Michael Obersteiner

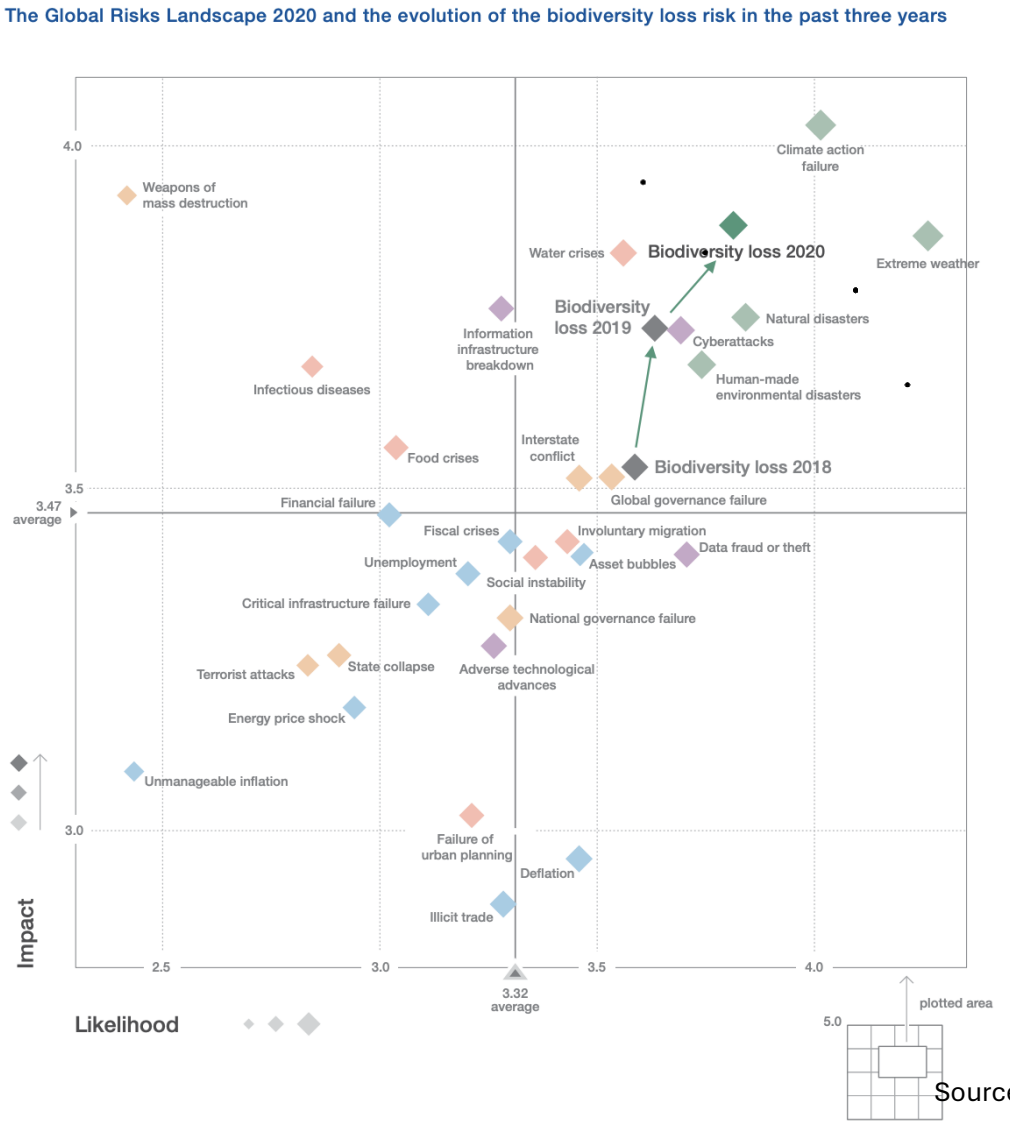
5th December, 2025

Aalto University

LUSA. Quo vadis?

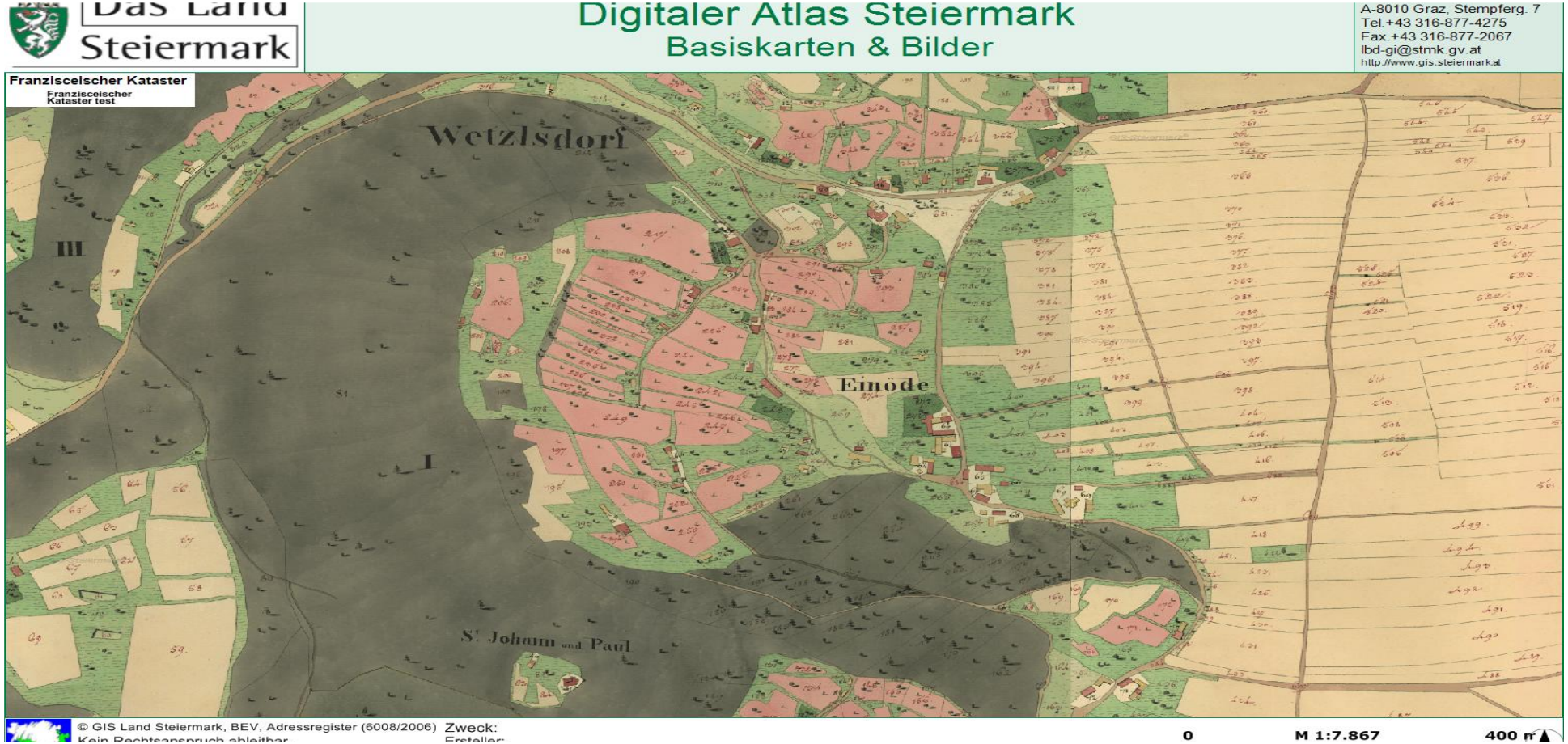
Nature sector is a giant

- Largest economic sector
  - 50% nature-based GDP (WEF)
  - Food system GDP in France 36% -FIN?
- Largest employer (Ag: 1 [2.5] billion)
  - 65% of working poor depend on ag
  - Largest source of childlabor
- AFOLU 23% of total GHGs emissions
  - Food system (21-37%)
  - Negative emissions [11.2 GtCO2/yr]
- Largest driver of Biodiversity decline
  - Largest source of Risk
- Largest source of N&P pollution



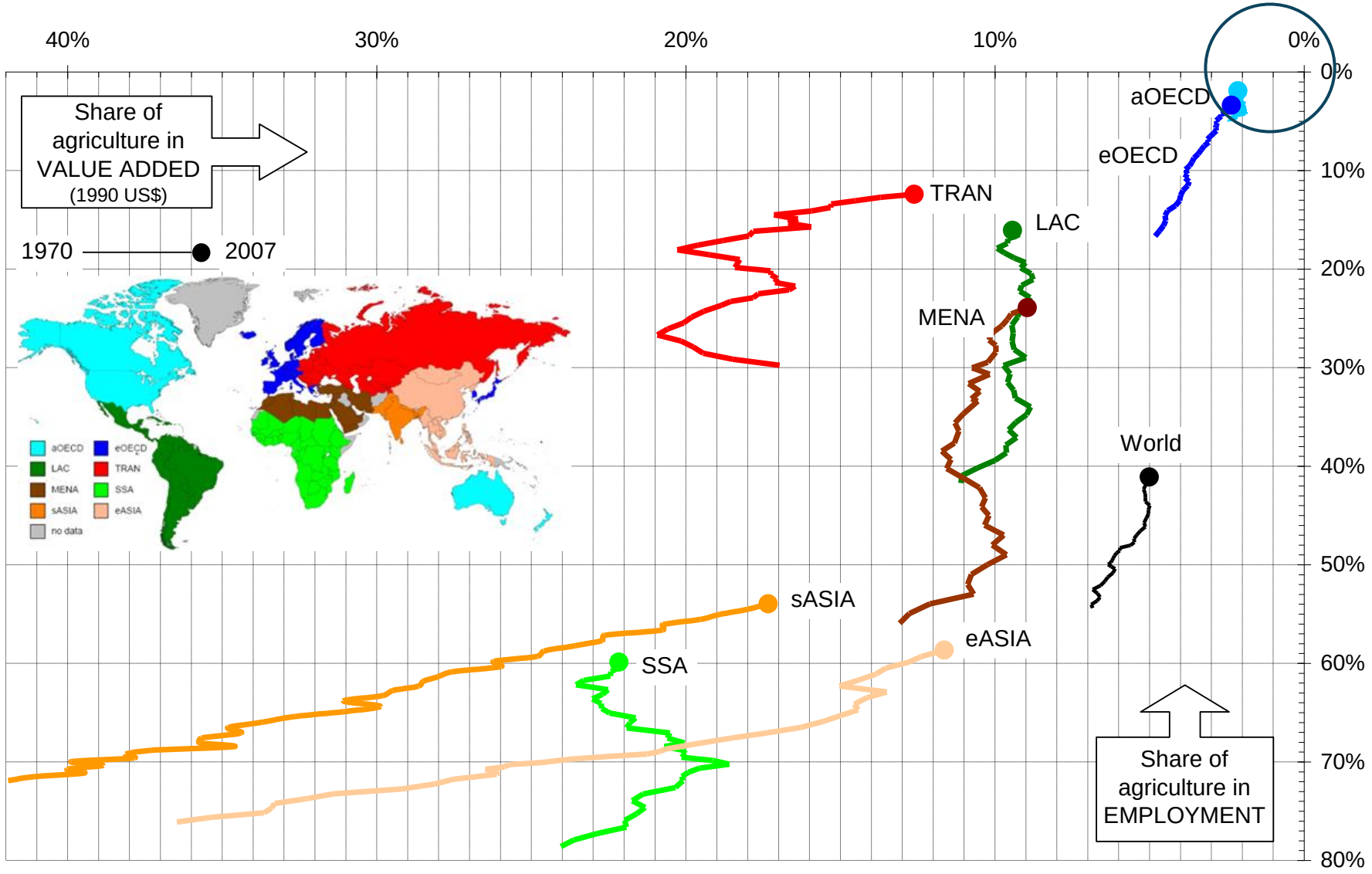
Source: WEF, 2020

Land use changes (1823-…)



Land use changes

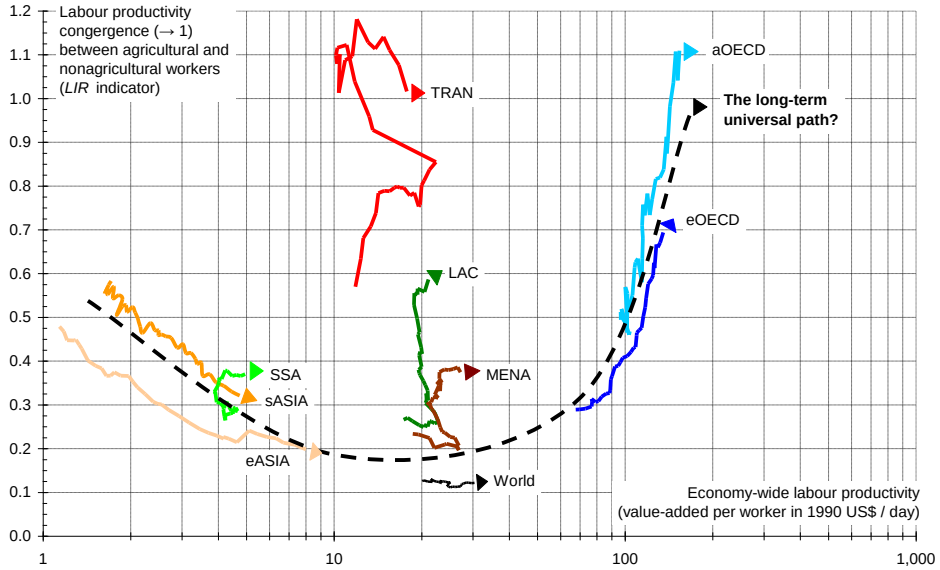
A World Without Agriculture



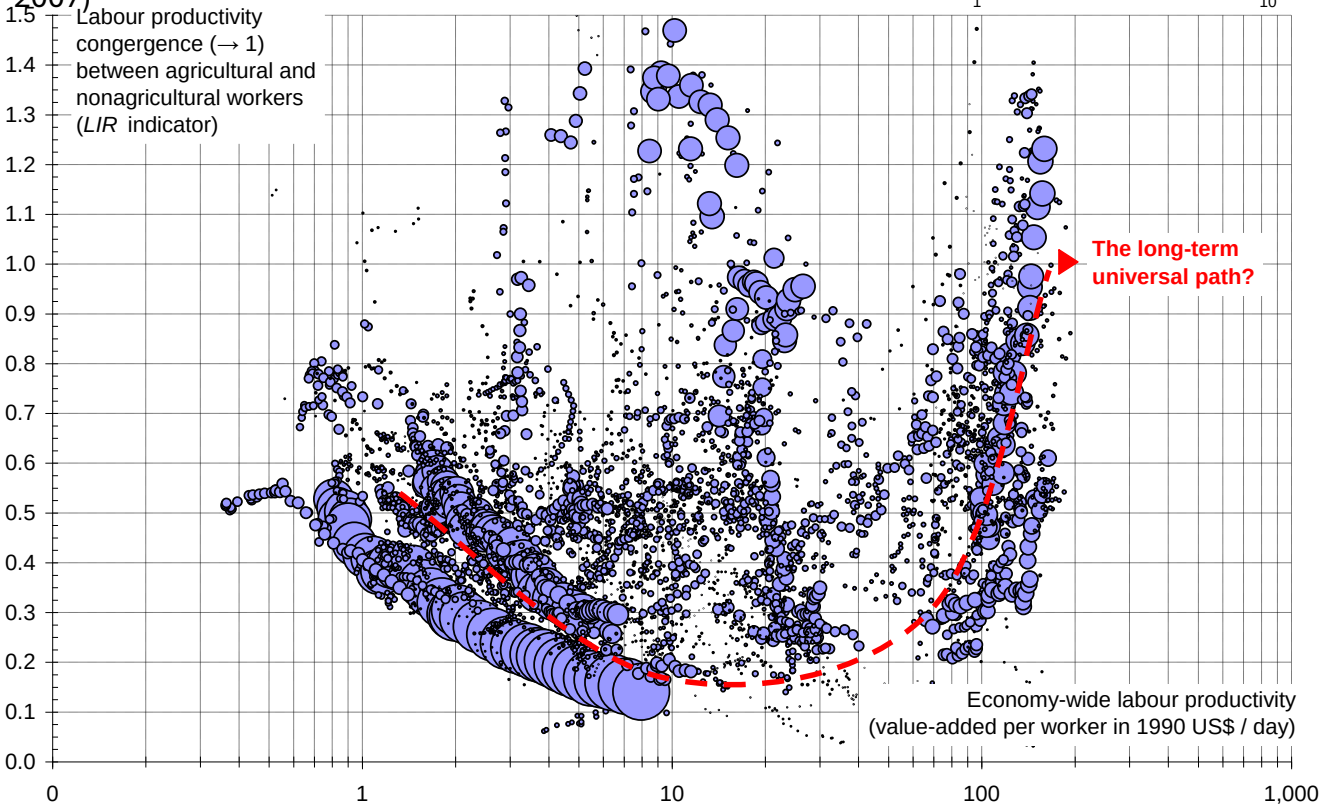
Source: Dorin, 2016

A long-term universal OECD path ???

All countries into eight regions (1970-2007)



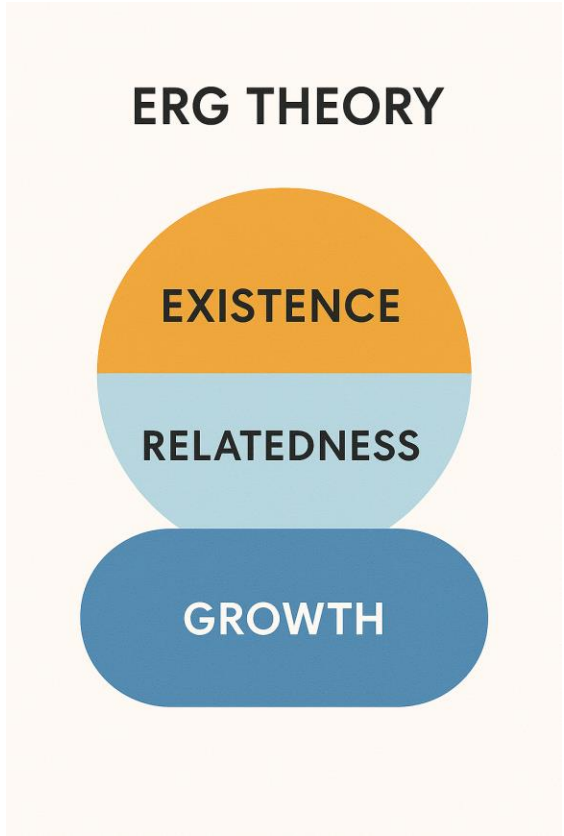
All countries weighted by their active population (1970-2007)



Source: Dorin, 2016

LUSA: Leverage points & paradigms

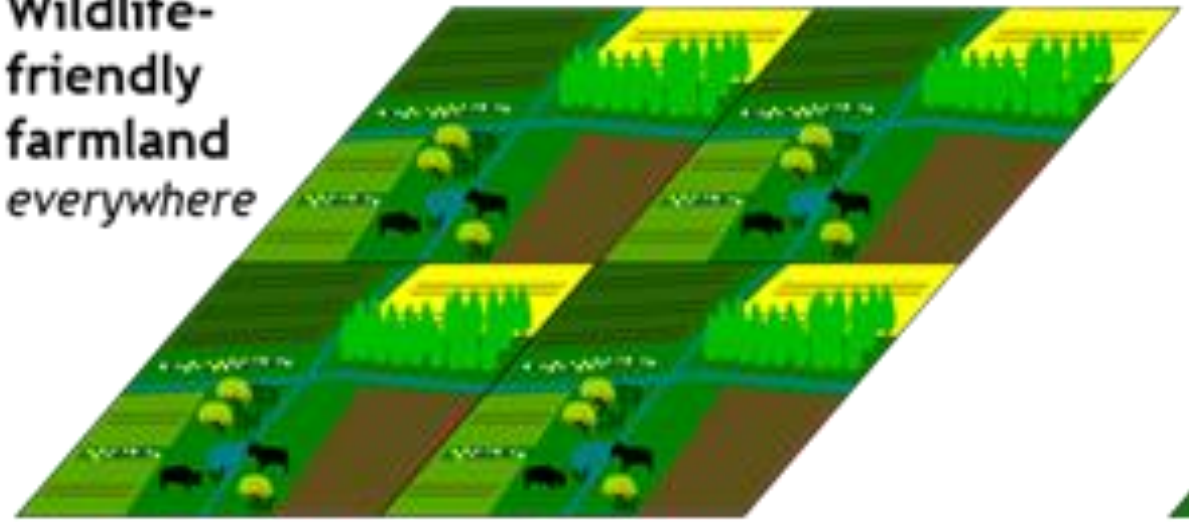
Meadows' places to intervene in a system (in increasing order of effectiveness)	Aggregated categories of system change	
12. **Numbers** (subsidies, taxes, standards)	**Improve**	optimise existing system
11. **Buffers** — the size of stabilising stocks		
10. Physical **stock-and-flow structure**		
9. **Delays** in system response		
8. Strengthening **balancing feedback** loops		
7. Weakening **reinforcing feedback** loops		
6. The **structure of information** flows	**Redesign**	reshape existing system
5. The **rules** of the system (incentives, punishments, constraints)		
4. The capacity for **self-organisation**		
3. The **goals** of the system	**Reorient**	redefine system goals and paradigms
2. The mindset or **paradigm** out of which the goals, rules, feedback structure arises		
1. **Transcending paradigms**		



Two competing paradigms

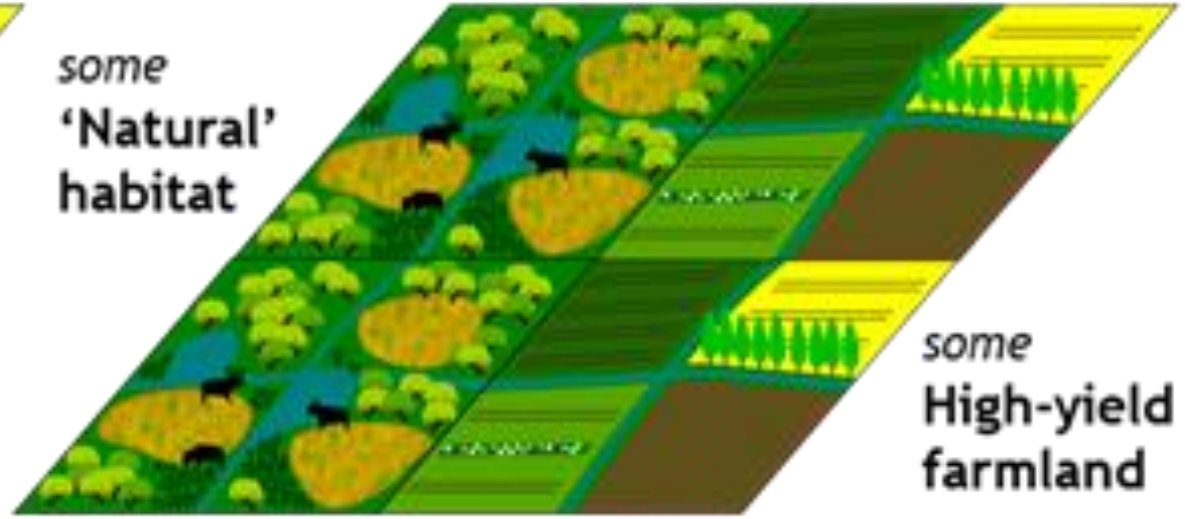
Land sharing

Wildlife-friendly farmland *everywhere*



Land sparing

some 'Natural' habitat



some High-yield farmland

Source: RSBP

AGROECOLOGY: AN AMBITIOUS, SYSTEMIC PROJECT

- *Jointly* addressing the challenges of ensuring sustainable food for Europeans, protecting biodiversity and natural resources, and mitigating climate change calls for a profound transition in our agri-food system. An **agro-ecological project based on abandoning pesticides and synthetic fertilisers and redeploying extensive grasslands and landscape infrastructures** would make it possible to tackle these challenges in a coherent manner.

=> Implies **land-sharing, less meat, but red meat**

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IDDRI

ASCA

Fondation Charles Léopold Mayer pour le Progrès de l'Homme


STUDY

N°09/18 SEPTEMBER 2018

An agroecological Europe in 2050: multifunctional agriculture for healthy eating

Findings from the Ten Years For Agroecology (TYFA) modelling exercise

Xavier Poux (AScA, IDDRI), Pierre-Marie Aubert (IDDRI)

With contributions from Jonathan Saulnier, Sarah Lumbroso (AScA), Sébastien Treyer, William Loveluck, Élisabeth Hege, Marie-Hélène Schwoob (IDDRI)

Mental map of economic growth & Land sparing

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Farm Sector

- Traditional, Backward
- Low productivity, Poverty
- Uneducated, Unskilled
- Unorganized, Informal

Lewisian pattern of growth
Modern economic growth
Structural transformation…

Labour

Modern techno/inputs

Non-Farm Sector(s)

- Modern, Developed
- Capital accumulation
- Educated, Skilled, Innovating
- Organized, Formal

Development economics

Barriers to modern agricultural technology *subject to exogenous technical change* ***jam the whole development process*** [Gollin & al., 2002]

New structural economics

Firms in developing countries can exploit the industrial and technological gap with developed countries [on the global technology frontier] by acquiring industrial and technological innovations that are consistent with their new comparative advantage [Lin, 2011]

Agricultural economics

Population pressure on land resources could be circumvented and ***labour productivity*** *increased by several multiples (****up to the levels of Western Europe in the early 1960s****) by investing in agricultural research, human capital and modern agricultural inputs*
[Hayami & Ruttan, 1971, 1985, 2002]

Neo-classical growth theory

Countries with access to identical technologies should converge to a common income level *…/…*

Countries that are poorer and have higher marginal productivity of capital should grow more rapidly in the transition to the long-run steady state …/…

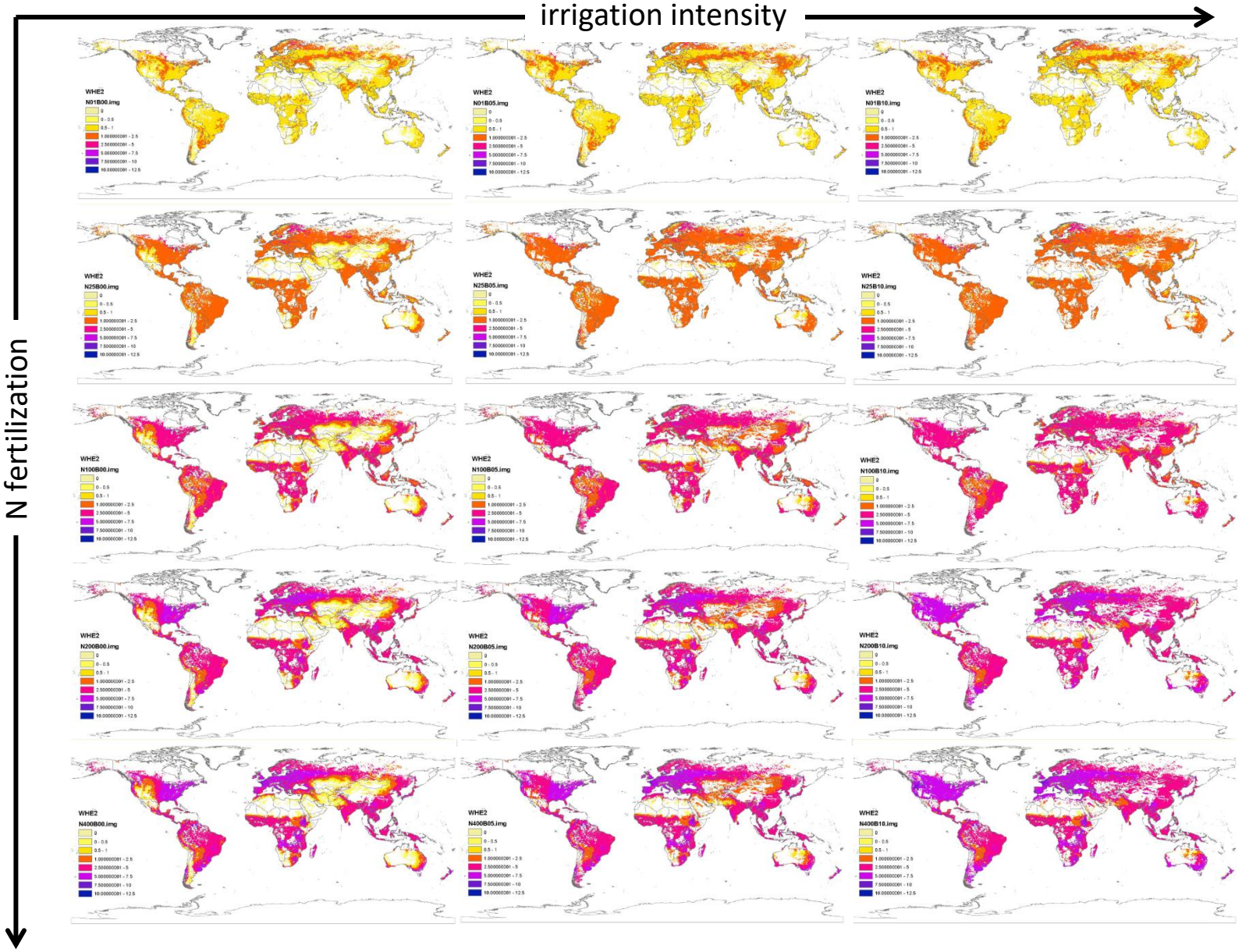
Open global economy, access to foreign capital and foreign markets further strengthen the convergence [in Rodrik, 2013]

Source: Dorin, 2016

If you want to help the environment:

⇨ Green techno-productivist = land sparing & eat more white meat or be vegan

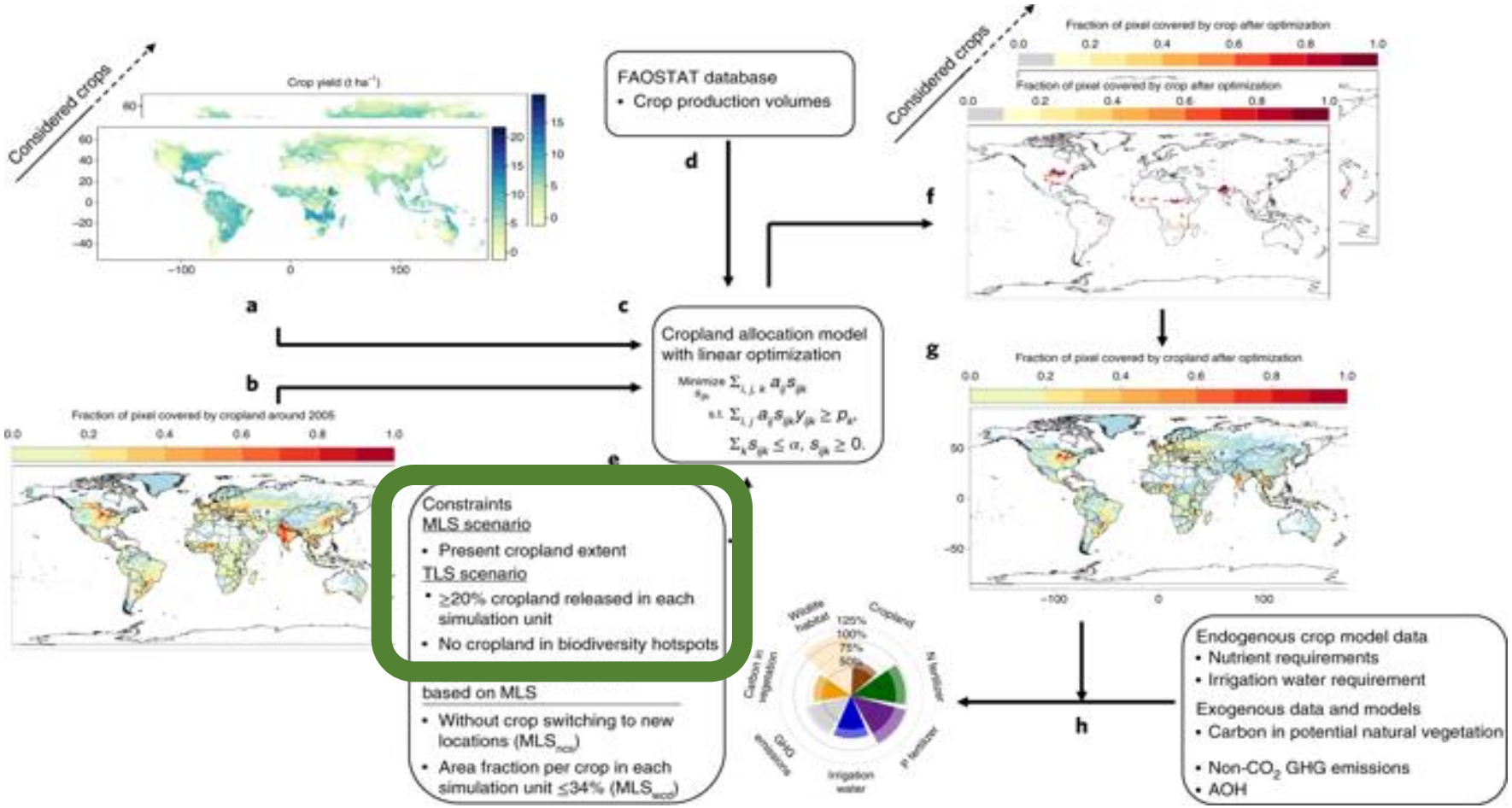
HyperCube: Production Possibility Sets, Yield



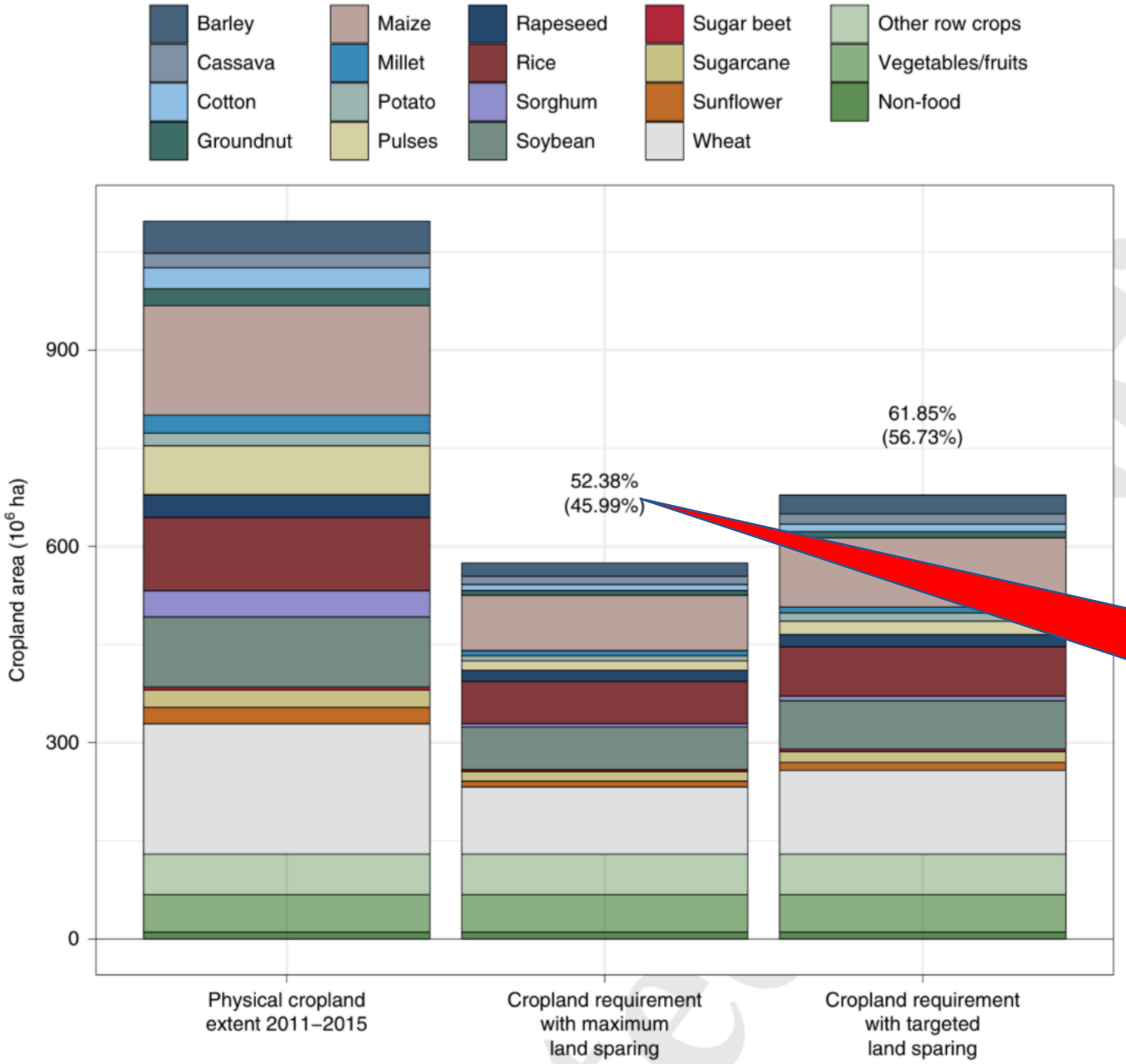
Source: IIASA

Land Sparing Potential

What if we produced crops with best available technology every where?



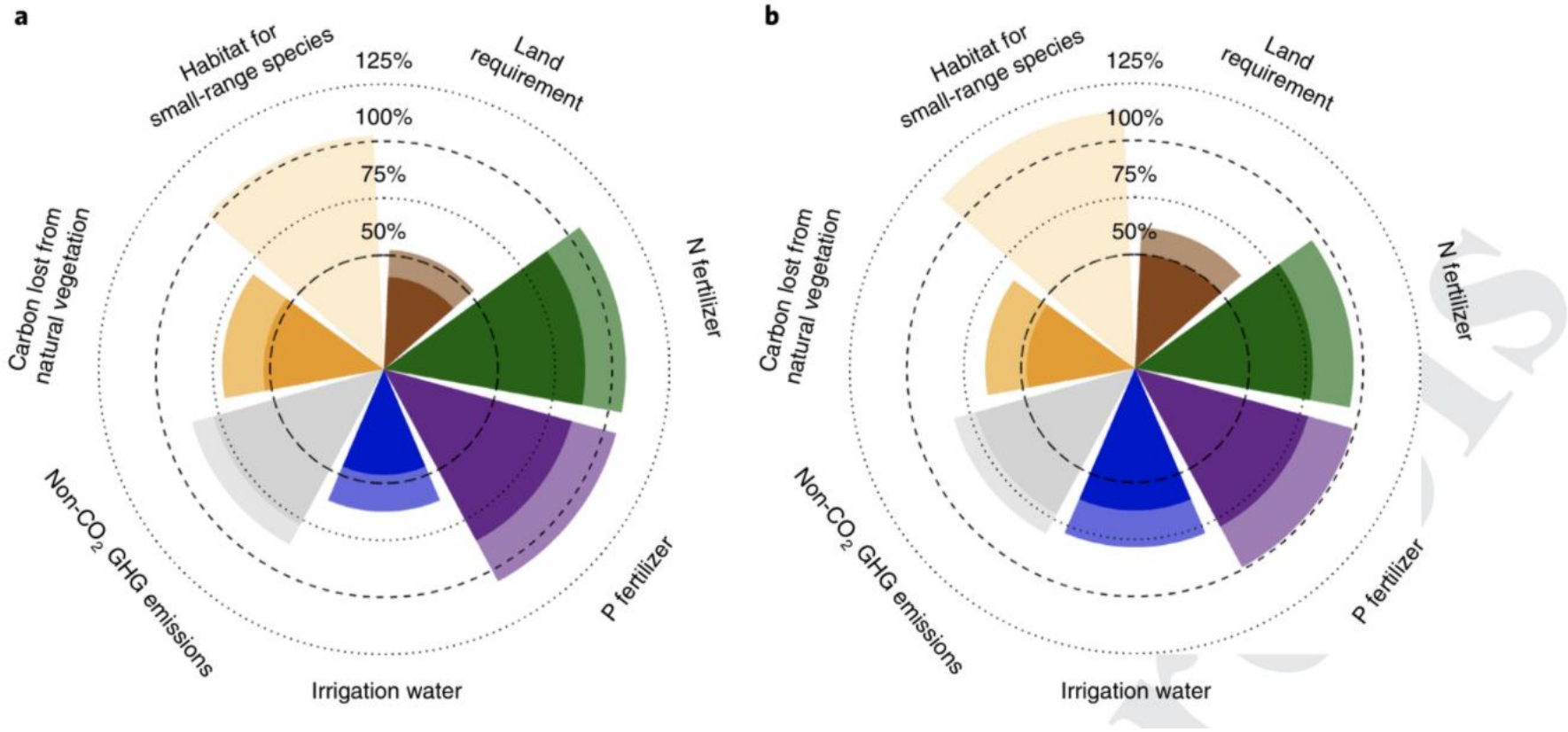
Folberth et al. 2020



We only need half of global cropland

Folberth et al. 2020

Other environmental impacts



Maximum Land Sparing

Targeted Land Sparing

Folberth et al. 2020

Techno-economic cost accounting

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REVENUES; Commodity sales, subsidies, ecosystem service payments

C1- Field costs

Field Input Direct Costs
- Seeds
- Fertilizer
- Crop Protection
- Irrigation Water


Field Work
- Labor
- Fuel
- Machinery

RETURN TO FARM – Contribution Margin 1 (movable)

C2- Farm Costs

Variable Costs
- Labor and energy for processes
- Labor and energy for operations on fallow land

Fixed Costs
- Financing Machinery
- Insurance Machinery
- Labor for administration
- Fixed utility costs


RETURN TO INFRASTRUCTURE – Contribution Margin 2 (immovable)

C3- Infrastr. Costs

Calculative Costs
- Depreciation of Buildings
- Repair and maintenance
- Maintenance of access roads
- Financing Buildings



RETURN TO LAND– Contribution Margin 3

Cost of land
- Land lease

RETURN TO FARMER / INVESTOR – Profit

Soybeans: Cost of production

Supply schedule

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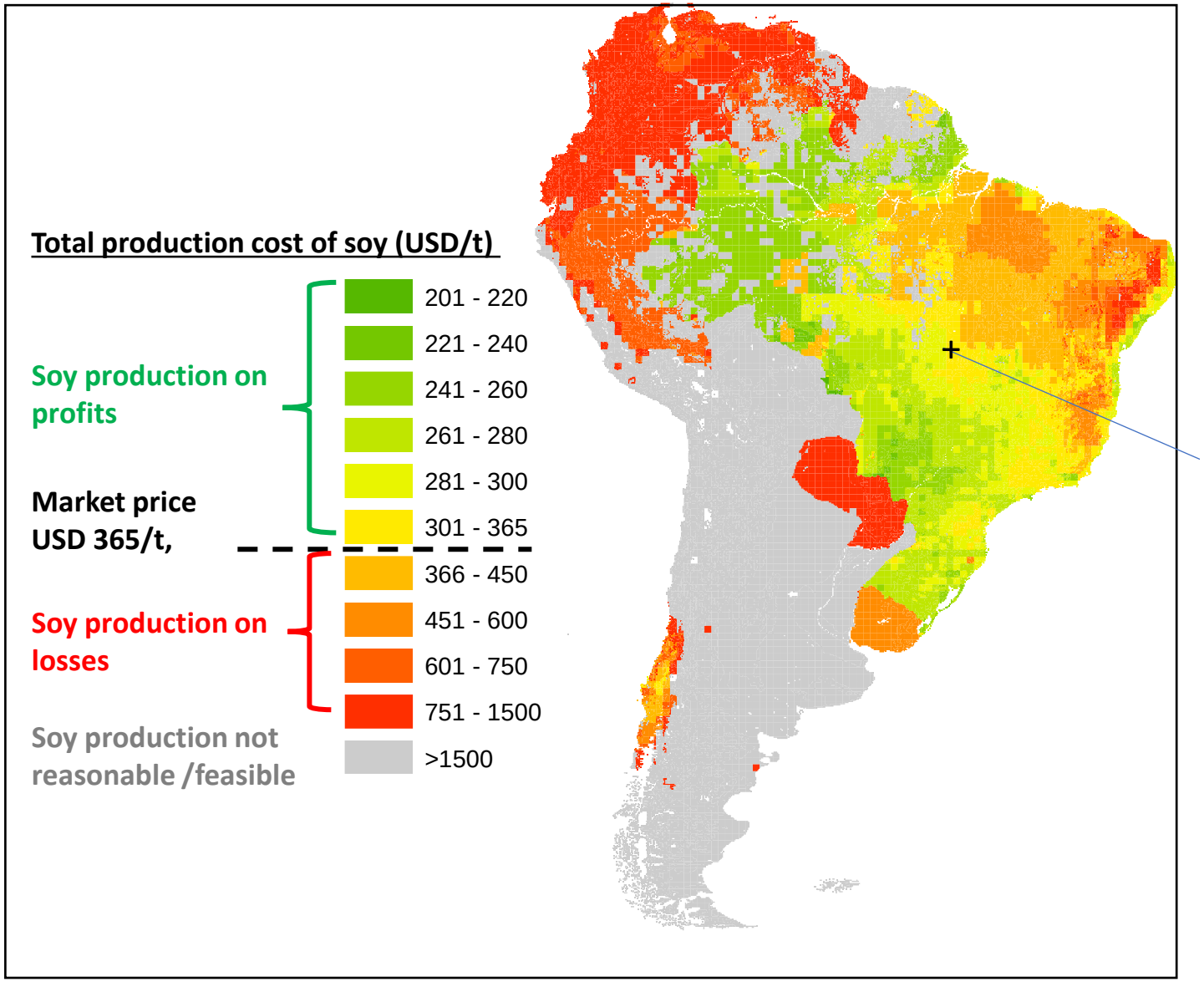
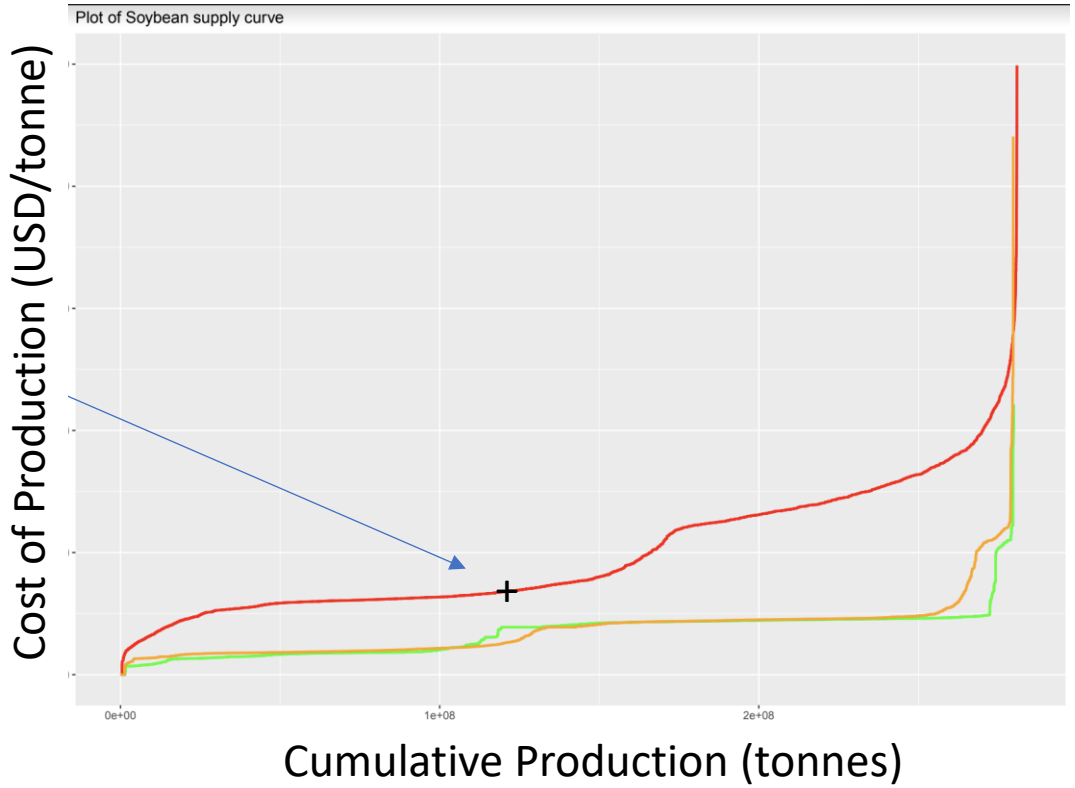
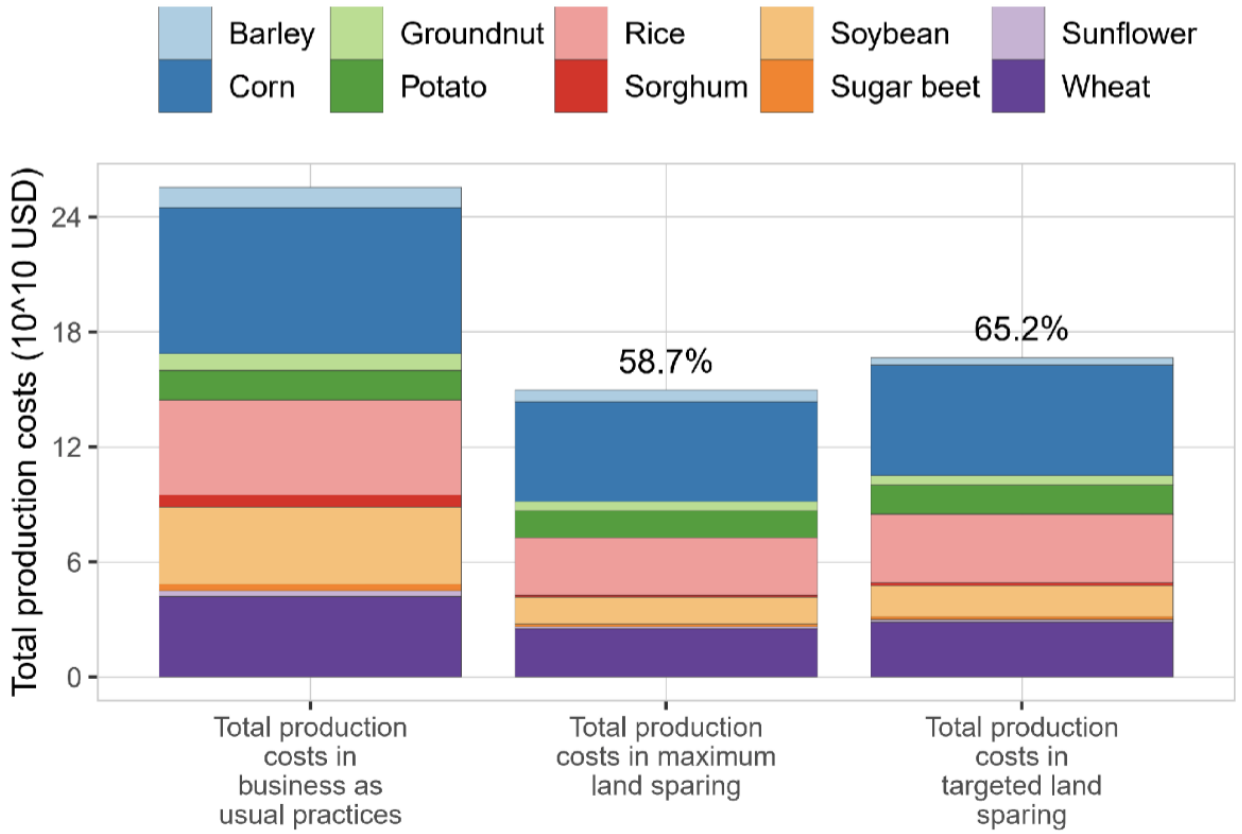




Vittis et al. (2020)

Land Sparing is reducing costs….



Vittis et al. (2021)

Under the MLS we would only need 20 Million farmers!!!

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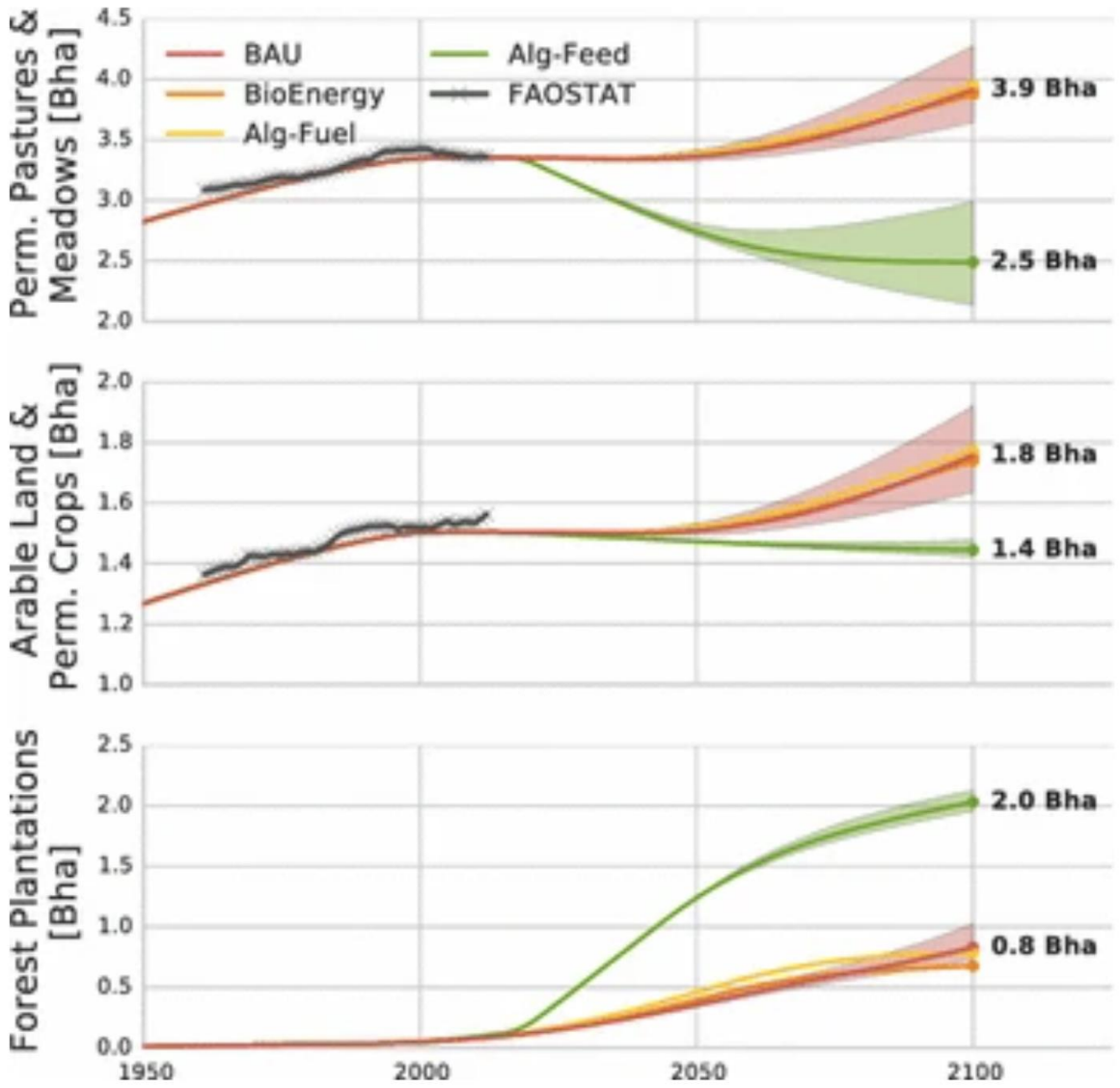
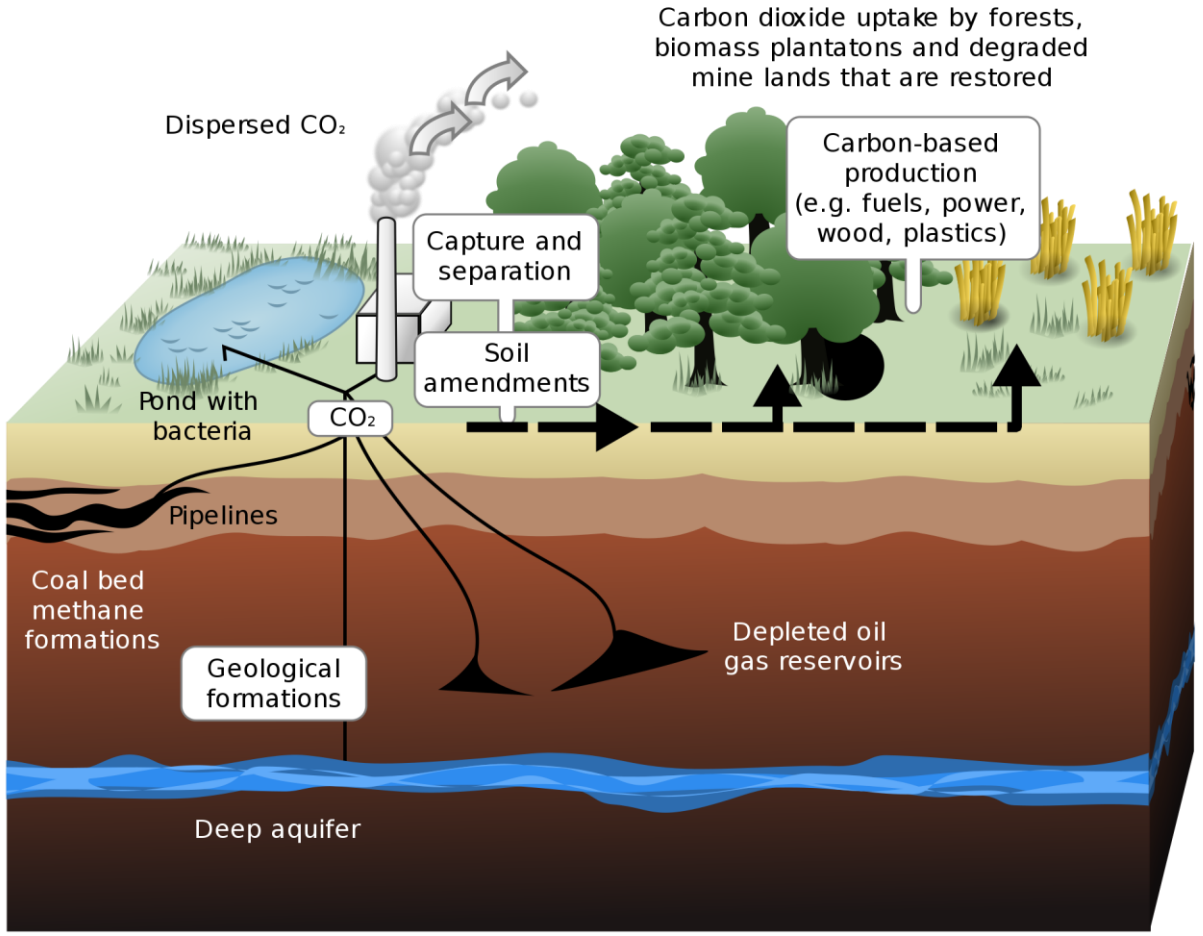
What could happen if there are new tech breakthroughs?

Impact of New Technologies

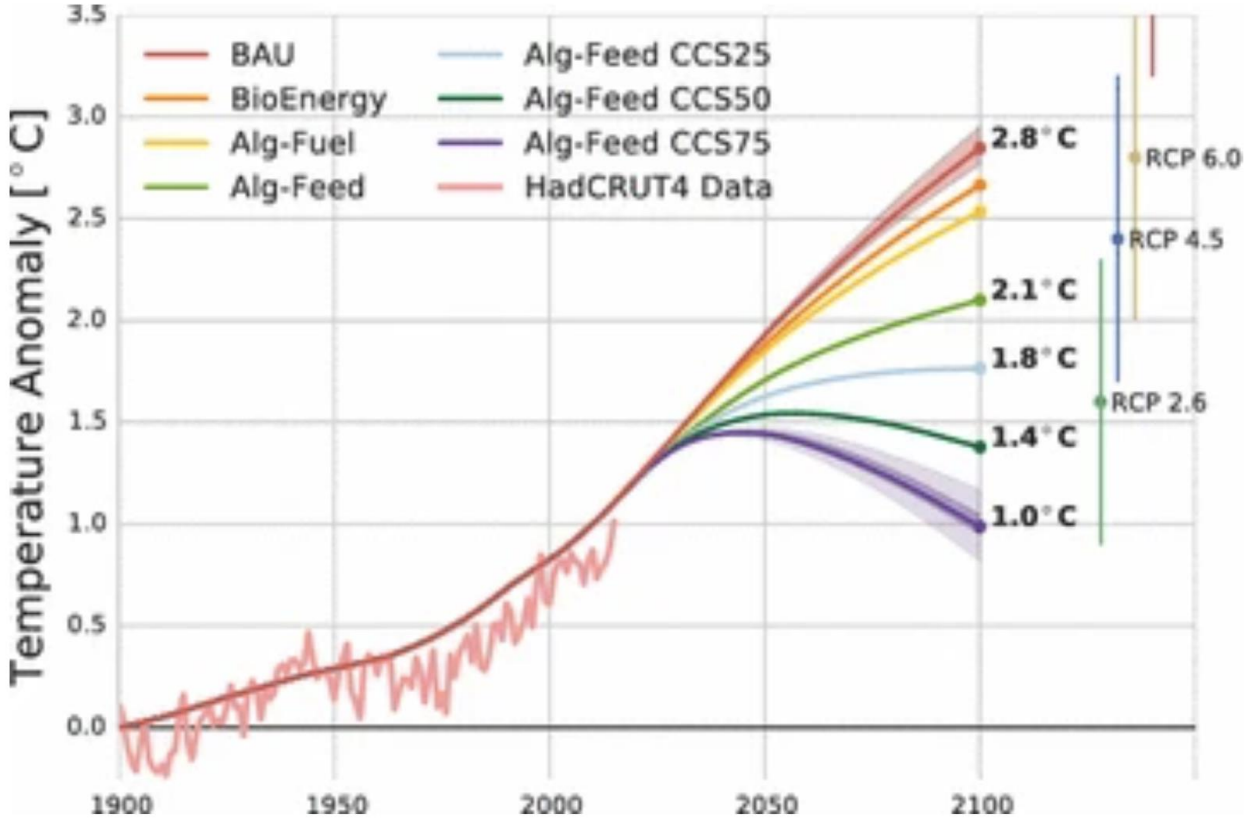
Algae farm to produce animal feed and recycle in a near closed loop


Perm. Pastures & Meadows [Bha]
BAU
BioEnergy
Alg-Fuel
Alg-Feed
FAOSTAT
3.9 Bha
2.5 Bha
Arable Land & Perm. Crops [Bha]
1.8 Bha
1.4 Bha
Forest Plantations [Bha]
2.0 Bha
0.8 Bha
1950
2000
2050
2100

Wood from Restoration for Bioenergy w Carbon Sequestration



We could still make the 1C world with Algae feed



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In the breakthrough scenario you are allowed eat meat again (unless you oppose the associated animal welfare implications)

….huge challenge to compute what is right or wrong

Challenges ahead

- Epistemic plurality and shifts
- Evolutions and bursts of technology
- Inter- & intra-generational justice

Remaining carbon budget
299
Gt CO_2

That amounts to
7x
the current annual emissions

Global settings

The remaining emissions are determined by:

Limit global warming to (°C)
1.5 1.6 1.7 1.8 1.9 2

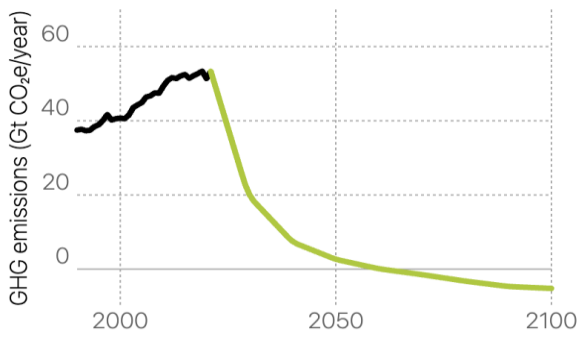
Acceptable risk of exceeding global warming limit
0.17 0.33 **0.5** 0.67 0.83

Reduction of non-CO_2 emissions
0.17 0.33 **0.5** 0.67 0.83

The allocation of these emissions over time is determined by:

End-of-century negative emissions
0.17 0.33 0.5 **0.67** 0.83

Timing of early-century mitigation
Immediate **Delayed**

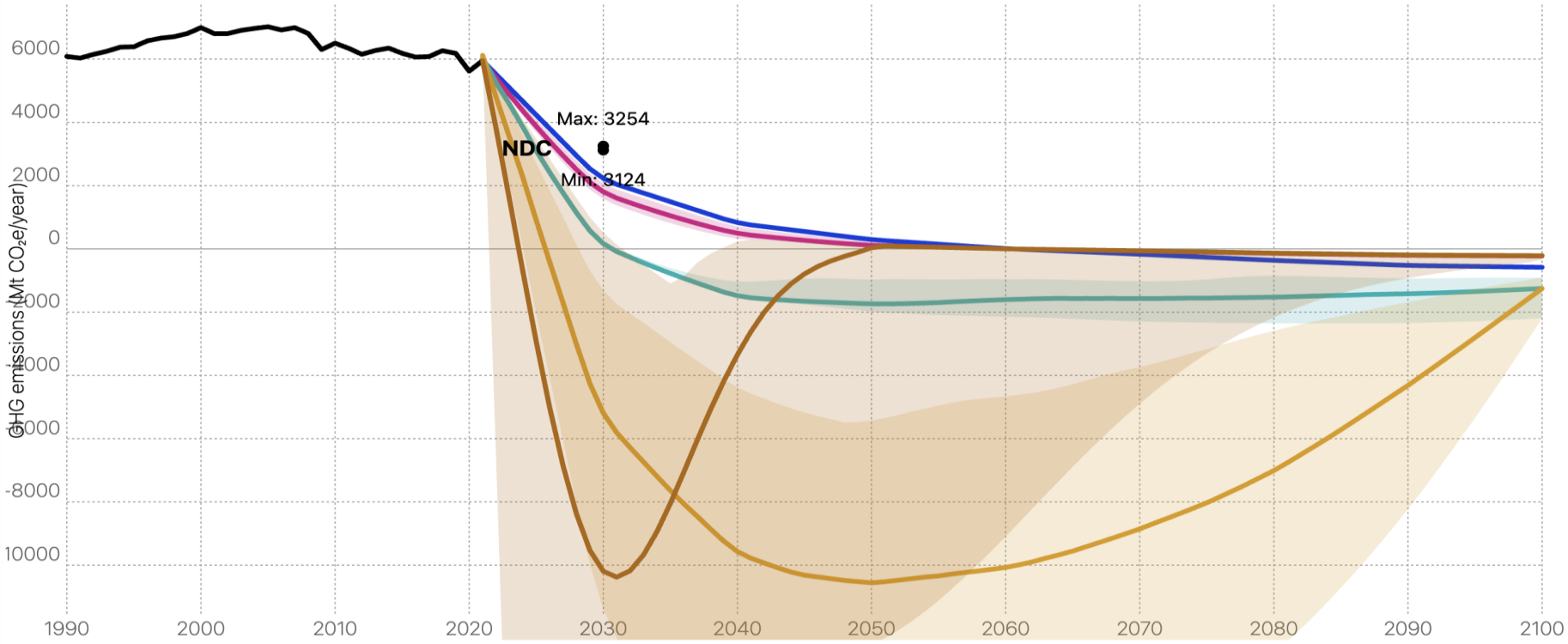


United States of America

MEMBER OF ▾

NDC ambition in 2030 relative to 2015: 44 to 47 % reduction

Allocation method	Grandfathering	Per capita	Per capita convergence	Ability to pay	GH development rights	Equal cumulative per capita
2030 reductions relative to 2015	63%	86%	70%	97%	199%	313%
2040 reductions relative to 2015	86%	95%	92%	124%	276%	168%
Display graph	☑	☑	☑	☑	☑	☑



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Global settings

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1.5 | 1.6 | 1.7 | 1.8 | 1.9 | 2

Acceptable risk of exceeding global warming limit
0.17 | 0.33 | **0.5** | 0.67 | 0.83

Reduction of non-CO_2 emissions
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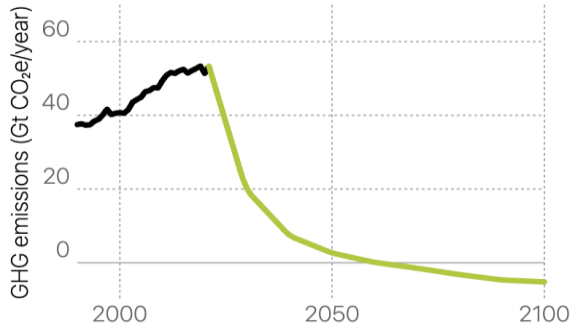
The allocation of these emissions over time is determined by:

End-of-century negative emissions
0.17 | 0.33 | 0.5 | **0.67** | 0.83

Timing of early-century mitigation
Immediate | **Delayed**

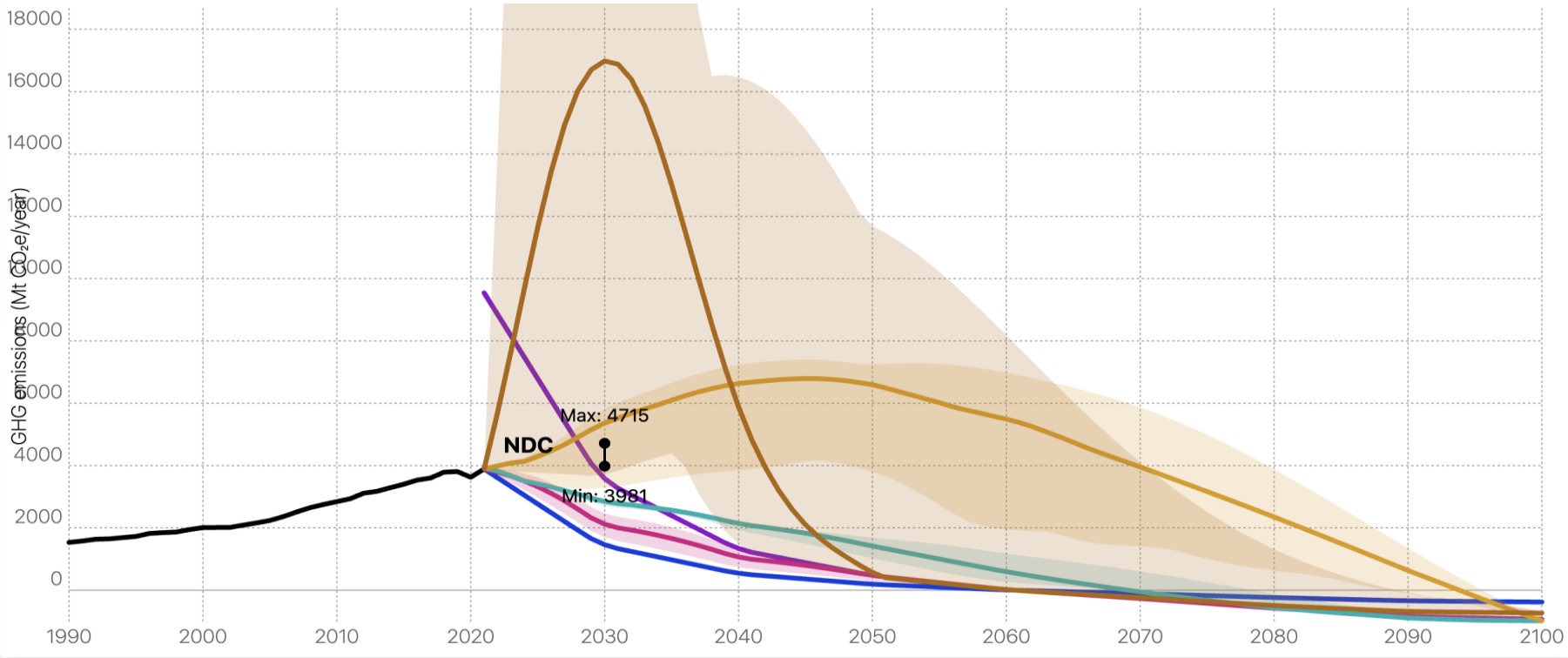


India

MEMBER OF ▾

NDC ambition in 2030 relative to 2015: 60 - 90 % increase

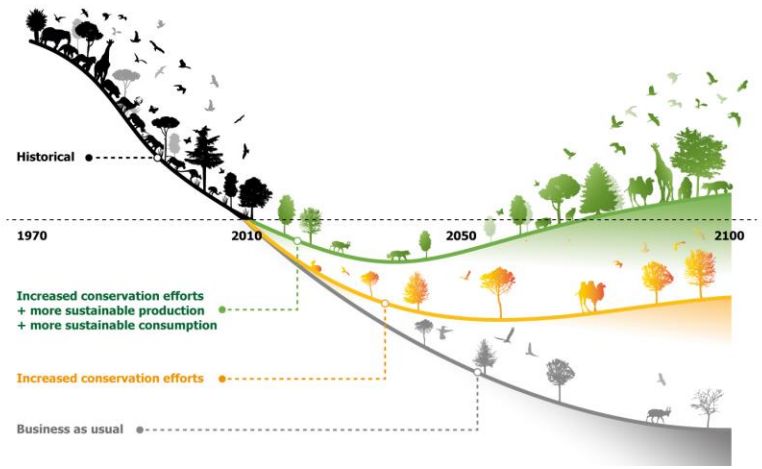
Allocation method	Grandfathering	Per capita	Per capita convergence	Ability to pay	GH development rights	Equal cumulative per capita
2030 reductions relative to 2015	5%	-133%	-38%	-86%	-229%	-1106%
2040 reductions relative to 2015	64%	13%	31%	-40%	-306%	-312%
Display graph	☑	☑	☑	☑	☑	☑



Challenges ahead

- Epistemic plurality and shifts
- Evolution and bursts of technology
- Inter- & intra-generational justice
- Multi-objective aspirations

Bending two curves on biodiversity and climate and still feed the world in country context?



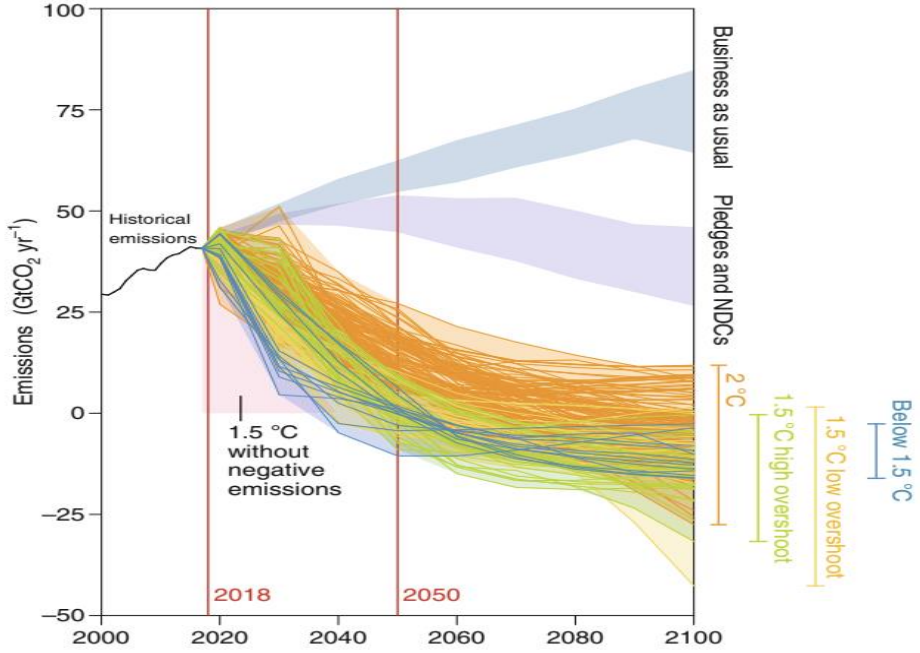


Fig. 1 | Global net anthropogenic CO_2 em… …ways in BAU, 2 °C and 1.5 °C model scenarios. The 2 °C (1… …ns, orange lines), 1.5

Leclere et al., 2020, WWF LPR2020

Challenges ahead

- Epistemic plurality and shifts
- Evolution and bursts of technology
- Inter- & intra-generational justice
- Multi-objective aspirations
- Impact uncertainties

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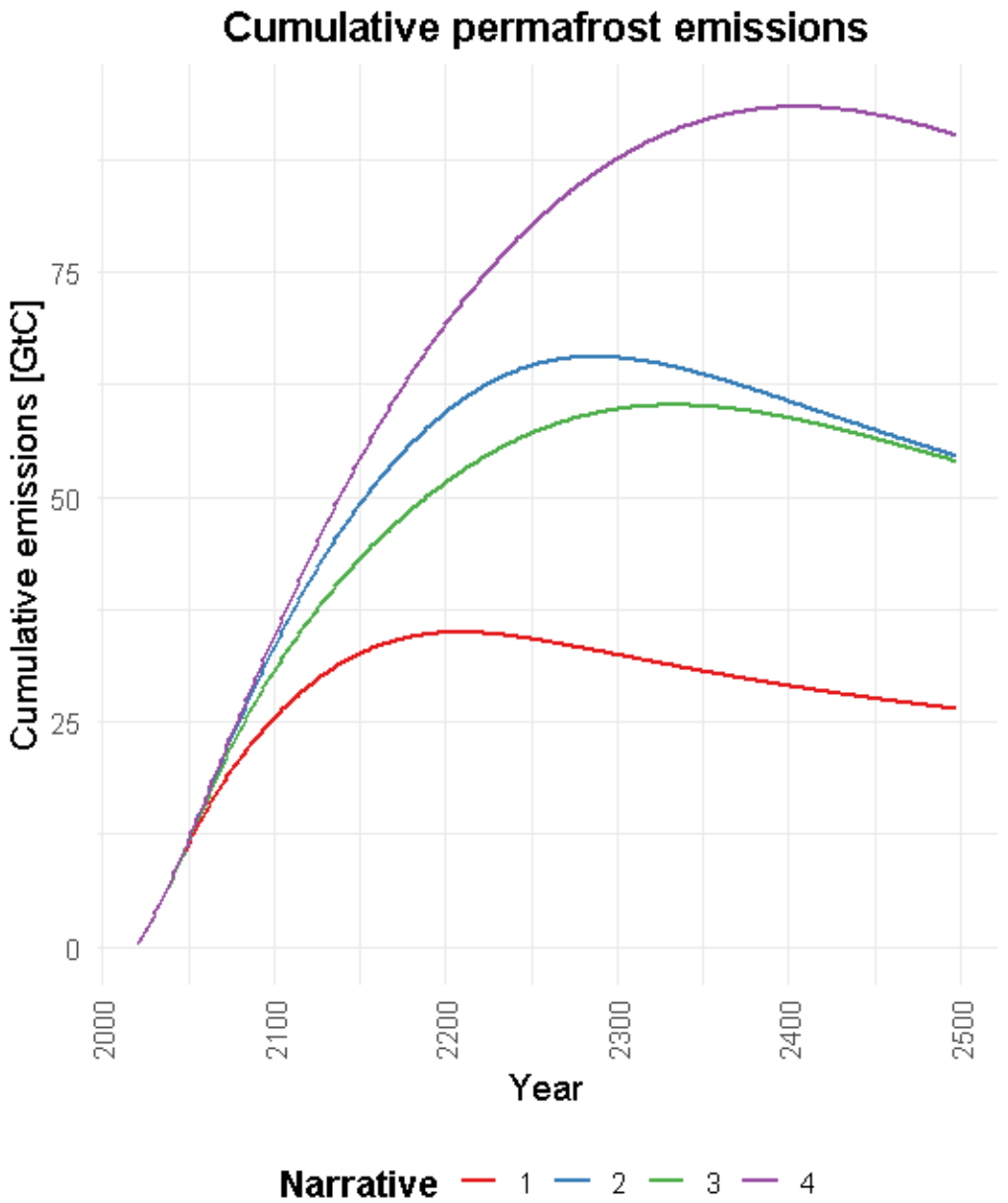

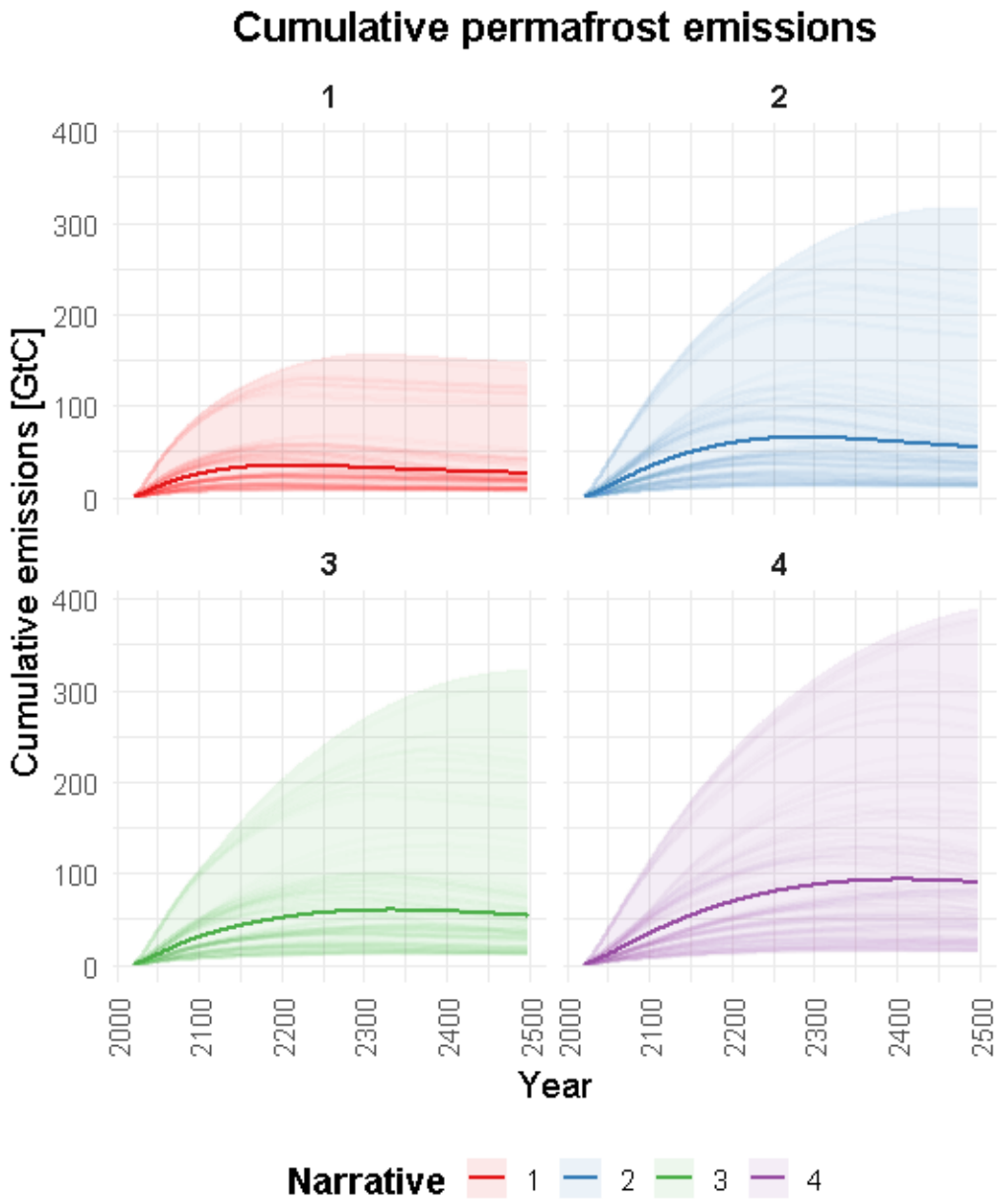

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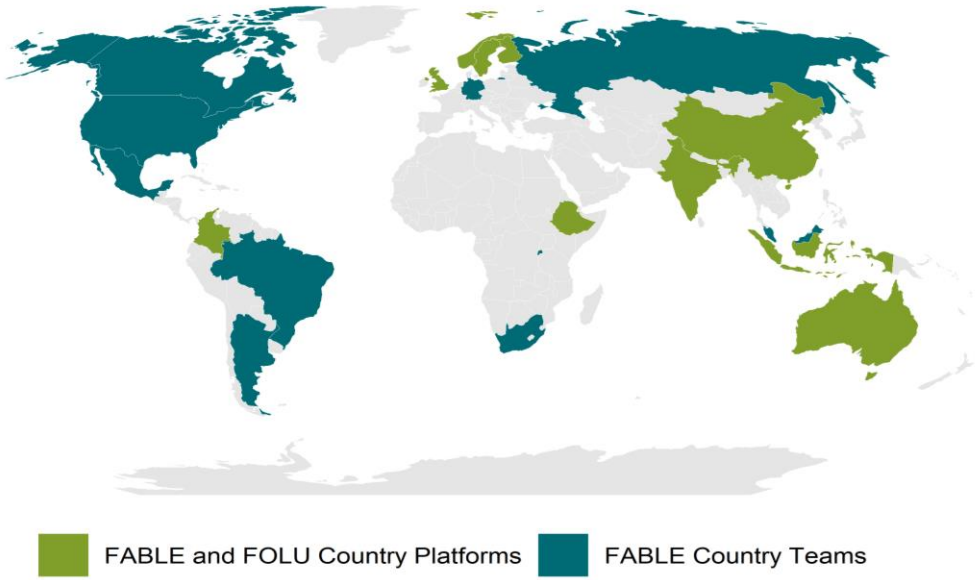
Major Coordination Challenge

The FABLE Consortium

- National and sub-national levels are critical for decision-making.
- In order to feed into the policy processes, we need scientists who are based in the countries.
- Countries are interdependent. Their decisions impact the others.



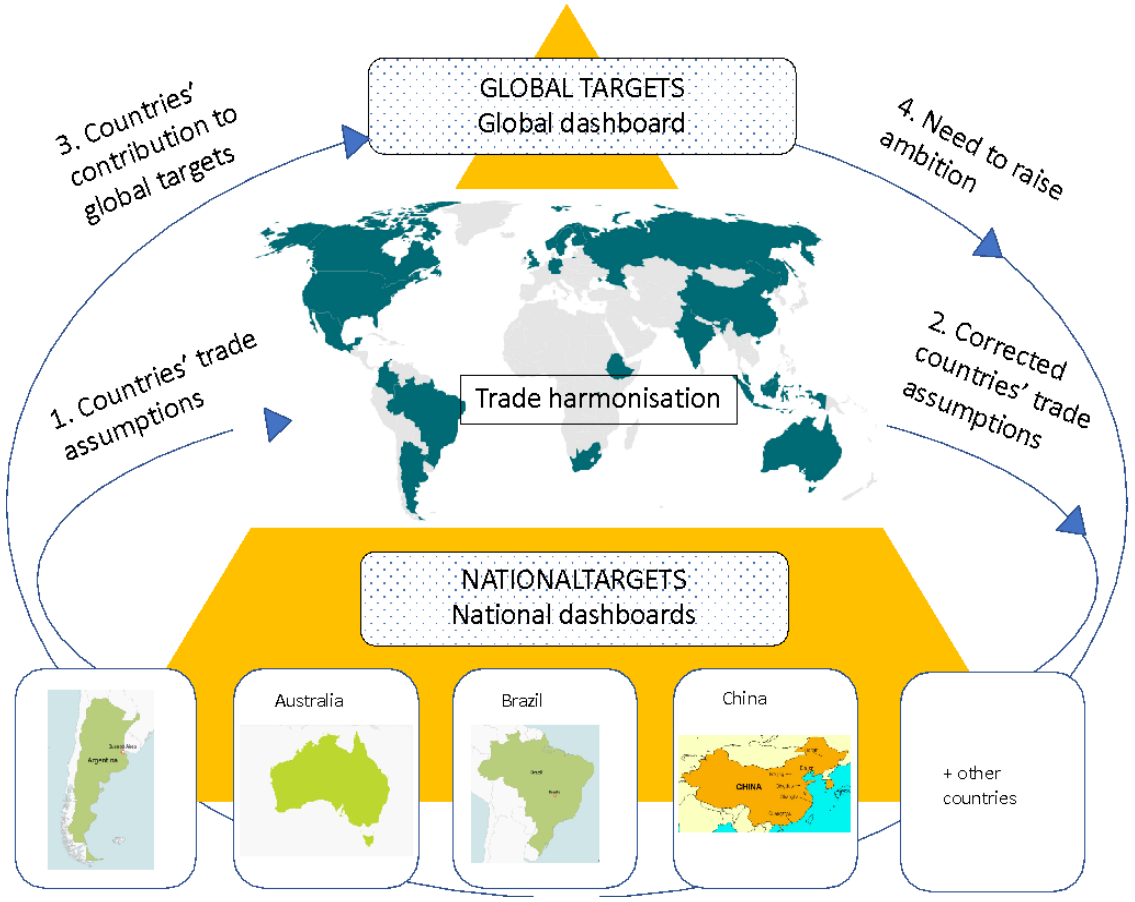
Scenathon [sɪˈnɑːθɒn]

Scenario + Marathon

- A SCENATHON is a time restricted scenario exercise building solution pathways.

Scenathon to Ensure Globally Consistent National Pathways

The Scenathon results can be monitored on the online Scenathon dashboard **https://www.scenathon.org/**



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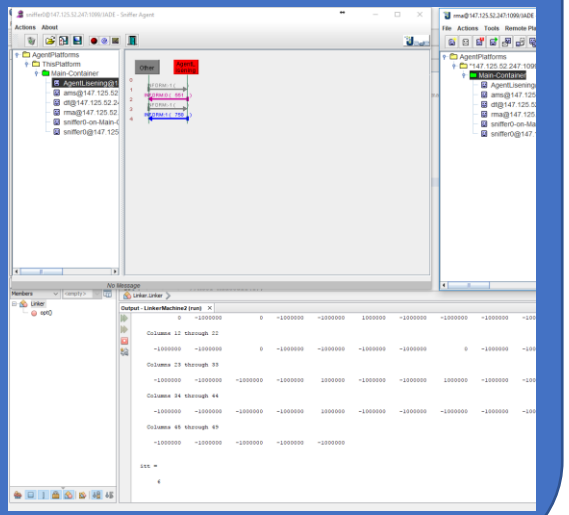
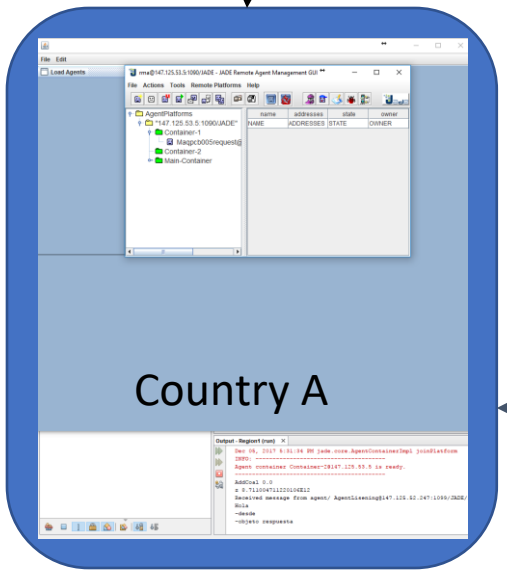
Linker machine



Trade consistency

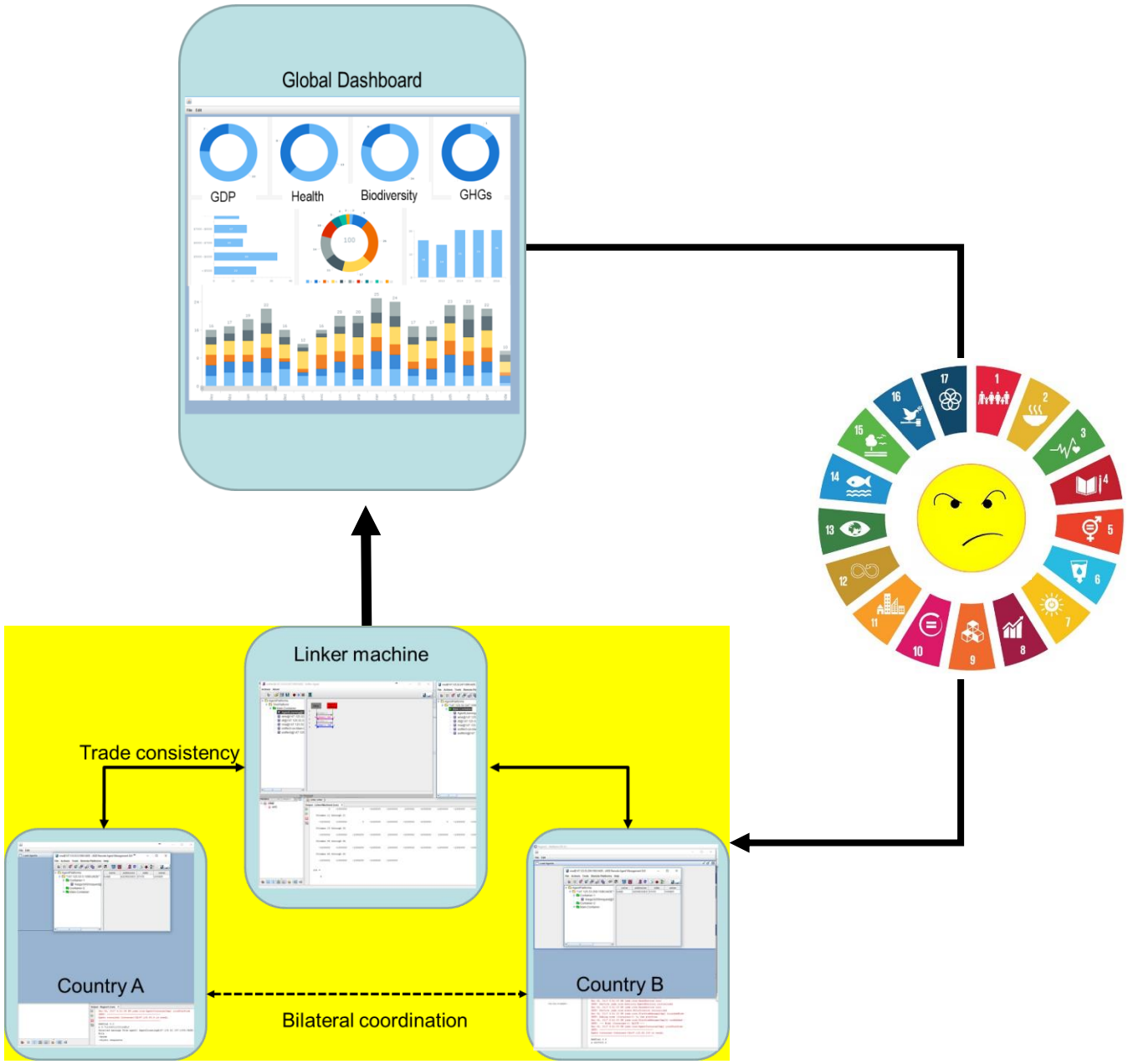


Country A

Country B

Bilateral coordination


Global Dashboard
GDP
Health
Biodiversity
GHGs
Linker machine
Trade consistency
Country A
Country B
Bilateral coordination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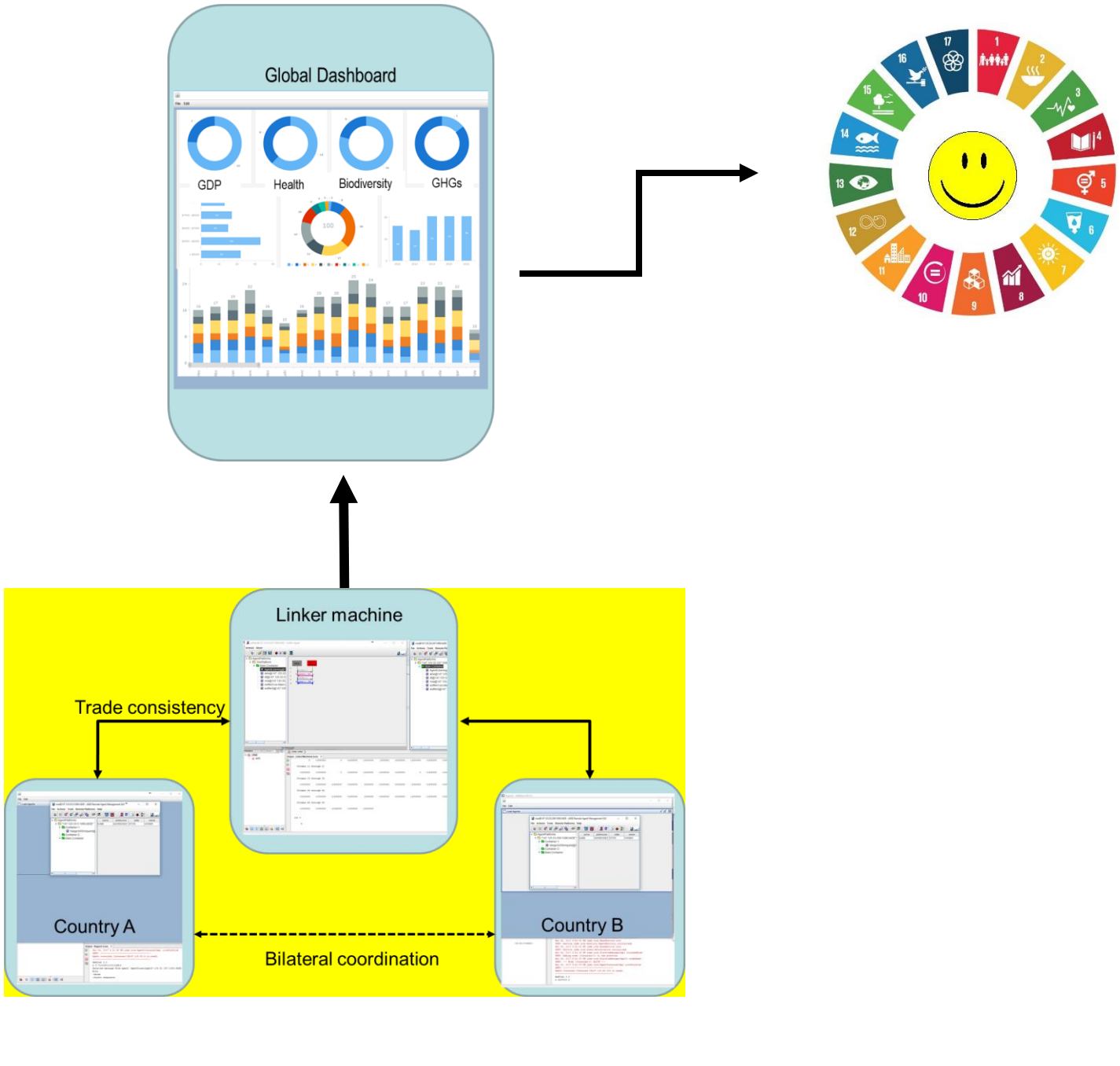

Global Dashboard
GDP
Health
Biodiversity
GHGs
Linker machine
Trade consistency
Country A
Country B
Bilateral coordination

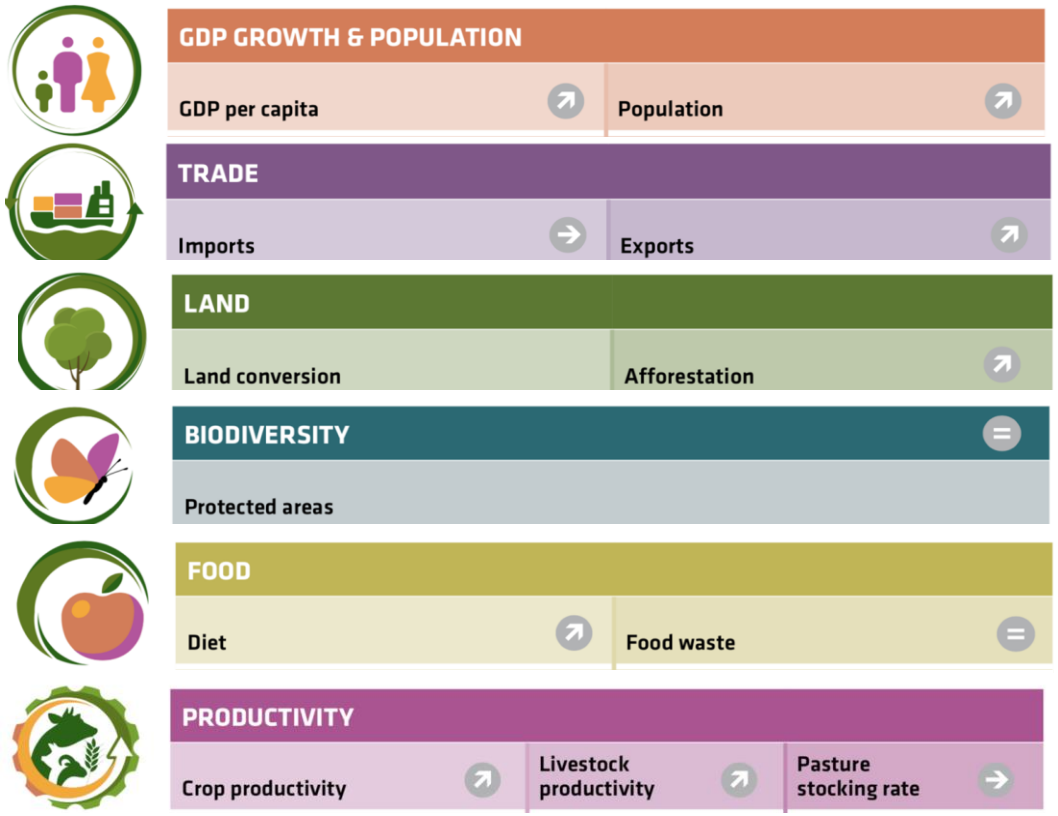
Global Targets

- FABLE country teams jointly decide on global targets to be achieved collectively
- Then each country team applies these targets to its country context.

AREA	GLOBAL TARGET
Land and Biodiversity	**A minimum share of earth's terrestrial land supports biodiversity conservation.** *No net loss by 2030 and an increase of at least 20% by 2050 in the area of land where natural processes predominate.*
	A minimum share of Earth's terrestrial land is within protected areas. *At least 30% of global terrestrial area by 2030*
	Zero net deforestation. *Forest gain should at least compensate for the forest loss at the global level by 2030*
Greenhouse gas emissions from AFOLU	**Greenhouse gas emissions from crops and livestock** *compatible with keeping the rise in average global temperatures to below 1.5°C, which we interpret as below 4 $GtCO_2e\ yr^{-1}$ by 2050 (3.9 Gt for non-CO_2 emissions and 0.1 Gt for CO_2 emissions)*
	Greenhouse gas emissions and removals from Land-Use, Land-Use-Change, and Forestry (LULUCF) *compatible with keeping the rise in average global temperatures to below 1.5°C. Negative global greenhouse gas emissions from LULUCF by 2050*
Food security	**Zero hunger.** *Average daily energy intake per capita higher than the minimum requirement in all countries by 2030*
	Low dietary disease risk. *Diet composition to achieve premature diet related mortality below 5%*
Freshwater	**Water use in agriculture** *within the limits of internally renewable water resources, taking account of other human water uses and environmental water flows. Blue water use for irrigation <2,453 km^3yr^{-1} (global estimates in the range of 670-4,044 km^3yr^{-1}) given future possible range (61-90%) in other competing water uses*
Nitrogen	**Nitrogen release from agriculture within environmental limits.** *N use <69 Tg N yr^{-1} total industrial and agricultural biological fixation (global estimates in the range of 52-113 Tg N yr^{-1}) and N loss from agricultural land <90 Tg N yr^{-1} (global estimates in the range of 50-146 Tg N yr^{-1}) by 2050*
Phosphorous	**Phosphorus release from agriculture within environmental limits.** *P use <16 Tg P yr^{-1} flow from fertilizers to erodible soils (global estimates in the range of 6.2-17 Tg P yr^{-1}) and P loss from agricultural soils and human excretion <8.69 Tg P yr^{-1} flow from freshwater systems into ocean by 2050*

Global Targets from the 2020 FABLE Report

National Pathways and Databases



2.1. Adaptation of the model to the local context

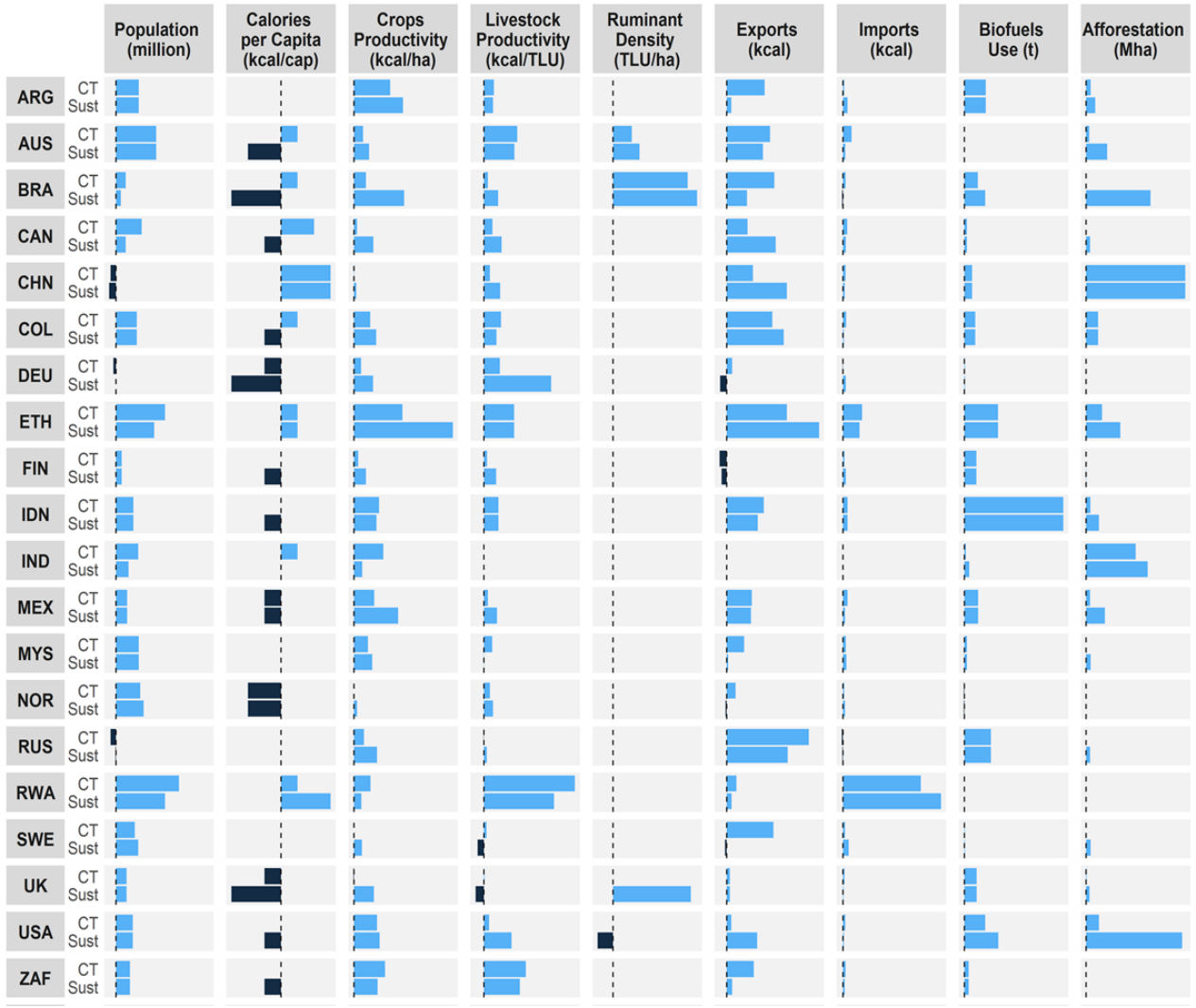
Tools agnostic but it should be able to compute indicators related to the targets

2. 2. Selection of the underlying assumptions in relation to political context

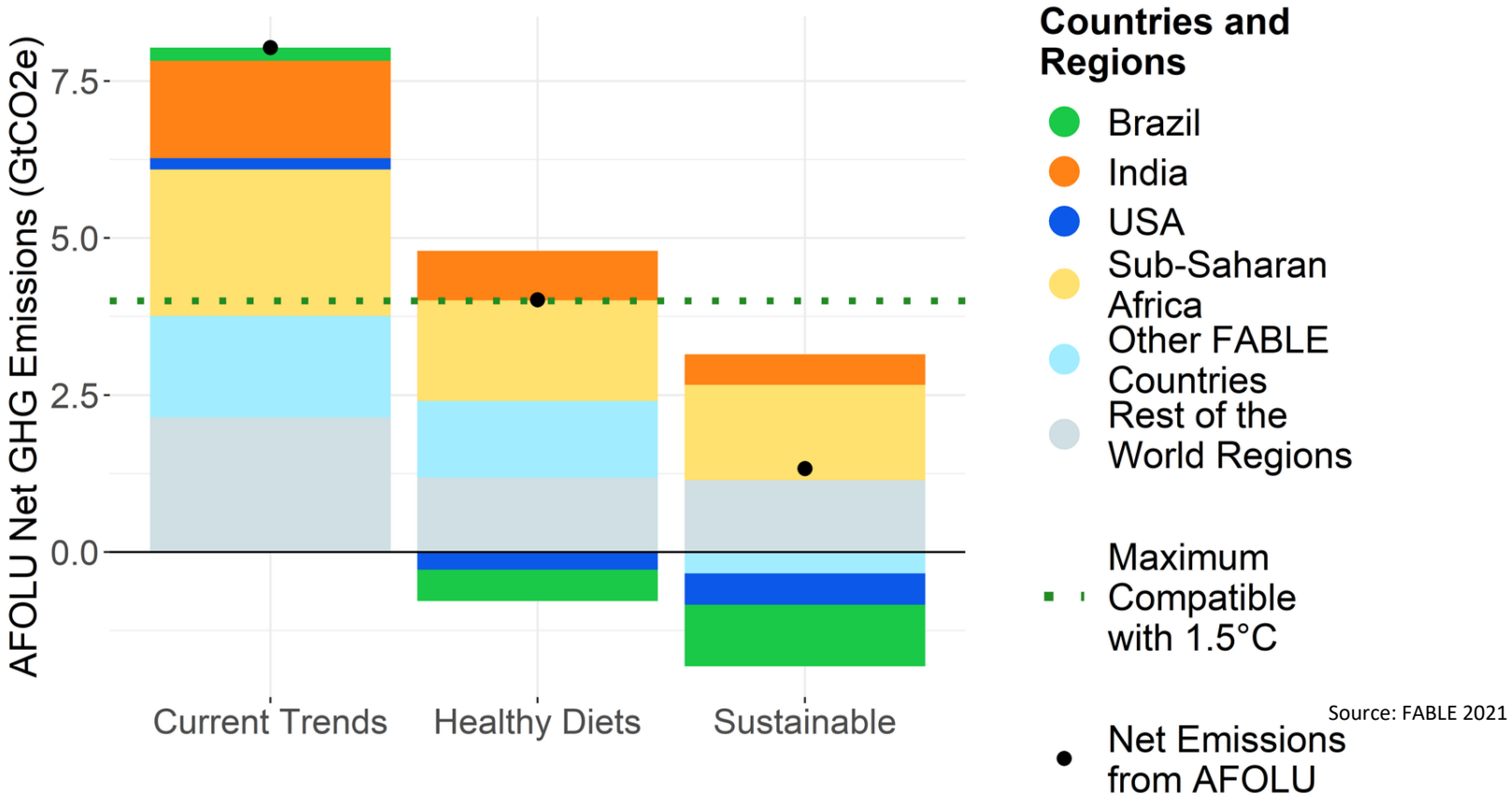
2.3. Review and analysis of the results

Automatic traffic light reports showing potential errors and large deviations with other benchmarks

Assumptions Dashboard



Global GHG emissions from AFOLU



Source: FABLE 2021

Quo Vadis?

How can global "SDGs" be socially produced?

- Design multi-objective intern'l (non-) cooperative "games"
- Transformation design & crowd coordination
- Enabled Machine – human co-creation