

Land Use-Change: Causes and Potential Trade-Offs

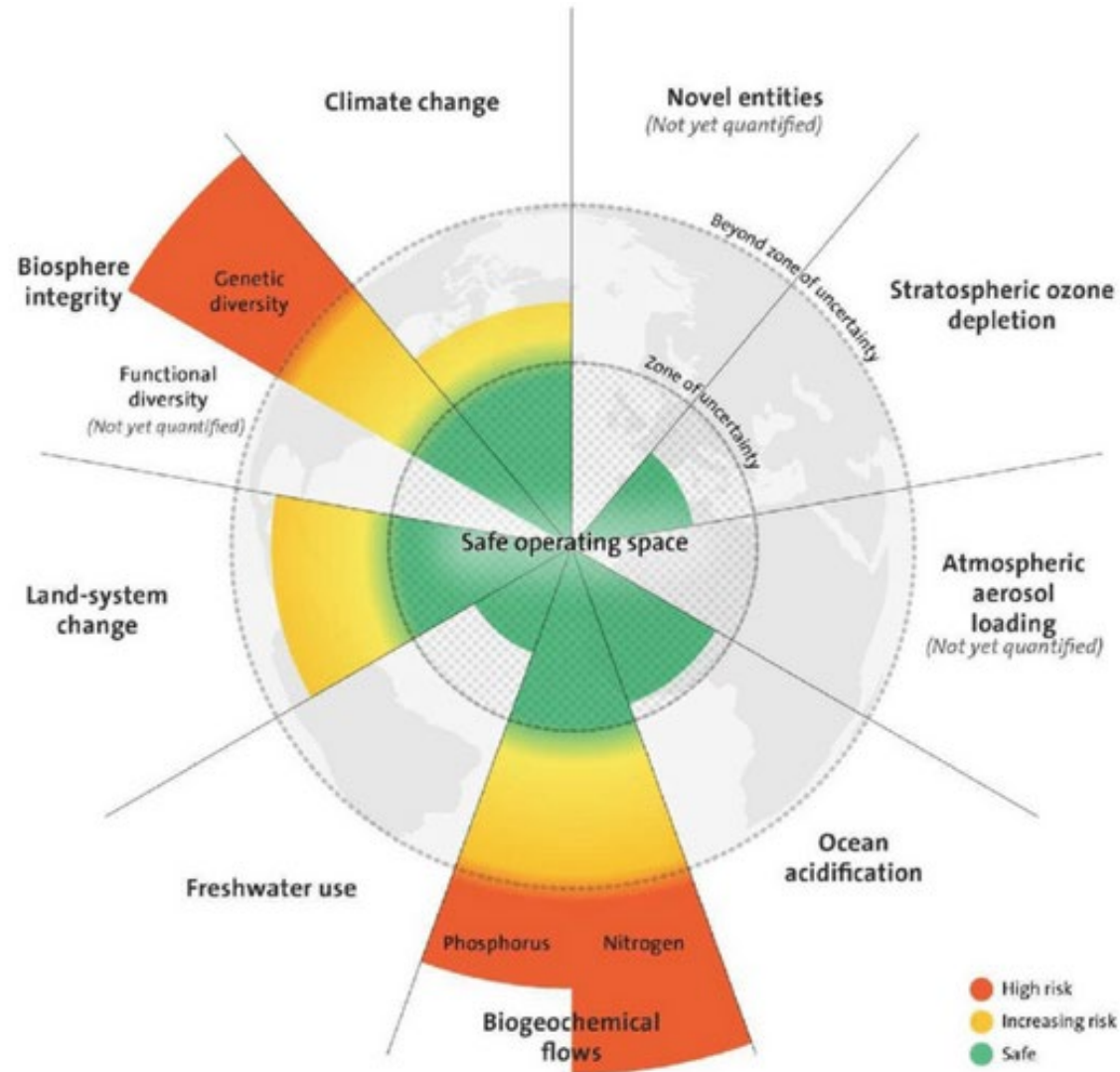
Prof. Dr. Ruth Delzeit, 12.12.2023
SFIAR Award Ceremony



Overview

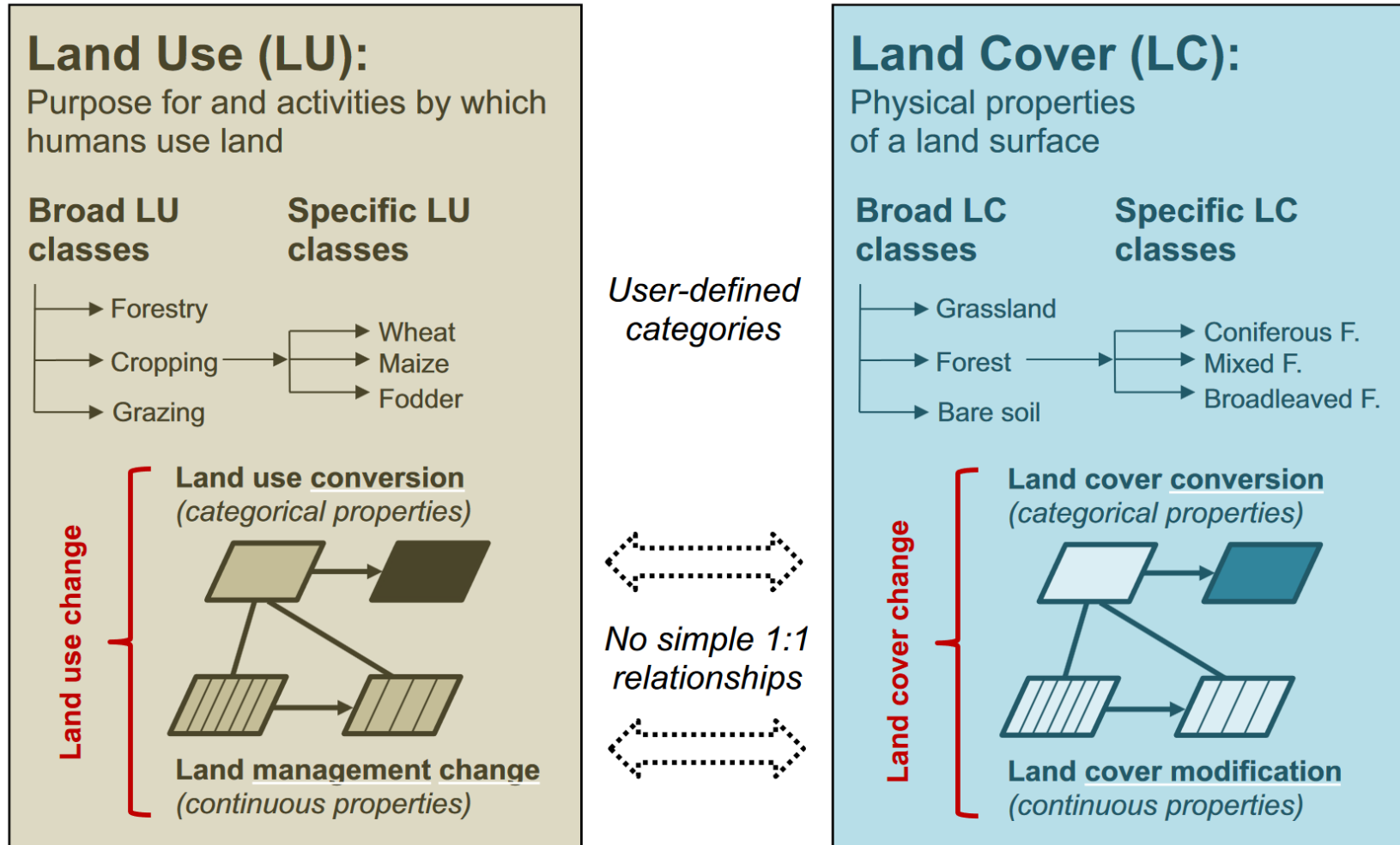
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- 1 Introduction
 - 2 Causes of land-use and land-cover change
 - 3 Conflicting goals of future land use
 - 4 Discussion of measures
-

Nine planetary boundaries



Source: Folke et al. 2021

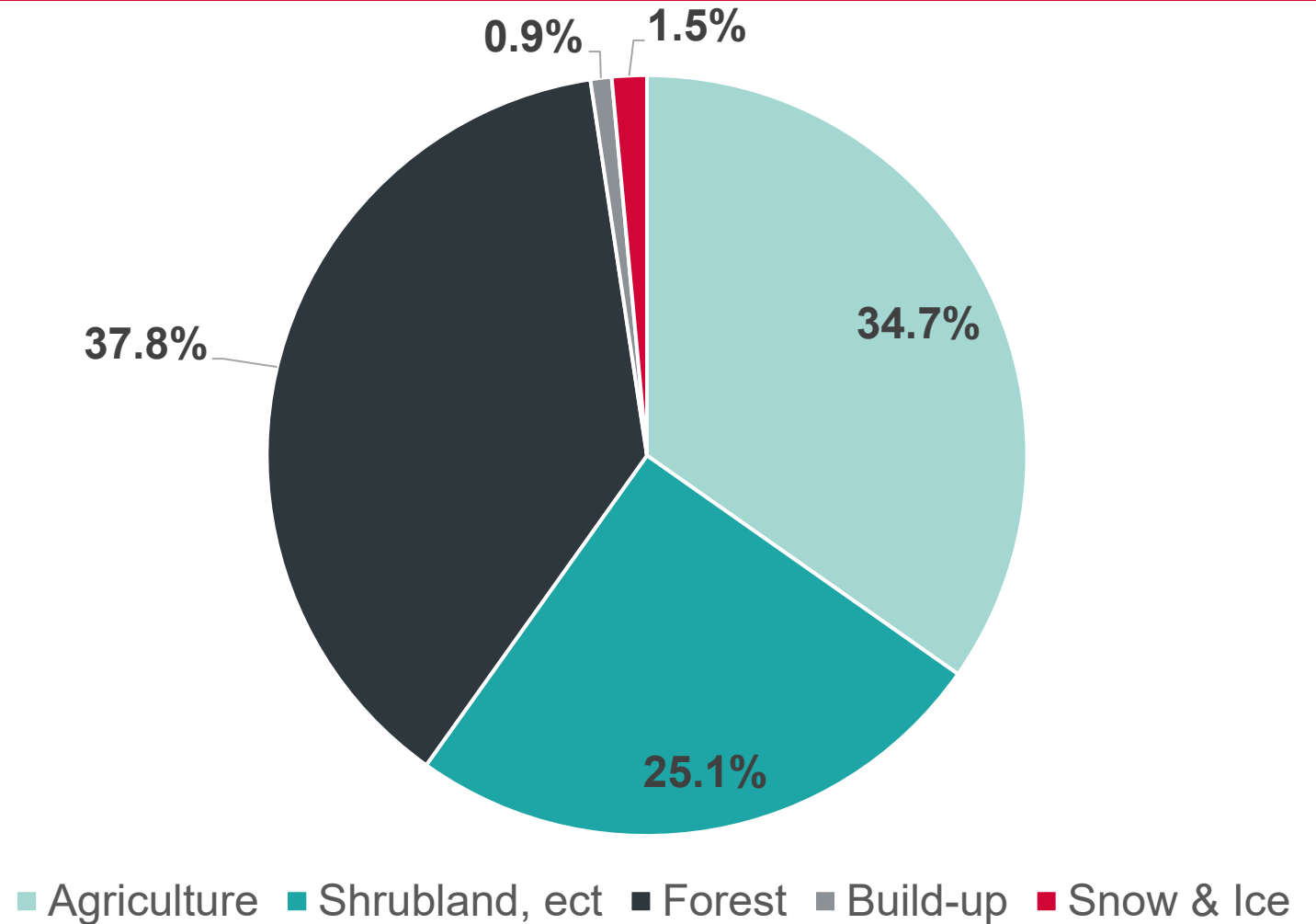
Clarifying the terminology



Source: Pongratz et al. 2018

Global land cover

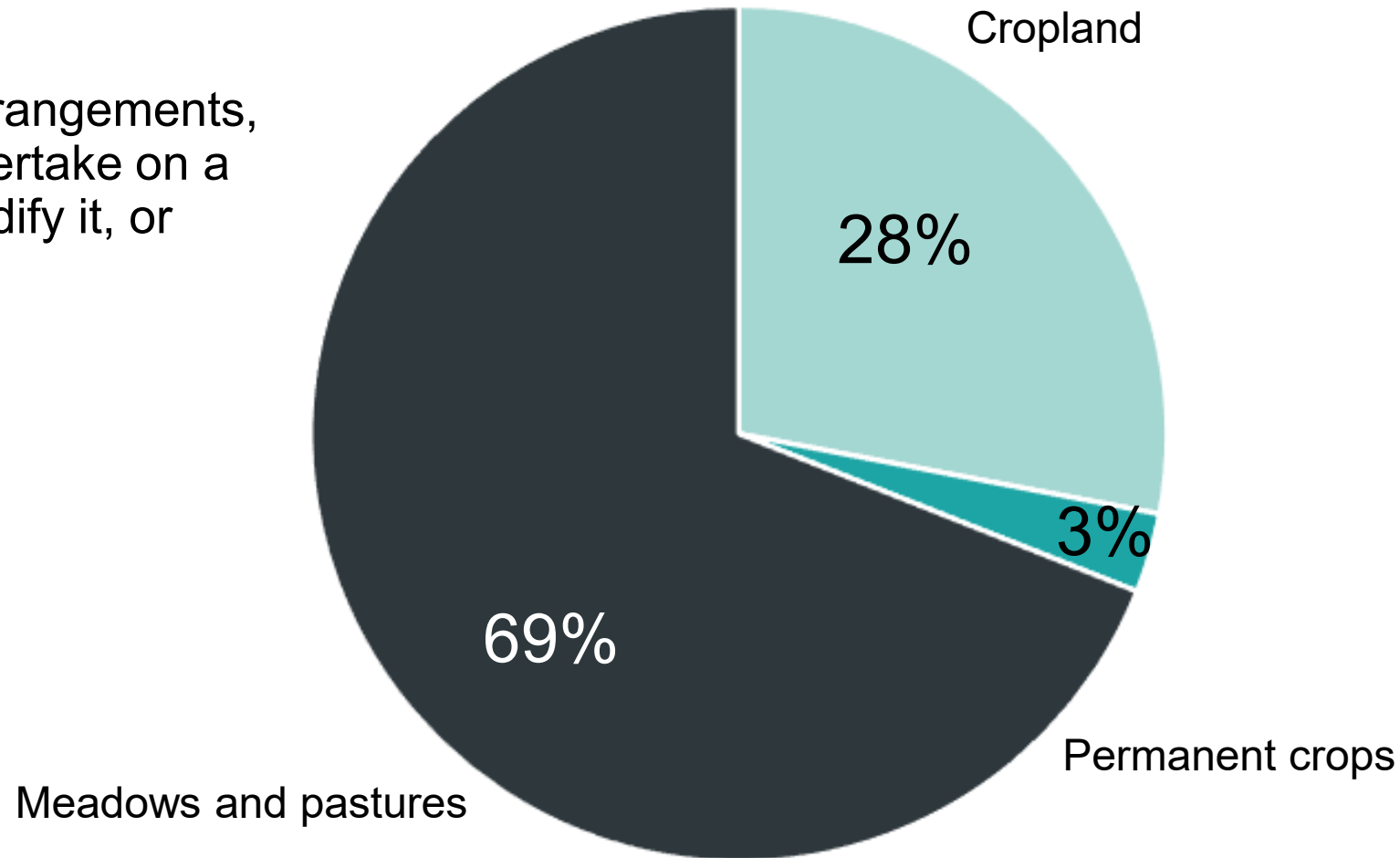
Land cover:
“observed (bio)physical
cover of the earth's surface”
(FAO 2000)



Data: Copernicus 2021

Global agricultural land use 2018

"Land use is characterized by the arrangements, activities and inputs that people undertake on a particular land cover to produce, modify it, or maintain it."
(FAO 2000)



Data: FAOSTAT 2021

Greenhouse Gases (GHG) Emissions

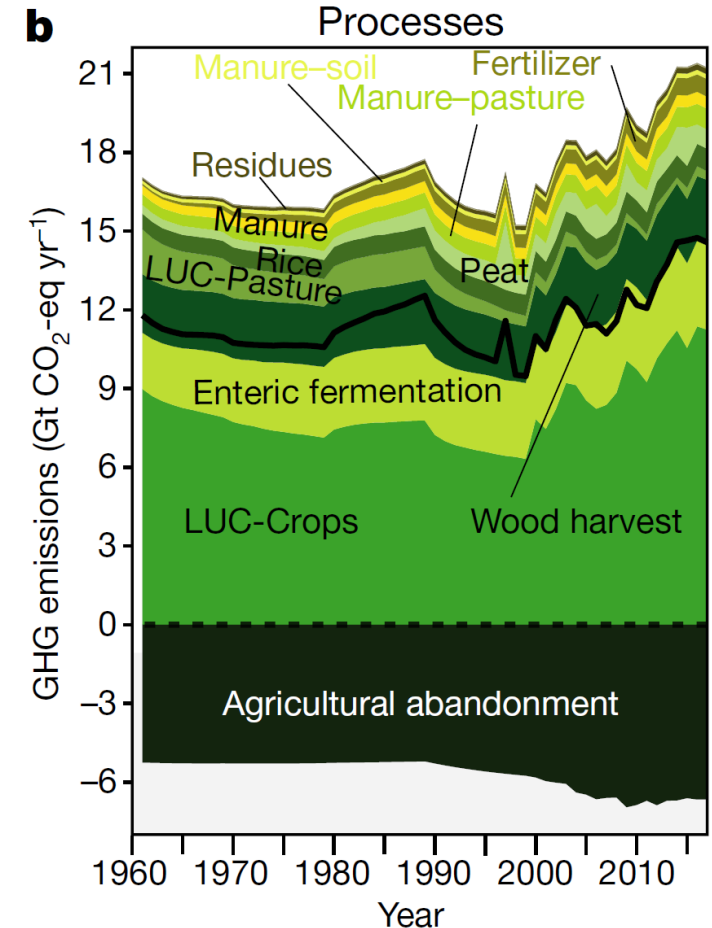
Land is both a **source** and **sink** of GHG

Carbon sink: increase vegetation uptake and storage of CO₂ (i.e. **Afforestation**)

Carbon source:
Deforestation and forest degradation
contributes 11% of annual global GHG emissions
(IPCC, 2019)

Net effect: LUC responsible for 12-20% of global total anthropogenic GHG emissions (Watson & Schalatek, 2020) or 22-29% (Hong et al. 2021)

Estimated emissions from LUC and Land management



Source: Hong et al. 2021

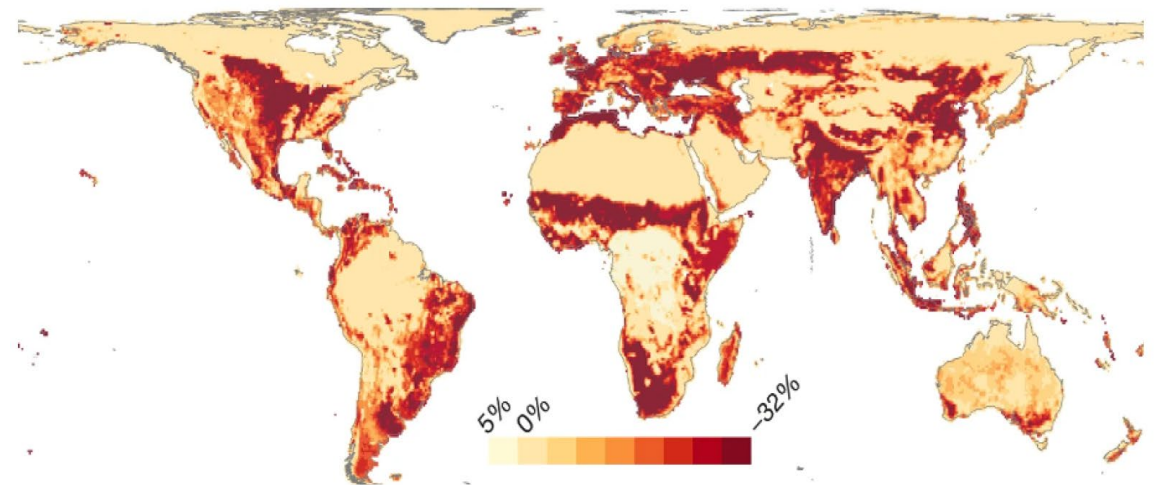
Biodiversity loss

LUC currently the **strongest driver** of terrestrial biodiversity loss worldwide (Knapp et al. 2000, Newbold et al. 2015)

Alteration, degradation & destruction of habitats:

- Clearing of land for agriculture
- Felling of forests for timber
- Pollution of the environment
- Fragmentation (reductions in genetic variation, loss of biotic interactions with pollinators)
- Draining of wetlands (“biological super systems”)

Change in Local Species Richness Caused by Land Use Pressures Between 1500 and 2000

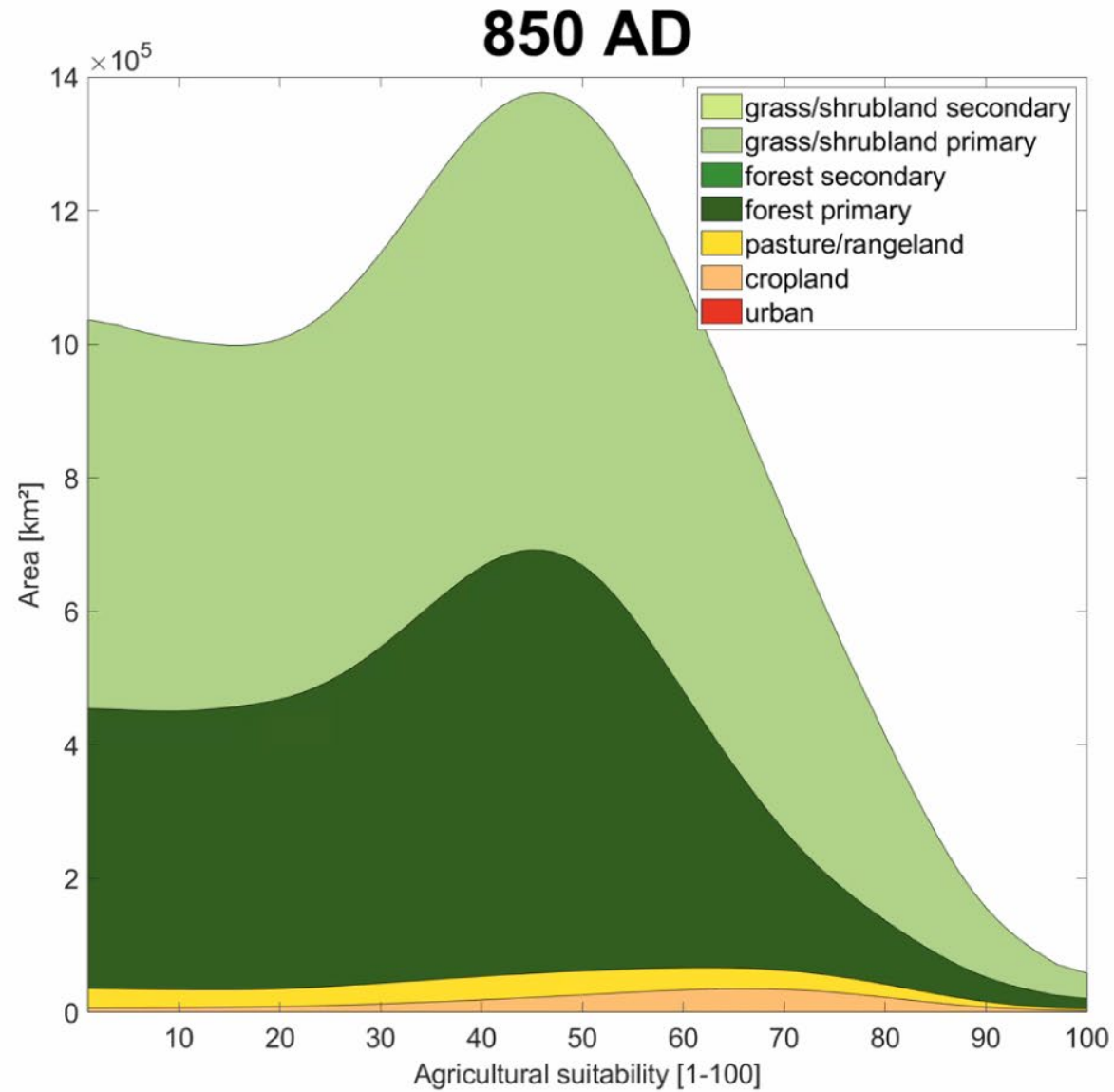


Source: Dasgupta P., 2021

Overview

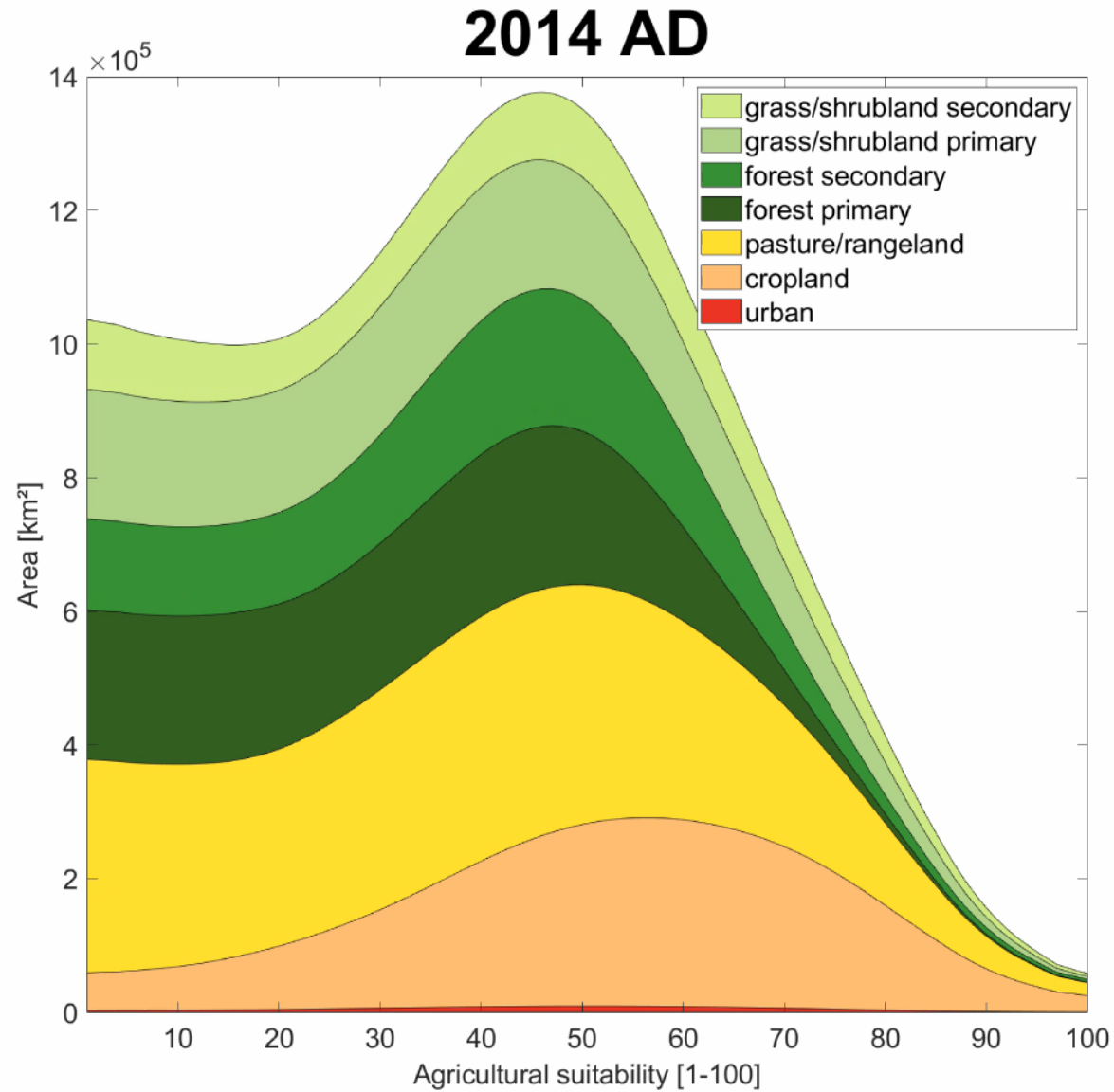
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Historical change in land cover



Source: Zabel & Schneider 2022

Historical change in land cover

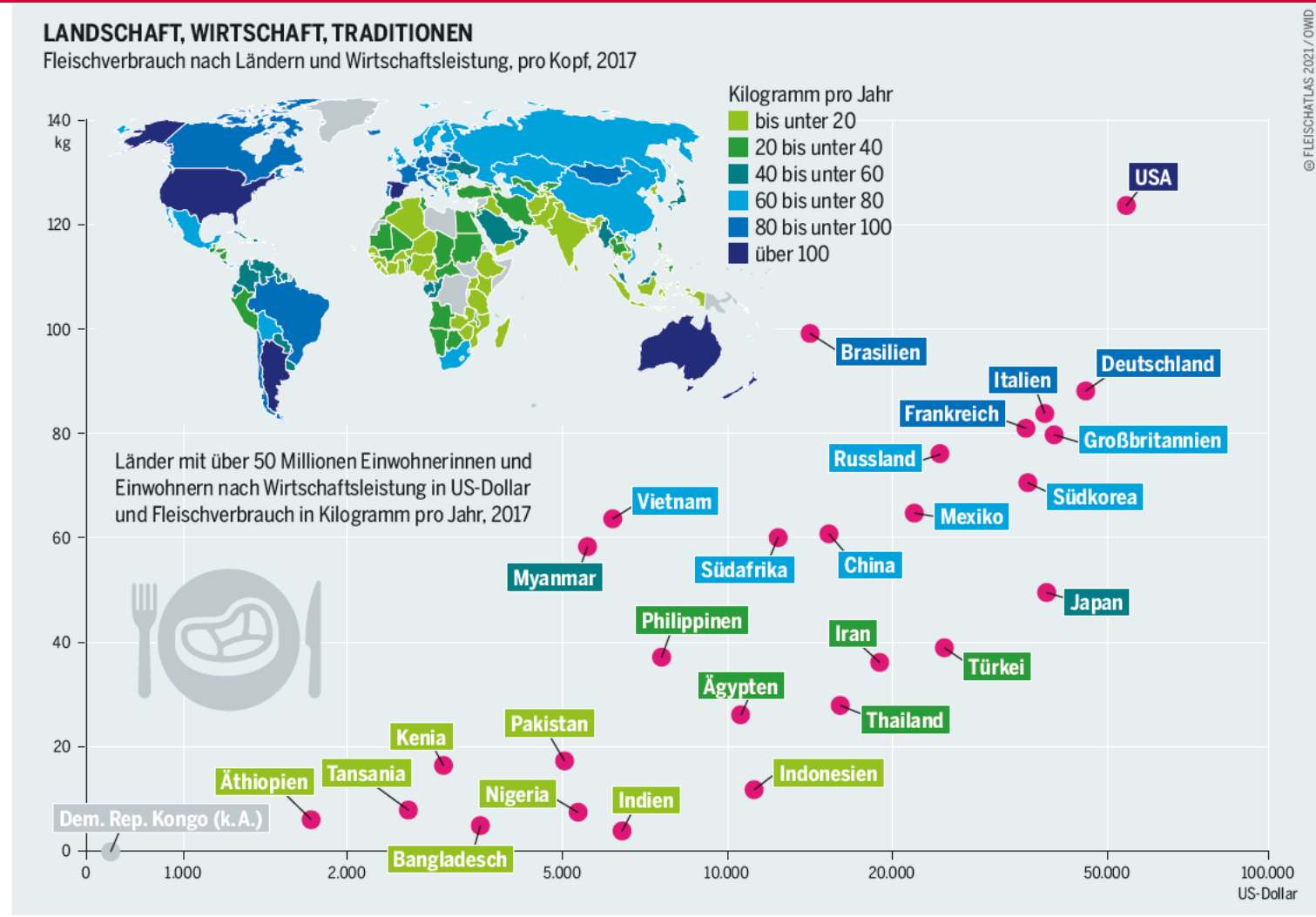


Source: Zabel & Schneider 2022

What are "drivers" (future) of land-use change?



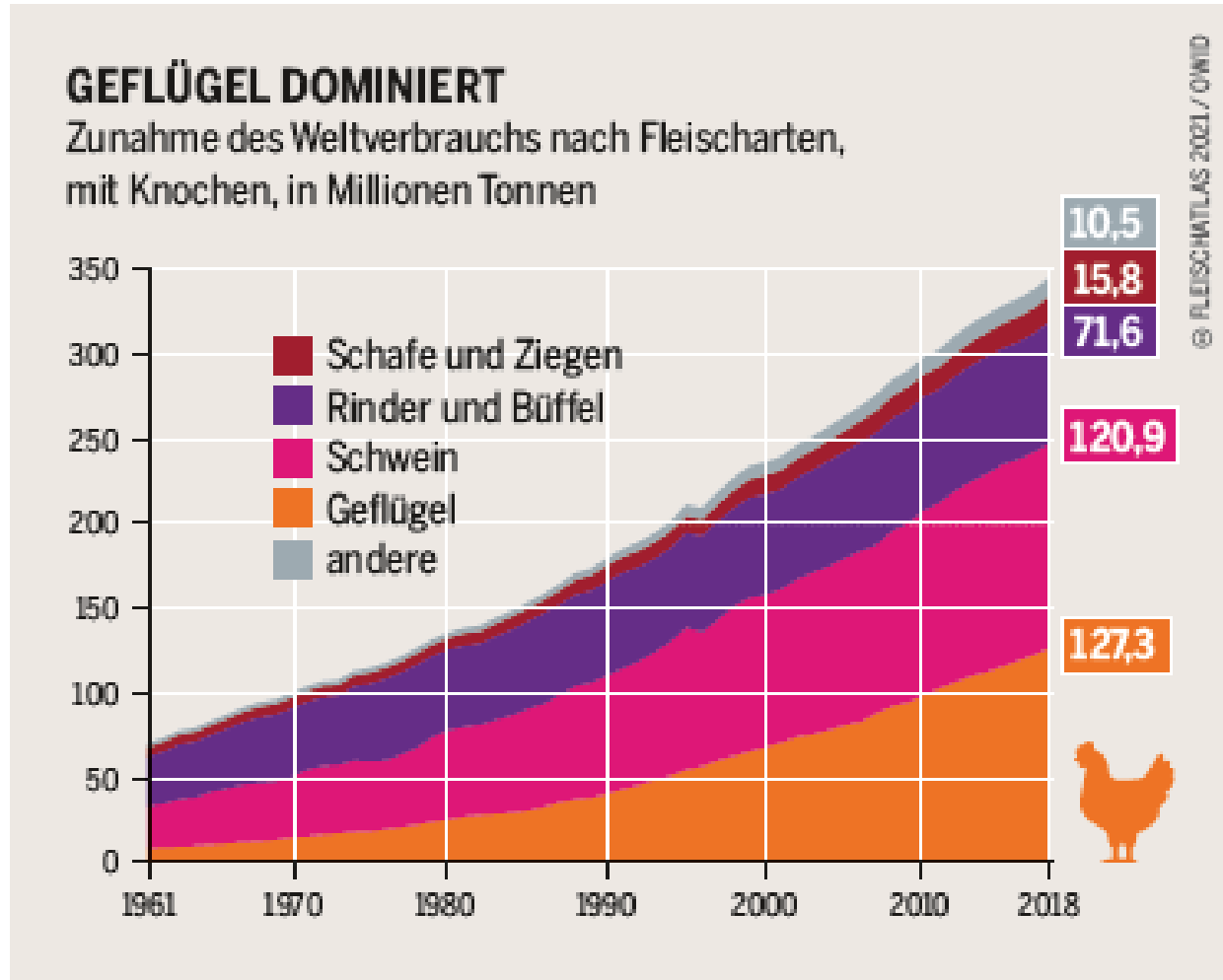
Meat consumption per capita



© FLEISCHATLAS 2021 / OWID

Source: Fleischatlas 2021

Development of meat consumption by meat type



Source: Fleischatlas 2021

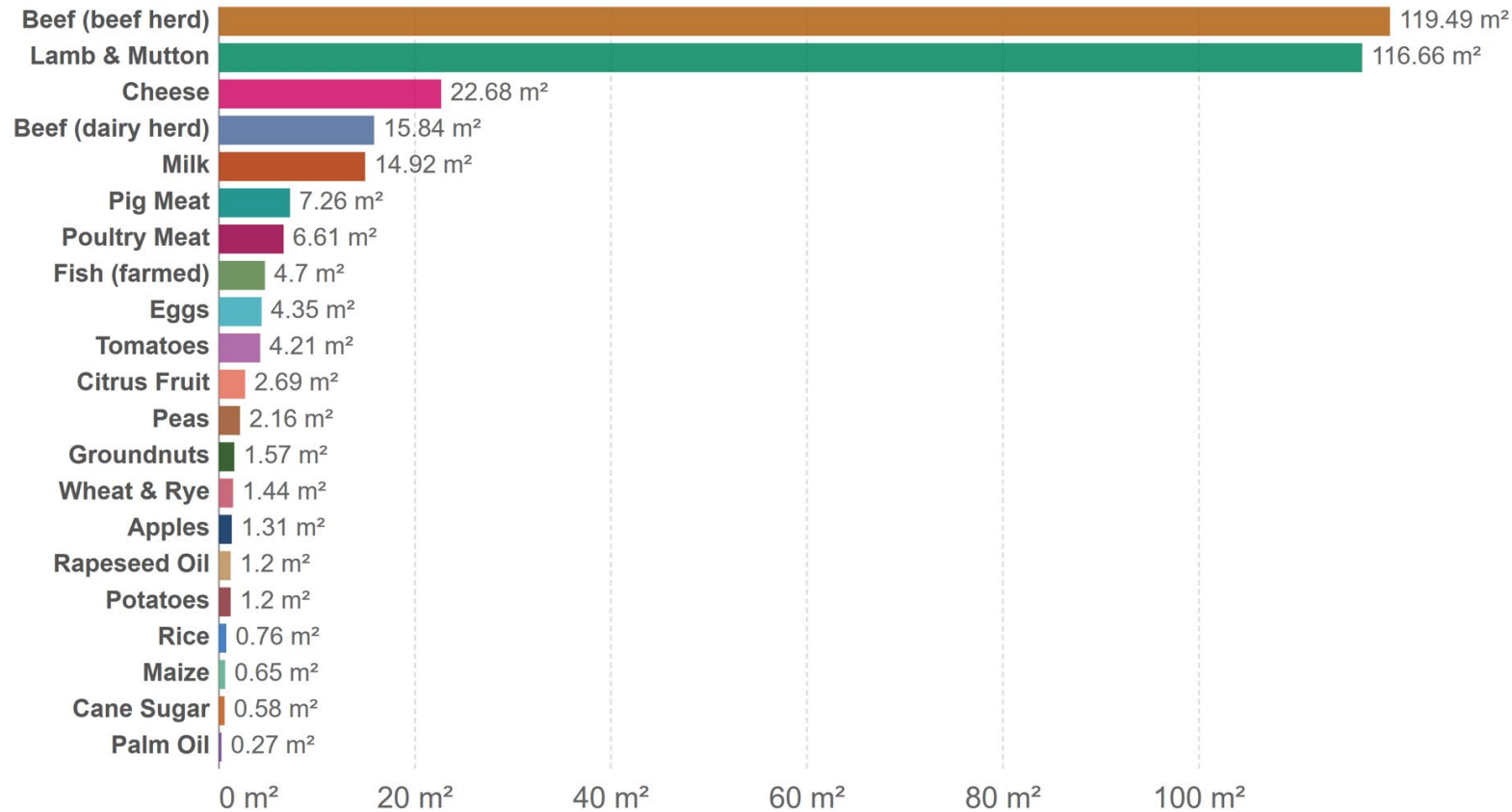
The land consumption of livestock production is higher than that of crops



Land use of foods per 1000 kilocalories

Our World in Data

Land use is measured in meters squared (m²) required to produce 1000 kilocalories of a given food product.



Source: Poore, J., & Nemecek, T. (2018). Additional calculations by Our World in Data.

Note: The median year of the studies involved in this research was 2010.

OurWorldInData.org/environmental-impacts-of-food • CC BY

Source: Our World in Data, 2019

What are "drivers" (future) of land-use change?



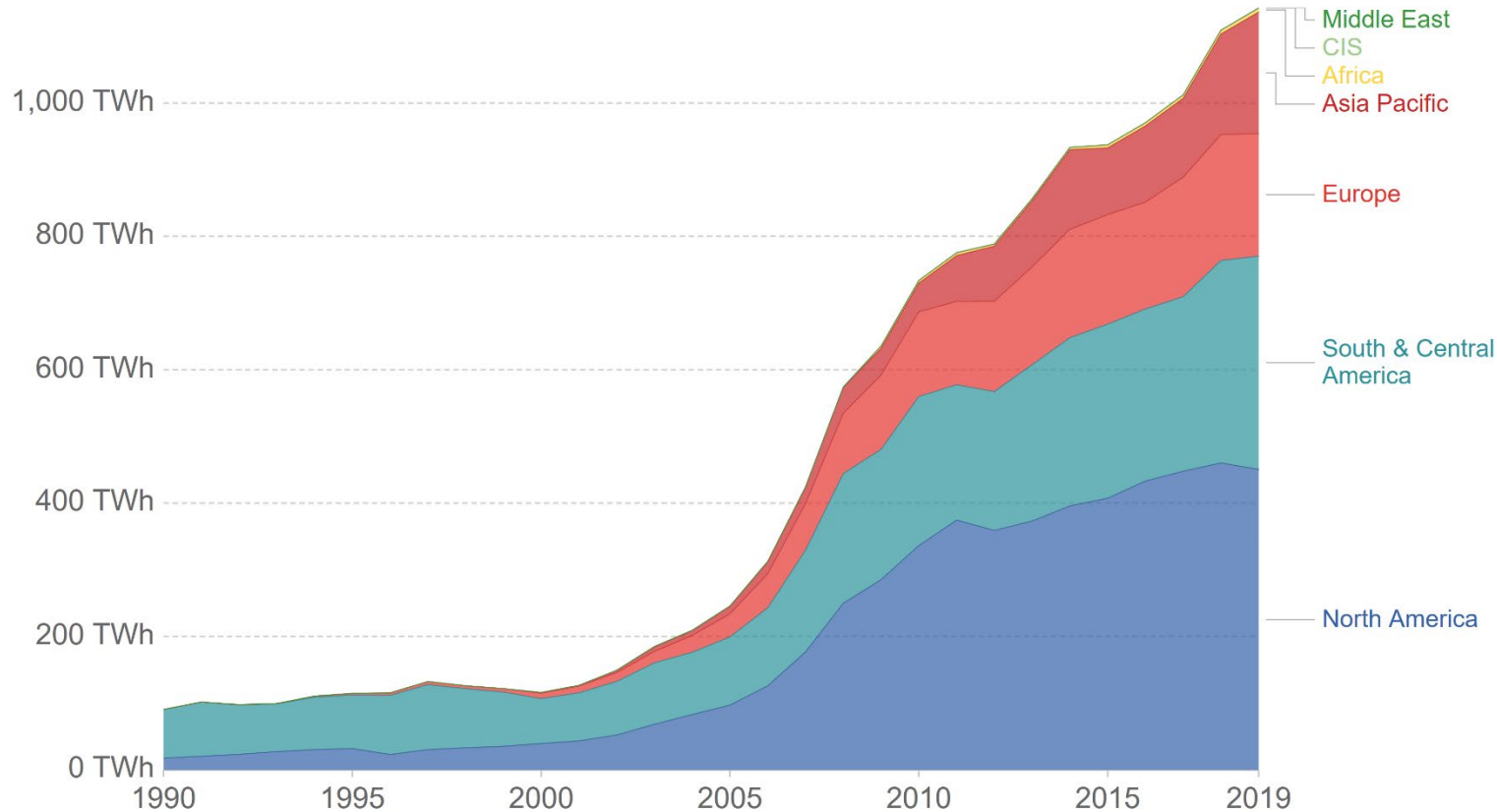
Increase in the production of biofuels



Biofuel production by region

Biofuel production is measured in terawatt-hours (TWh) per year, and includes both bioethanol and biodiesel.

Our World
in Data



Biggest producers:
USA, Brazil, Malaysia/Indonesia

Largest consumers:
USA, EU

Source: BP Statistical Review of Global Energy (2020)

OurWorldInData.org/renewable-energy • CC BY

Note: CIS (Commonwealth of Independent States) is an organization of ten post-Soviet republics in Eurasia following break-up of the Soviet Union.

Source: Our World in Data, 2021

What are "drivers" (future) of land-use change?



What is mainly traded?



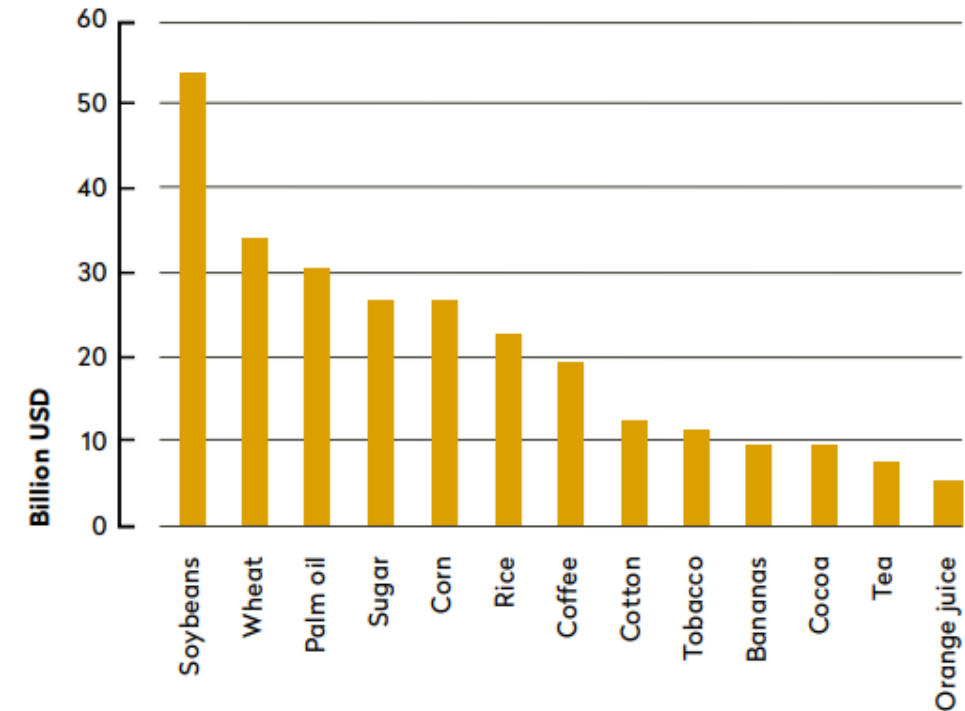
Shelf-stable products and staple foods

Goods from tropical regions exported mainly to northern countries.

Global trade volume tripled between 2010 and 2016

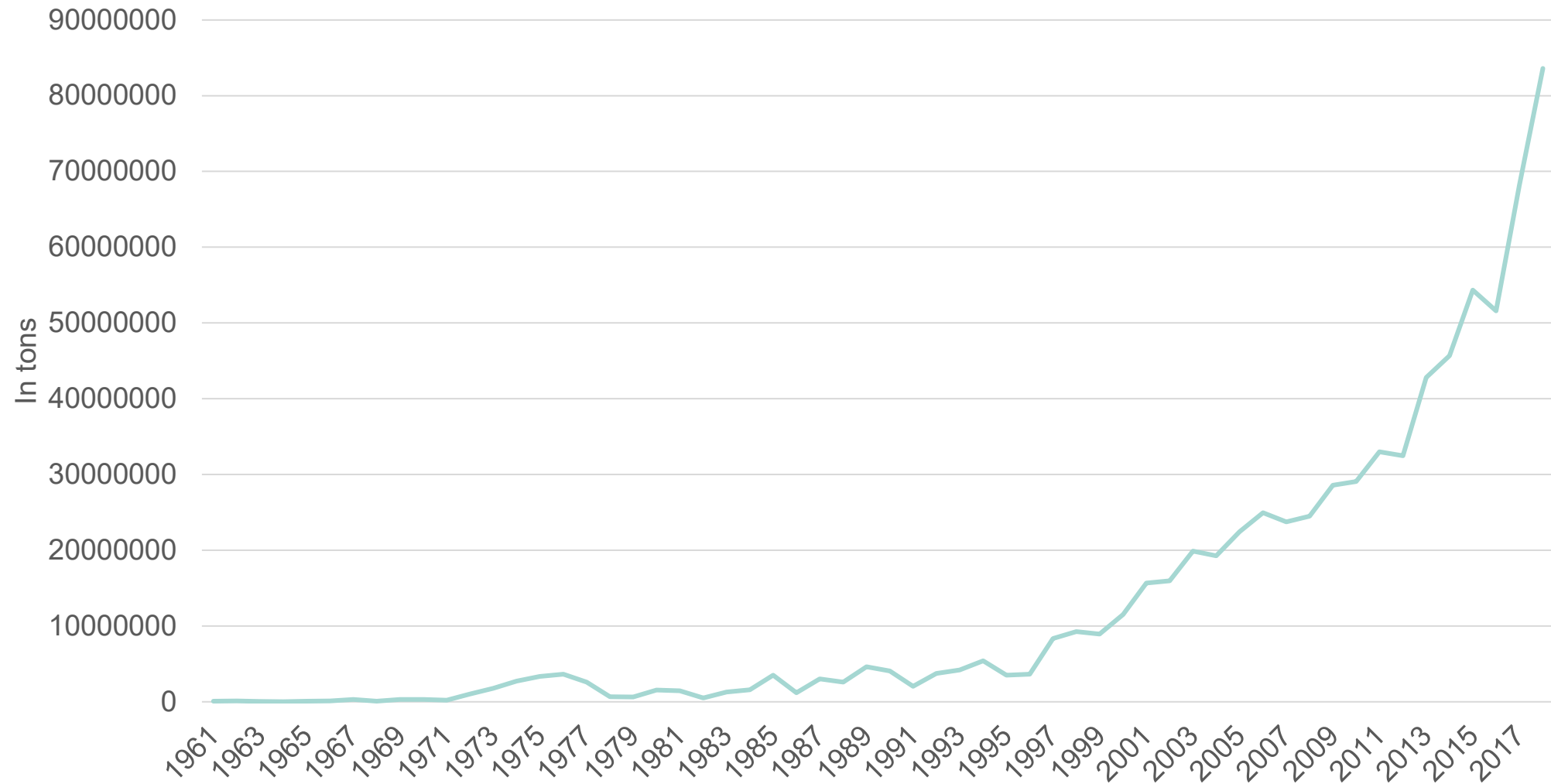
Soybeans: a sharp increase in recent decades. Feed (and biofuel).

Figure 2.3 – Export value of important agricultural commodities, average 2015–2017



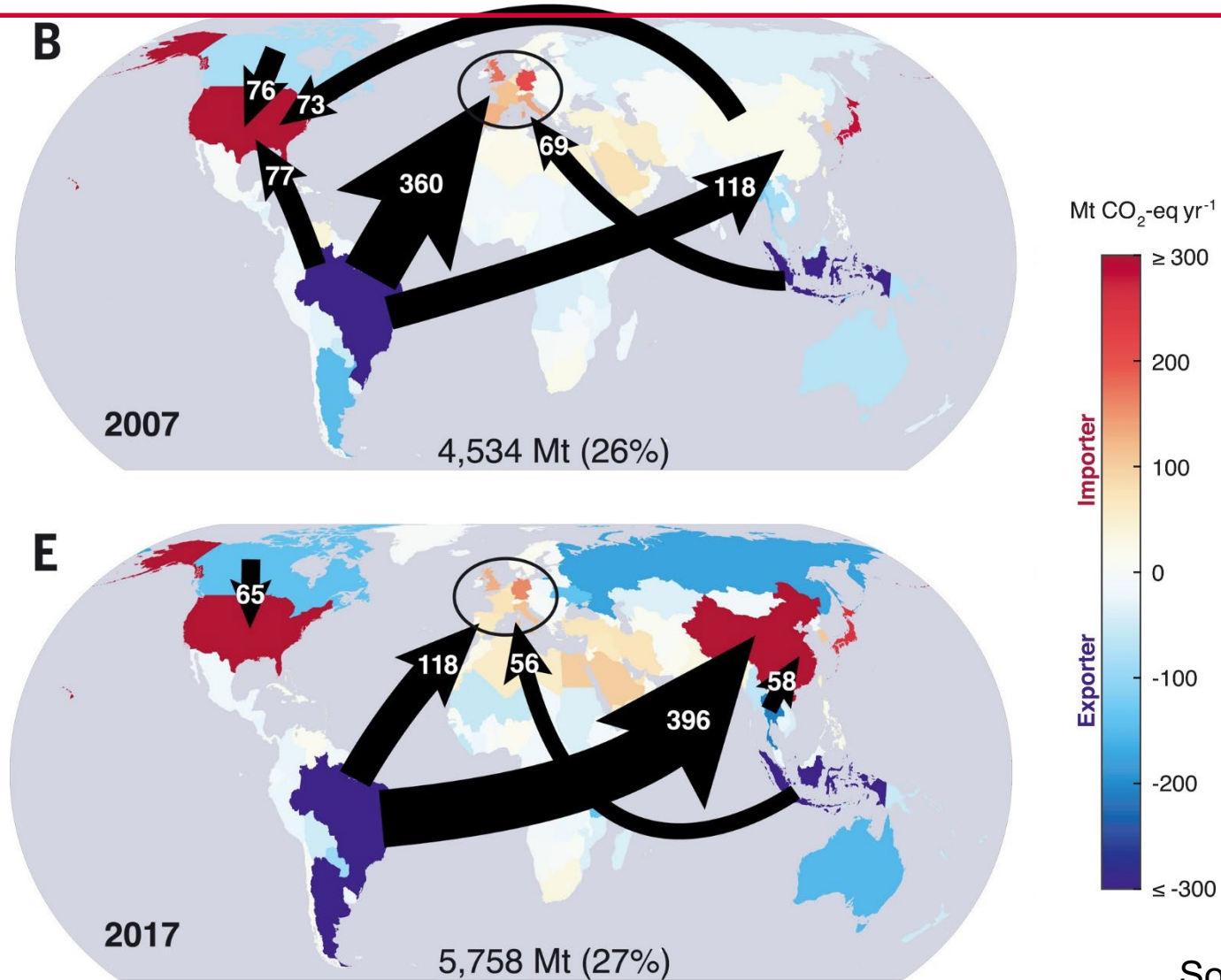
Source: Calculations based on data from [ITC Trade Map](#)

Development of trade in soybeans: Exports Brazil



FAO 2021

Land-Use emissions embedded in trade



Source: Hong et al. 2022

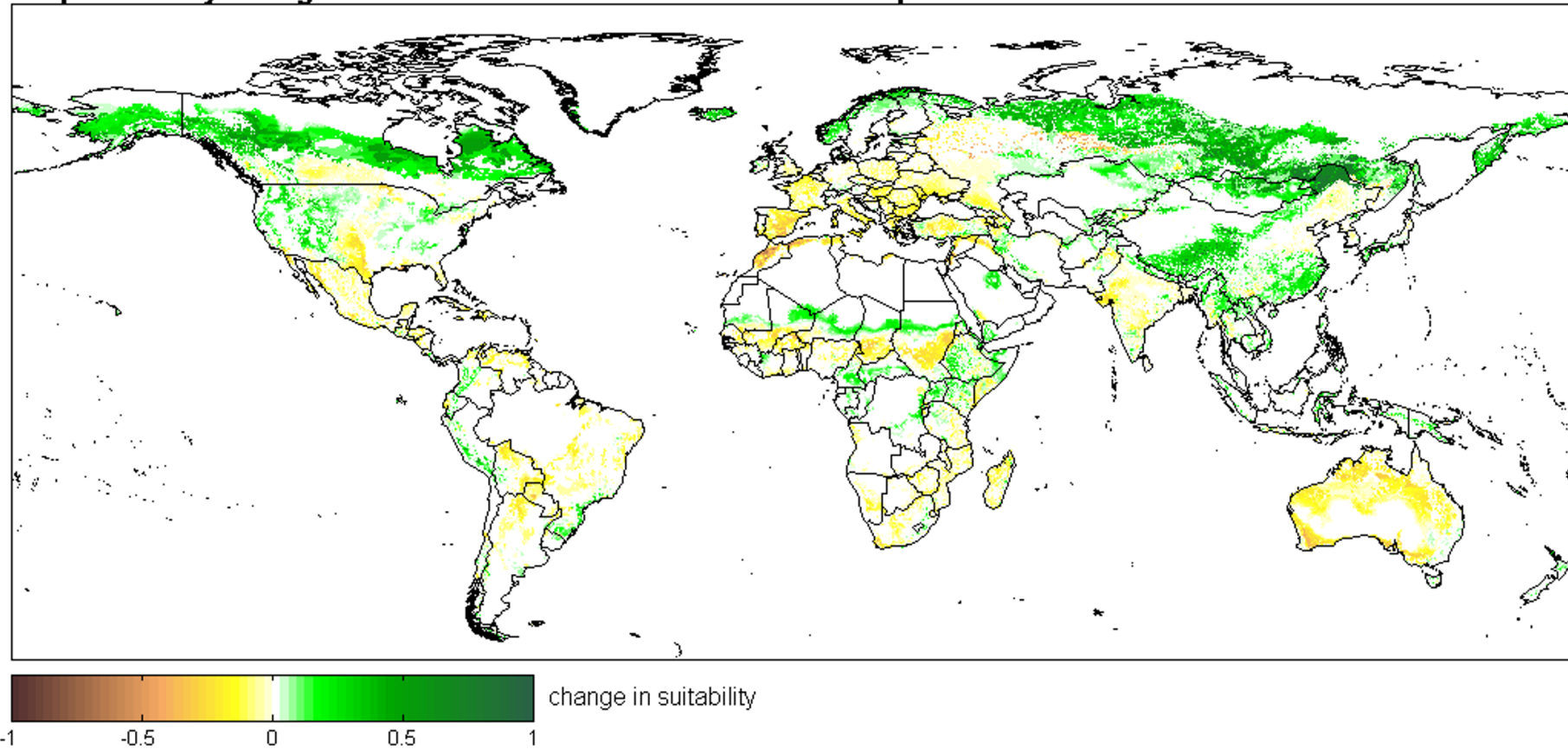
What are "drivers" (future) of land-use change?



Change in suitability under climatic conditions (2071-2100).

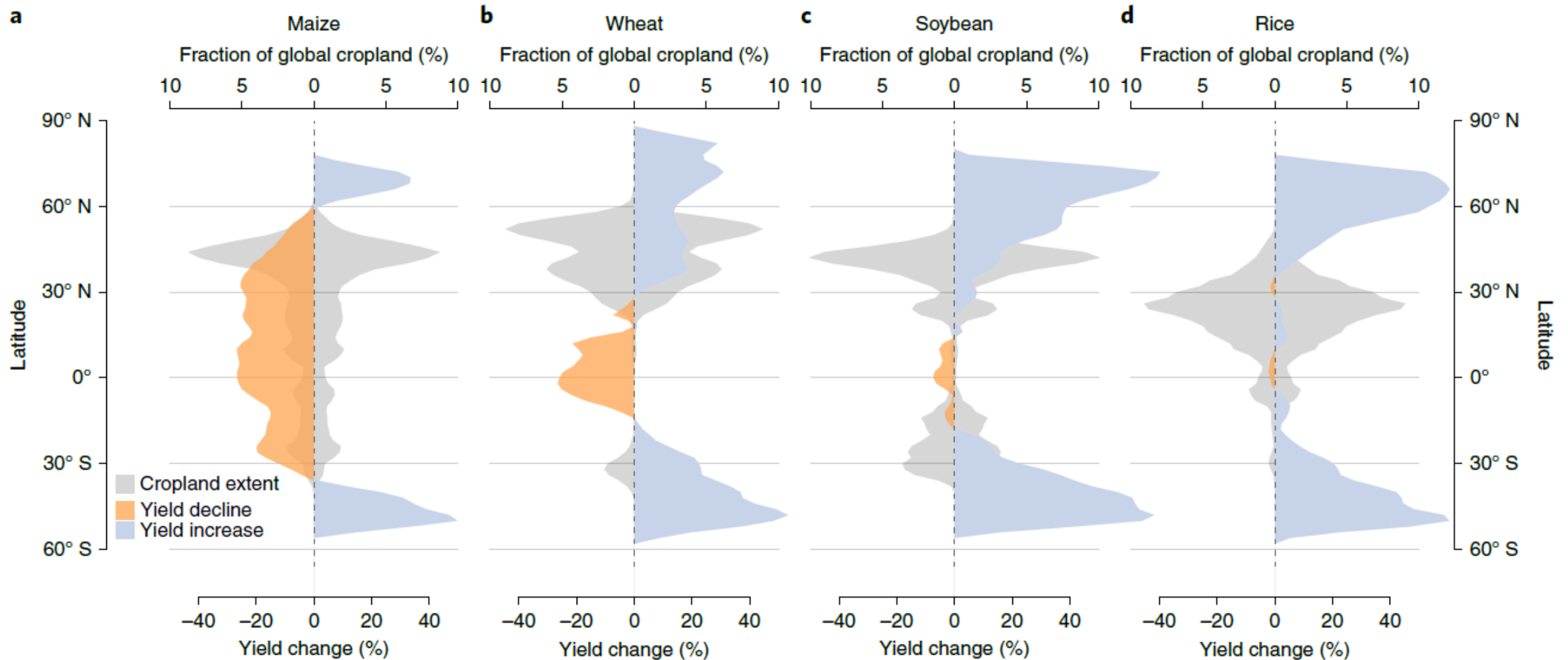


Crop-Suitability Change between 1980-2009 and 2070-2099 - RCP 8p5



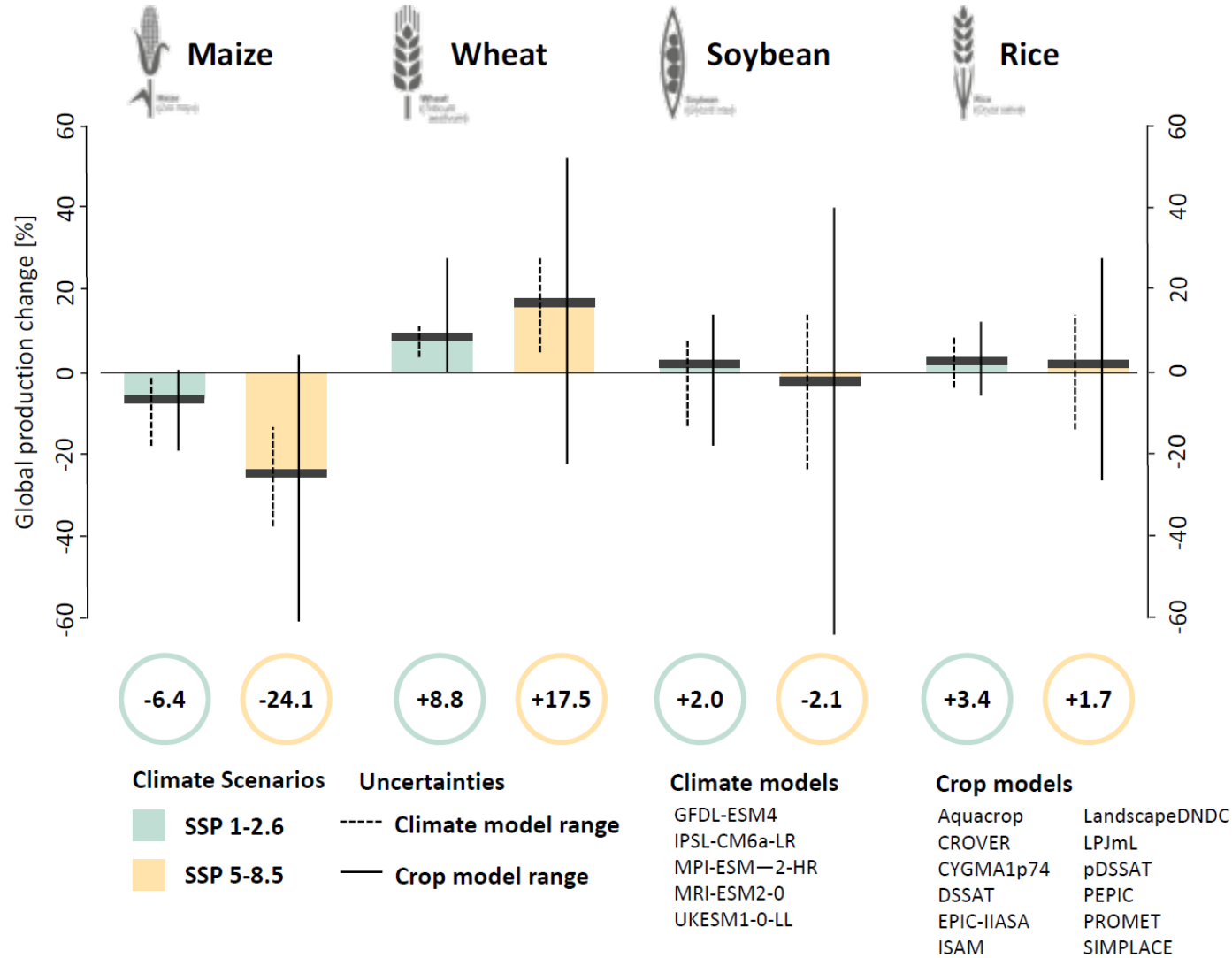
Source: Zabel et al. 2014, updated 2016

Yield changes (climate scenario SSP585, 2069-2099).



Source: Jägermayr et al. 2021

Yield changes (climate scenario SSP585, 2069-2099).



Source: Jägermayr et al. 2021

Overview

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17 Sustainable Development Goals



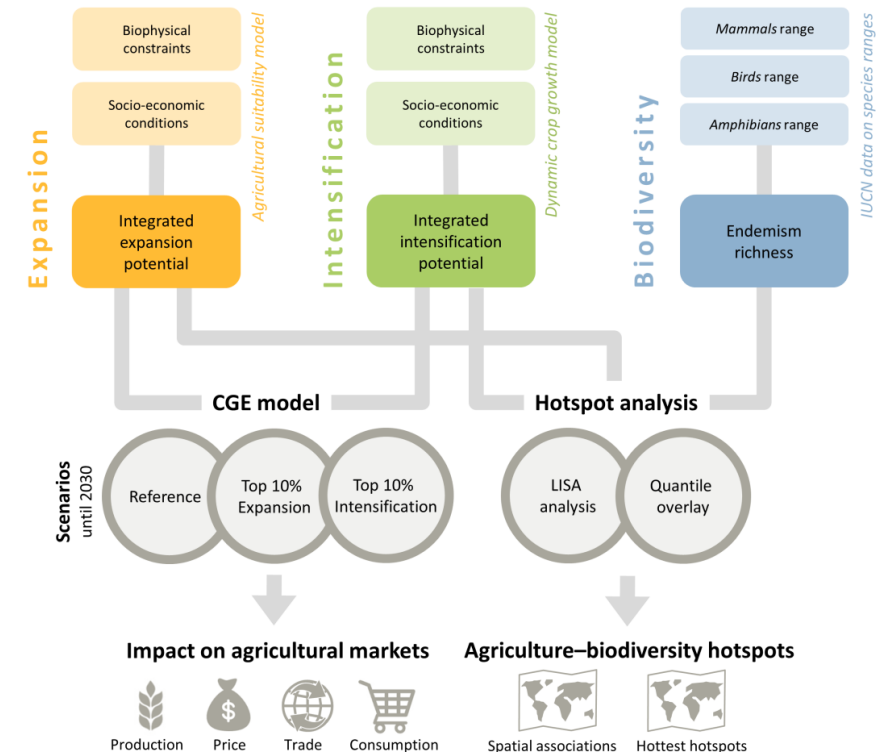
Biodiversity vs. food security?

- There are several strategies to improve food security.
- One of them is to increase production. How?
- More land
- More intensive land use

How do each of these two strategies affect agricultural markets and land with high biodiversity?

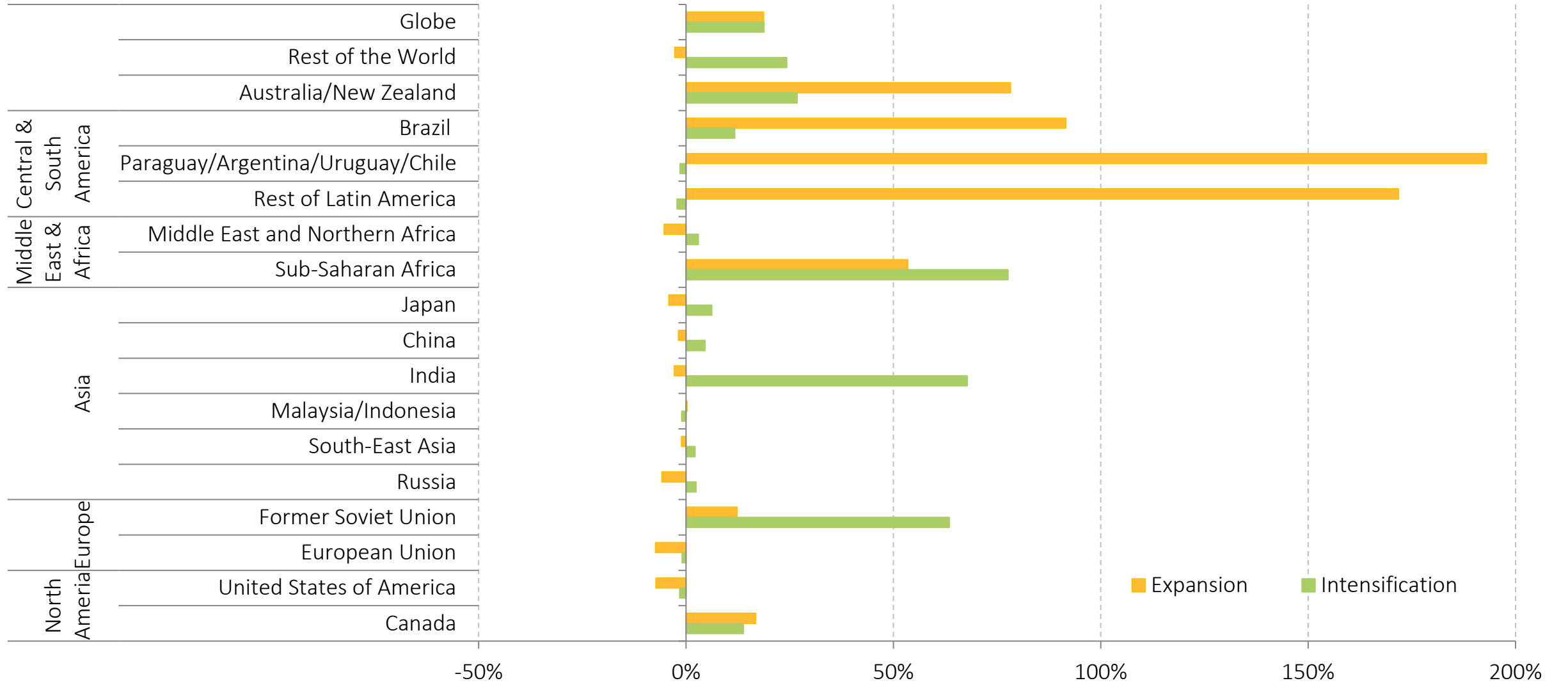
Scenarios

- Reference: current trends of population dynamics, GDP, tariffs, subsidies, consumption preferences.
- Top 10% Expansion: area expansion of the most suitable areas.
- Top 10% Intensification: yield increases on the top 10% areas with highest intensification potential. In total, the same increase in production.



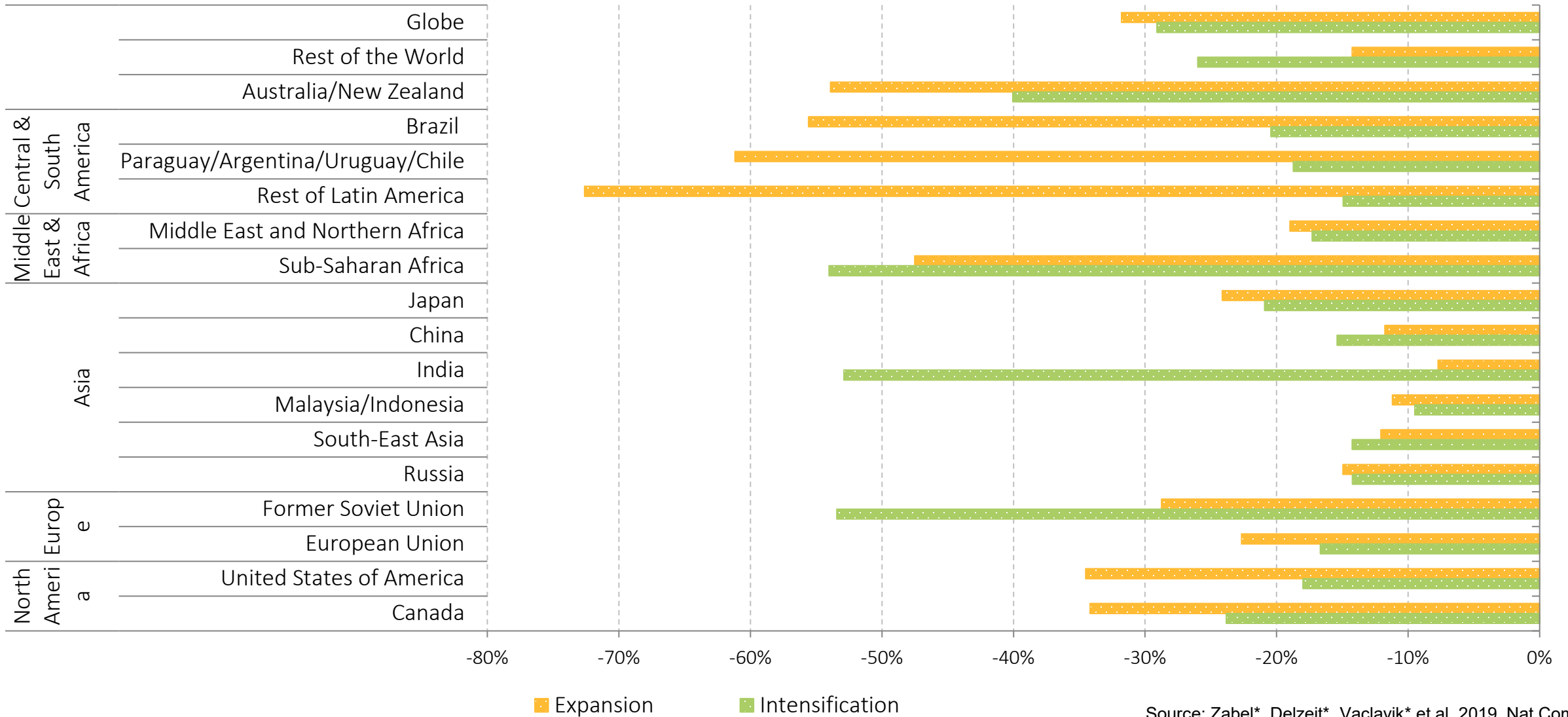
Source: Zabel*, Delzeit*, Vaclavik* et al. 2019, Nat Comm
* Equal contributions

Change in the production of arable crops



Source: Zabel*, Delzeit*, Vaclavik* et al. 2019, Nat Comm
* Equal contributions

Change in prices of arable crops



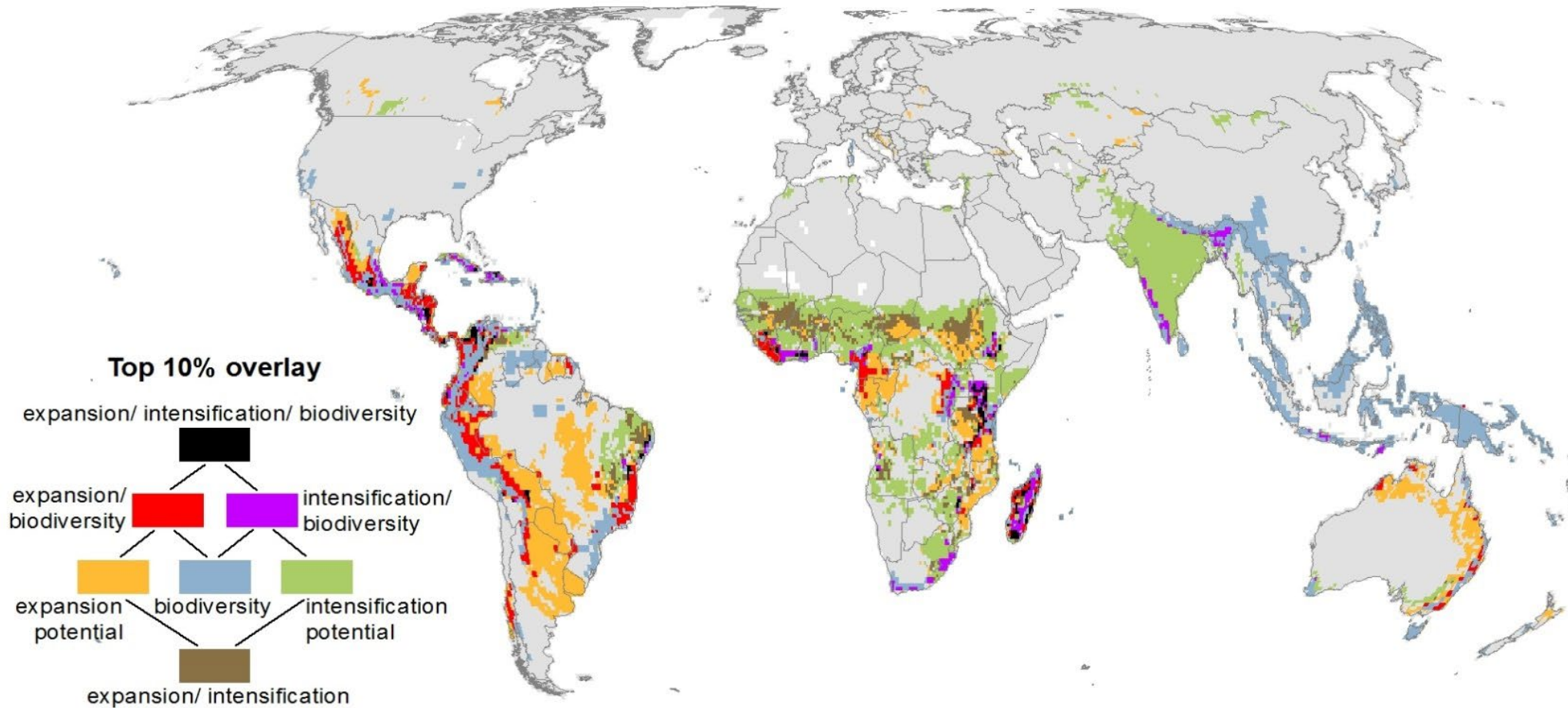
Source: Zabel*, Delzeit*, Vaclavik* et al. 2019, Nat Comm
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Changes in consumption and trade

- Food consumption in India and to a smaller degree in Sub-Saharan Africa increased more under the intensification scenario (+35 and 28%, respectively) compared to the expansion scenario (+4 and 21%, respectively)
- Trade: India turned from net importers in the cropland expansion scenario to net exporters in the intensification scenario.
- Income matters: e.g. Sub-Saharan-Africa large intensification potentials, but additional production is partly exported

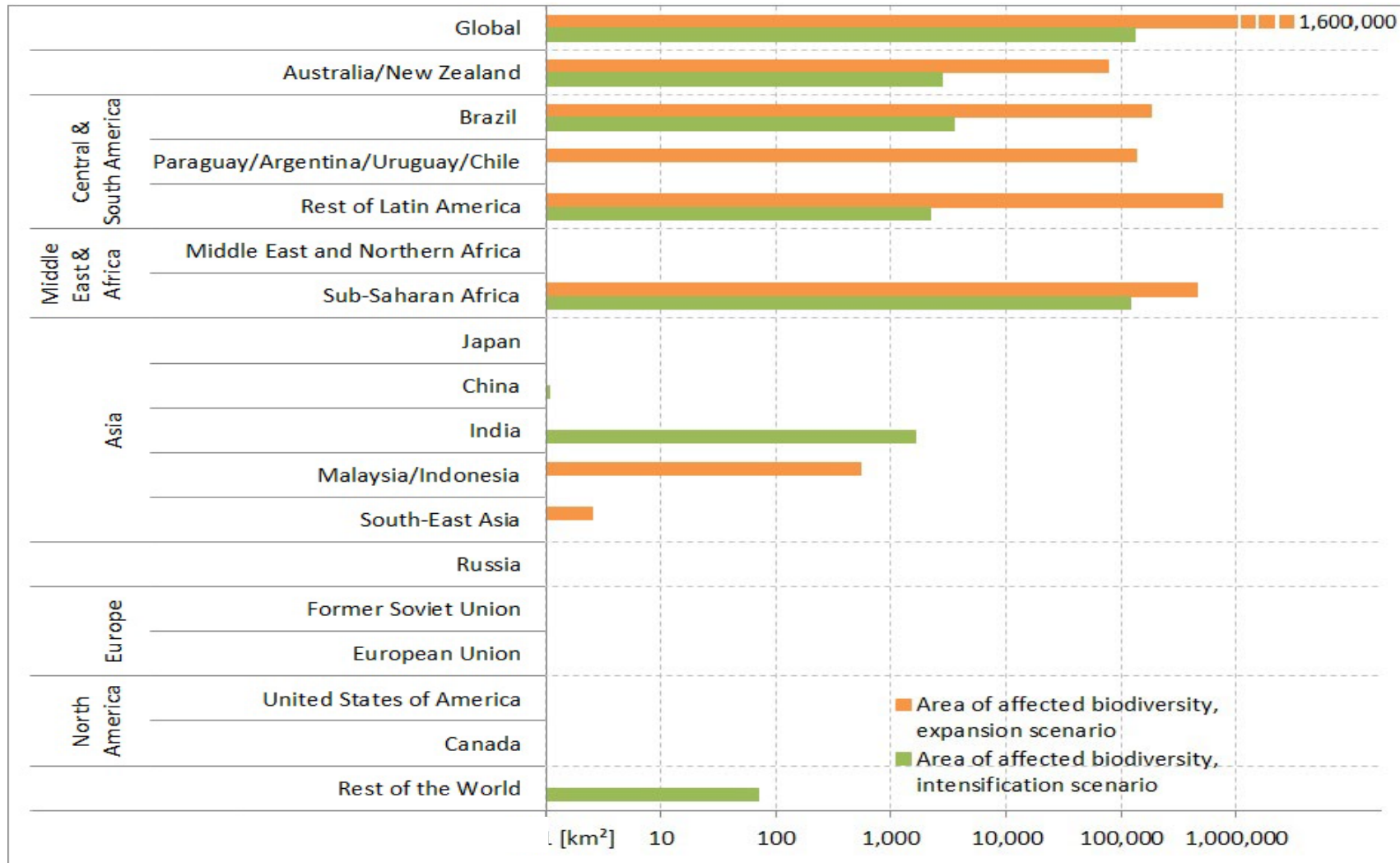
Source: Zabel*, Delzeit*, Vaclavik* et al. 2019, Nat Comm
* Equal contributions

Where are top 10% of spatial overlaps with biodiversity?



Source: Zabel*, Delzeit*, Vaclavik* et al. 2019, Nat Comm
* Equal contributions

How much area is affected?



Source: Zabel*, Delzeit*, Vaclavik* et al. 2019, Nat Comm
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How can conflicting land use goals be reduced?

- Reduction of food waste
- Change in consumer behavior
- Information on area (and CO₂eq) intensity of products
- Evidence-based decisions on conservation areas
- Consider land-use efficiency when promoting renewable energy
- Improvement of governance
- Improvement of land management
- ...



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Thank you very much
for your attention.