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science for global insight

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Achieving the Paris agreement: implications for the agriculture sector : insights from GLOBIOM

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Ecosystems Services and Management Program

www.globiom.org

Global framework for the assessment climate change mitigation and adaptations

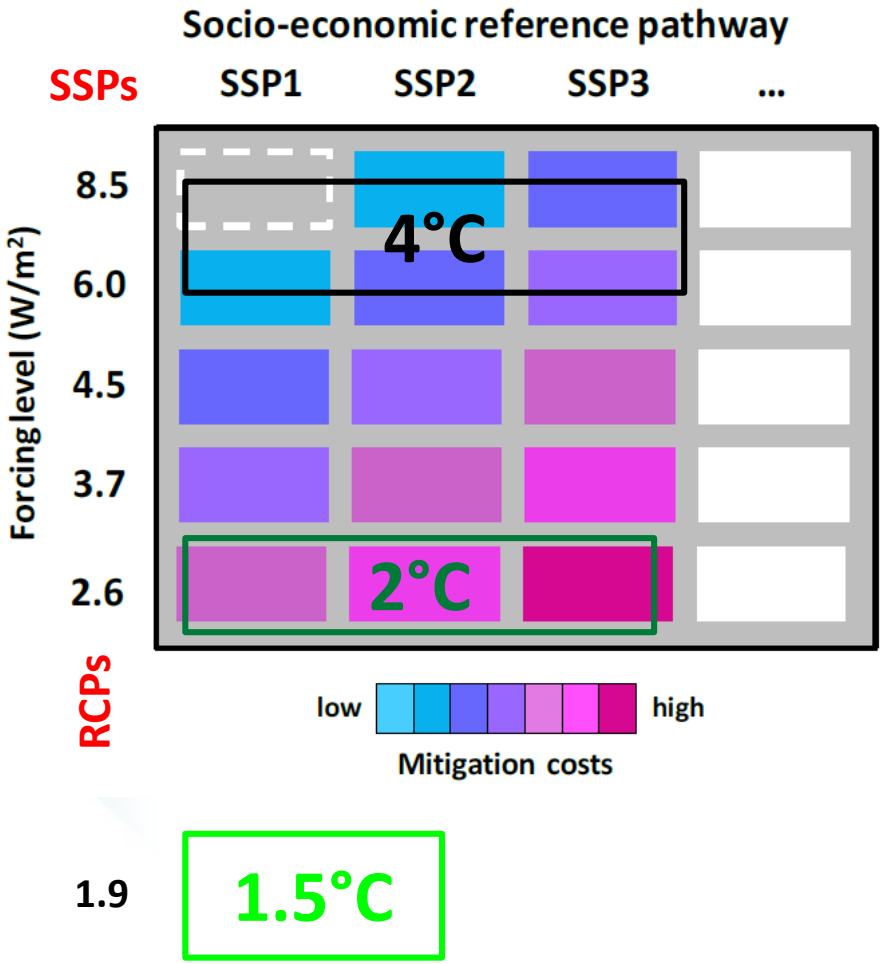
- Combination of two types of scenarios for the assessment of climate change, its impacts, and response options:
  - Representative Concentration Pathways (RCPs): used by the Climate Models (CMs or GCMs) to derive future climate change
  - Shared Socio-economic Pathways (SSPs) used as input by the Integrated Assessment Models (IAMs) to study interlinkages between the human and the natural system

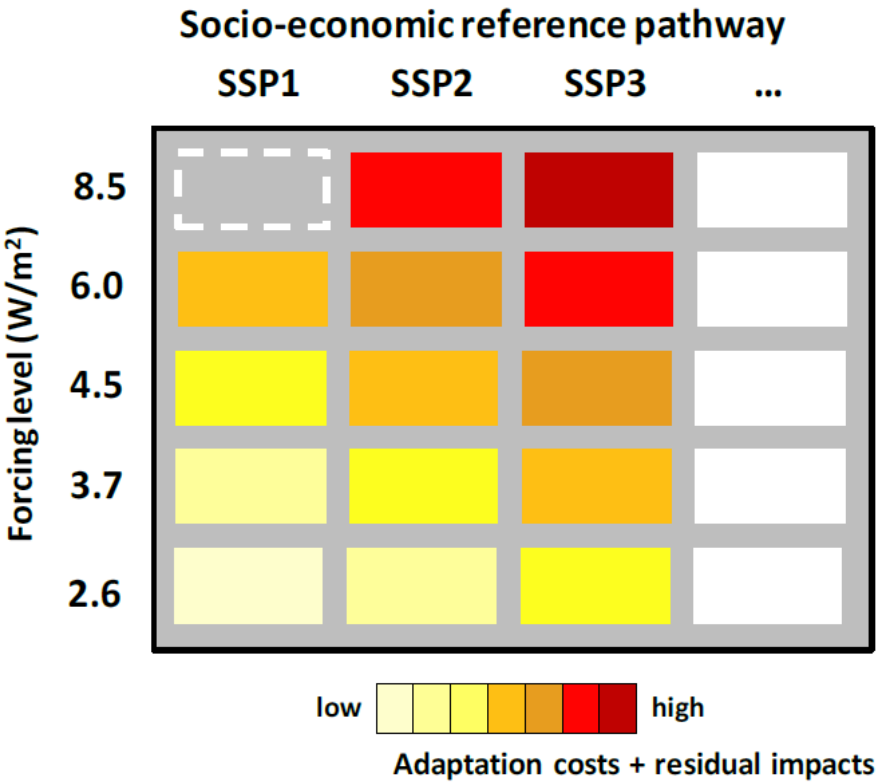
Shared Socio-economic Pathways (SSPs) narratives

- First, key elements of SSPs were identified and second, basic narratives for each of five SSPs were developed, along with qualitative indications (direction and magnitude) of trends in key elements.

O Neil et al., 2015

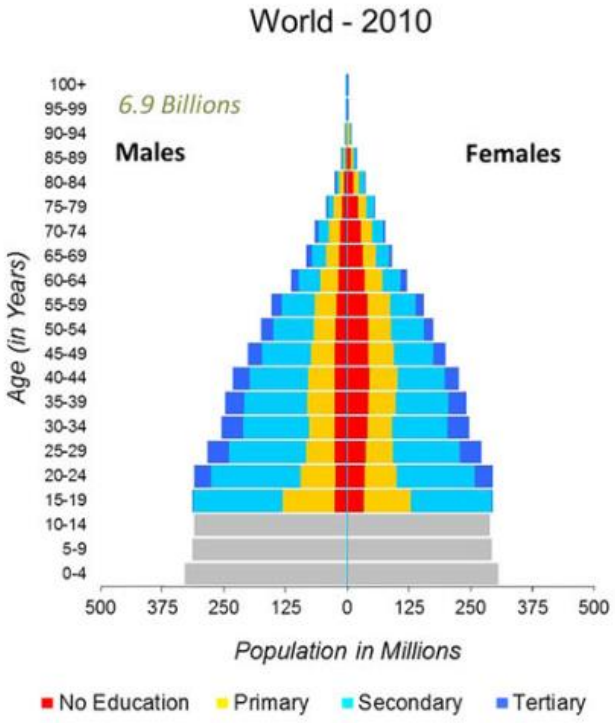
Global framework for the assessment climate change mitigation and adaptations

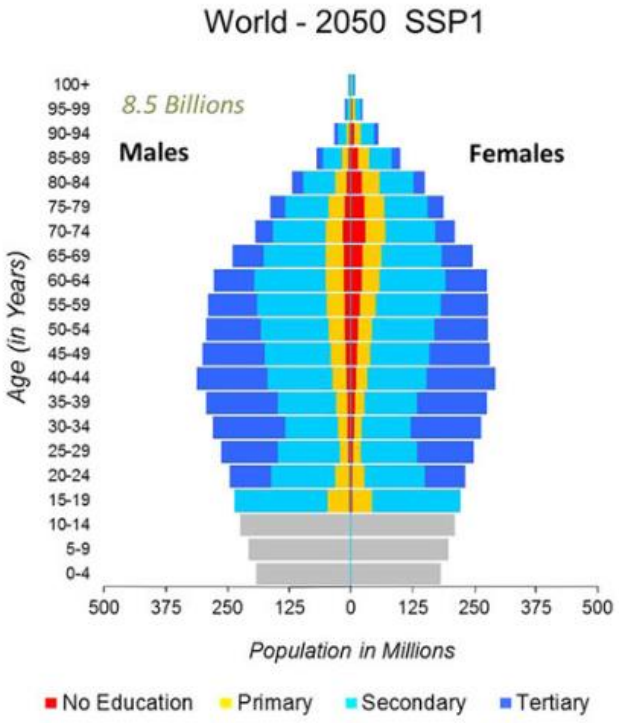


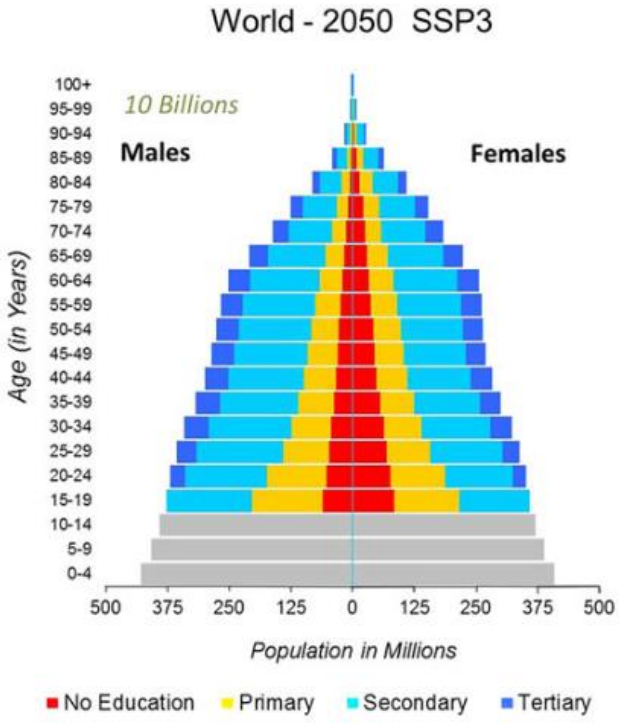


1.9 **1.5°C**

Population across SSPs

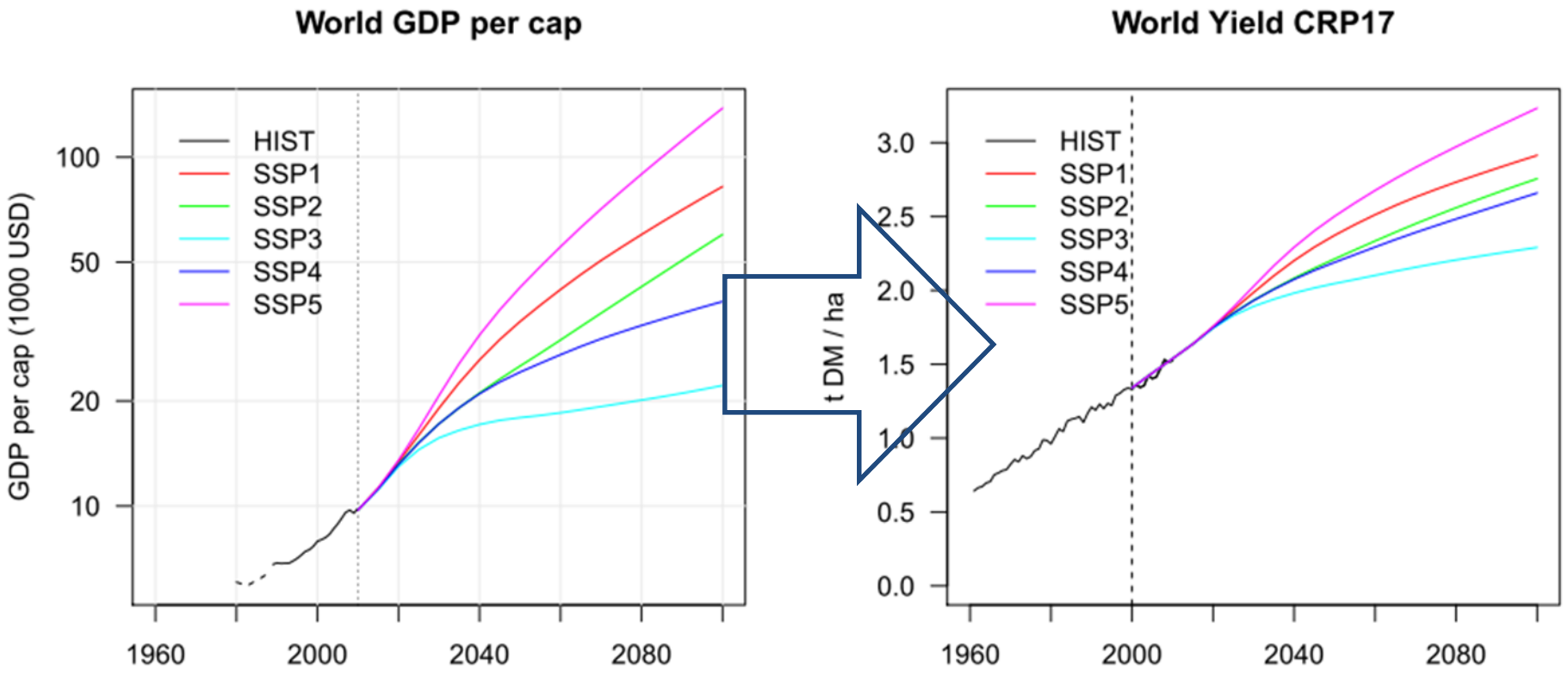






(KC & Lutz, 2014)

GDP and crop yield development across SSPs

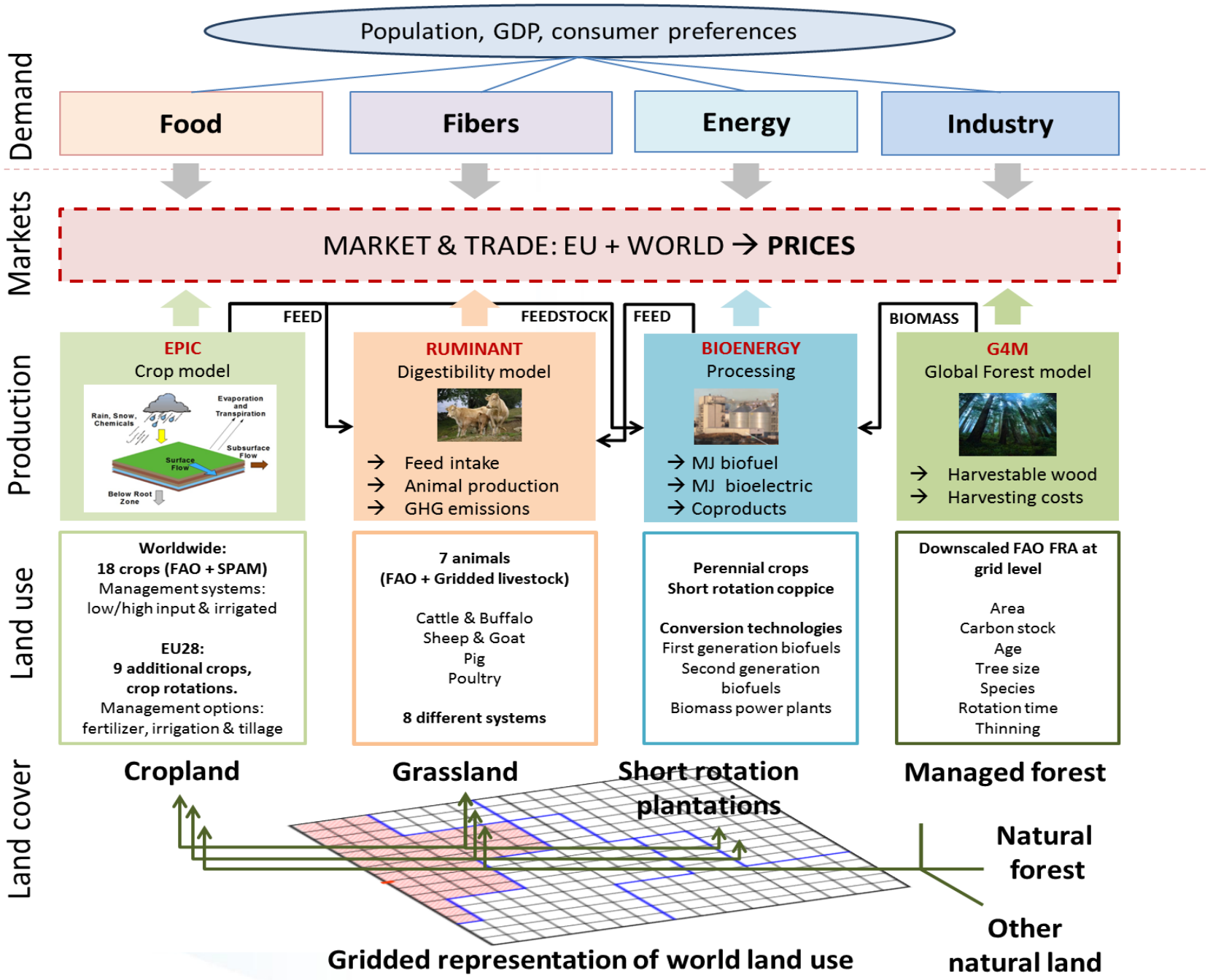


Crop yield developments projected as a function of GDP per capita
based on econometric estimation on 1980-2010, and 4 income group clusters.

Participatory scenarios in Southeast Asia

4 scenarios emerging from the stakeholder workshop:

- "***Land of the golden Mekong***"
  - Unification of Southeast Asia and strength and inclusiveness of governance, strong climate resilience
- "***Buffalo, buffalo; water flows uphill***"
  - Corruption scandals, high oil and food prices increases pressure on land, regional tensions, big plantations sector but large inequalities, huge environmental degradation
- "***The doreki dragon***"
  - ASEAN regional market, effective political focus on big business (agriculture industrialization), hugh urbanization, extreme environmental degradation, large inequalities.
- "***Tigers on the train***"
  - Increased regional cooperation and protectionism toward other economies, limited but effective investments in agriculture.


Population, GDP, consumer preferences
Demand
Food
Fibers
Energy
Industry
Markets
MARKET & TRADE: EU + WORLD → PRICES
Production
FEED
FEEDSTOCK
FEED
BIOMASS
EPIC
Crop model
Rain, Snow, Chemicals
Evaporation and Transpiration
Subsurface Flow
Surface Flow
Below Root Zone
RUMINANT
Digestibility model
→ Feed intake
→ Animal production
→ GHG emissions
BIOENERGY
Processing
→ MJ biofuel
→ MJ bioelectric
→ Coproducts
G4M
Global Forest model
→ Harvestable wood
→ Harvesting costs
Land use
Worldwide:
18 crops (FAO + SPAM)
Management systems:
low/high input & irrigated
EU28:
9 additional crops,
crop rotations.
Management options:
fertilizer, irrigation & tillage
7 animals
(FAO + Gridded livestock)
Cattle & Buffalo
Sheep & Goat
Pig
Poultry
8 different systems
Perennial crops
Short rotation coppice
Conversion technologies
First generation biofuels
Second generation biofuels
Biomass power plants
Downscaled FAO FRA at grid level
Area
Carbon stock
Age
Tree size
Species
Rotation time
Thinning
Land cover
Cropland
Grassland
Short rotation plantations
Managed forest
Natural forest
Other natural land
Gridded representation of world land use

GHG accounting in GLOBIOM

Sector	Source	GHG	Reference
Land use change	Deforestation	CO_2	FRA 2005 carbon in above ground and below ground living biomass downscaled at 0.5 degree (Kindermann et al. 2008)
	Conversion of other vegetation types	CO_2	Ruesch and Gibbs (2008)
Crops	Soil carbon changes	CO_2	EPIC model (Williams, 1995)
	Biomass carbon	CO_2	EPIC model (Williams, 1995)/IPCC
	Fertilizer application to soils	N_2O	Requirements from EPIC/IFA, emission coefficients from IPCC
	Rice production	CH_4	Average value per ha from FAO
Livestock	Enteric fermentation	CH_4	RUMINANT model (Herrero et al. 2008)/IPCC
	Manure management	N_2O, CH_4	RUMINANT model (Herrero et al. 2008)/IPCC
	Manure in pastures/cropland	N_2O	RUMINANT model (Herrero et al. 2008)/IPCC

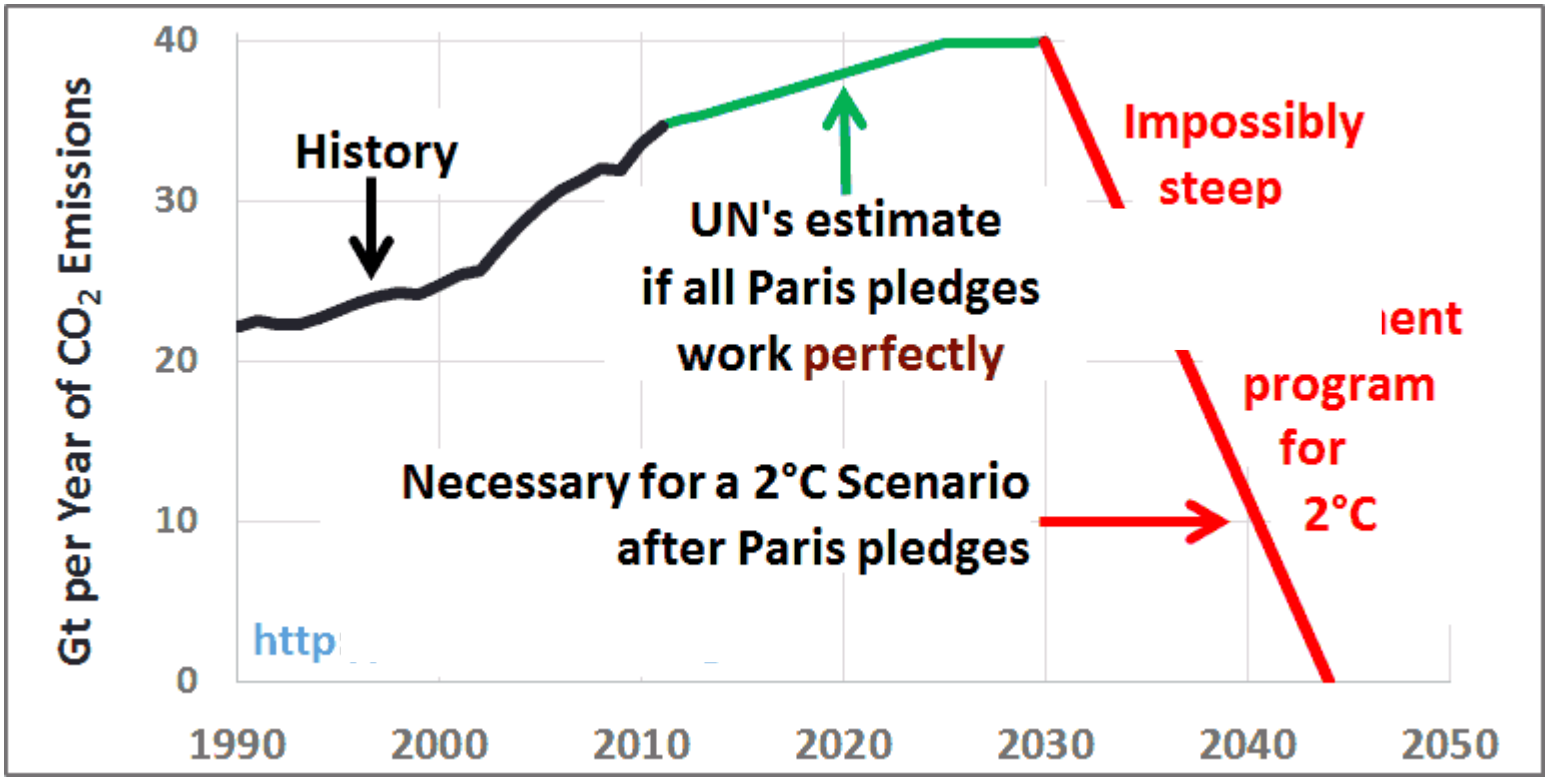
CO2 emissions

Non-CO2 emissions

Implications of climate stabilization at the global level

Results from Integrated Assessment Models (IAMs) incl. MESSAGE-GLOBIOM

Mitigation challenge

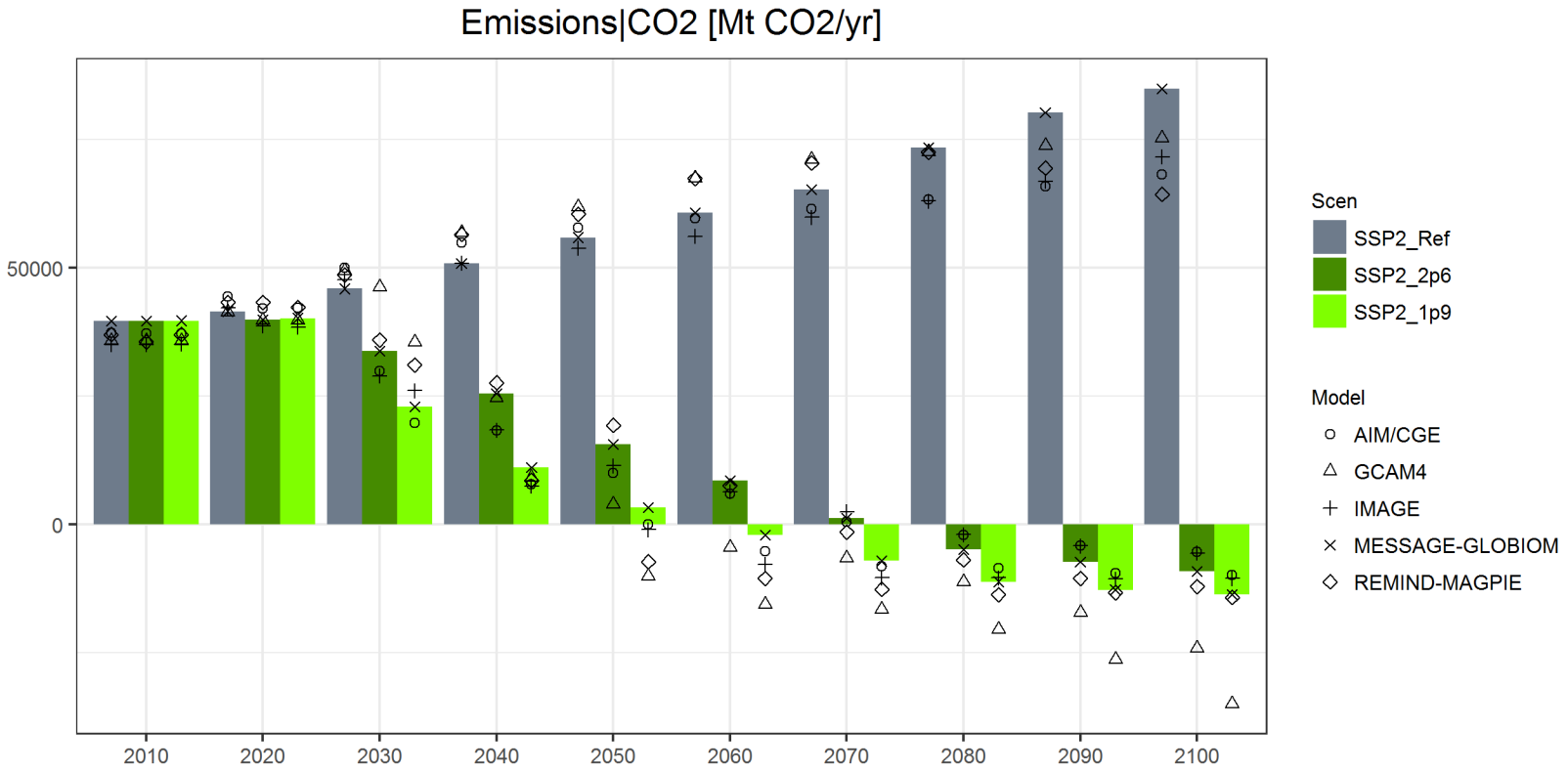


Carbon price used by IAMs to reach the stabilization by 2050:

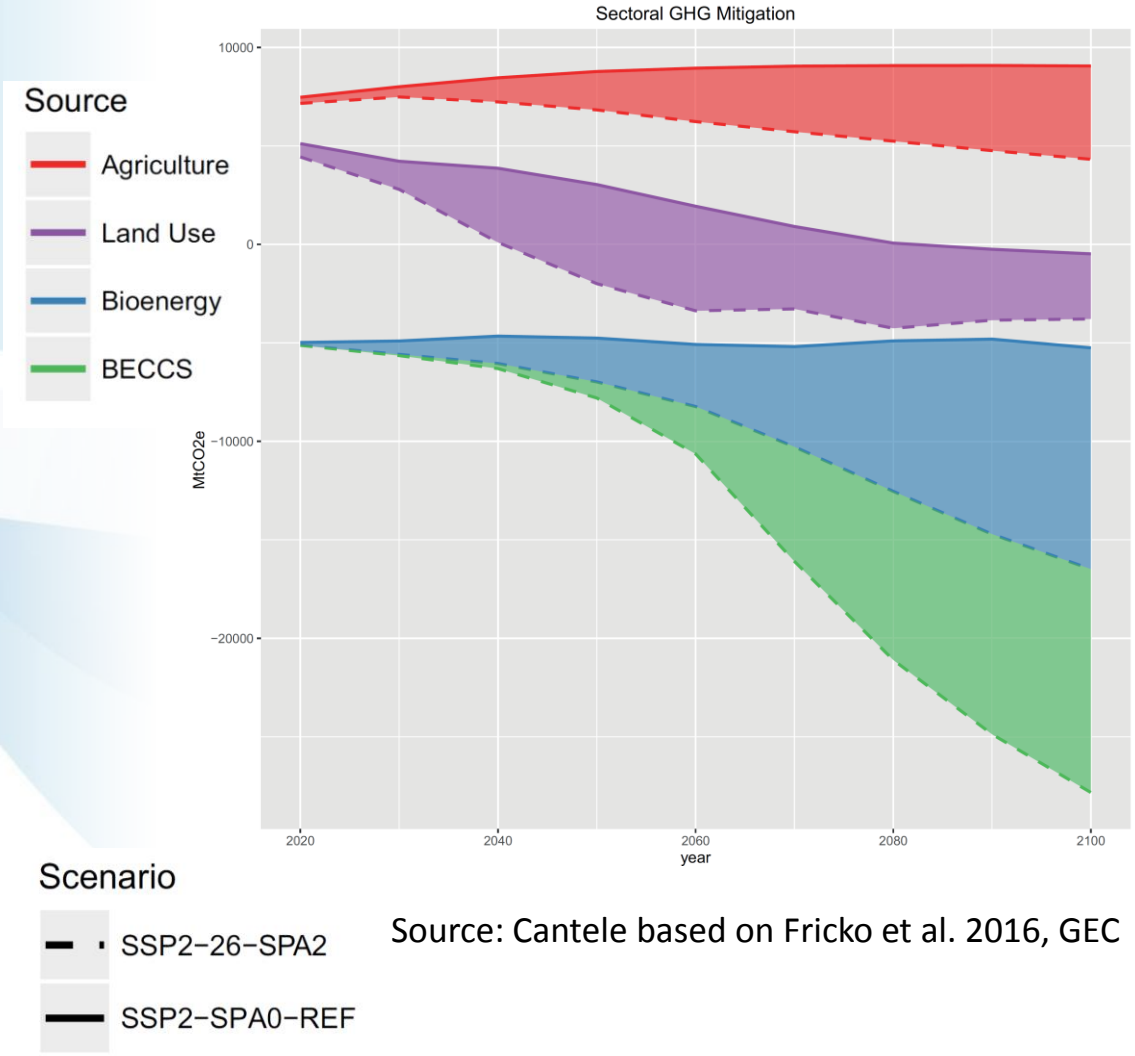
- 100$ for 2°C
- 400$ for 1.5°C

Climate stabilization well below 2 degrees

- Negative emissions necessary: Afforestation and BECCs
  - As of 2070 for 2°C while as of 2050 for 1.5°C
  - As of 2040 for land use CO2 emissions



Land use sectors contribution to mitigation



Source: Cantele based on Fricko et al. 2016, GEC

- Land use sectors provide 20 to 30% of total mitigation effort, 50% in 2020
- Agriculture non-CO2 emissions with stable share of 4 to 5%
- Land use decreasing share from 30 to 3%
- Bioenergy and BECCS 7 to 22%
- Large amount cropland to be dedicated to energy crops: 170 Mha for 2°C and 270 Mha for 1.5°C by 2050

Technical non-CO_2 mitigation options

GLOBIOM

Non-CO_2 mitigation mechanisms

- **Technical add-on options** (EPA; Beach et al., 2015)
  - Crops & livestock
  - Most recent EPA data

- **Structural adjustments in production** (Havlík et al., 2014)
  - Reallocation of production within a region
  - Transition of livestock and crop production systems
  - International trade

- **Demand adjustment** (Valin et al., 2015)
  - Consumers' response to price signals
  - Diet shifts (not considered in this study)

Technical non-CO_2 mitigation options - livestock

Mitigation option	Method
Increased animal productivity • Antibiotics • bST (bovine growth hormone)	Based on EPA global database on mitigation options • Costs in $/head • Emission reduction in %/head • Impact on productivity in %/head
Feed supplements to reduce enteric fermentation • propionate precursors • anti-methanogen vaccination	
Changes in herd management i.e. intensive grazing	
Anaerobic digesters • 13 different digesters	

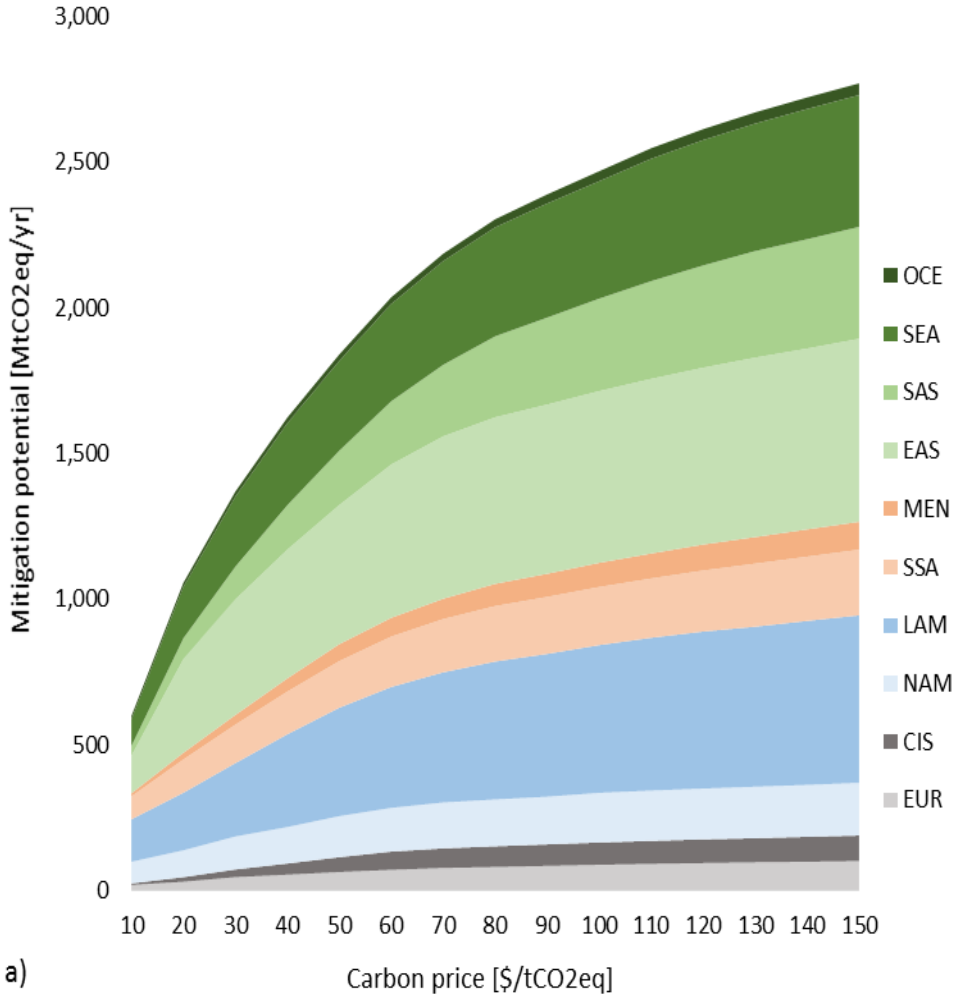
(EPA; Beach et al., 2015)

Technical non-CO2 mitigation options – crops

Mitigation option	Method
Improved fertilizer management • Nitrogen inhibitors • Split fertilization • Auto-fertilization • Adjusted fertilizer use	Based on EPA global database on mitigation options • Costs in $/ha • Emission reduction in %/ha • Impact on productivity in %/ha
Improved crop management • No tillage • Residue incorporation	
Improved rice management systems • Residue management • Fertilization • Water management	

(EPA; Beach et al., 2015)

Global non-CO2 MACC by region in 2050



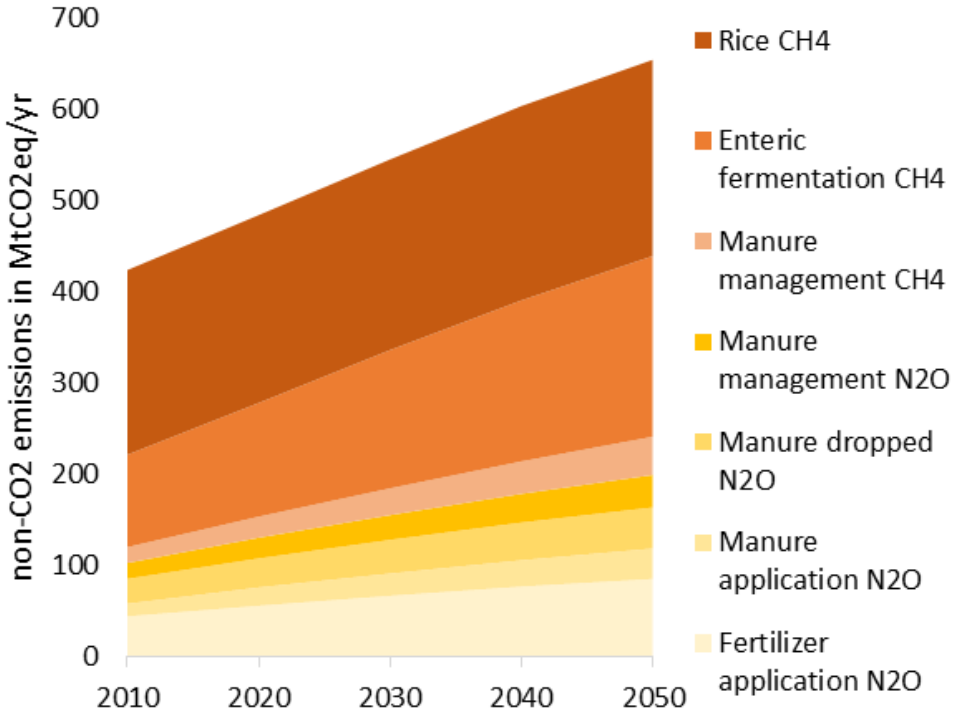
a)

- 2.5 GtCO2eq at 100$/tCO2eq
- 40% GHG reduction compared to baseline
- South East Asia accounts for 14% of global mitigation potential
- Developed regions contribute to much smaller extent due to limited importance as non-CO2 emitters by 2050

Note: SSP2 set-up

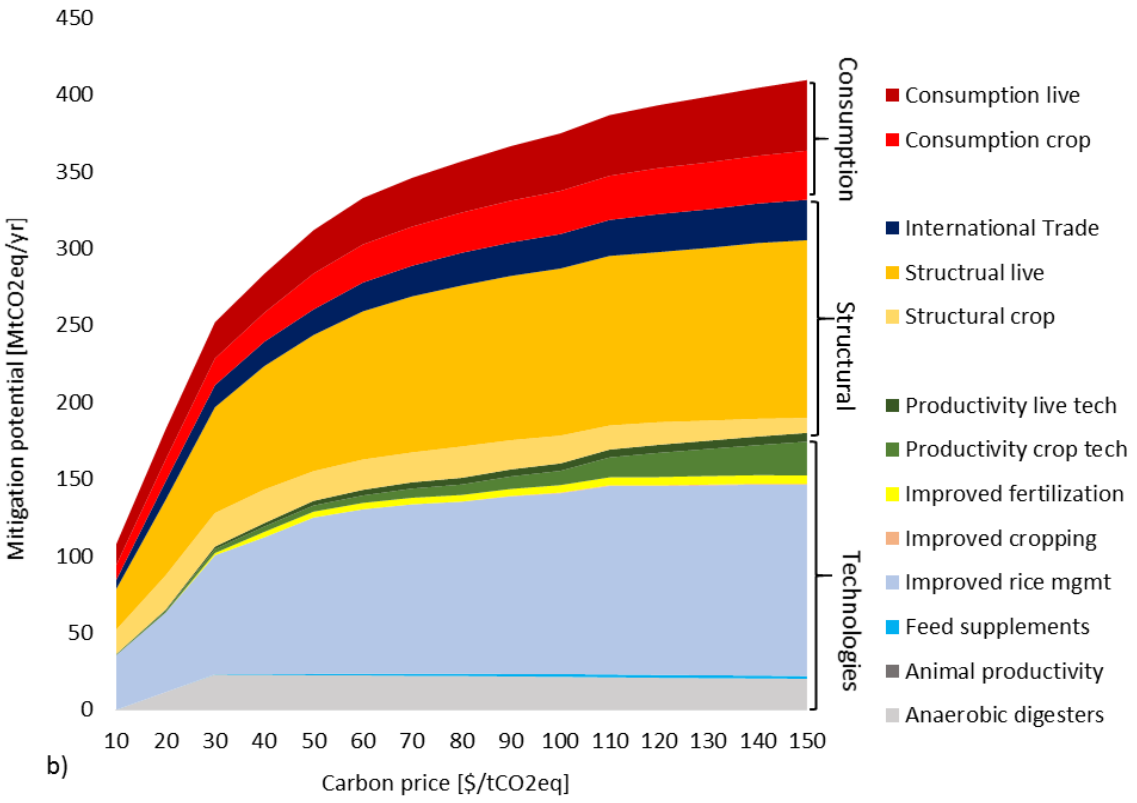
South East Asia – Baseline emissions

- In SSP2 scenario:
  - Population increase +25% by 2050
  - GDP per capita x4 by 2050
- Increasing and wealthier population drives demand for food
- Doubling of calorie intake from livestock products
- Emissions +55% in 2050 in BAU scenario

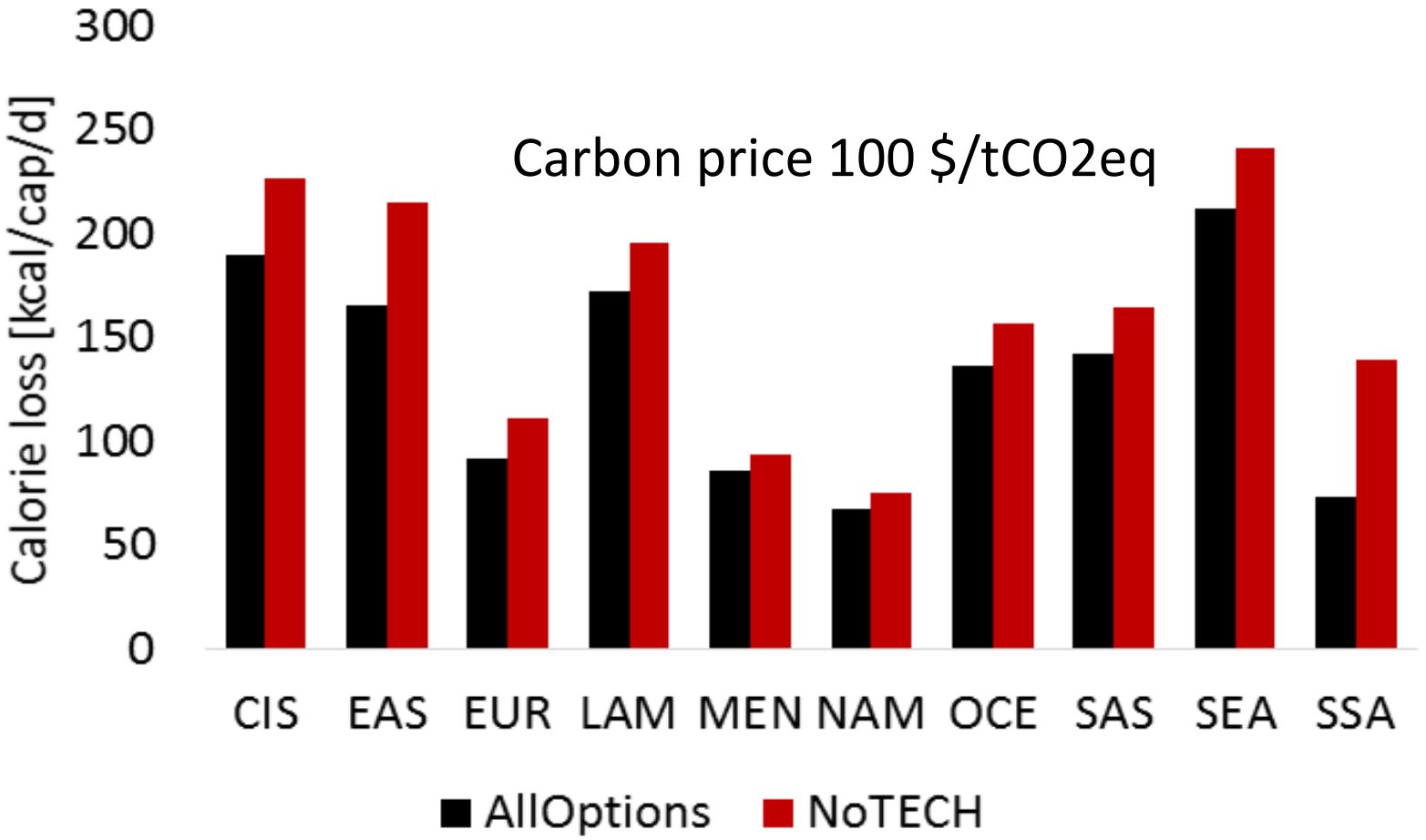


South East Asia – mitigation potential

- Mitigation of 40% at 150$/tCO2eq compared to BAU
- Related to:
  - Improved rice management e.g. reduced flooding of rice paddies
  - Livestock system transition
- **Co-benefits for land use change CO2 mitigation**



Impact on food availability



- Technological options help buffering impact on food availability

Conclusion

What is needed to build foresight analysis?

- To develop scenarios which are meaningful to the stakeholders of the country/region through interactions between modelers and stakeholders
- To maintain and share transparent and up-to-date statistics for population, agriculture, land cover/land use, and emissions factors with the modeling team
- To keep a critical view on model's results and send feedback to the modeling team about strange/inaccurate results
- To build internal capacity to use and further "tailor" models to the national context e.g. by providing modeling courses at university and in technical government bodies

Thank you for your attention

For more information:

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Rice production mitigation options

- Midseason drainage
- Continuous flooding
- Alternative wetting/drying
- Dry seeding
- Dryland rice
- 100% or 50% residue incorporation
- No-till
- Ammonium sulfate fertilizer
- Reduced fertilization 10%, 20% or 30%
- Optimal fertilization
- Nitrification inhibitors
- Slow release fertilizers

Beach et al. (2015)

Improved rice water management

Table 1 Relative mitigation potential (GHG emissions) of various water management practices as compared to traditional flooding in rice

Reference	Suggested practice	GHG	Mitigation potential[a] (%)
Yagi et al. (1996)	Intermittent irrigation	CH_4	38
Cai et al. (1997)	Mid-season drainage	CH_4	50
Corton et al. (2000)	Mid-season drainage	CH_4	43
Zheng et al. (2000)	Mid-season drainage	CH_4	36
Adhya et al. (2000)	Intermittent irrigation	CH_4	15
Yu et al. (2004)	No flooding (wet)	CH_4, N_2O	59
Minamikawa and Sakai (2005)	Mid-season drainage	CH_4	64
	Intermittent irrigation	CH_4	26
Towprayoon et al. (2005)	Mid-season drainage	CH_4, N_2O	27
	Multiple drainage	CH_4, N_2O	35
Zou et al. (2005)	Mid-season drainage	CH_4, N_2O	42
Hadi et al. (2010)	Intermittent irrigation	CH_4, N_2O	34
Tyagi et al. (2010)	Mid-season drainage	CH_4	37
	Multiple drainage	CH_4	41
Itoh et al. (2011)	Mid-season drainage	CH_4, N_2O	72
Yang et al. (2012)	Controlled irrigation	CH_4, N_2O	67
Katayanagi et al. (2012)	Alternate wetting and drying	CH_4	73
Pathak et al. (2012)	Mid-season drainage	CH_4, N_2O, CO_2	33
Hou et al. (2012)	Controlled irrigation	CH_4, N_2O	27
Feng et al. (2013)	Intermittent irrigation	CH_4, N_2O	54
Win et al. (2013)	Water saving irrigation	CH_4, N_2O	60

Hussain et al. (2015)