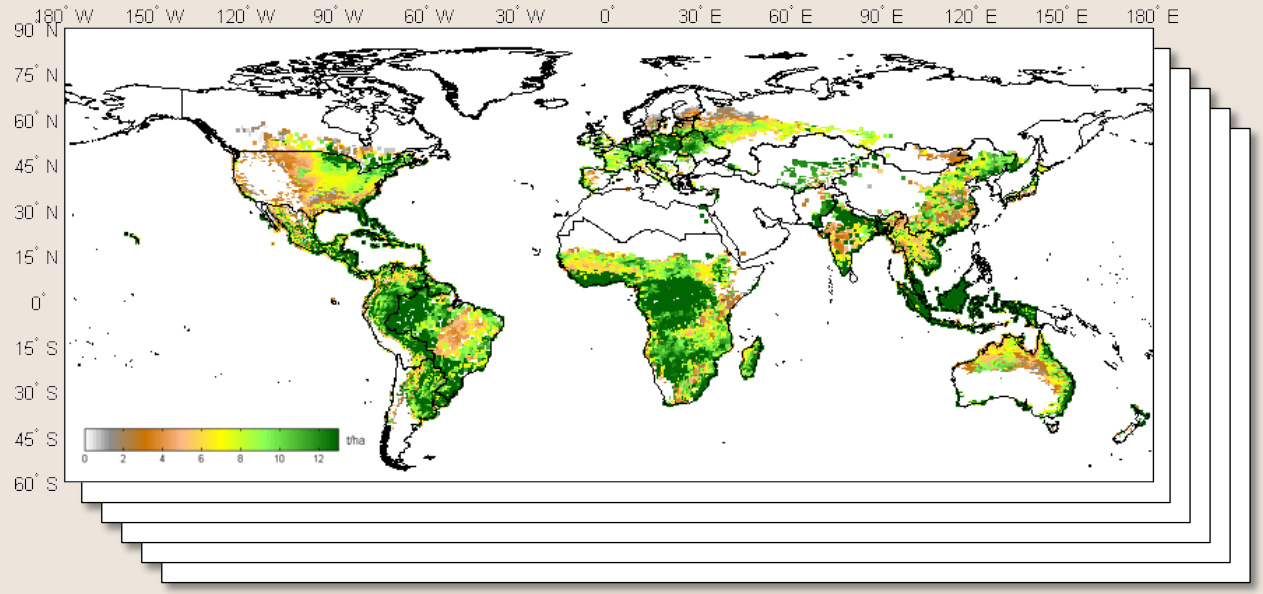
DART

Multi-Regional Global
General Equilibrium
Model

Socio-economic
Scenarios

GTAP
Database

Potential agro-economic yield

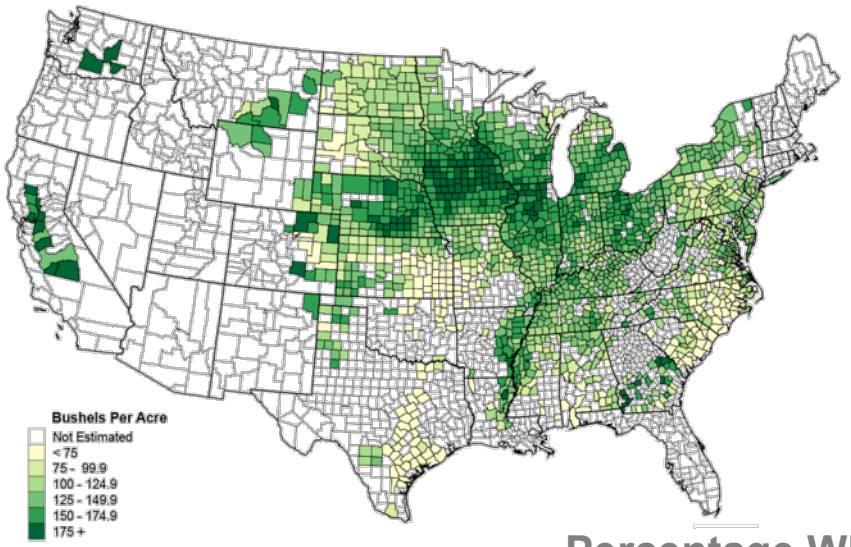


18 crops:Maize, Rice, Wheat, Oilpalm, Potato, Soy, Sugarcane...

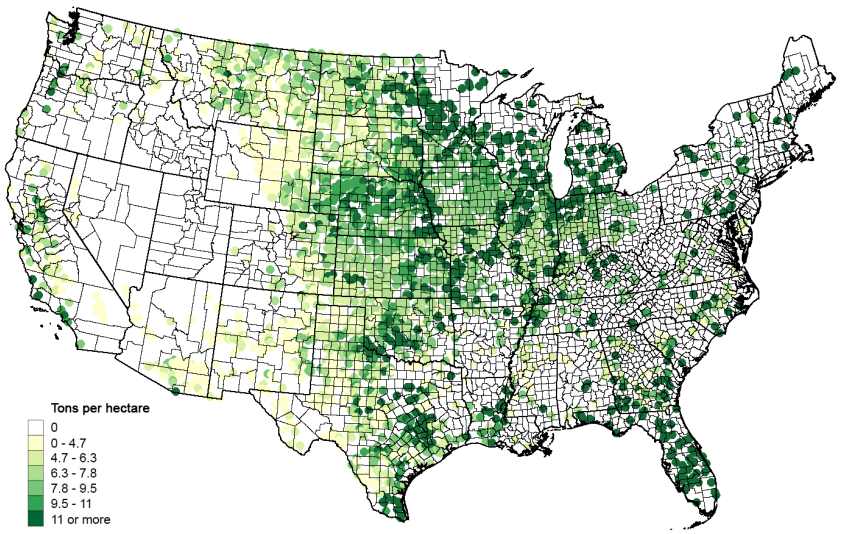
Reconstruction of Yields and Land Use

Yield Maize

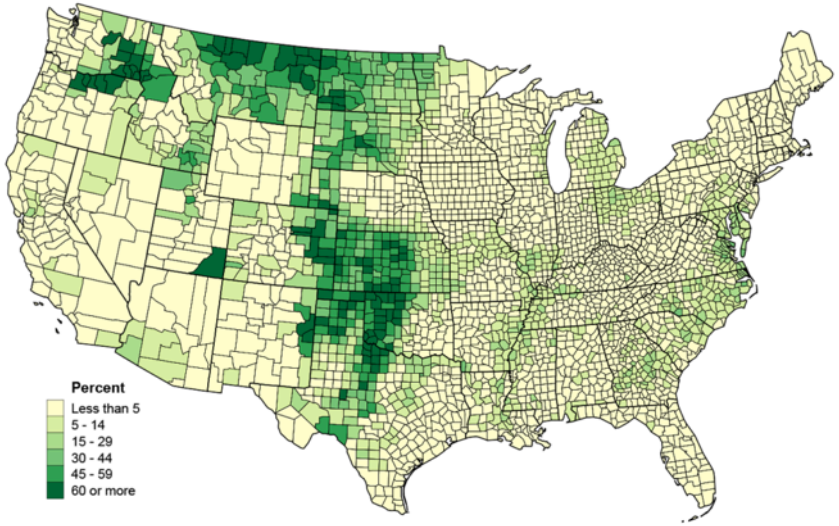
USDA Statistics (2007)

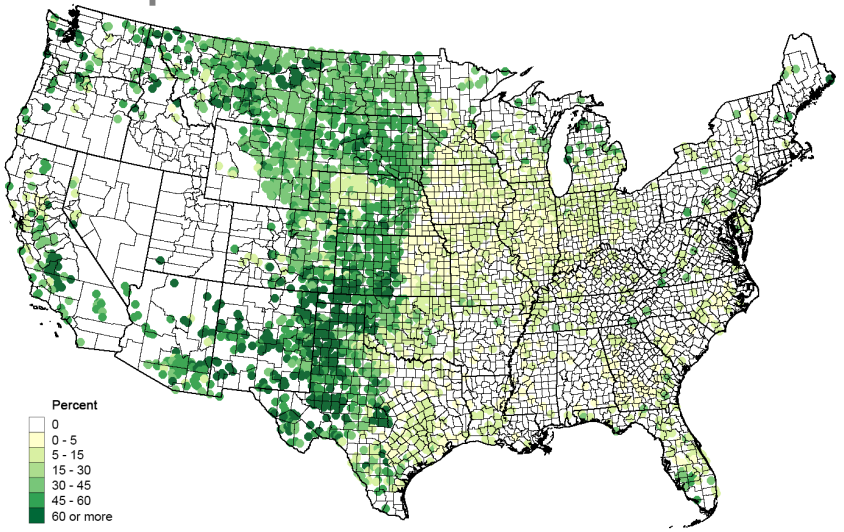


Modeled (1981-2010)

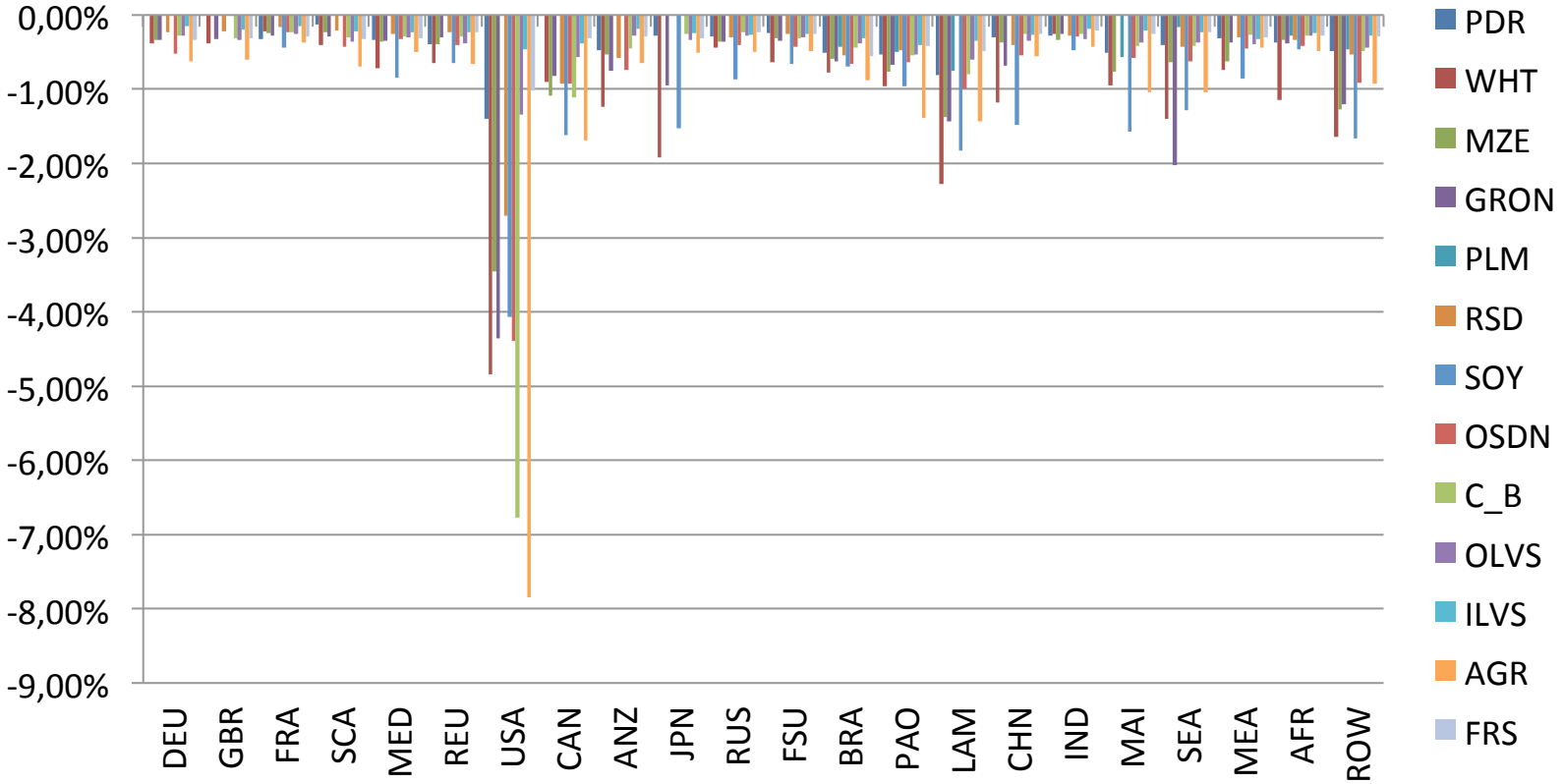


Percentage Wheat of Cropland





Closing Yield Gaps in USA: Change in Crop Prices



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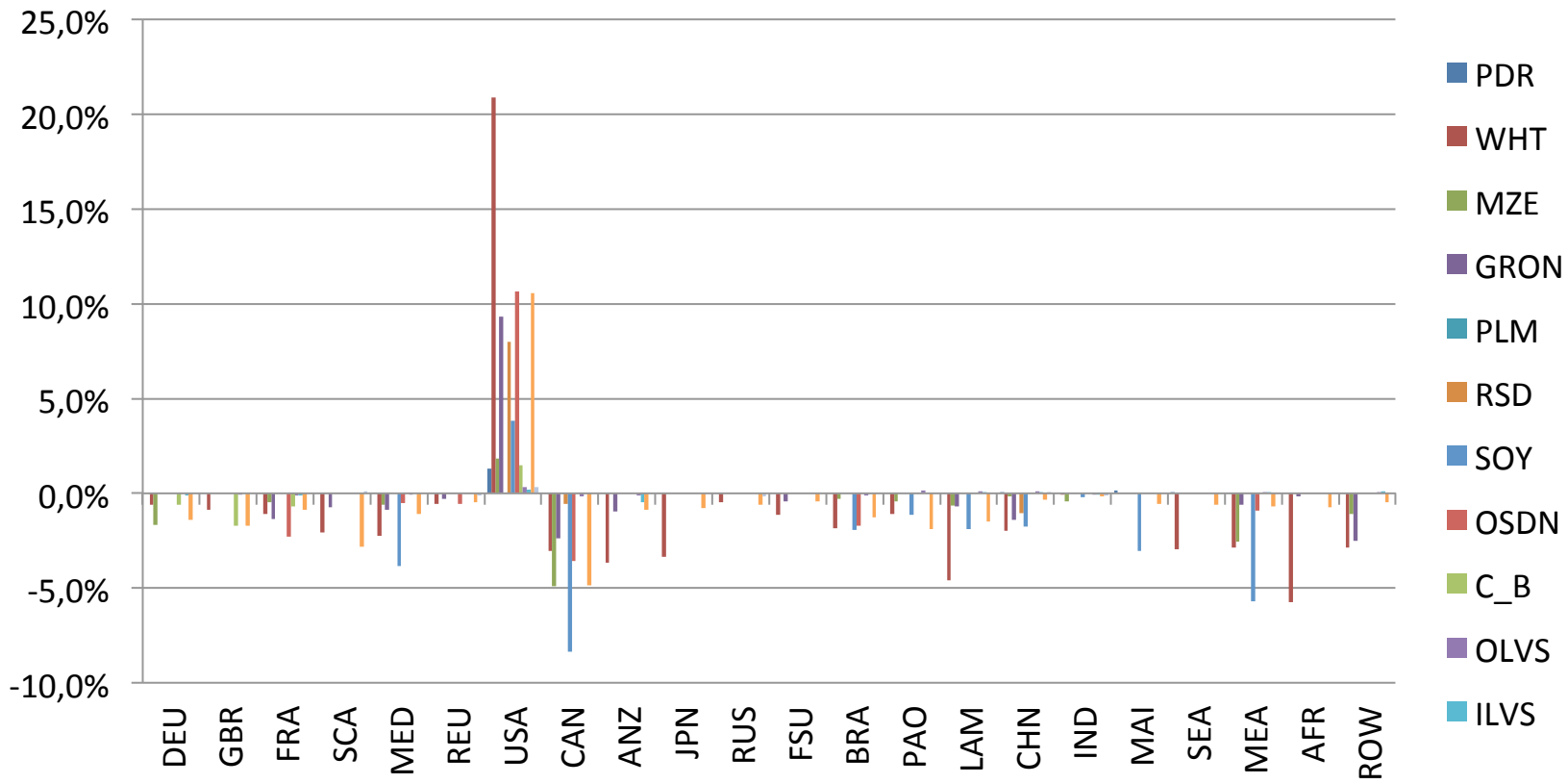
Closing Yield Gaps in USA: Change in Output



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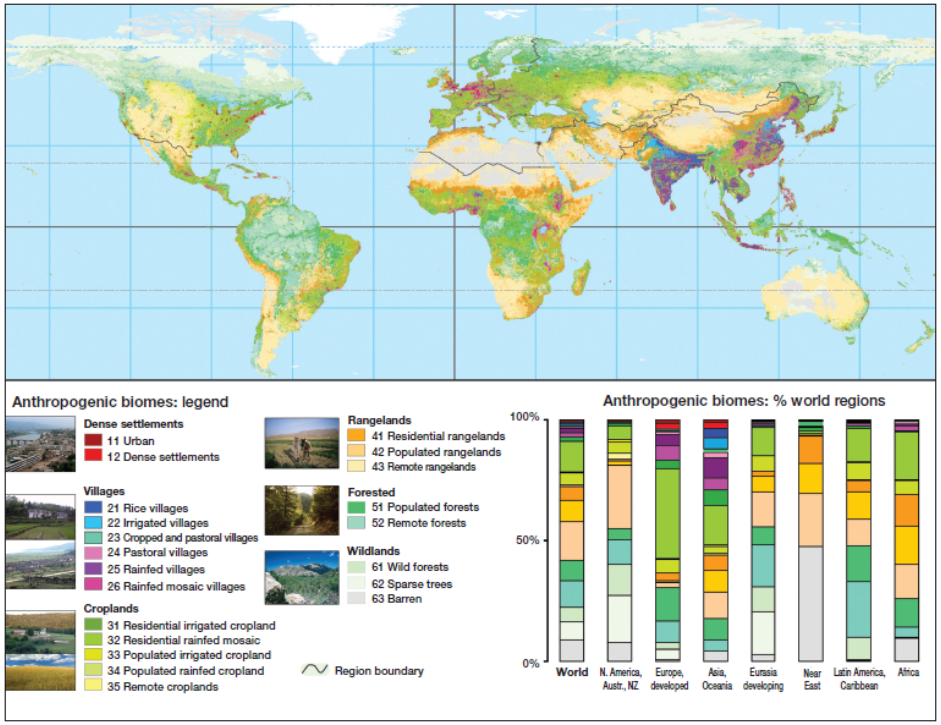
Current representations of land systems

Focus on broad-scale representations of land cover with limited consideration of human influence or land use intensity (GLC 2000; GlobCover): “Anthromes”

Recent studies

- Used indirect or a few direct indicators of land-use intensity (population, livestock density)
- Applied top-down approaches to define land system classes, e.g. “expert rules”

(Ellis & Ramankutty 2008, Letourneau et al. 2012, vanAsselen & Verburg 2012)



Aim: Mapping archetypical patterns of land systems

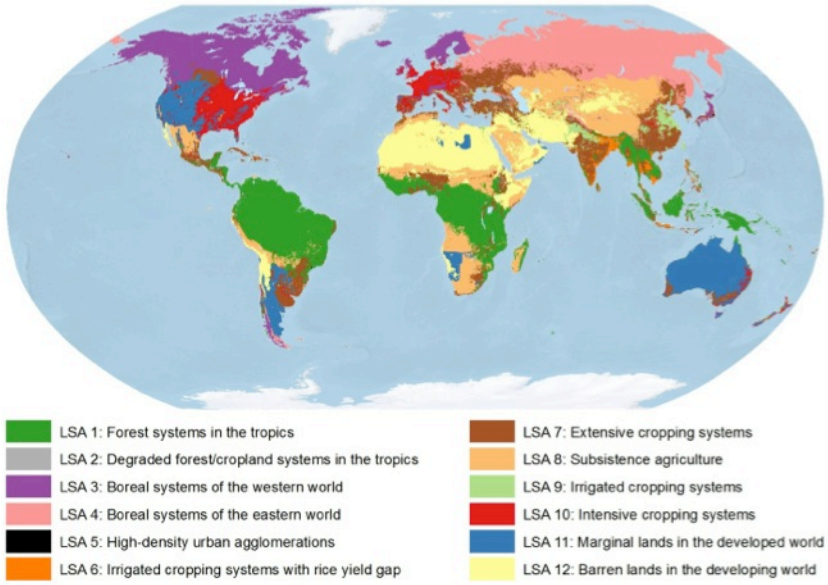
Represent human-environment interactions

- Using unbiased, bottom-up approach driven by most up-to-data data
- Accounting for multidimensional aspects of land-use intensity

Land system archetypes: unique patterns of:

- land-use intensity
- environmental conditions
- socioeconomic factors

that appear repeatedly across the terrestrial surface of the earth



Václavíc et al. 2013 GEC

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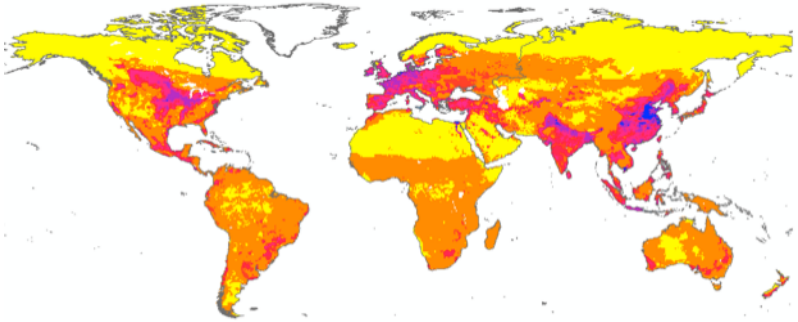
Data: global indicators of land systems

32 global variables at 5 arc-minute resolution (~9.3×9.3 km at the equator)

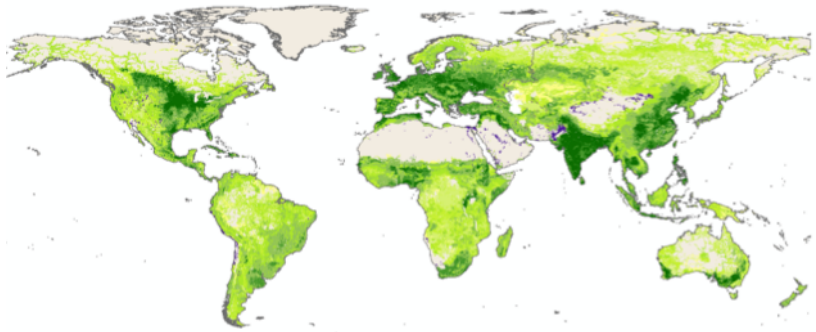
1) Land-use inputs/outputs

Factor	Unit
Cropland area	km^2 per grid cell
Cropland area trend	km^2 per grid cell
Pasture area	km^2 per grid cell
Pasture area trend	km^2 per grid cell
N fertilizer	kg ha^{-1}
Irrigation	Ha per grid cell
Soil erosion	Mg ha^{-1} $year^{-1}$
Yields (wheat, maize, rice)	t ha^{-1}
Yield gaps (wheat, maize, rice)	1000 t
Total production index	index
HANPP	% of NPP_0

Nitrogen fertilizer



HANPP



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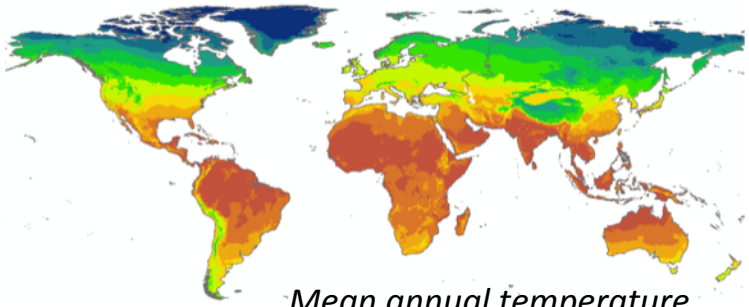
Data: global indicators of land systems

Environmental conditions

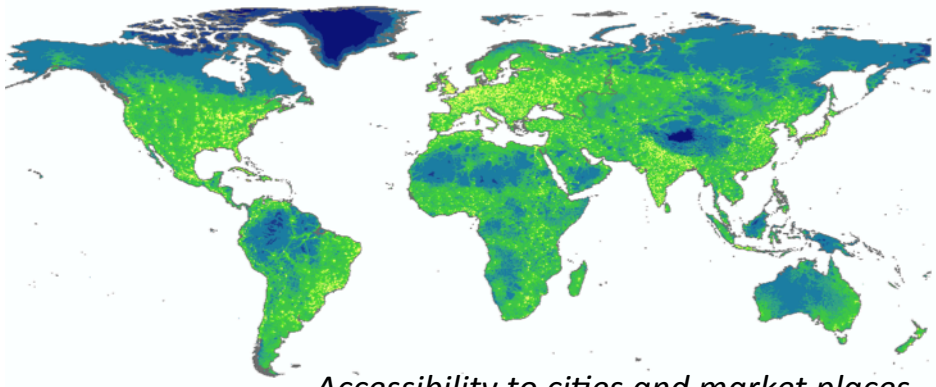
Factor	Unit
Temperature	°C × 10
Diurnal temperature range	°C × 10
Precipitation	mm
Precipitation seasonality	coeff. of variation
Solar radiation	W m^{-2}
Climate anomalies	°C × 10
NDVI – mean, seasonality	index
Soil organic carbon	g C kg^{-1} of soil
Species richness	# of species



Mean annual temperature

Socioeconomic conditions

Factor	Unit
Gross Domestic Product	$ per capita
GDP in agriculture	% of GDP
Capital Stock in agriculture	$
Population density	persons km^{-2}
Population density trend	persons km^{-2}
Political stability	index
Accessibility	travel time



Accessibility to cities and market places

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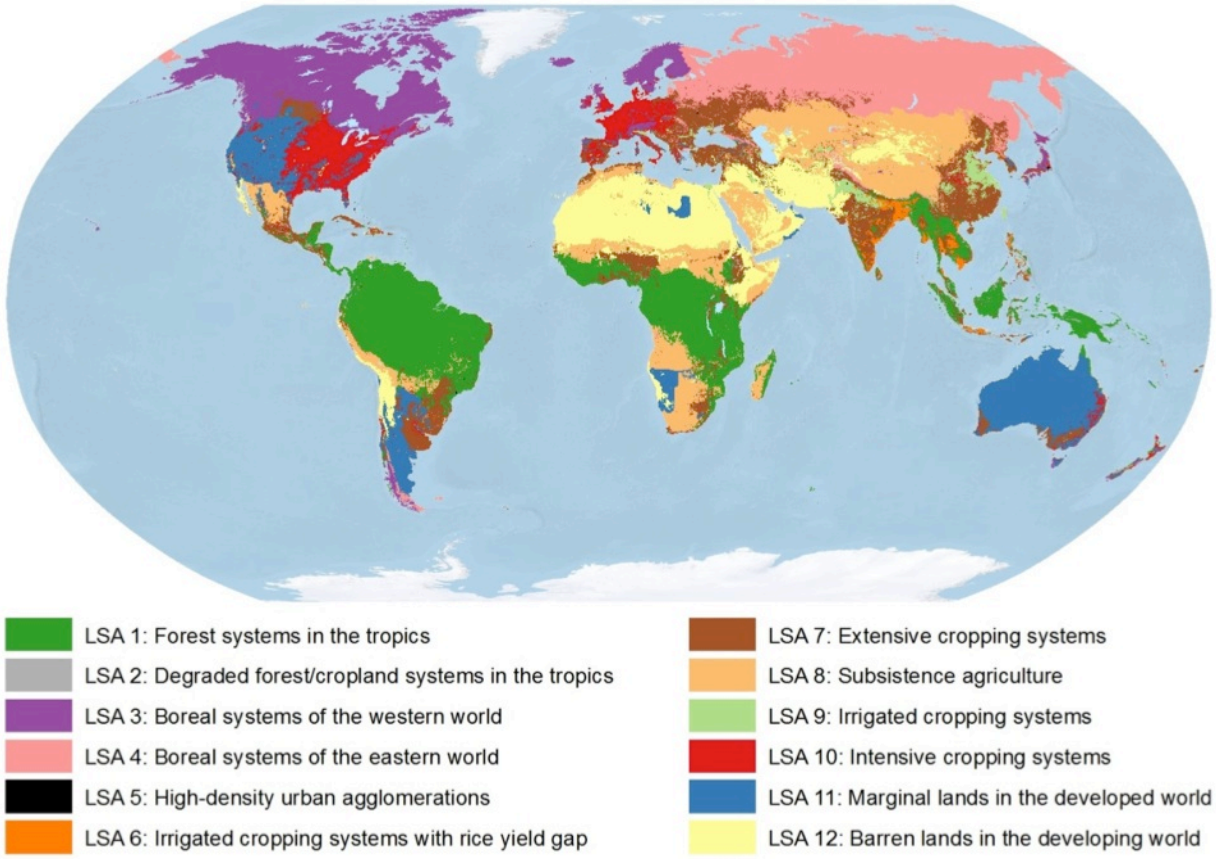
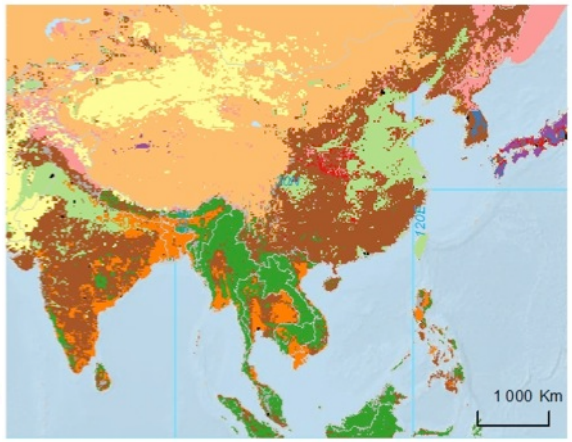
Results: Land system archetypes



Similarities in land systems across the globe but still a diverse pattern at the sub-national scale



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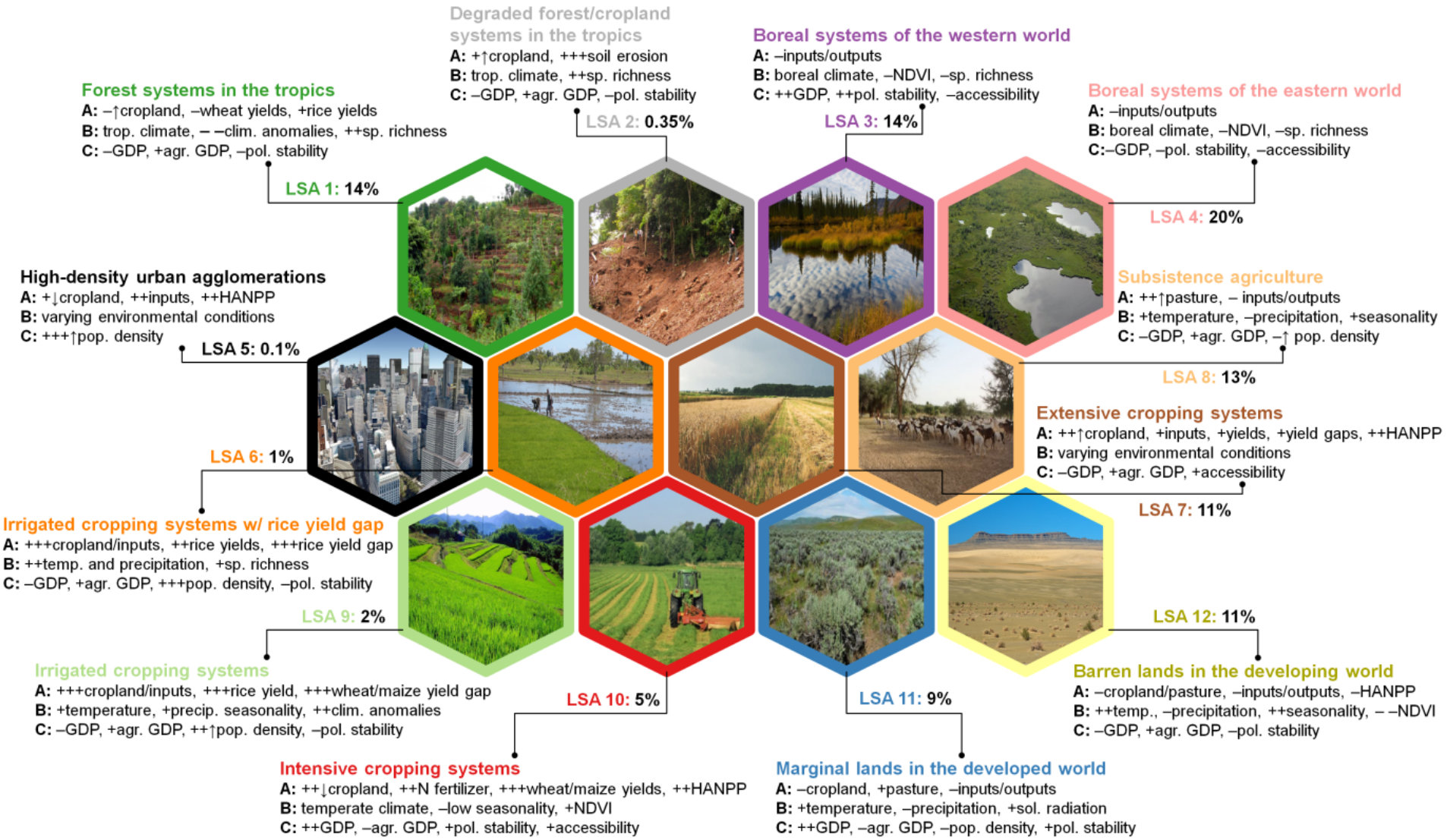
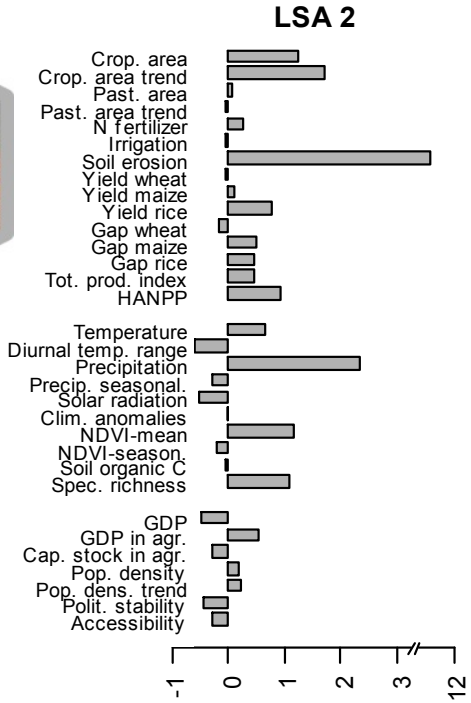


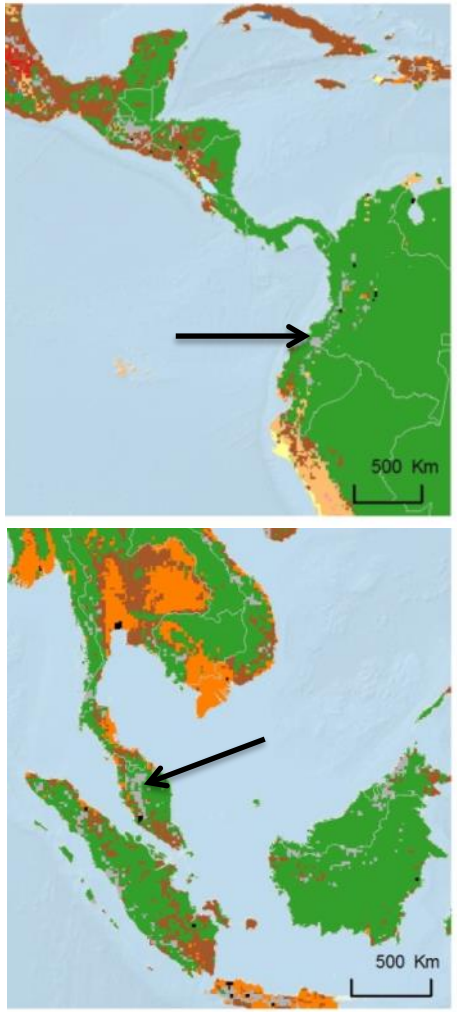
Land pressures and environmental threats

LSAs provide opportunities to detect major land pressures and environmental threats

Example: Soil erosion

- LSA: **Degraded forest/ cropland systems in the tropics**
- Particularly vulnerable to loss of soil fertility due to:
  - High agricultural inputs
  - Low GDP
  - Strong dependence on agricultural production





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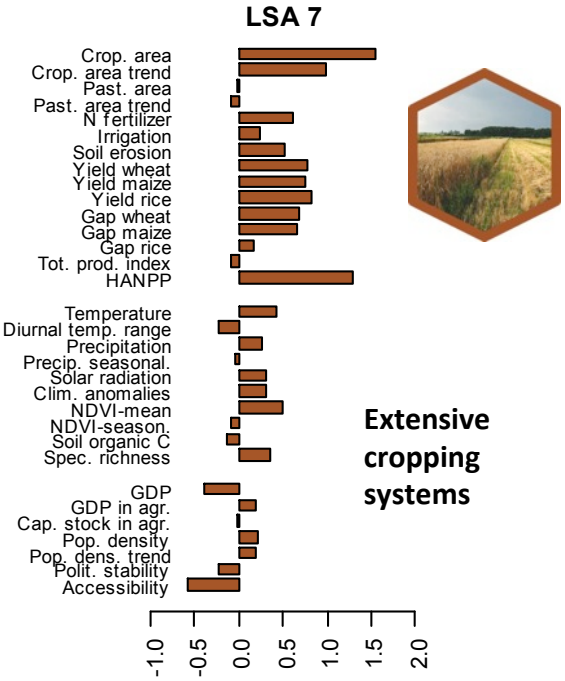
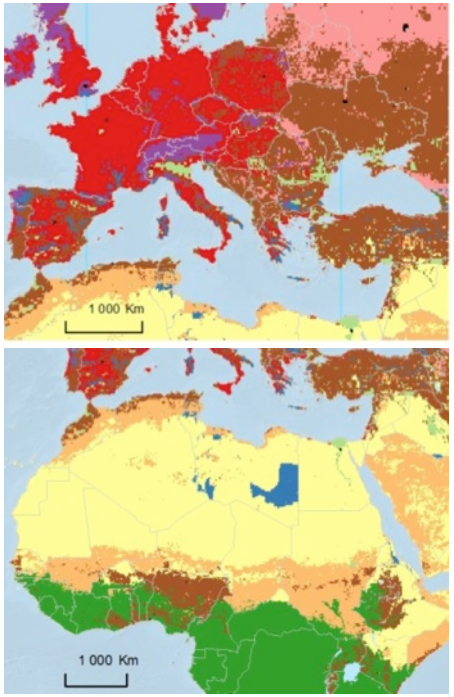
Knowledge to cope with challenges of global change

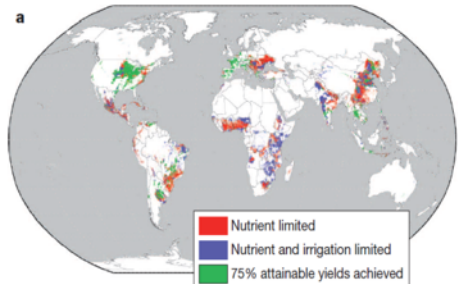
Knowledge for regionalized strategies to cope with the challenges of global change

Example: Yield improvements

- Large differences between realized and attainable yields
- Large production gains could be achieved if yields were increased to only 50% of attainable yields







Václavíc et al. 2013 GEC

Mueller et al., 2012

Outlook

Global Change research...

- Needs to ground on regional scale results
- Use consistant global frameworks for scenarios and analysis, synthesis
- Support transferability of results
- Support outreach and products as well as link to international conventions and processes

Seppelt et al. (2013, COSUST)

www.landYOUs.org

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