



International Institute for  
Applied Systems Analysis  
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Sustainable Development  
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# Future food demand drivers and pathways towards sustainability

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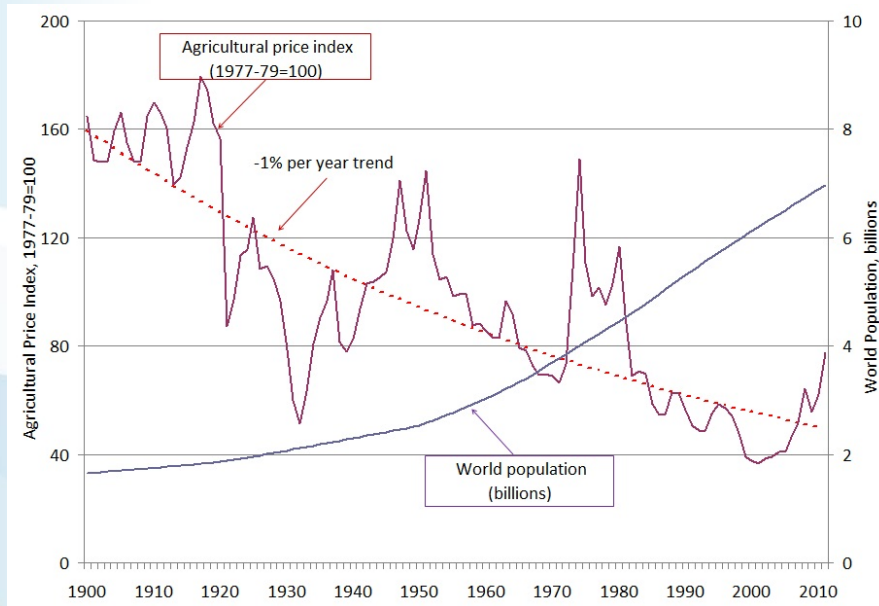


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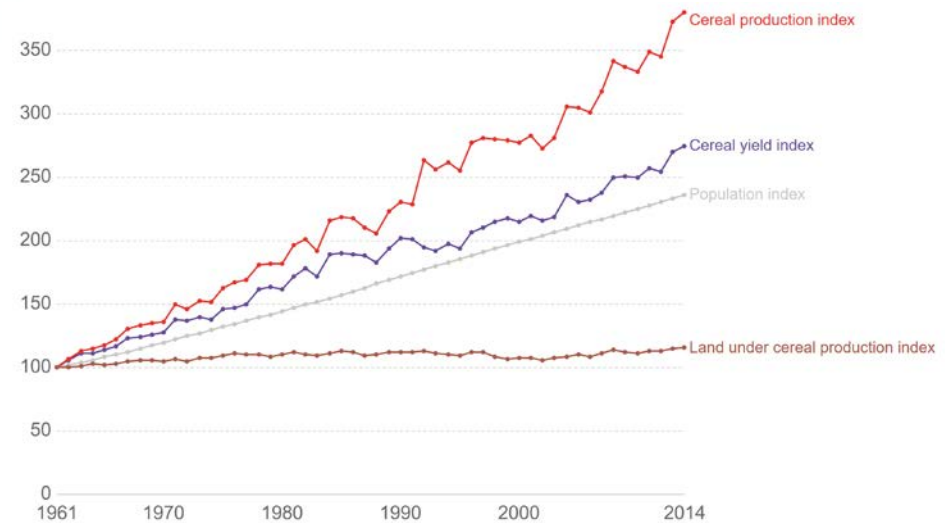
science for global insight

# Introduction

## ► Beyond the Malthusian perspective



Source: Fuglie et al., 2012



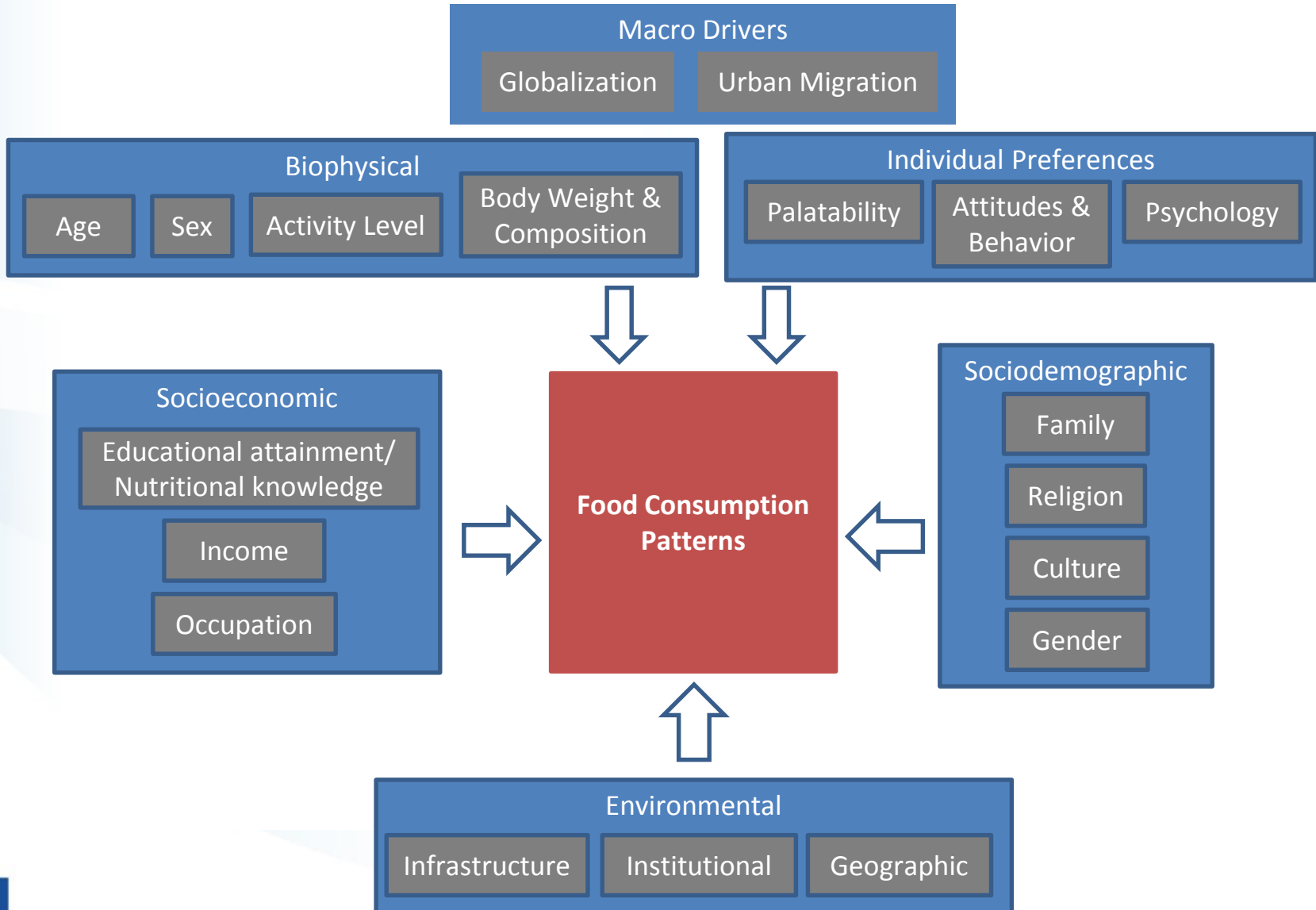
Source: OWID based on World Bank, World Development Indicators (WDI) [OurWorldInData.org/yields-and-land-use-in-agriculture/](http://OurWorldInData.org/yields-and-land-use-in-agriculture/) • CC BY

Source: OWID, based on World Bank WDI

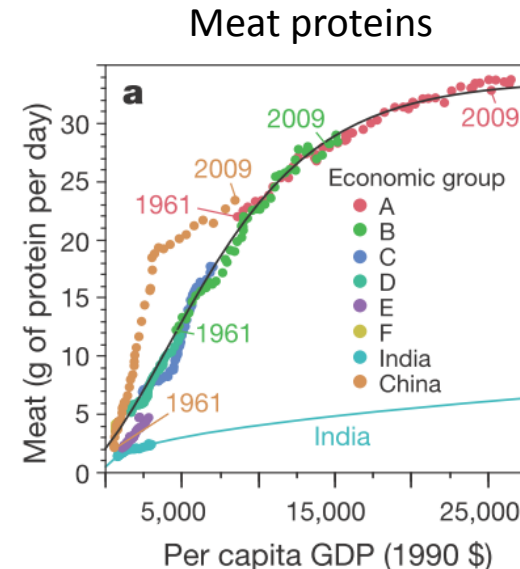
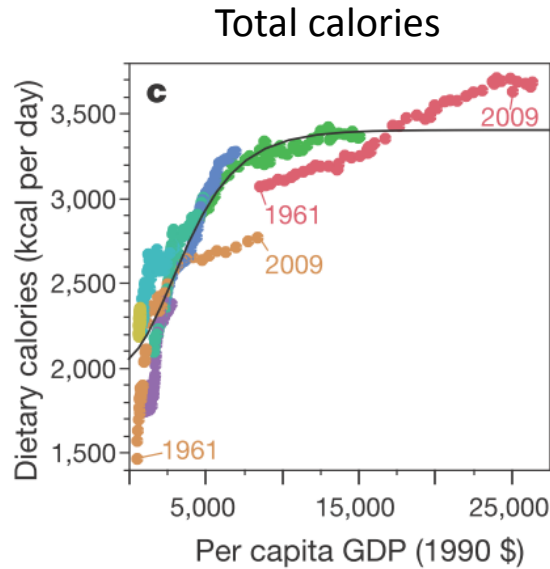
## ► Scope of this presentation

- Socioeconomic elements and future food demand
- Consistent modelling of pathways to sustainability

# Drivers of food demand



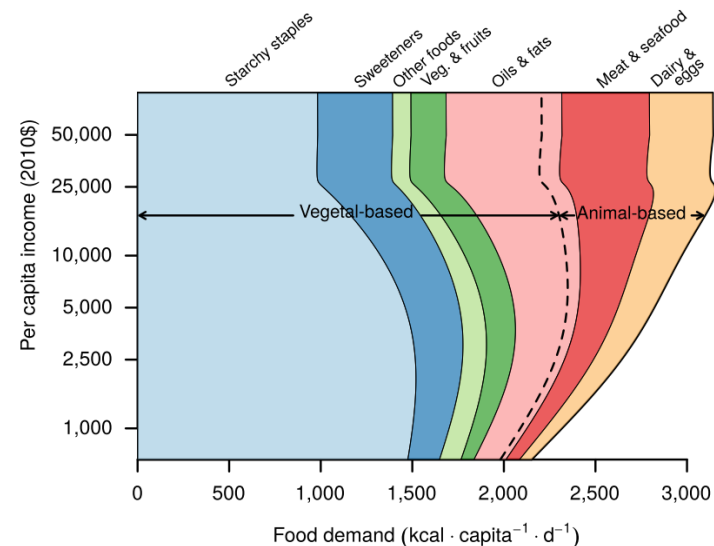
# Economic growth will explain a large share of future demand



Source: Tilman and Clark, Nature, 2014

## ▶ Diet composition changes with income growth

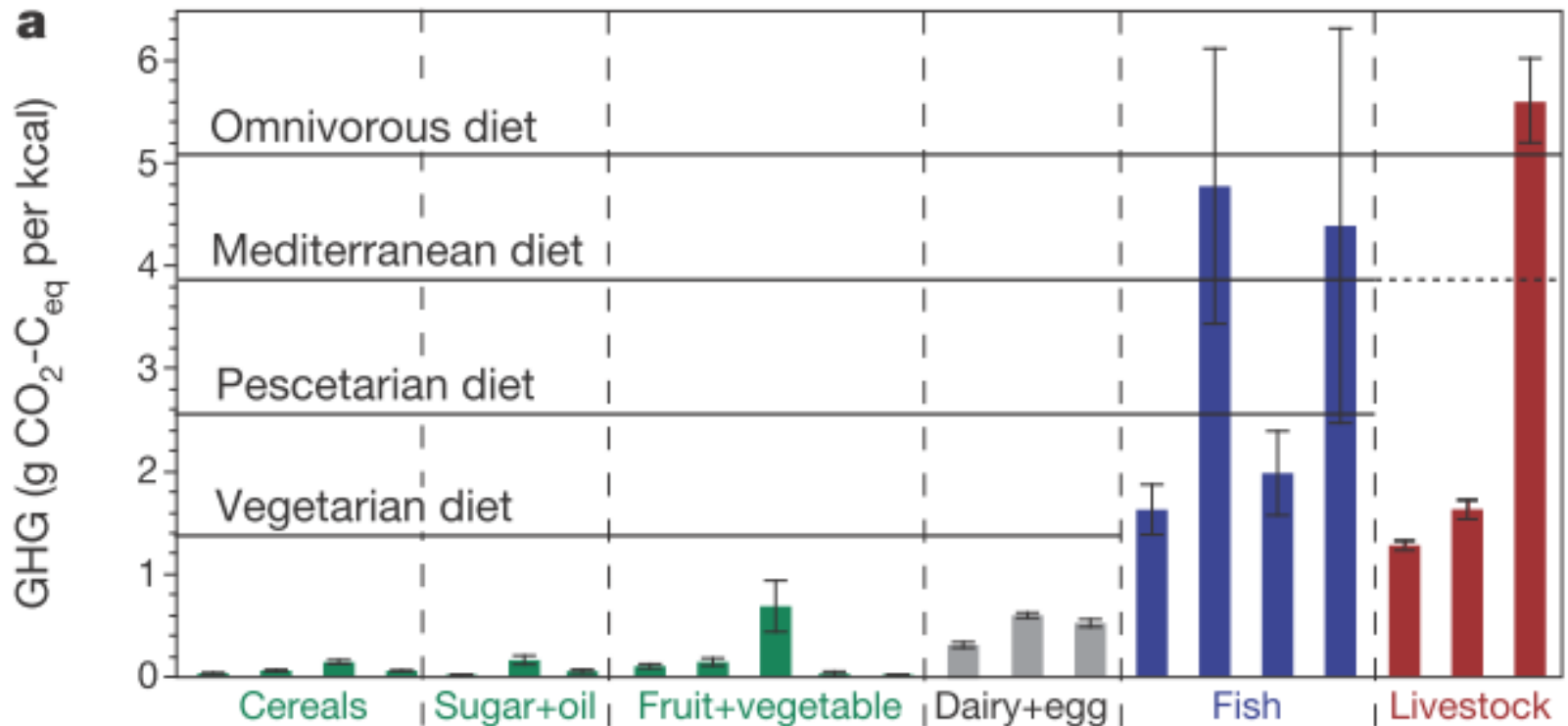
- ▶ Less starchy crops
- ▶ Animal products and seafood
- ▶ Dairy and eggs
- ▶ Oils and fats



Source: Gouel and Guimbar, 2017, AJAE

# Sustainability challenges

- ▶ Current demand towards products of higher environmental impact footprint



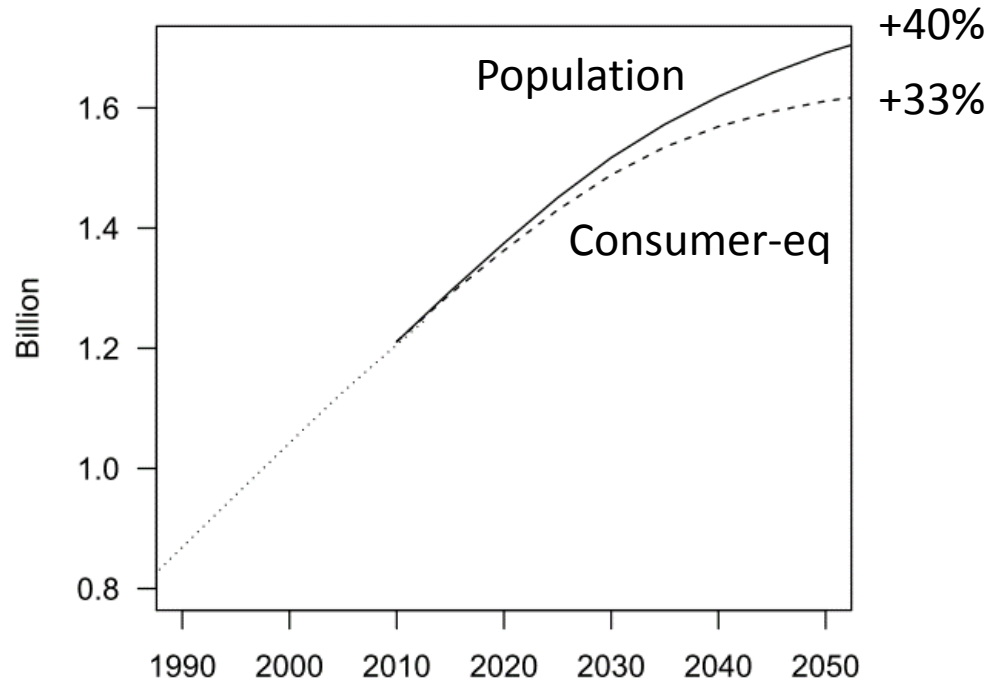
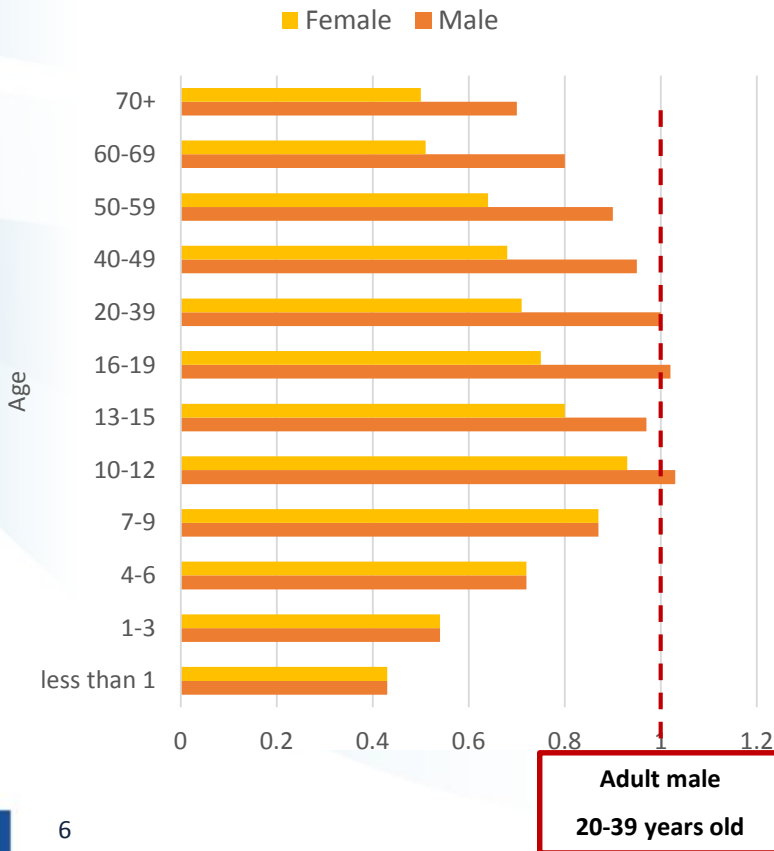
# Other socioeconomic determinants

- ▶ Importance of socioeconomic heterogeneity: age and gender

- ▶ **Example of India**

- ▶ Physiological food requirements

- ▶ Consumer-eq vs population growth



Source: KC et al., 2017

# Role of urbanization and lifestyle

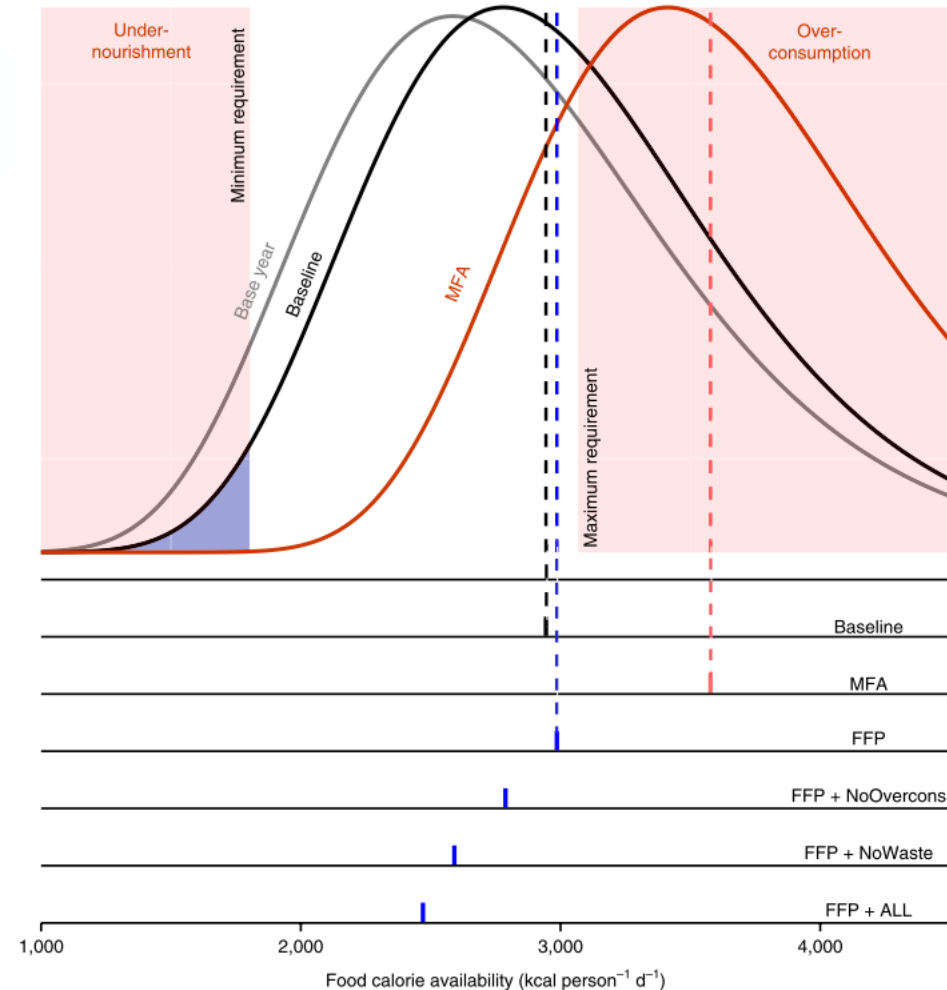
Daily energy needs from food intake (kilocalorie per capita per day)

Gender	Age (years)	Physical Activity Level <sup>b</sup>		
		Sedentary	Moderately Active	Active
<b>Child (female and male)</b>	2-3	1,000-1,200 <sup>c</sup>	1,000-1,400 <sup>c</sup>	1,000-1,400 <sup>c</sup>
<b>Female<sup>d</sup></b>	4-8	1,200-1,400	1,400-1,600	1,400-1,800
	9-13	1,400-1,600	1,600-2,000	1,800-2,200
	14-18	1,800	2,000	2,400
	19-30	1,800-2,000	2,000-2,200	2,400
	31-50	1,800	2,000	2,200
	51+	1,600	1,800	2,000-2,200
<b>Male</b>	4-8	1,200-1,400	1,400-1,600	1,600-2,000
	9-13	1,600-2,000	1,800-2,200	2,000-2,600
	14-18	2,000-2,400	2,400-2,800	2,800-3,200
	19-30	2,400-2,600	2,600-2,800	3,000
	31-50	2,200-2,400	2,400-2,600	2,800-3,000
	51+	2,000-2,200	2,200-2,400	2,400-2,800

Source: USDA dietary guidelines

# Food distribution and waste

- ▶ Inequality of income (Gini) determines poverty and undernutrition
- ▶ Availability approach to SDG2  
“More Food for All (MFA): +22%
- ▶ Targetted use approach to SDG2  
“Food for the Poor” (FFP): +3%
- ▶ Reducing waste and over-consumption complementary
- ▶ Policies tackling food distribution more efficient than policies oriented towards production?



Source: Hasegawa et al., Nature Sustainability, 2019



# Shared Socio-economic Pathways (SSPs)

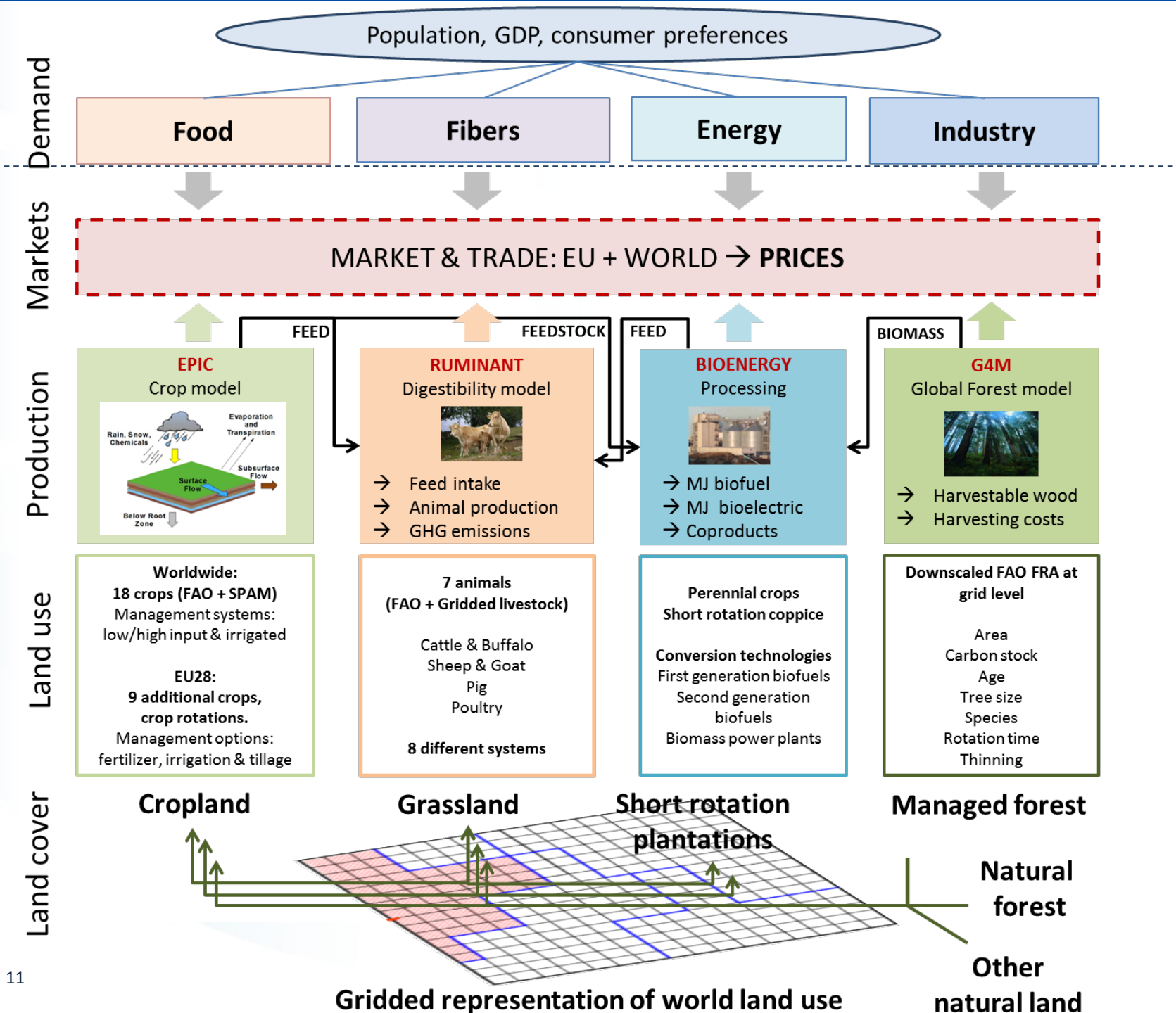


Source: O'Neil et al., 2015

# SSP Economy, lifestyle, policies and institutions

SSP element	SSP1	SSP2	SSP3	SSP4	SSP5
<b>Economy &amp; lifestyle</b>					
Growth (per capita)	High in LICs, MICs; medium in HICs	Medium, uneven	Slow	Low in LICs, medium in other countries	High
Inequality	Reduced across and within countries	Uneven moderate reductions across and within countries	High, especially across countries	High, especially within countries	Strongly reduced, especially across countries
International trade	Moderate	Moderate	Strongly constrained	Moderate	High, with regional specialization in production
Globalization	Connected markets, regional production	Semi-open globalized economy	De-globalizing, regional security	Globally connected elites	Strongly globalized, increasingly connected
Consumption & Diet	Low growth in material consumption, low-meat diets, first in HICs	Material-intensive consumption, medium meat consumption	Material-intensive consumption	Elites: high consumption lifestyles; Rest: low consumption, low mobility	Materialism, status consumption, tourism, mobility, meat-rich diets
<b>Policies &amp; institutions</b>					
International Cooperation	Effective	Relatively weak	Weak, uneven	Effective for globally connected economy, not for vulnerable populations	Effective in pursuit of development goals, more limited for envt. goals
Environmental Policy	Improved management of local and global issues; tighter regulation of pollutants	Concern for local pollutants but only moderate success in implementation	Low priority for environmental issues	Focus on local environment in MICs, HICs; little attention to vulnerable areas or global issues	Focus on local environment with obvious benefits to well-being, little concern with global problems
Policy orientation	Toward sustainable development	Weak focus on sustainability	Oriented toward security	Toward the benefit of the political and business elite	Toward development, free markets, human capital
Institutions	Effective at national and international levels	Uneven, modest effectiveness	Weak global institutions/ natl. govts. dominate societal decision-making	Effective for political and business elite, not for rest of society	Increasingly effective, oriented toward fostering competitive markets

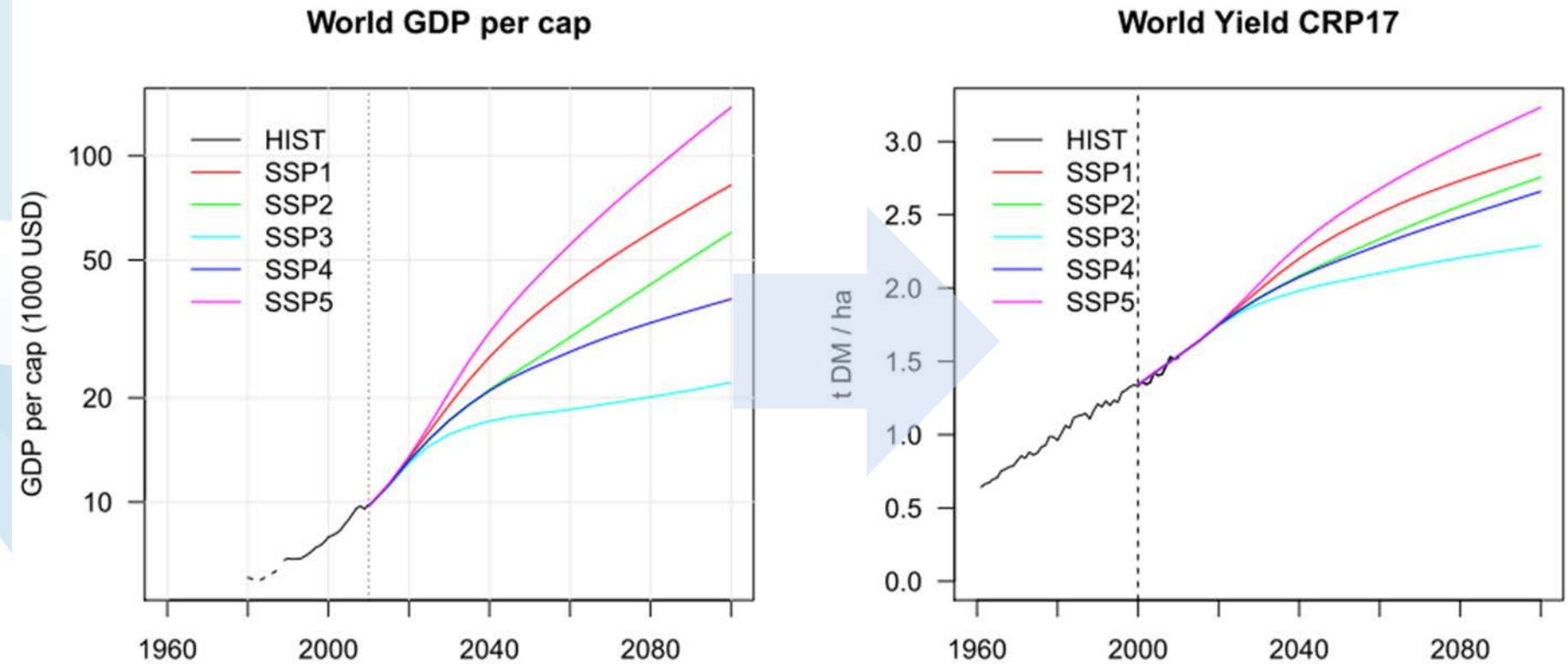
Source: O'Neil et al., 2015



# GLOBIOM SSP scenario elements

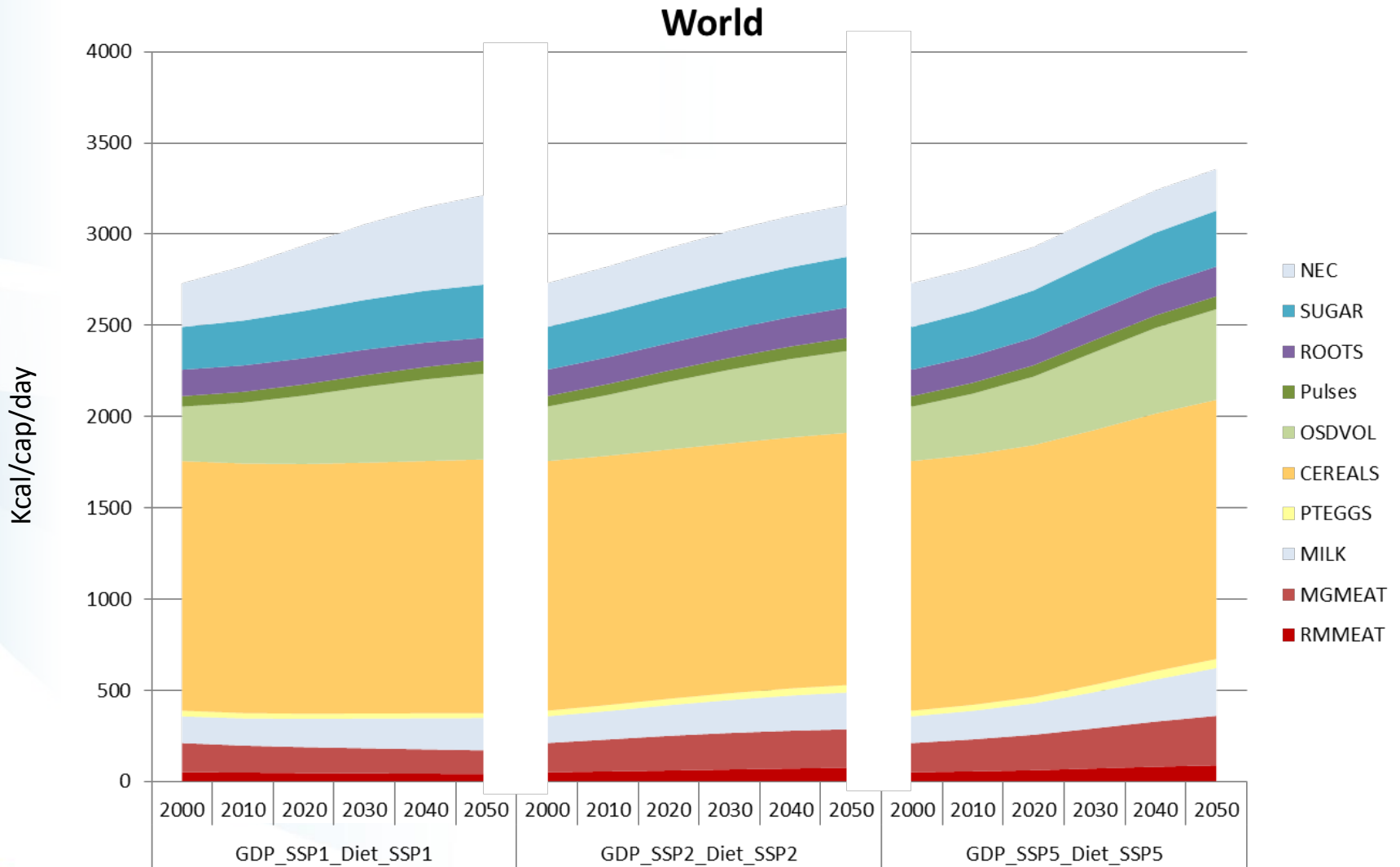
Agriculture and land use			
	SSP1	SSP2	SSP3
<b>Net deforestation</b>	Afforestation (No net deforestation by 2050, +3% forest area by 2100 compared to 2010)	Deforestation/Afforestation (Forest loss of 1% by 2050, back to 2010 area by 2100)	Deforestation (Net forest loss of 3% by 2050 and 6% by 2100 compared to 2010)
<b>Land productivity growth</b>			
<b>Crops: Yields</b>	High yield growth (Annual yield growth from 0.51% p.a. in the North to 0.66% in the South)	Moderate yield growth (Annual yield growth from 0.46% p.a. in the North to 0.60% in the South)	Slow yield growth (Annual yield growth from 0.35% p.a. in the North to 0.35% in the South)
<b>Crops: Input intensity</b>	Low intensity (Elasticity of variable inputs incl. fertilizer use wrt technological change: 0.75)	Medium intensity (Elasticity of variable inputs incl. fertilizer use wrt technological change: 1.00)	High intensity (Elasticity of variable inputs incl. fertilizer use wrt technological change: 1.25)
<b>Livestock: Feed conversion efficiency</b>	Enhanced efficiency growth (Annual feed conversion efficiency change from 0.10% in the North to 0.26% in the South)	Moderate efficiency growth (Annual feed conversion efficiency change from 0.10% in the North to 0.24% in the South)	Slow efficiency growth (Annual feed conversion efficiency change from 0.07% in the North to 0.14% in the South)
<b>Livestock: Endogenous productivity growth</b>	High livestock systems transition (Annually, up to 5% of livestock production systems can be converted to an alternative system or the activity can be abandoned)	Medium livestock systems transition (Annually, up to 2.5% of livestock production systems can be converted to an alternative system or the activity can be abandoned)	Low livestock systems transition (No adjustment in the ruminant production system structure)
<b>Environmental impact of food consumption</b>			
<b>Food demand</b>	Slow consumption growth and more sustainable and healthy diets (Calorie consumption per capita growing – North : 1%, South: 16%. Livestock product share decreases in North by one third but increases in South, leading to a stable share of 15% globally)	Moderate consumption growth and increasing share of livestock products in the diet (Calorie consumption per capita growing by 11% in the North and 22% in the South. Livestock product share in the diet growing from 15% to 18%.)	Substantial consumption growth but lagging demand for animal proteins in diet in the South (Calorie consumption per capita growing by 5% in the North and 15% in the South. Livestock product share stays at 15%.)
<b>Losses &amp; Wastes</b>	Fast reduction of losses & wastes (L&W) (L&W in the processing chains reduced from 12% to 7% in the Oilseed and Pulses sector and from 7% to 2.5% in the dairy sector over 2000 and 2050)	Medium reduction of losses & wastes (L&W) (L&W in the processing chains reduced from 12% to 7.5% in the Oilseed and Pulses sector and from 7% to 3% in the dairy sector over 2000 and 2050)	Slow reduction of losses & wastes (L&W) (L&W in the processing chains reduced from 12% to 9% in the Oilseed and Pulses sector and from 7% to 4.5% in the dairy sector over 2000 and 2050)

# Crop yield development in GLOBIOM



- ▶ Crop yield developments projected as a function of GDP per capita based on econometric estimation on 1980-2010, and 4 income group clusters.

# Quantification of diet preferences



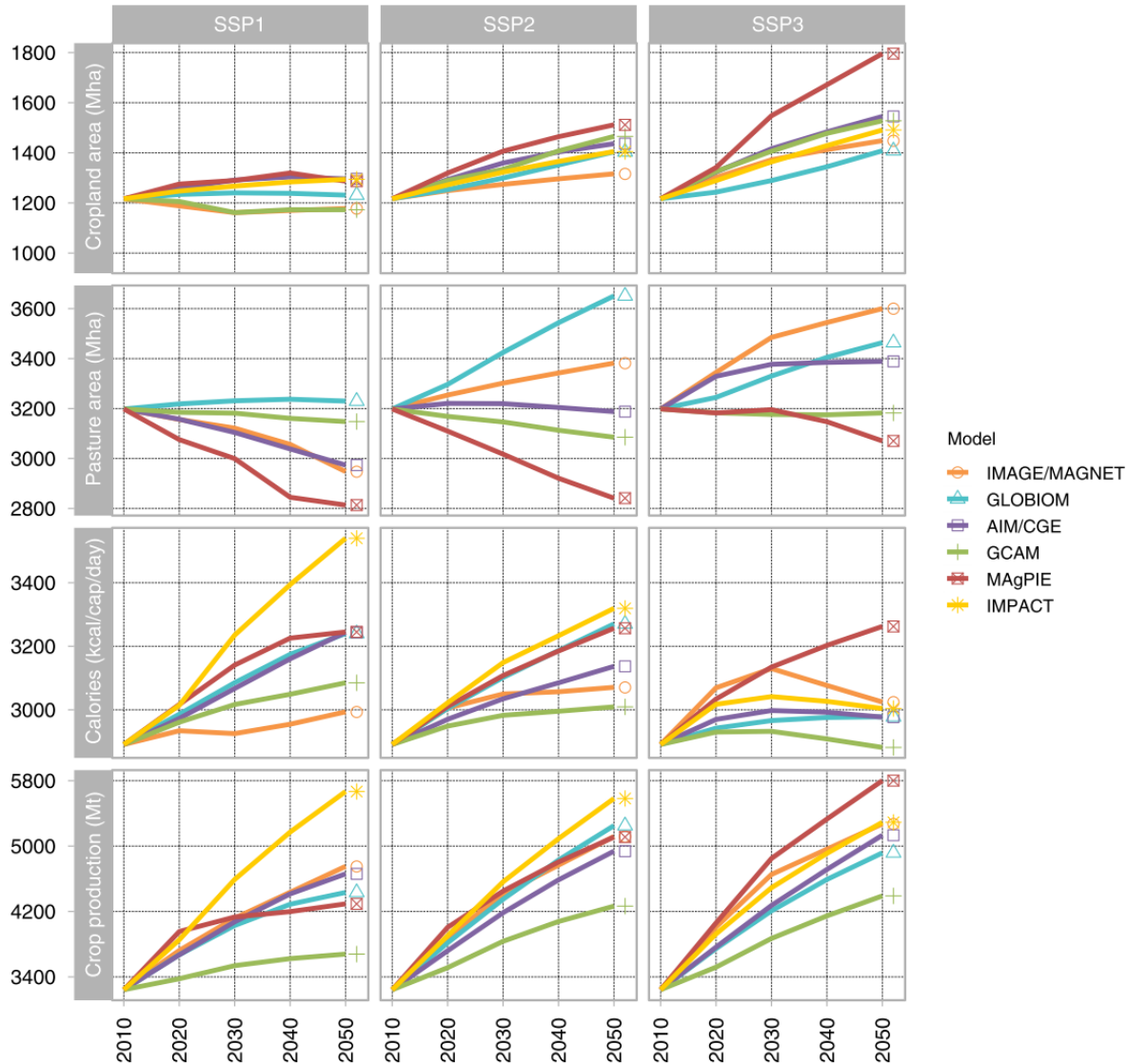
# SSP projections in Integrated Assessment Models

Cropland

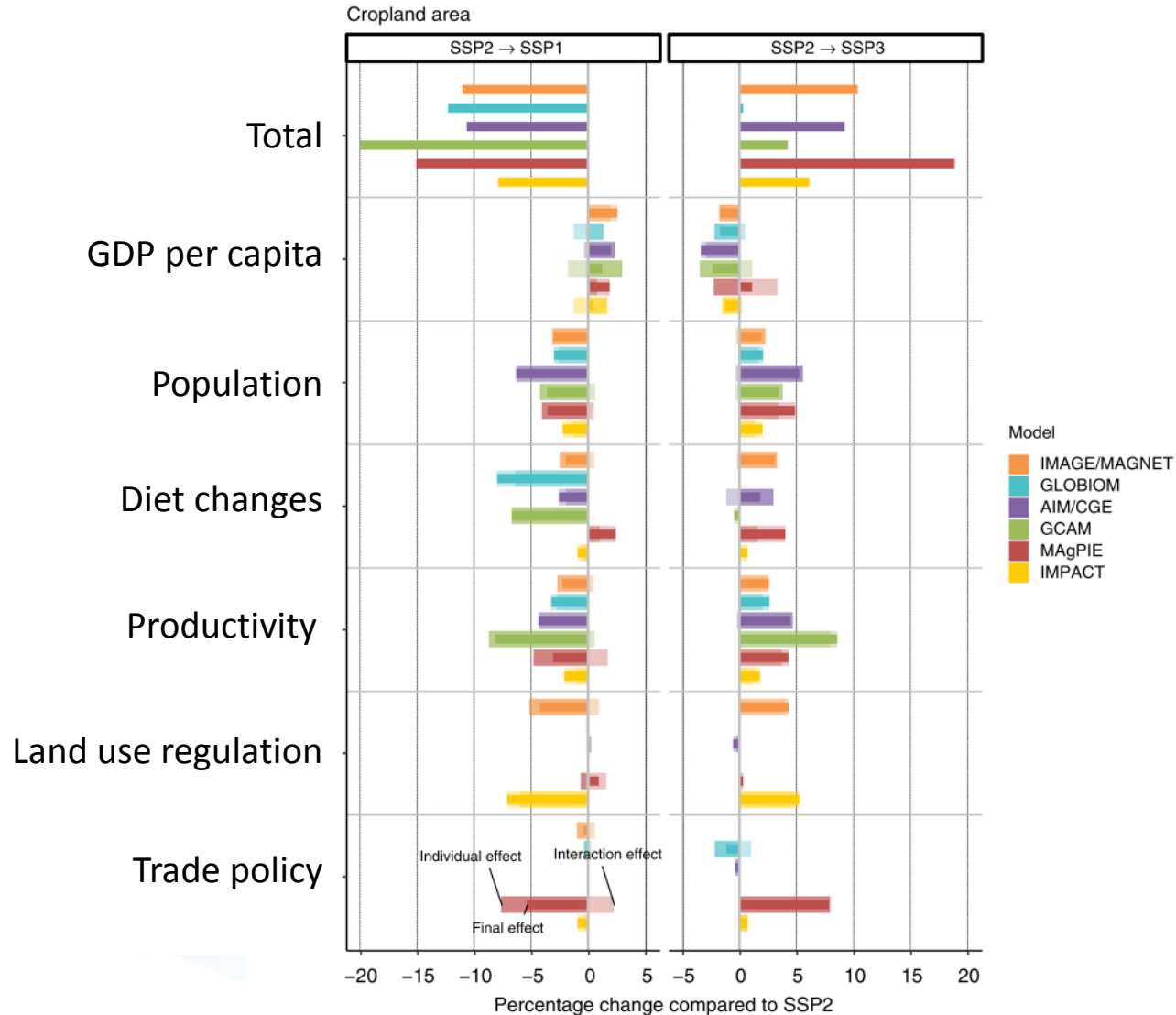
Pasture land

Calories per capita

Crop production



# Decomposition of drivers on cropland area by 2050

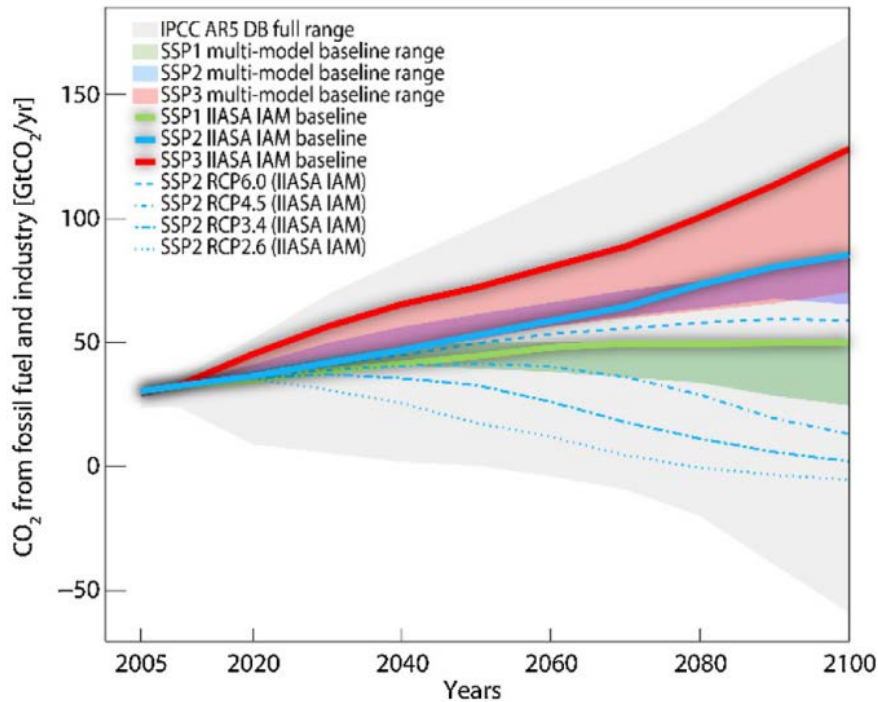


Source: Stehfest et al., Nature Comm., 2019

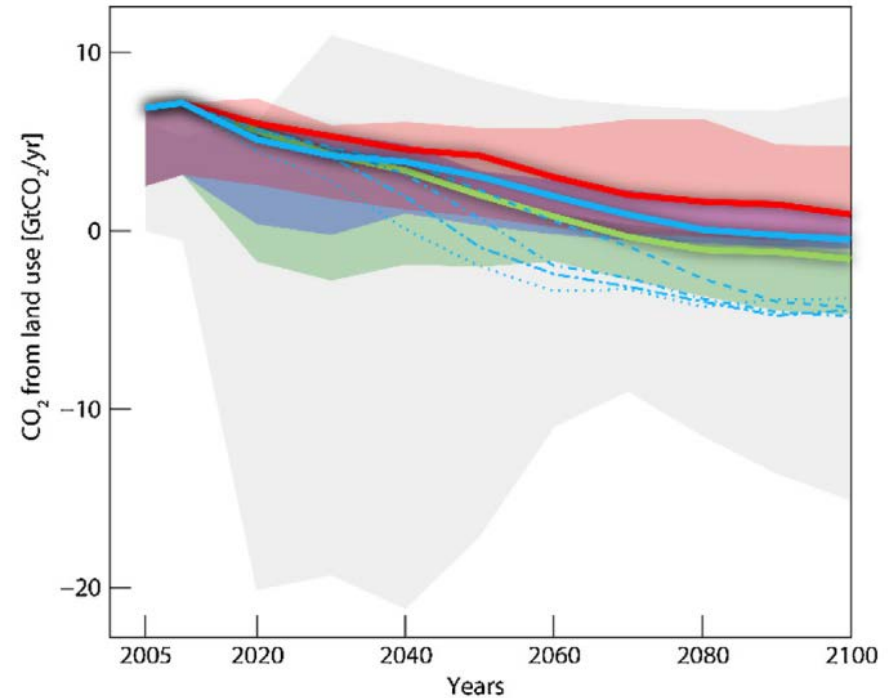


# SSPs are not sufficient to reach the SDGs

## Energy sector GHG emissions



## Agriculture and forestry GHG emissions

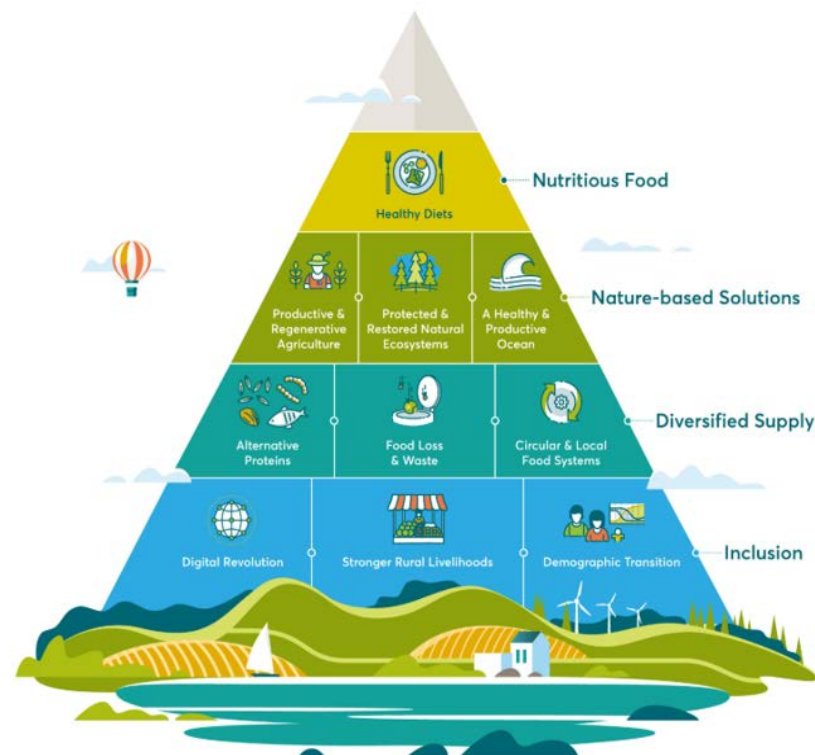


Source: Fricko et al., 2017

# Sustainability transformations

- ▶ Need to go beyond the changes in SSPs
  - ▶ Need of nature-based solution for climate change mitigation
  - ▶ Land restoration need for biodiversity
- ▶ Sustainability wedges
  - ▶ More sustainable and healthy diets
  - ▶ Less losses and waste along the food chain
  - ▶ Increased yield productivity
  - ▶ Massive land restoration programs
  - ▶ Climate smart production practices
  - ▶ More inclusive growth
- ▶ Food and Land Use Coalition report (released today!) based on GLOBIOM modelling

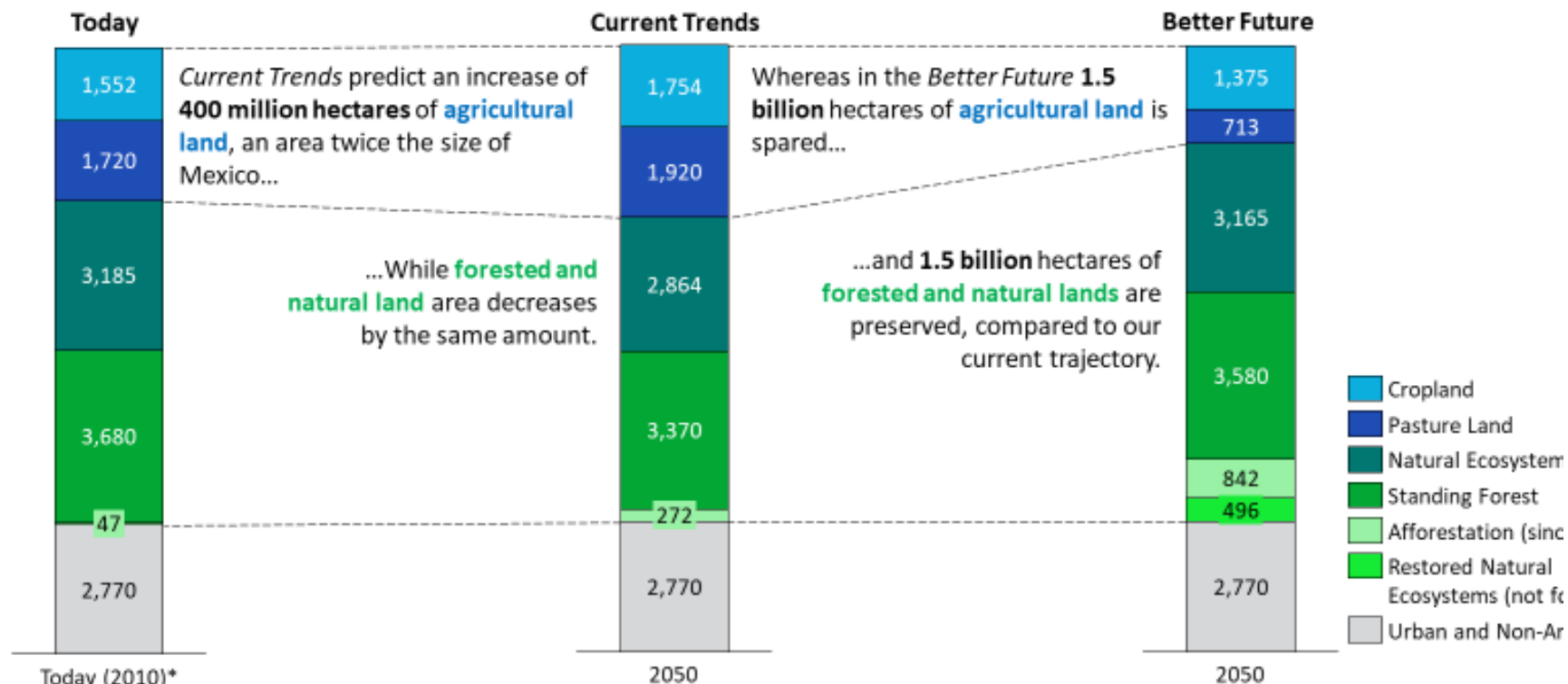
Food and Land Use Transformation Pyramid



Source: Food and Land Use Coalition 2019

# Ambitious land use transformation scenario
















Total Surface Land Use: million hectares



\* Baseline data forecast from 2000  
Source: IASA GLOBIOM 2019

Note: According to IASA estimates, parts of the permanent pastures, as defined in the IPCC 2019 Special Report on Climate Change and Land report, are pastures without significant contribution to total livestock production and thus, are included in the land use classification 'Natural Ecosystems Land'. The 'Pasture' land use classification includes only grassland utilized for agricultural production.

# Implementation challenges of transformations

Scale of challenge							
<span style="color: green;">●</span> Low	<span style="color: yellow;">●</span> Medium	<span style="color: brown;">●</span> High	 Policy & Regulation	 Finance	 Tech & Innovation	 Behavioural Change	 Overall Assessment
	Healthy Diets	<span style="color: yellow;">●</span>	<span style="color: green;">●</span>	<span style="color: green;">●</span>	<span style="color: brown;">●</span>	<span style="color: brown;">●</span>	
	Productive & Regenerative Agriculture	<span style="color: yellow;">●</span>	<span style="color: yellow;">●</span>	<span style="color: green;">●</span>	<span style="color: yellow;">●</span>	<span style="color: yellow;">●</span>	
	Protecting & Restoring Nature	<span style="color: brown;">●</span>	<span style="color: brown;">●</span>	<span style="color: green;">●</span>	<span style="color: yellow;">●</span>	<span style="color: brown;">●</span>	
	A Healthy & Productive Ocean	<span style="color: yellow;">●</span>	<span style="color: yellow;">●</span>	<span style="color: green;">●</span>	<span style="color: yellow;">●</span>	<span style="color: yellow;">●</span>	
	Diversifying Protein Supply	<span style="color: yellow;">●</span>	<span style="color: green;">●</span>	<span style="color: yellow;">●</span>	<span style="color: green;">●</span>	<span style="color: green;">●</span>	
	Food Loss & Waste	<span style="color: yellow;">●</span>	<span style="color: green;">●</span>	<span style="color: green;">●</span>	<span style="color: yellow;">●</span>	<span style="color: yellow;">●</span>	
	Local Loops & Linkages	<span style="color: yellow;">●</span>	<span style="color: yellow;">●</span>	<span style="color: green;">●</span>	<span style="color: yellow;">●</span>	<span style="color: yellow;">●</span>	
	Digital Revolution	<span style="color: yellow;">●</span>	<span style="color: green;">●</span>	<span style="color: green;">●</span>	<span style="color: green;">●</span>	<span style="color: green;">●</span>	
	Stronger Rural Livelihoods	<span style="color: yellow;">●</span>	<span style="color: brown;">●</span>	<span style="color: green;">●</span>	<span style="color: brown;">●</span>	<span style="color: brown;">●</span>	
	Gender & Demography	<span style="color: yellow;">●</span>	<span style="color: green;">●</span>	<span style="color: green;">●</span>	<span style="color: yellow;">●</span>	<span style="color: yellow;">●</span>	

Source: Food and Land Use Coalition, 2019

# Conclusion

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- ▶ World population is growing...
  - ▶ But also many other socioeconomic transitions currently taking place
  - ▶ Unprecedented sustainability challenges
  - ▶ Evolution of other factors in the food and agricultural system
- ▶ Current SSP trends across IAMs insufficient to meet the SDG targets
  - ▶ In particular climate change and biodiversity challenges
- ▶ More ambitious transformation (“Critical transitions”) needed
  - ▶ Beyond slight shifts in trends
  - ▶ Large reallocation of land use for climate and biodiversity benefits without compromising food security
  - ▶ Economically achievable

# Thank you !

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