International Institute for Applied Systems Analysis
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# Exploring the role of agricultural trade in the future of nature and people

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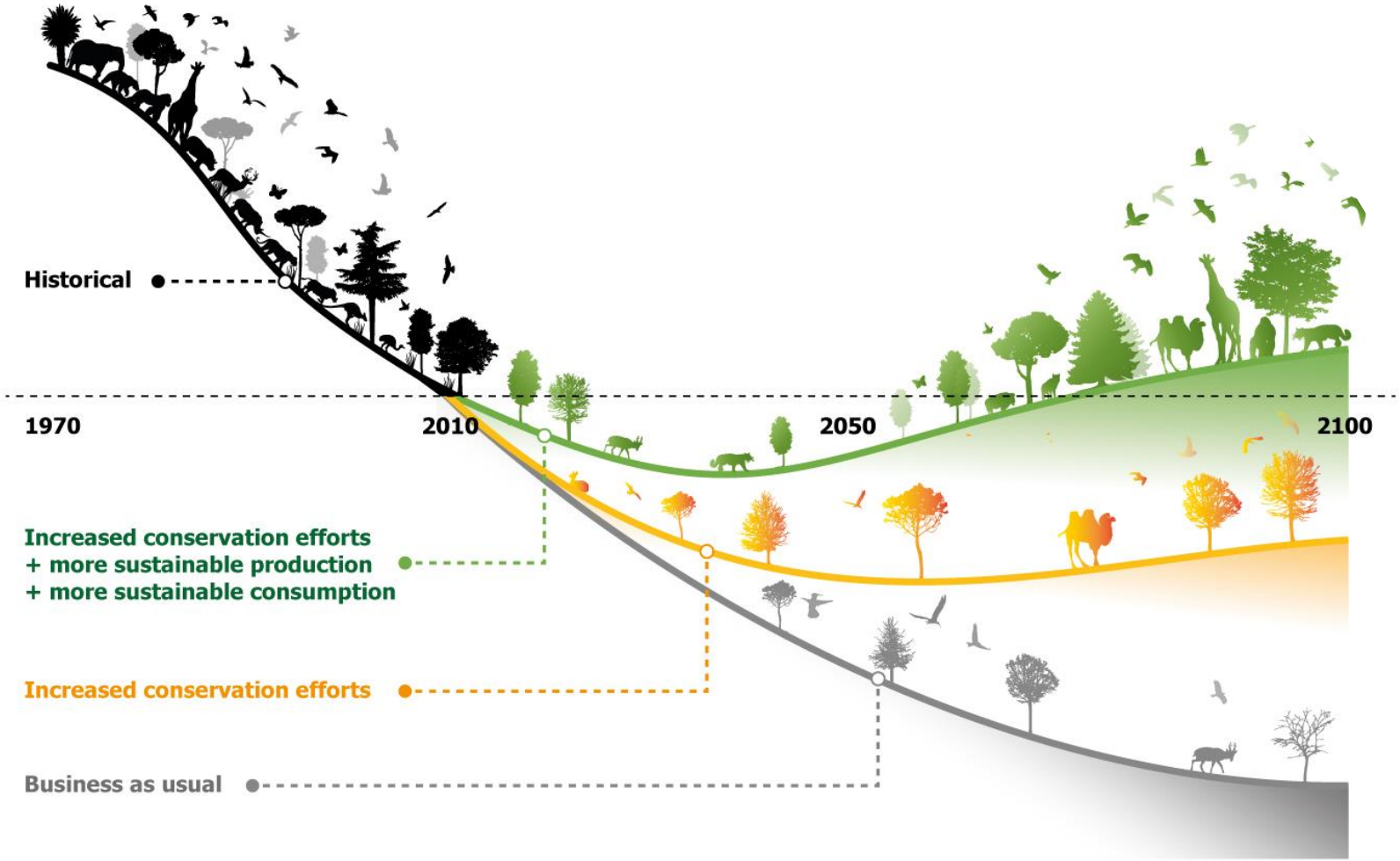
**Session 34: Assessment of Biodiversity Impacts using Agricultural and Economic Models (Room 1K)**

# Introduction

# Bending the curve: what about trade?

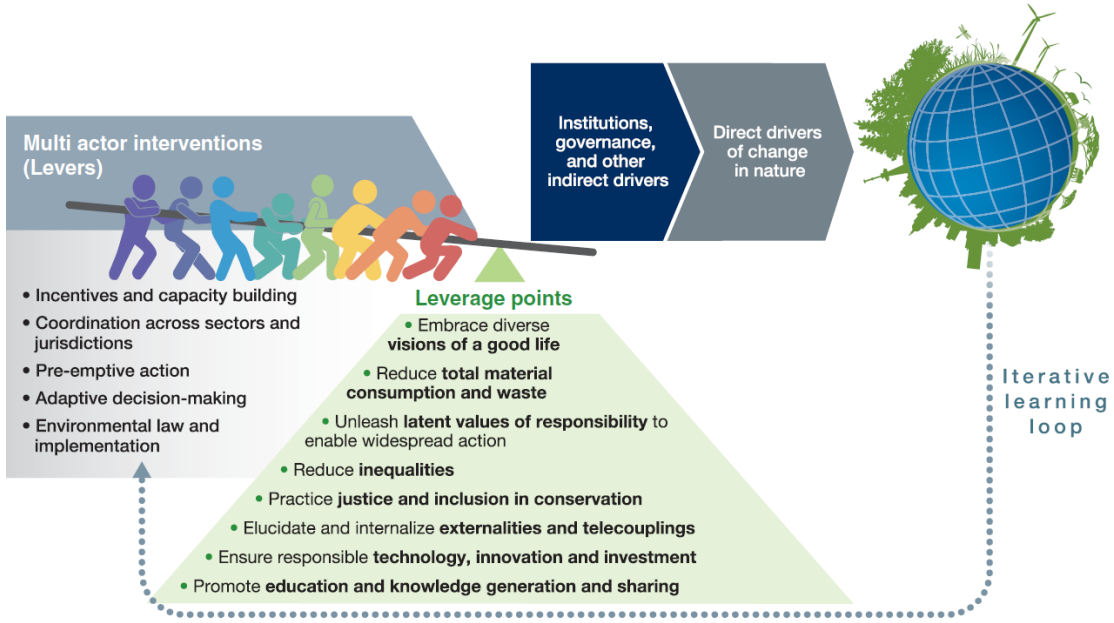
- Models and scenarios used to explore global pathways towards ambitious goals (Leclere et al 2020)
- A transformation of the global food system is needed
- **Little exploration of the role of trade**




A. Islaam (IIASA) after Leclère et al. 2020, *Nature*

# The role of trade for biodiversity

- Increasing but complex role in biodiversity loss
  - Connecting production from tropical countries to global demand vs land sparing effect (Marques et al 2021, Kastner et al 2021)
  - Commodity-, region- and scale- (regional vs global) specific net impact
    (Kastner et al 2021, Roux et al 2021)
- Mediating impacts of domestic policies
  - Spillovers & leakage (Meyfroidt et al 2020)
- High transformative change potential
  - Telecoupling governance (Chan et al 2020)
  - E.g., through acting on a few value chain actors
  - E.g., through multilateral negotiation




*Chan et al. 2020*

# Scope of the study

**Main research questions:**

- How could future agricultural trade be affected by efforts towards ambitious biodiversity goals?

- To what extent can alternative governance of agricultural trade support or imped progress towards ambitious biodiversity goals?

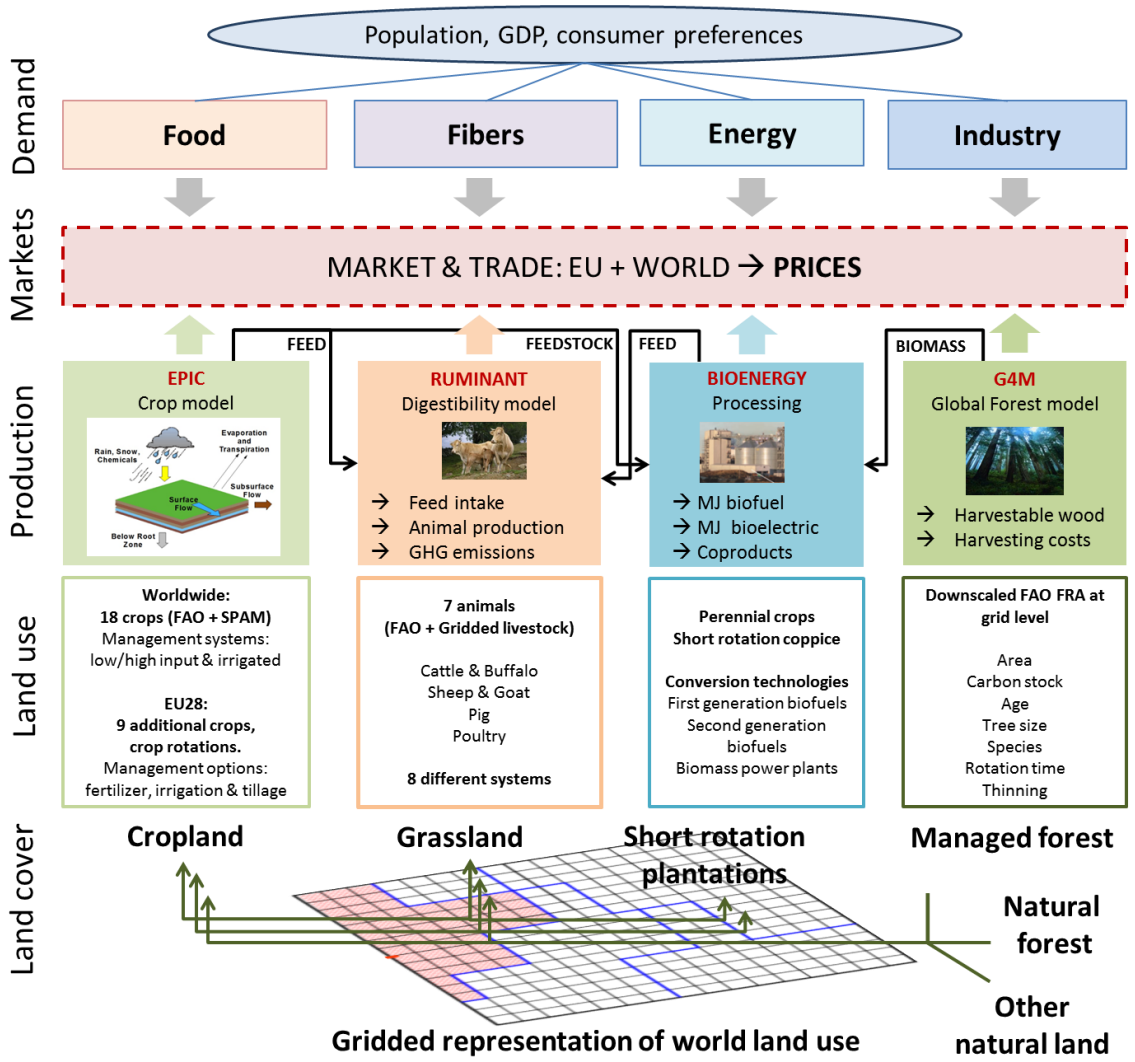
**Methodological approach:**

- Develop new future scenarios using the GLOBIOM global partial equilibrium model articulating conservation and food system efforts towards ambitious biodiversity goals and alternative agricultural trade governance

# Scenarios & modeling

# Models & scenarios to explore the role of trade

- GLOBIOM partial equilibrium model of agriculture, forestry and bioenergy sectors (Havlík et al 2014)
- Detailed representation of
  - Endogenous dynamics of various components of the food system (from producers to consumers)
  - Land use change and agricultural producers (gridded)
  - Bilateral trade flows (50+ commodities & 37 regions), incl. trade costs (tariffs, transport; Janssens et al 2020)
- Projecting environmental (e.g., land use change, biodiversity, see Leclere et al 2020) and socioeconomic (e.g., production, trade, hunger, see Hasegawa et al 2019) indicators from 2000 to 2100 (10-year step)




https://iiasa.github.io/GLOBIOM/

# Trade analysis highlights and set up

- Spatial price equilibrium approach
- Homogenous goods
- Separated but connected markets, bilateral trade flows
- Regional prices differences determined by trade costs (includes tariffs and transport costs) and trade calibration (Jansson and Heckelei, 2009)
- Trade expansion faces a non-linear cost
- Base year data sourced from BACI and MAcMap and calibrated with FAOSTAT
- Indirectly driven by comparative advantage through land allocation based on supply side productivity/resources

$$P_s = P_r + \tau_{r,s}^{M} + \tau_r^{X} + \tau_{r,s}^{NTM} + TC_{r,s}(x_{r,s}) + c_{r,s}$$

where $P_r$ and $P_s$ are domestic market prices for the regions r and s,

$\tau_{r,s}^{M}$ is the bilateral tariff applied by region s on exporter r,

$\tau_r^{X}$ is the export tax applied by exporter r,

$\tau_{r,s}^{NTM}$ is the NTM equivalent trade cost,

$TC_{r,s}(x_{r,s})$ is the variable transportation cost,

$c_{r,s}$ is calibration constant specific to each bilateral relation

# Trade analysis highlights

Food Sec. (2014) 6:29–44
DOI 10.1007/s12571-013-0319-z

ORIGINAL PAPER

## Global food markets, trade and the cost of climate change adaptation

Aline Mosnier · Michael Obersteiner · Petr Havlík · Erwin Schmid · Nikolay Khabarov · Michael Westphal · Hugo Valin · Stefan Frank · Franziska Albrecht

nature climate change
ARTICLES
https://doi.org/10.1038/s41558-020-0847-4
Check for updates

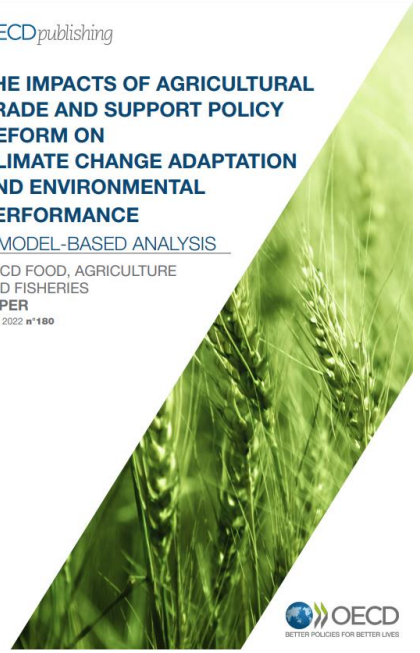
## Global hunger and climate change adaptation through international trade

Charlotte Janssens[1,2]✉, Petr Havlík[2], Tamás Krisztin[2], Justin Baker[3], Stefan Frank[2], Tomoko Hasegawa[2,4], David Leclère[2], Sara Ohrel[5], Shaun Ragnauth[5], Erwin Schmid[6], Hugo Valin[2], Nicole Van Lipzig[1] and Miet Maertens[1]

ARTICLES
https://doi.org/10.1038/s43016-022-00572-1
nature food
Check for updates

## A sustainable future for Africa through continental free trade and agricultural development

Charlotte Janssens[1,2]✉, Petr Havlík[2], Esther Boere[2], Amanda Palazzo[2], Aline Mosnier[3], David Leclère[2], Juraj Balkovič[2] and Miet Maertens[1]



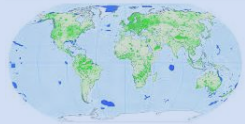
# Additional metrics: biodiversity, value added and footprinting

- Average Biodiversity Intactness Index (ABII) 0.5 degree
- Global species loss at WWF ecoregion
- Global species loss in domestic supply (ERDS), domestic consumption (ERDC), exports (EREX) and imports (ERIM) at WWF ecoregion
- Land and biodiversity "footprinting"
  - Tracing the trade of all primary product inputs in region where product sourced
- Farm income from the agricultural sector
  - Based on GTAP database

# 1) Scenarios exploring the action space for biodiversity

| Scenario | Description | Further BTC details |
|---|---|---|
| **BASE** | Based on SSP2 Middle of the Road | Continuation of historical trends |
| **C** | Increased Conservation | Increased extent and management of protected areas |
| | | Increased restoration and landscape-level conservation planning |
| **C+SS** | Increased Conservation + Supply Side | Scenario assumptions from C<br>Sustainable increase in crop yields |
| **IAP** | Increased Conservation + Supply Side +Demand Side | Scenario assumptions from C+SS scenarios |
| | | Reduced waste of agricultural goods from field to fork |
| | | Diet shift to a lower share of animal calories (in developed countries) |

What does trade look like in ambitious biodiversity pathways?



Pressures at the interface agriculture vs natural land

Agricultural systems transformations

Consumption patterns, better nutrition and human health



Adapted from scenarios presented in Leclère et al., 2020, *Nature,* https://doi.org/10.1038/s41586-020-2705-y

# 2) Explorative scenarios for the future of trade

| Name | Narrative | GLOBIOM implementation |
|---|---|---|
| **Baseline** | Drawn from 'Middle of the road' SSP2, prolongation of historical trends (further liberalization and global integration) | Observed changes in tariffs 2000-2020 & default SSP2 (moderate decrease in trade costs over time) |
| **Exacerbated liberalization** | Accelerated liberalization of trade and reduction of transport costs (following SSP1) | Full elimination of tariffs by 2030 & strong reduction in other trade costs (e.g., transportation) |
| **Frictions and reconfigurations** | Increased trade costs (following SSP3), trade routes shift in reaction to new priorities (e.g., reducing environmental damages associated with the consumption of imported goods) | Increase in trade costs by 2030 & capping of exports of deforestation commodities (Soya, Oil Palm, Beef) from tropical countries |
| **Greening of trade** | Comprehensive measures implemented to reduce the imported biodiversity footprint of every nation | Baseline + biodiversity border adjustment mechanism by 2030 (tax on imported extinction risks) |

# Combination Scenario Matrix

Bending the Curve for Biodiversity Loss Scenarios

Trade governance scenarios

| | BASE | C | C+SS | IAP |
|---|---|---|---|---|
| **Baseline** | Baseline (BASE) | Baseline (C) | Baseline (C+SS) | Baseline (IAP) |
| **Frictions and reconf.** | Frictions and reconfig. (BASE) | Frictions and reconfig. (C) | Frictions and reconfig. (C+SS) | Frictions and reconfig. (IAP) |
| **Exacerb. Lib.** | Exacerb. Lib. (BASE) | Exacerb. Lib. (C) | Exacerb. Lib. (C+SS) | Exacerb. Lib. (IAP) |
| **Greening** | Greening (BASE) | Greening (C) | Greening (C+SS) | Greening (IAP) |

# Preliminary results

# Global sustainability indicators (prelim. results)

**Baseline: econ. vs env. trade-off**

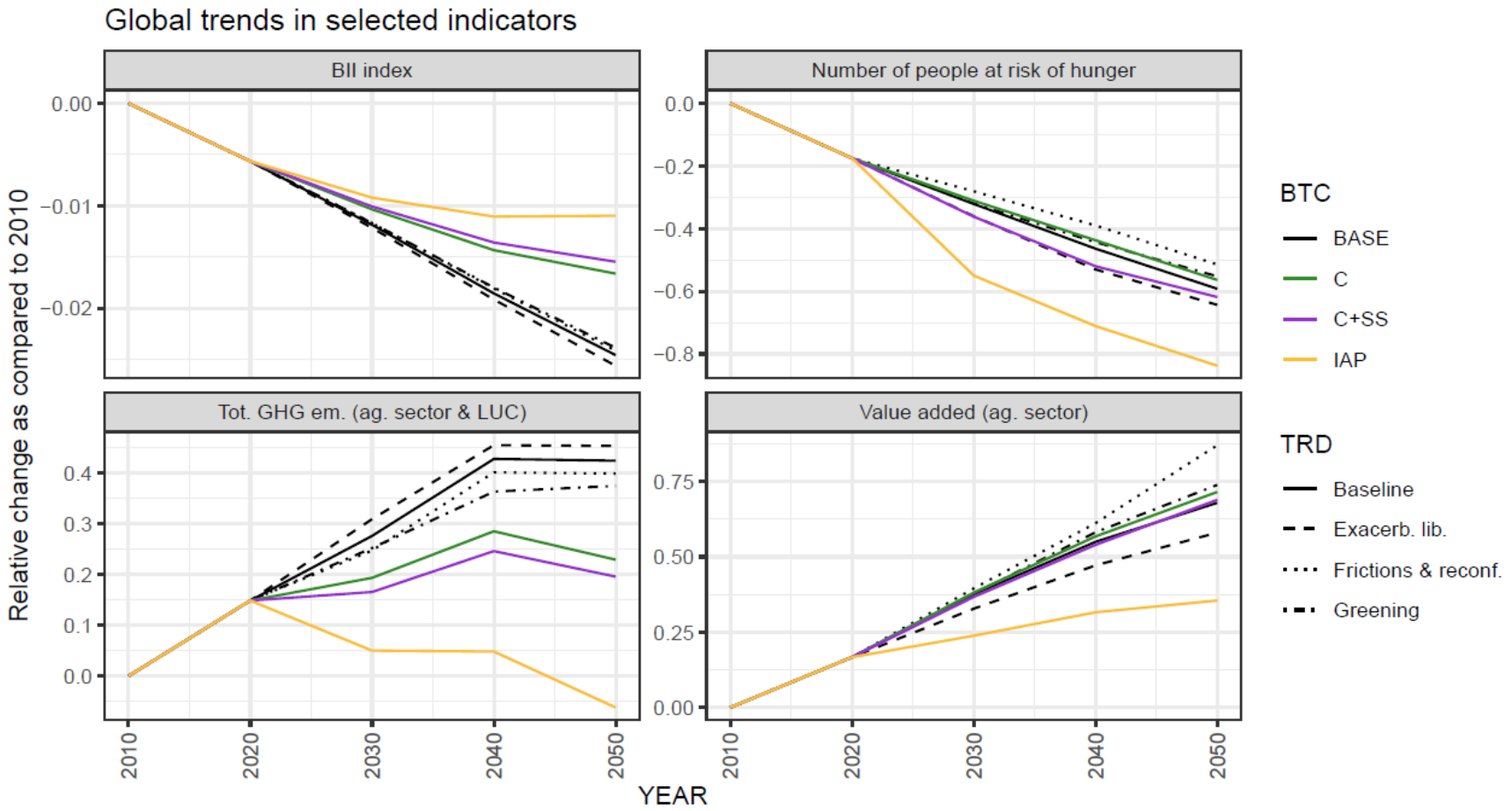
Decreases in hunger and increased ag. value added comes at the cost of increased GHG emissions & biodiversity loss

**Differentiated impacts of trade gov.**

Liberalization and trade restrictions play in opposite direction, often moderate impacts. Trade greening most adhesive to societal goals.

**Disruptive bending the curve efforts**

Increased conservation & restoration (C) reduce future env. impacts, w. limited adverse soc.-econ. impacts if combined with supply-side measures (C+SS). Adding demand-side measures (IAP) is more disruptive, with significant losses in value added.



# Trade in deforestation commodities (prelim. results)

2010

**Alternative trade governance scenarios**:

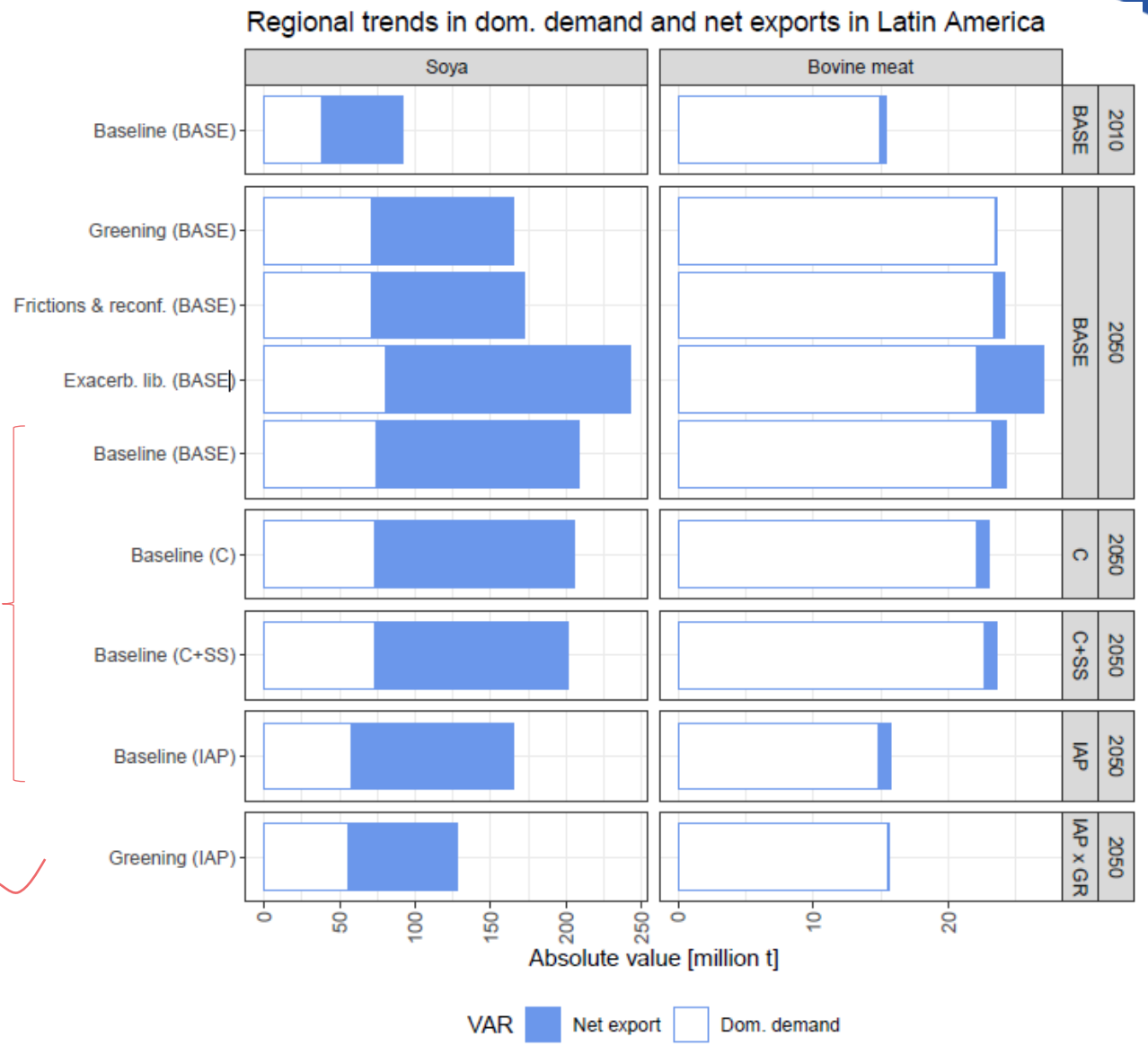
Highest impact, with similar decrease / baseline for 'Frictions and Reconfigurations' and 'Trade greening' scenario, vs increase for 'Exacerbated trade liberalization' scenario

**Other Bending the curve scenarios:**

A potentially large margin for sustainable trade, more trade as compared to both 2010 and as compared to even when considering demand interventions

**Combining bending the curve and trade greening**:

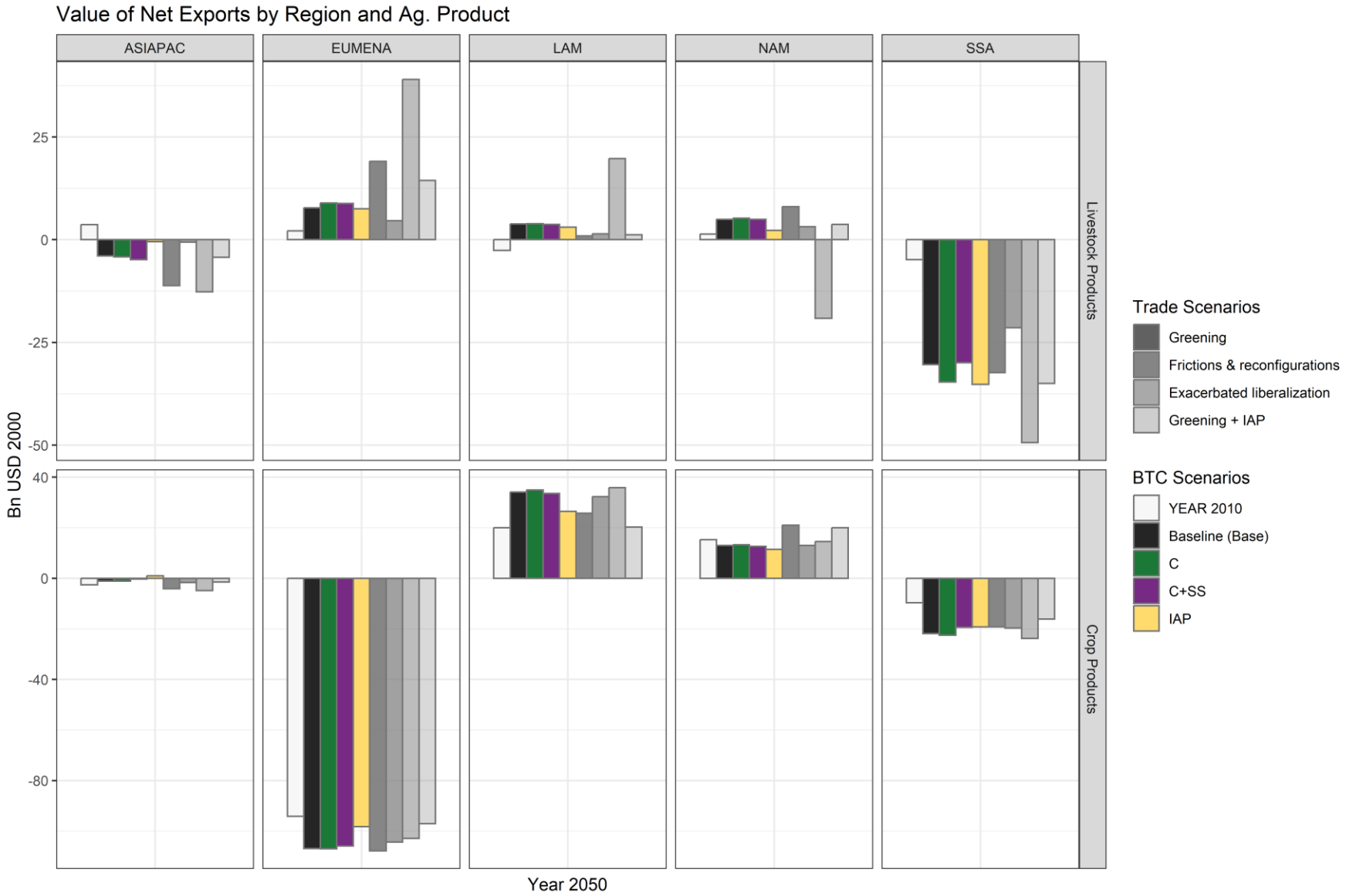
Projected future increase in trade for some commodities



# Value of Net Exports by Region

**Similar picture at more aggregated trade outcomes**:

- Higher impact of trade than BTC scenarios on value of net exports (left) and share of production traded
- Trade positions move in the same directions across BTC scenarios, not always the case for trade scenarios (esp. Livestock products)

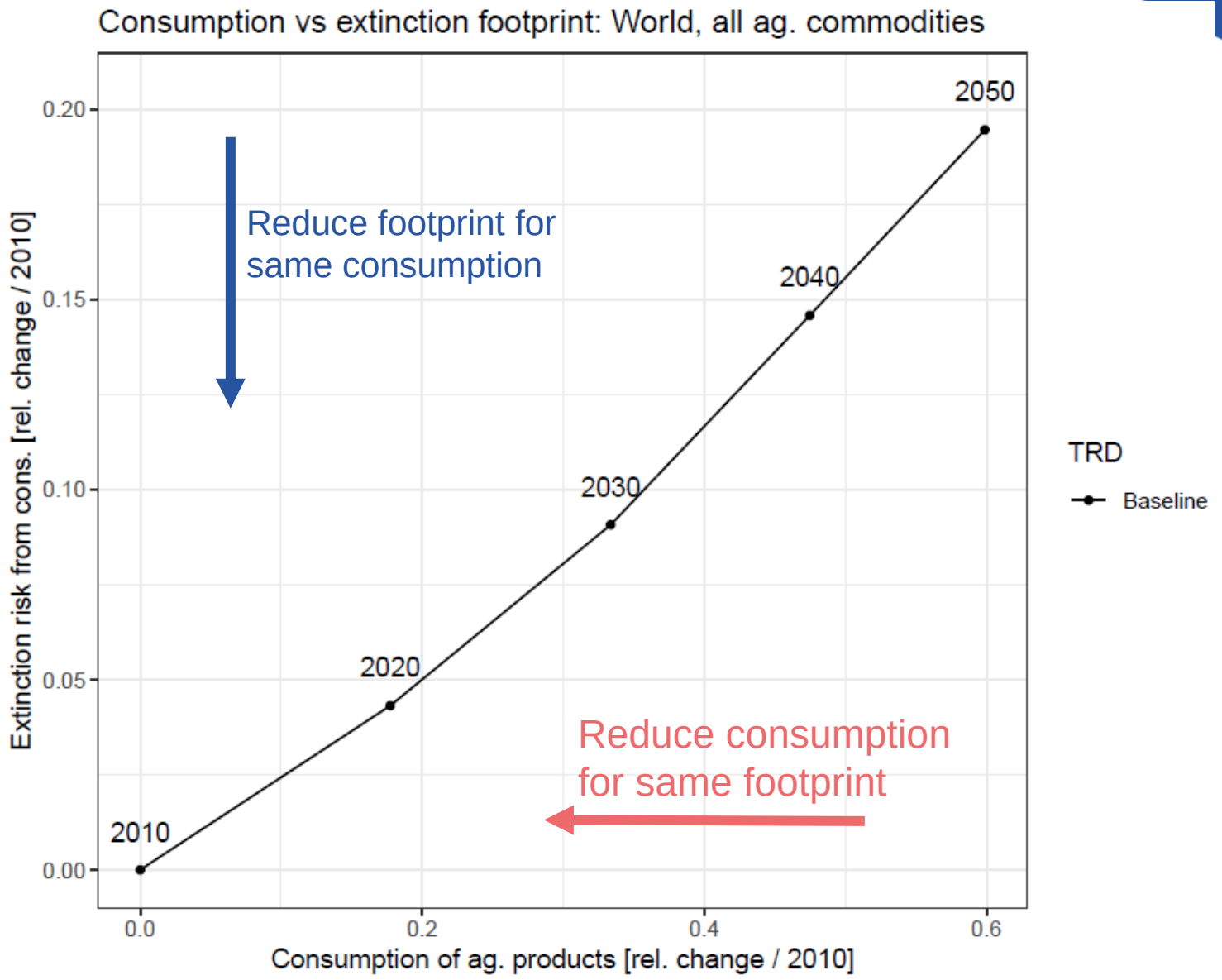


# Demand vs footprint reduction (prelim. results)

**On demand vs footprint reduction**

Both footprint and demand are expected to grow in the future.

How much can we decrease footprint without also decreasing demand?



# Demand vs footprint reduction (prelim. results)

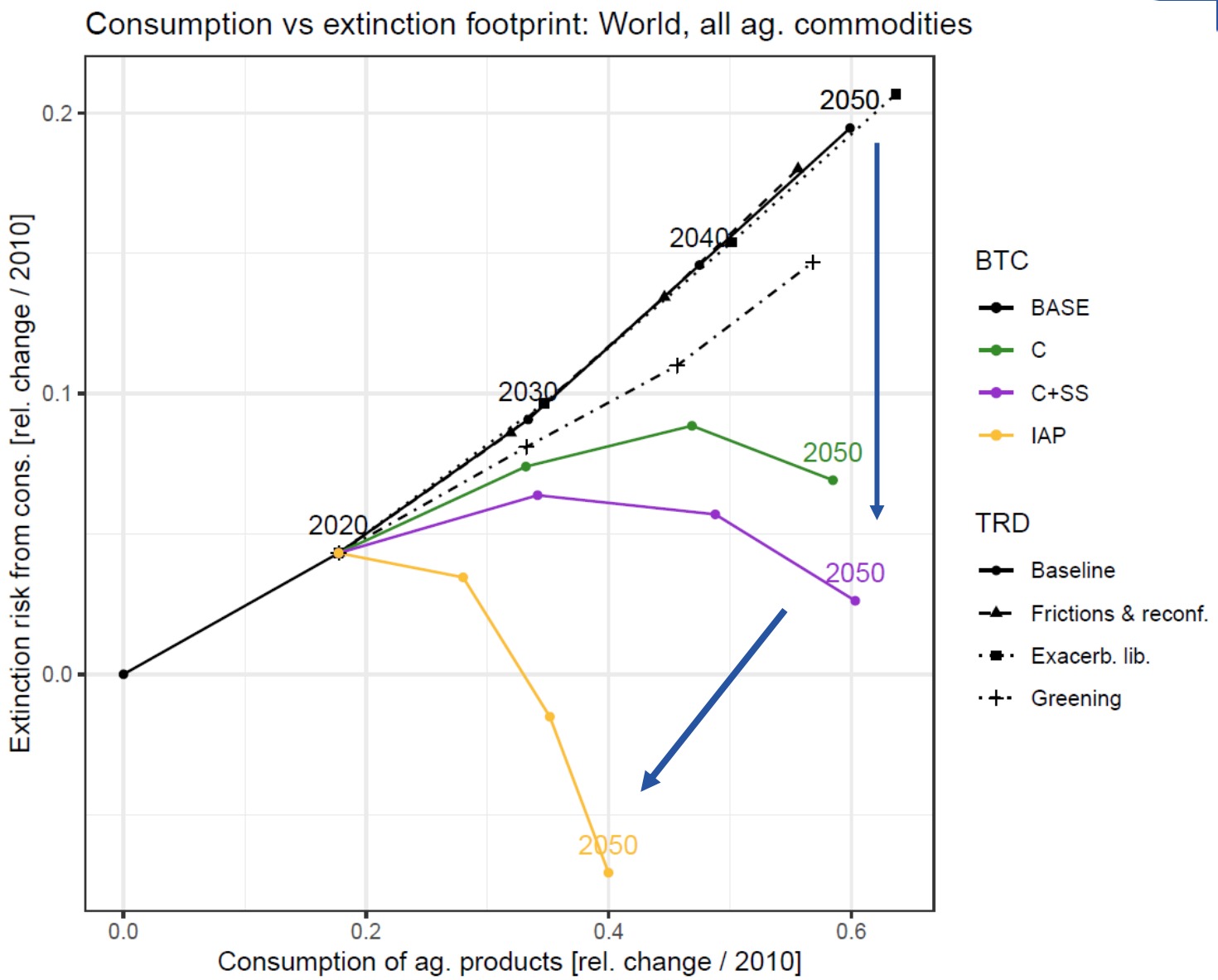
**Reduced footprint of consumption …**

Trade greening scenario achieves better decrease in the footprint of consumption than Frictions and Reconfigurations

But a lot less than when considering conservation & supply-side measures

**… can only take us that far without more alternative consumption choices**

While IAP scenario leads to less significant decrease in extinction risks / 2010, we may at best stabilize to 2020 levels w/o demand-side measures (C+SS)

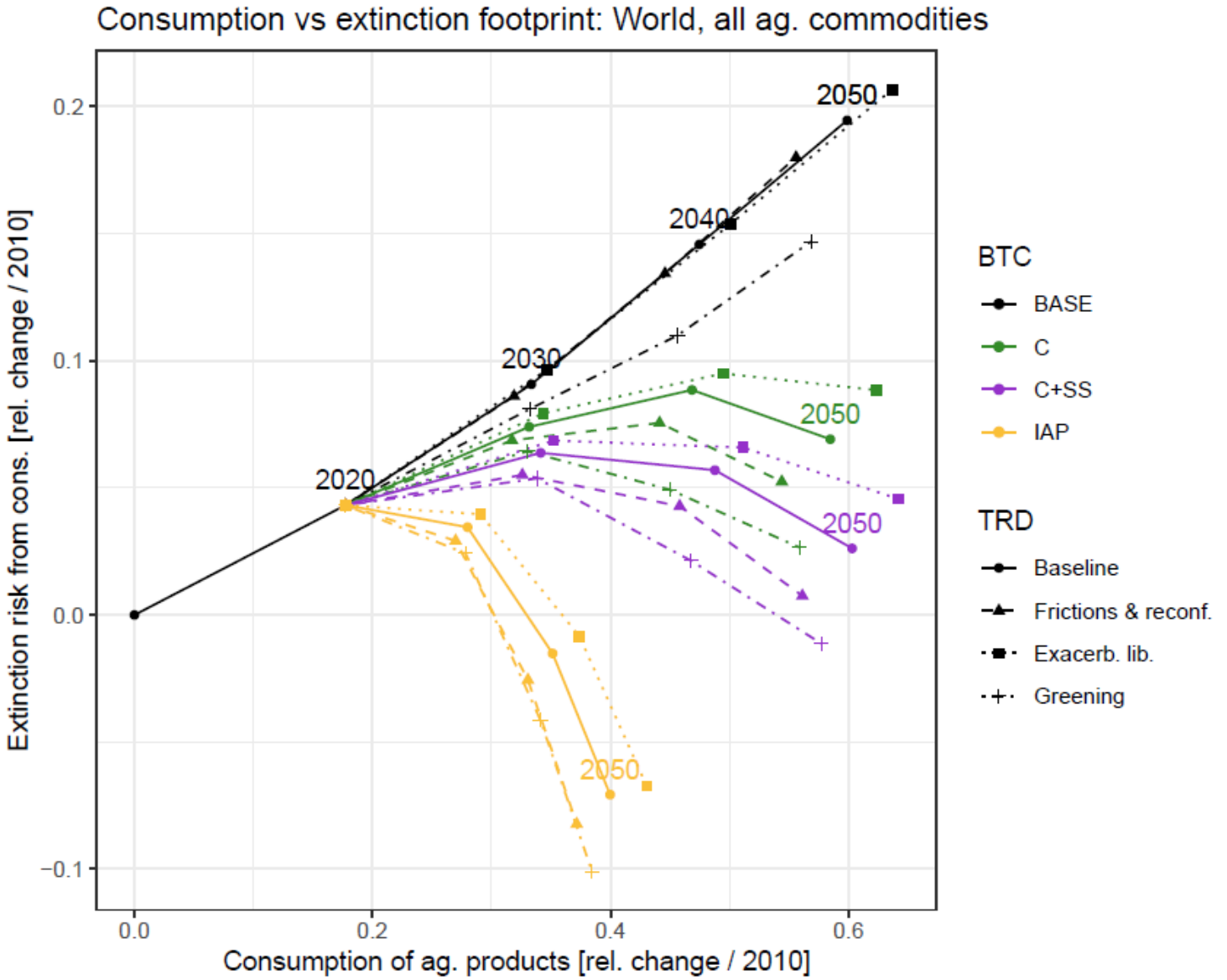


# Demand vs footprint reduction (prelim. results)

**Interactions between scenario dimensions**

The impact the trade governance scenarios (e.g., Trade greening – baseline) is:

- larger under C & C+SS than under BASE scenario …
- but smaller than BASE scenario when demand-side measures are considered (IAP)



# Undernourishment and farm incomes (prelim. results)

**More significant effect of trade gov.**

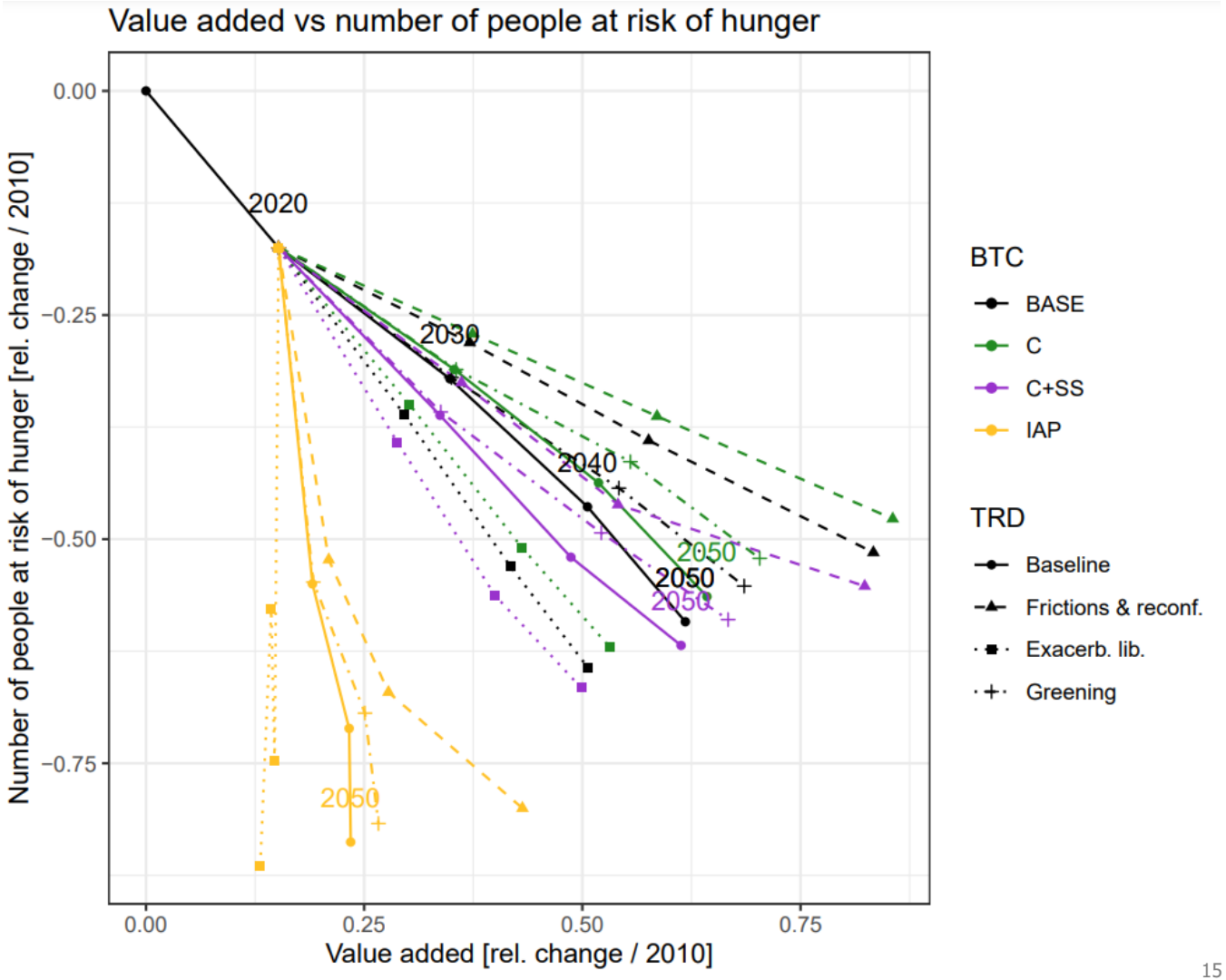
- Globally, trade restrictions favor producers at the expense of consumers, and the way around for trade liberalization
- Trade restrictions have larger impacts than when uncoordinated (Frictions and reconfigurations vs Trade Greening)

**Demand-side measures are disruptive**

- Significant transfer from producers to consumers

**Less interactions**

- Except still smaller than BASE scenario when demand-side measures are considered (IAP)



# Discussion & conclusion

# Discussion

## Preliminary results

- Trade differently affected by efforts towards ambitious biodiversity goals:
  - > Large trade potential under increased conservation and sustainable intensification
  - > Sustainable consumption measures (waste reduction, diet shift) more disruptive (not just to trade) and needed
  - > Still some margins to increase trade when considering demand-side measures
- Alternative trade futures have differentiated impacts on sustainability objectives
  - > Stronger impacts on socio-economic than environmental indicators
  - > Trade liberalization could work against biodiversity, uncoordinated restrictions against food security
  - > While some options like greening look promising, some trade-offs remain (e.g., producers)
  - > Interactions between trade and conservation / supply-side / demand-side can be large

## Limits

- Complexity: trade challenging to project, effect on several sustainability indicators even more so
- The devil is in the details: picture contrasted across regions & supply chains

# Next steps

- Potential improvements to this analysis:
  > Explore indicators more traditionally discussed in ag. trade circles
  (comparative advantage, revenues from tariffs etc.; a vehicle for engaging with trade policy circles)
  > Have a closer look at regional effects & interactions across scenario dimensions:
  (is trade within continents responding similarly to trade across continents?)

- Designing new scenarios exploring specific trade governance intervention options
  > Trade and supply chain governance instruments
  (e.g., environmental provisions in PTAs & due diligence impact on specific supply chains, leakage, TRASE)
  > Geopolitical dynamics around environmental & trade agreements
  (e.g., EU-MERCOSUR ratification conditional to action under Paris Agreement & post-2020 GBF)

# Thanks! Questions

**TradeHub project** https://tradehub.earth/


**Psssst … job position open!!**

- [IIASA, our team]
  Postdoc on trade & sustainable development

More info on the job advert here!

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# Extras

# Share of exports in global production volume

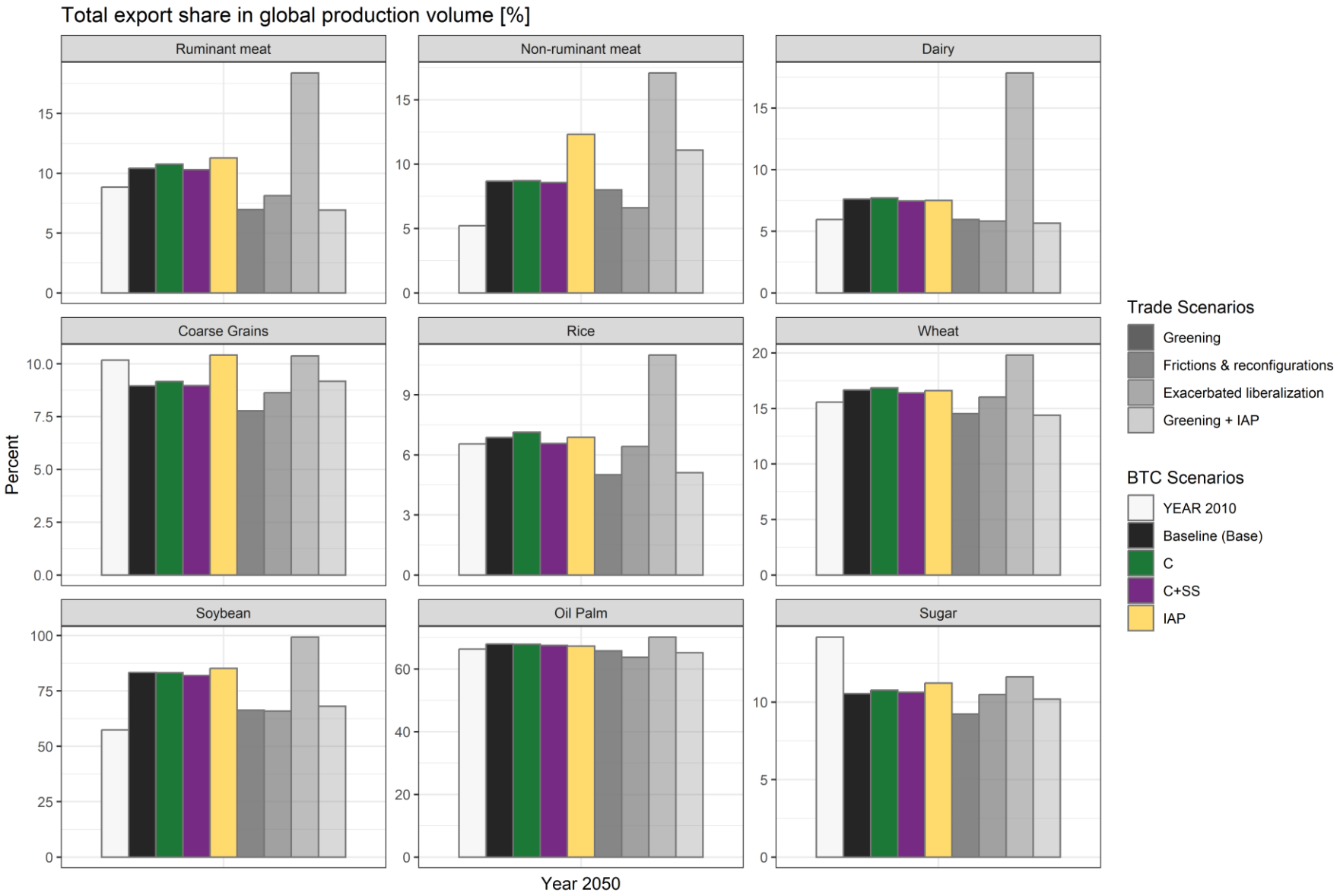
**Alternative trade governance scenarios**:

Exacerbated liberalization ->greatest trade share (for almost all products) [specialization], Greening/Frictions and reconfig -> lowest trade share

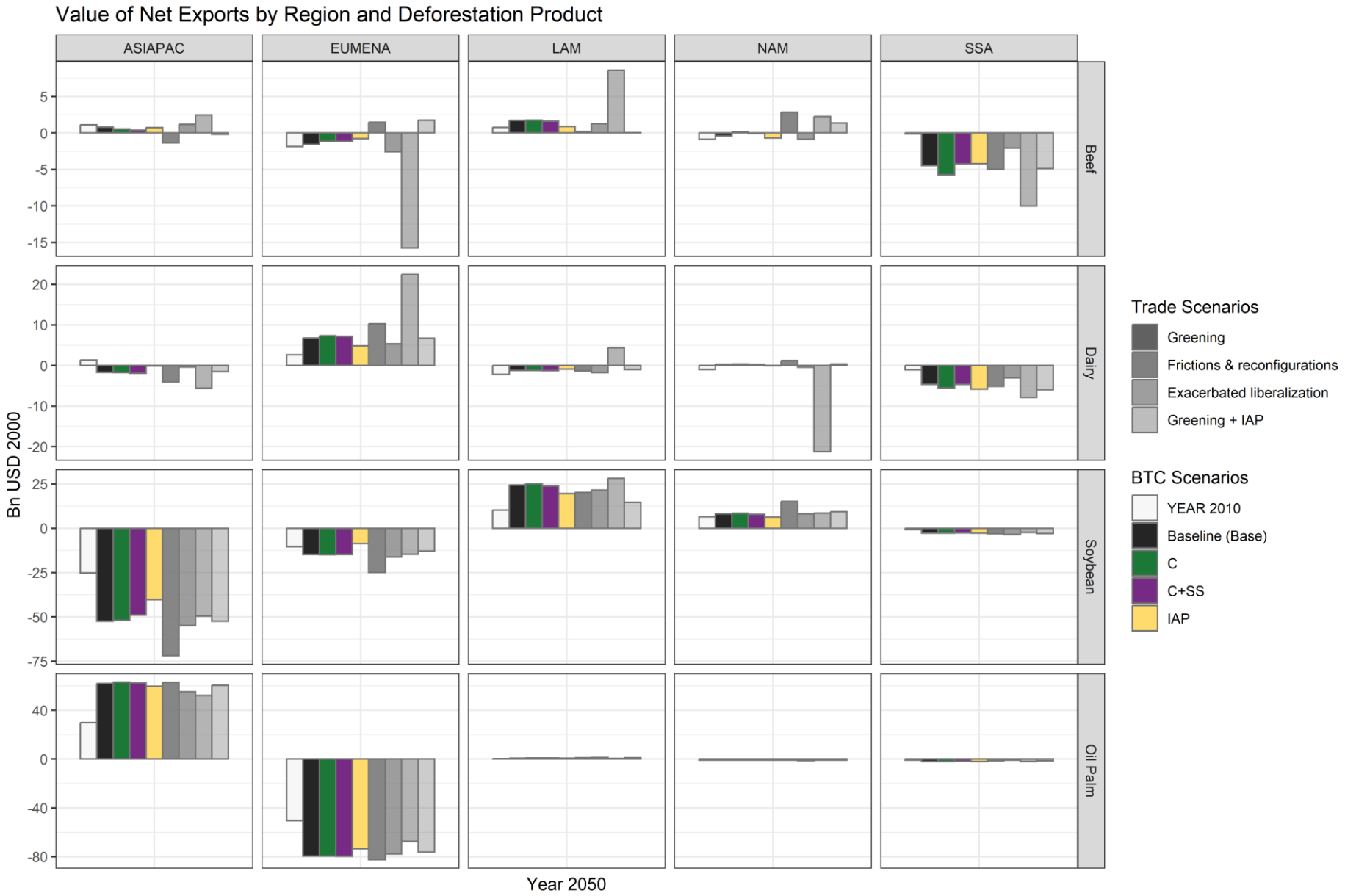
**Livestock products:**

Liberalization raises the trade share

**Other Bending the curve scenarios:**
IAP also results in some specialization (increase trade share for livestock products, grains/sugar)



# Extra: Value of Net Exports by Region Deforestation Products



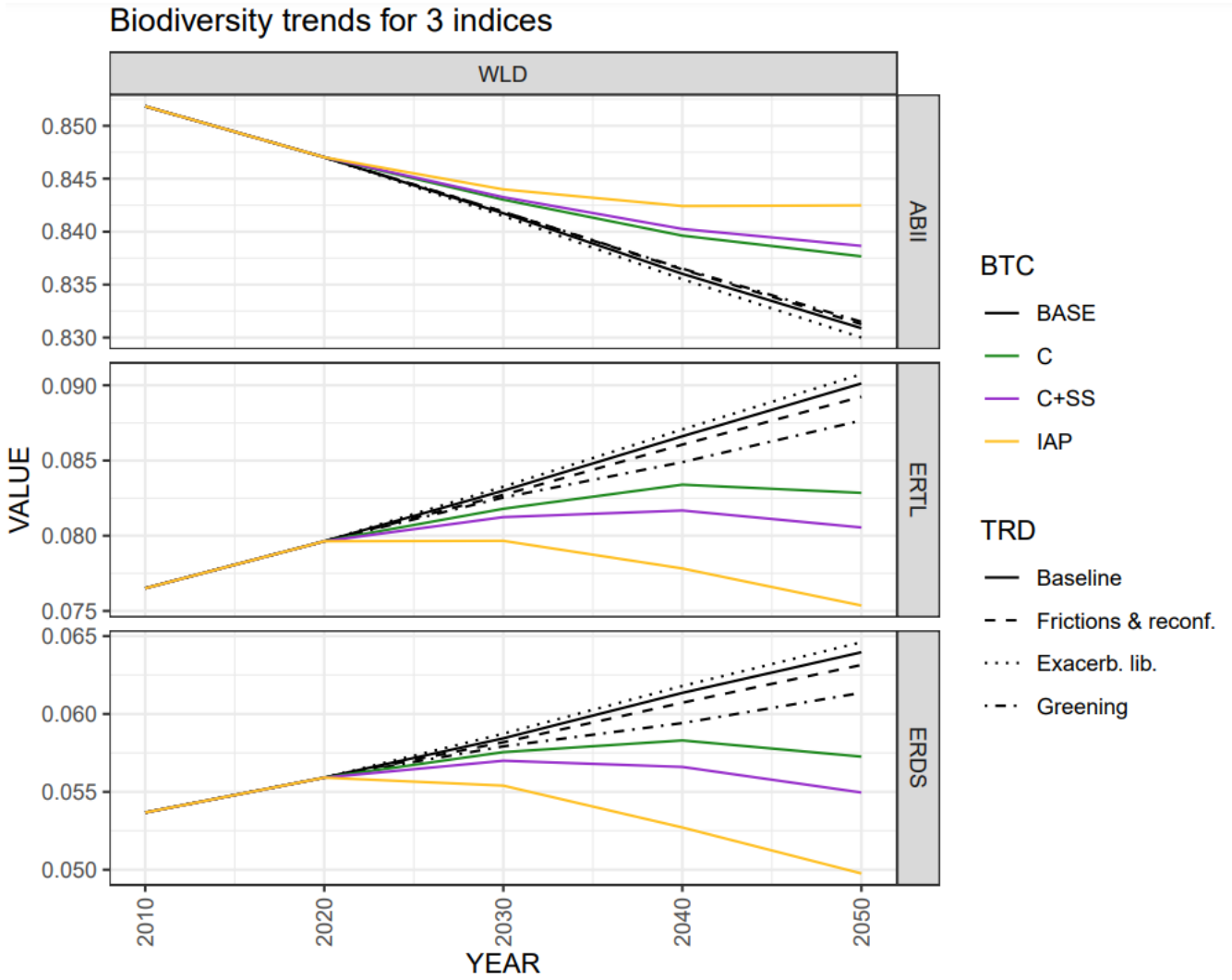
# Global biodiversity trends (prelim. results)

**Globally consistent trends across indicators**

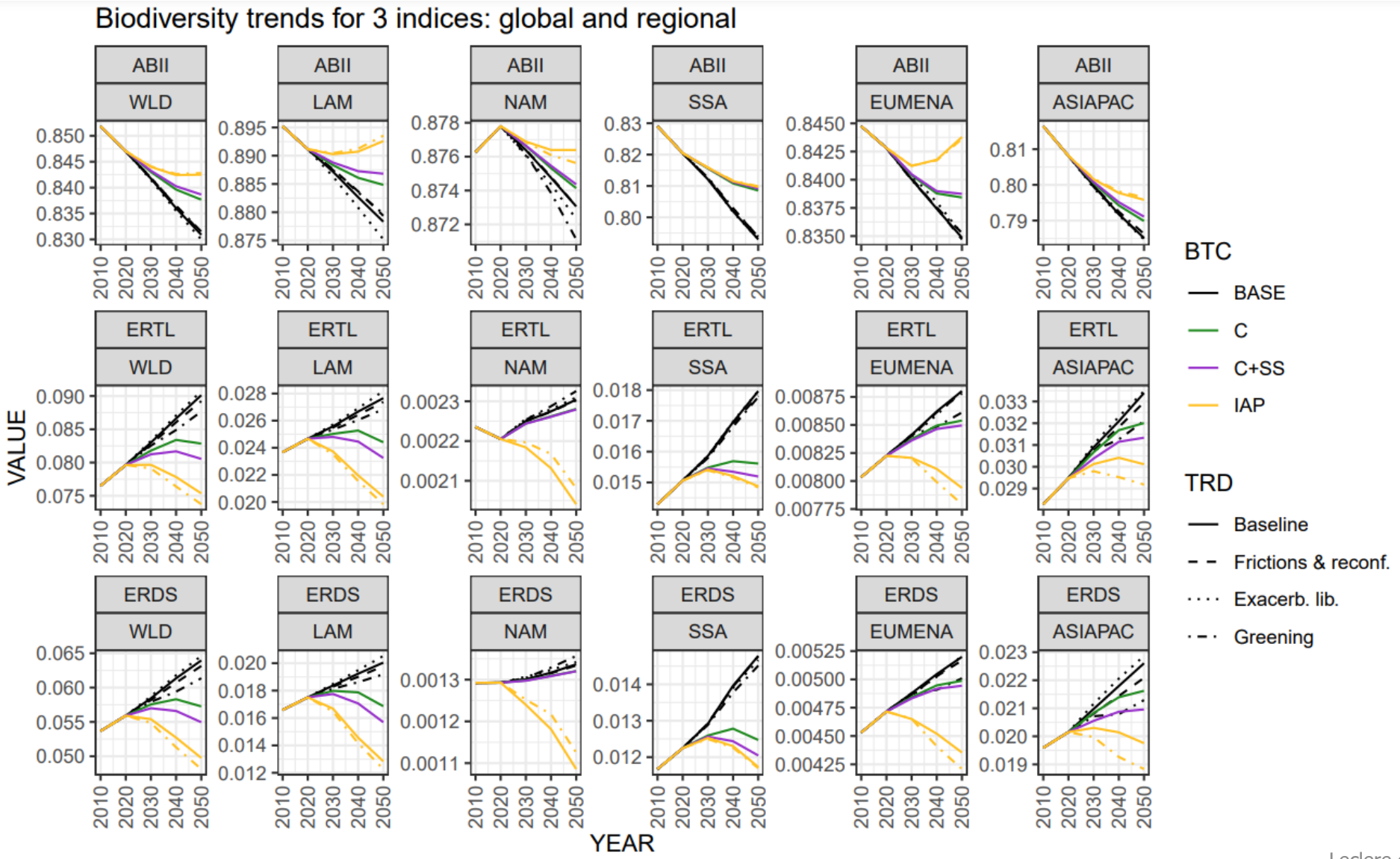
- Modest impacts from trade scenarios, negative for Exacerbated liberalization and positive for trade restrictions
- Achieving a reversal of biodiversity loss by 2050 requires increased conservation and restoration measures & food system transformation
- Trade greening could help (except for NAM)

**Differences across biodiversity indicators**

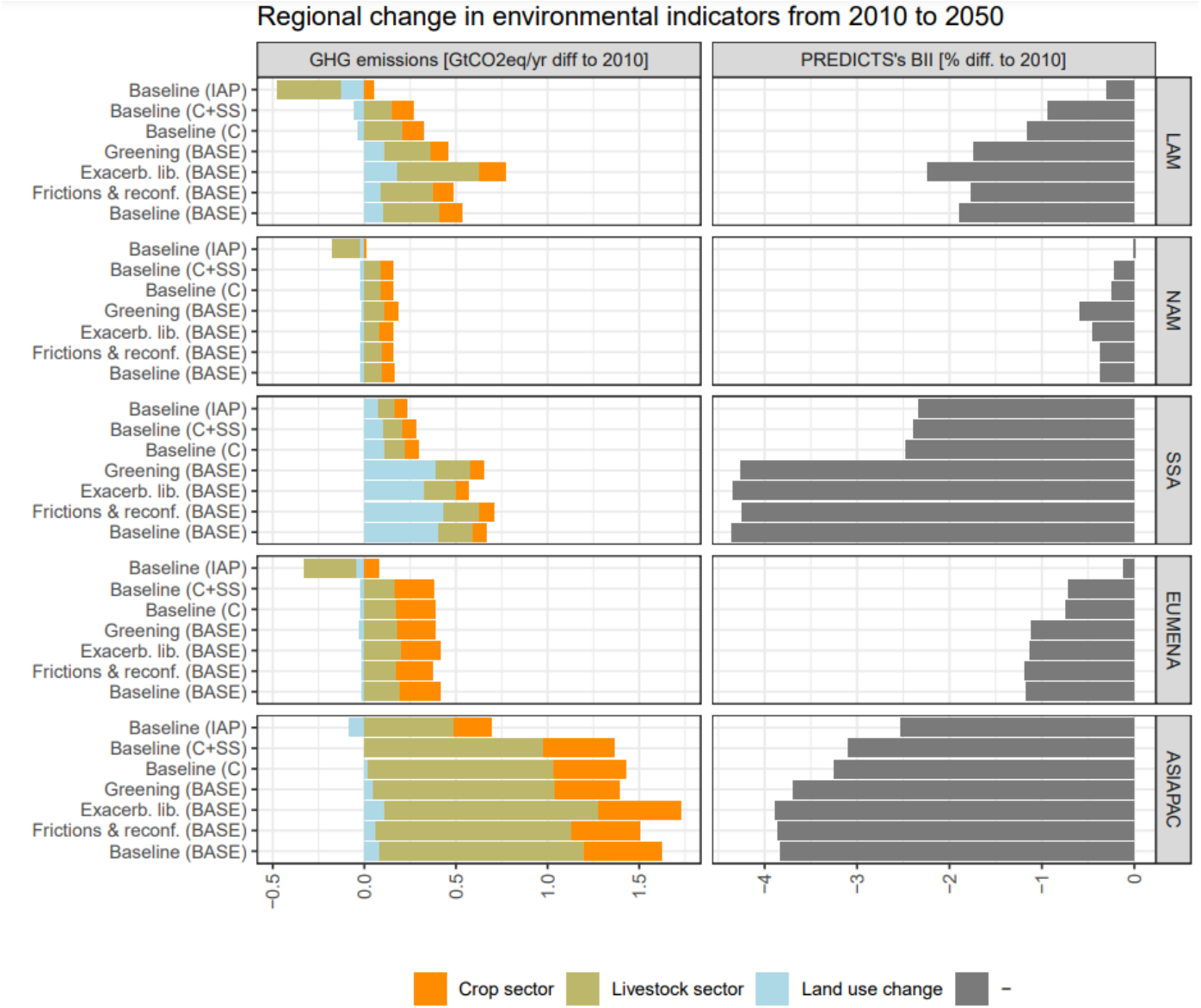
- More pronounced bending for extinction risk-based indicators (ERDS, ERTL) than local compositional intactness (BII) [temporal recovery]
- More than 2/3rd of extinction risks from ag. Sector, and all of the bending



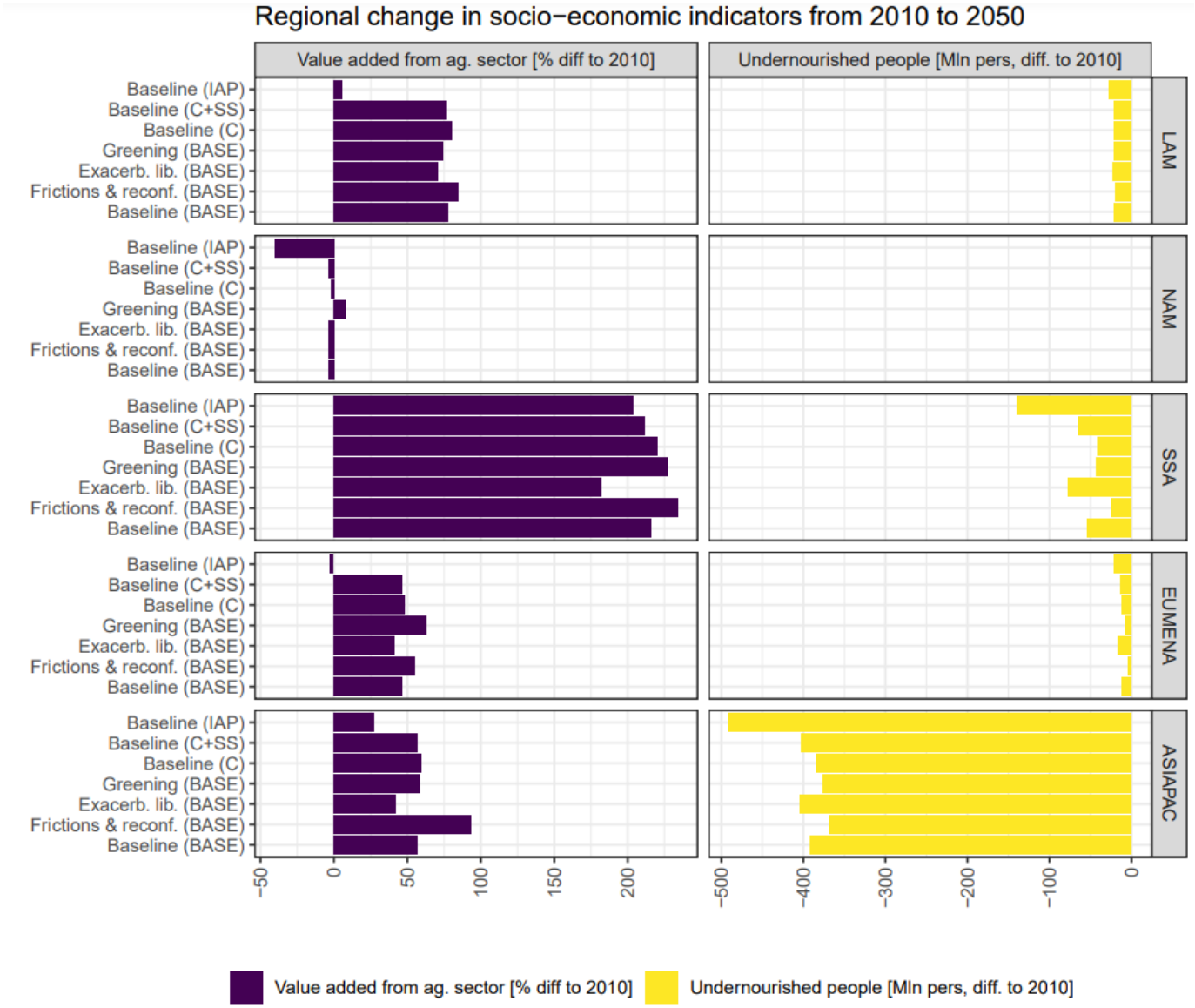
# Extra: biodiversity trends by region & indicator



# Extra: biodiversity vs GHG emissions at regional level



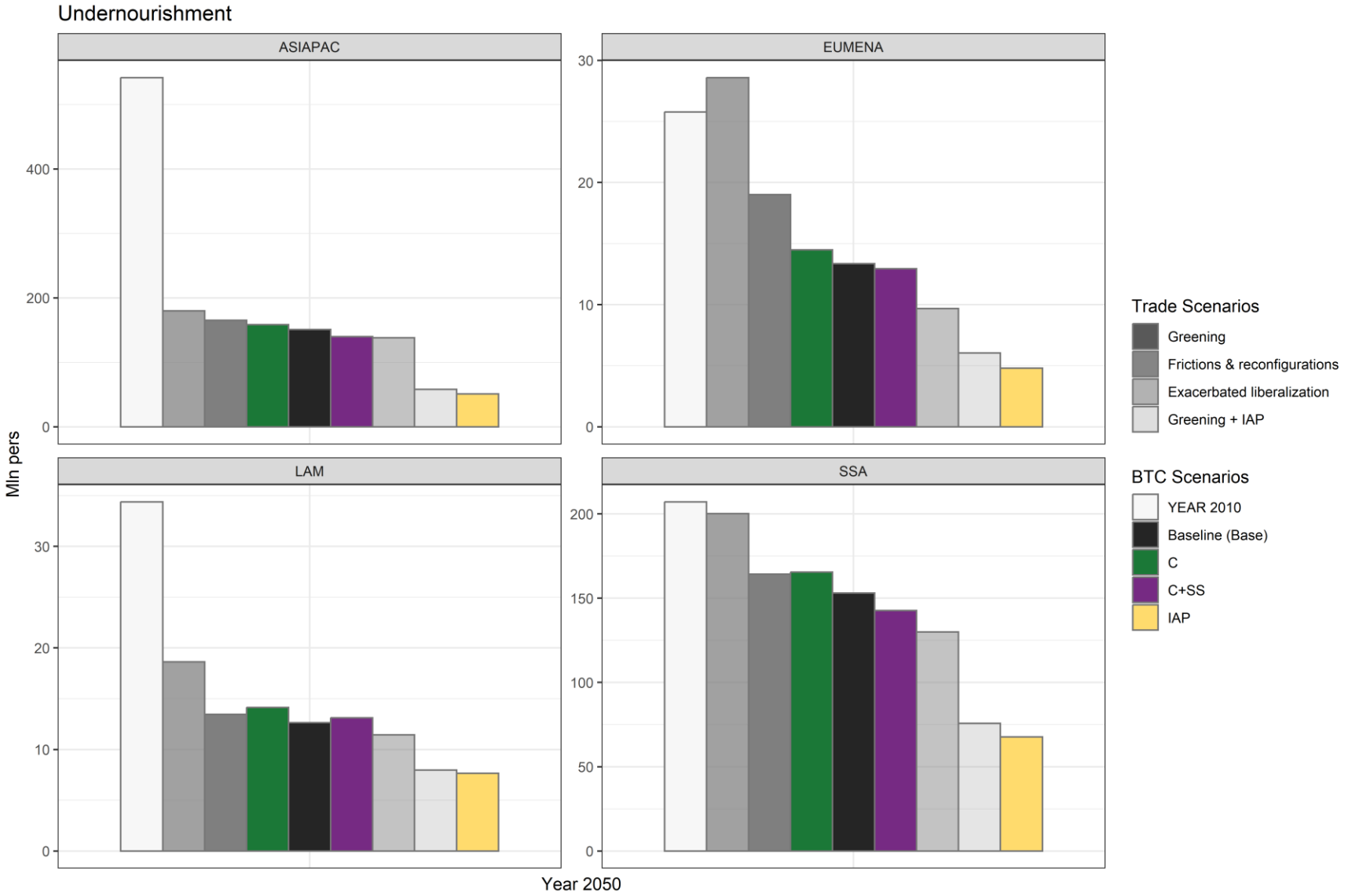
# Extra: food security vs value added by region



# Food Security: Undernourishment in 2050 (prelim. results)

**Key messages**

- Under the baseline, undernourishment decreases than by 2050.
- Conservation slightly increases undernourishment compared to baseline in 2050. CC+SS (in most regions) reduces slightly.
- Exacerbated liberalization decreases
- Frictions and recofig increase # undernourished in EUMENA
- BTC-IAP results in lowest levels of undernourishment Regional trends follow global trends except for the C+SS in LAM
- As TG +IAP help to achieve other goals including undernourishment



# Land use change (prelim. results)

**Baseline: losses to nat. land**
Highest losses to forests and other natural vegetation in ASIPAC, SSA, LAM and EUMENA

**Bending the curve: net gain in nat. land**
Highest losses to forests and other natural vegetation in ASIPAC, SSA, LAM and EUMENA

**Regionalized responses to scenarios:**

Trade gov.: decrease in nat. vegetation highest for Exacerbate liberalization in LAM, but for Frictions and reconfigurations in ASIAPAC.

Bending the curve efforts: while demand-side measures (IAP vs C+SS) has the largest impact on losses to nat. vegetation & land restoration, increased conservation & restoration have a dominant role in EUMENA & LAM, and dominant in SSA.

# Additional metrics: biodiversity

| Acronym | Name | Biodiversity aspect measured | Taxonomic coverage | Impact measured | Sectoral coverage | Assumed temporal recovery under restoration | Parameters (source) | Parameters (spatial resolution) |
|---|---|---|---|---|---|---|---|---|
| ABII | **Average Biodiversity Intactness Index** (BII) | Average compositional intactness of local community assemblages | All vertebrates | Total local land use composition (as compared to pristine state) | All land activities (forestry, agriculture, bioenergy) | Exponential, half time 25 years (Isbell et al 2019) | Newbold et al 2016, as compiled and used in Leclere et al 2020 | 30 arcminutes (incl. potential ecosystem map, type of pasture and potential NPP) |
| ERTL | **Global species loss** | Global species at risk of extinction from local land use | Vascular plants, mammals, birds, reptiles, amphibians | Total local land use composition (as compared to pristine state) | (same as above) | Immediate (potential biodiversity) | UNEP-SETAC 2016, as compiled and used in Leclere et al 2020 | WWF ecoregions |
| ERDS, ERDC, EREX, ERIM | **Global species loss in domestic supply** (ERDS), **domestic consumption** (ERDC), **exports** (EREX) and **imports** (ERIM) | Global species at risk of extinction embedded in commodity flows | (same as above) | Local pasture and cropland use from primary product inputs (as compared to pristine state) | Land activity related to commodity flow | (same as above) | (same as above) | WWF ecoregions |