A Scenario Analysis of Global GHG Mitigation Policies on World Agriculture, as Countermeasure against Climate Change

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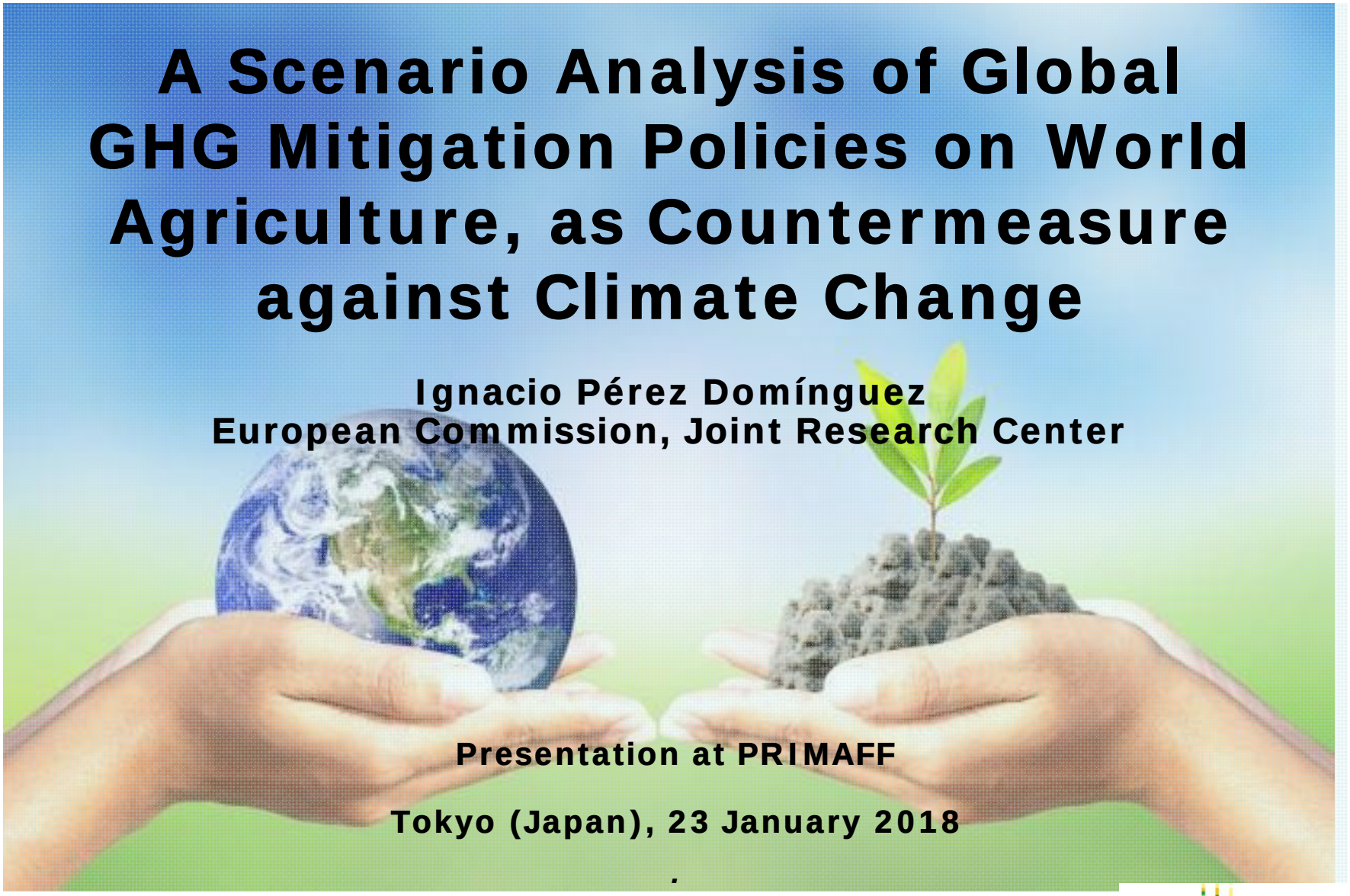

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Motivation

- The Paris Agreement was agreed in 2015 during the 21st Conference of Parties (COP21) to the United Nations Convention on Climate Change (UNFCCC).
- Its objective is to decelerate global warming well below 2 degrees Celsius compared to pre-industrial levels and pursue efforts to limit the temperature increase to 1.5 degree Celsius
- In order to achieve this goal, zero net anthropogenic greenhouse gas emissions should be reached during the second half of the 21st century.
- The Agreement will not become binding until 55 parties who produce over 55% of the world have ratified the Agreement.

Objectives of the Study

- The project *"Challenges of Global Agriculture in a Climate Change Context by 2050"(AGCLIM50)* assesses the impact of climate change on global agriculture by 2050.
- The main objectives of this project are:
  - To analyse the potential global impacts of climate change on agricultural supply, demand, prices and trade by 2050
  - To identify the potential of stringent mitigation policies (e.g. greenhouse gas emission taxes).
  - To combine in the analysis three important dimensions:
    - (a) different Shared Socio-Economic Pathways (SSPs)
    - (b) different climate change levels
    - (c) different mitigation efforts

Methods

- Five global multi-region multi-sector models were employed. This set of models includes one computable general equilibrium (CGE) model, three partial equilibrium (PE) models and one integrated assessment model.

Model	Institution	Type	Economy coverage	Agric. policies
MAGNET	Wageningen Economic Research, The Netherlands	CGE	Full economy	Price wedges, quota (adjusted from GTAP)
GLOBIOM	IIASA, Austria	PE	Agriculture, Forestry, Bioenergy	Implicitly assumed unchanged
MAgPIE	PIK, Germany	PE	Agriculture, Bioenergy, Water	Implicitly assumed unchanged
CAPRI	University of Bonn, Germany	PE	Agriculture	Explicitly represented
IMAGE	PBL, The Netherlands	IAM	Linked to MAGNET	See MAGNET, plus agricultural GHG mitigation based MACC curves

Scenario Assumptions

- Projection year: 2050
- Comparative-static analysis
- Three dimensions:
  - SSPs: prospective views about the world, including assumptions about macroeconomic developments and
  - Climate Change Effects: assessed through the potential effects on agricultural yields of different greenhouse gas emission trajectories
  - Global mitigation effort: assessed through the capacity of reversing climate effects through human action (i.e. path towards a low carbon economy)

Shared Socio-Economic Pathways (SSPs)

- SSPs were developed by the climate change research community to represent the socioeconomic dimension of the new climate scenarios

Climate Change Effects (I)

- A representative selection of climate change impact scenarios on crop yields was selected based on multiple combinations of results from General Circulation Models (GCMs) and Global Gridded Crop Growth Models (GGCMs) facing different climate change levels.
- Climate change is modelled as Representative Concentration Pathways (RCPs), which describe four possible climate futures, all of which are considered possible depending on how much greenhouse gases are emitted in the years to come
- The four RCPs (RCP2.6, RCP4.5, RCP6, and RCP8.5), are named after a possible range of radiative forcing values in the year 2100 relative to pre-industrial values (W/m2)

Climate Change Effects (II)

- In our study RCP6.0 was used to model pure climate change impacts (global warming up to 3ºC) and RCP2.6 for mitigation (global warming below 2ºC).
- Yield shocks from the GGCMs were aggregated at country level for the economic models
- No CO2 fertilization assumed *(although available)*

GCM name*	Reference
HADGEM2-ES	Jones et al. 2011
IPSL-CM5A-LR	Dufresne et al. 2013
MIROC-ESM-CHEM	Watanabe et al. 2011
GFDL-ESM2M	Dunne et al. 2013a; Dunne et al. 2013b
NorESM1-M	Bentsen et al. 2013; Iversen et al. 2013

GGCM name*	Reference
LPJmL	Bondeau et al. 2007
pDSSAT	Jones et al. 2003; Elliott et al. 2014

Mitigation Policies

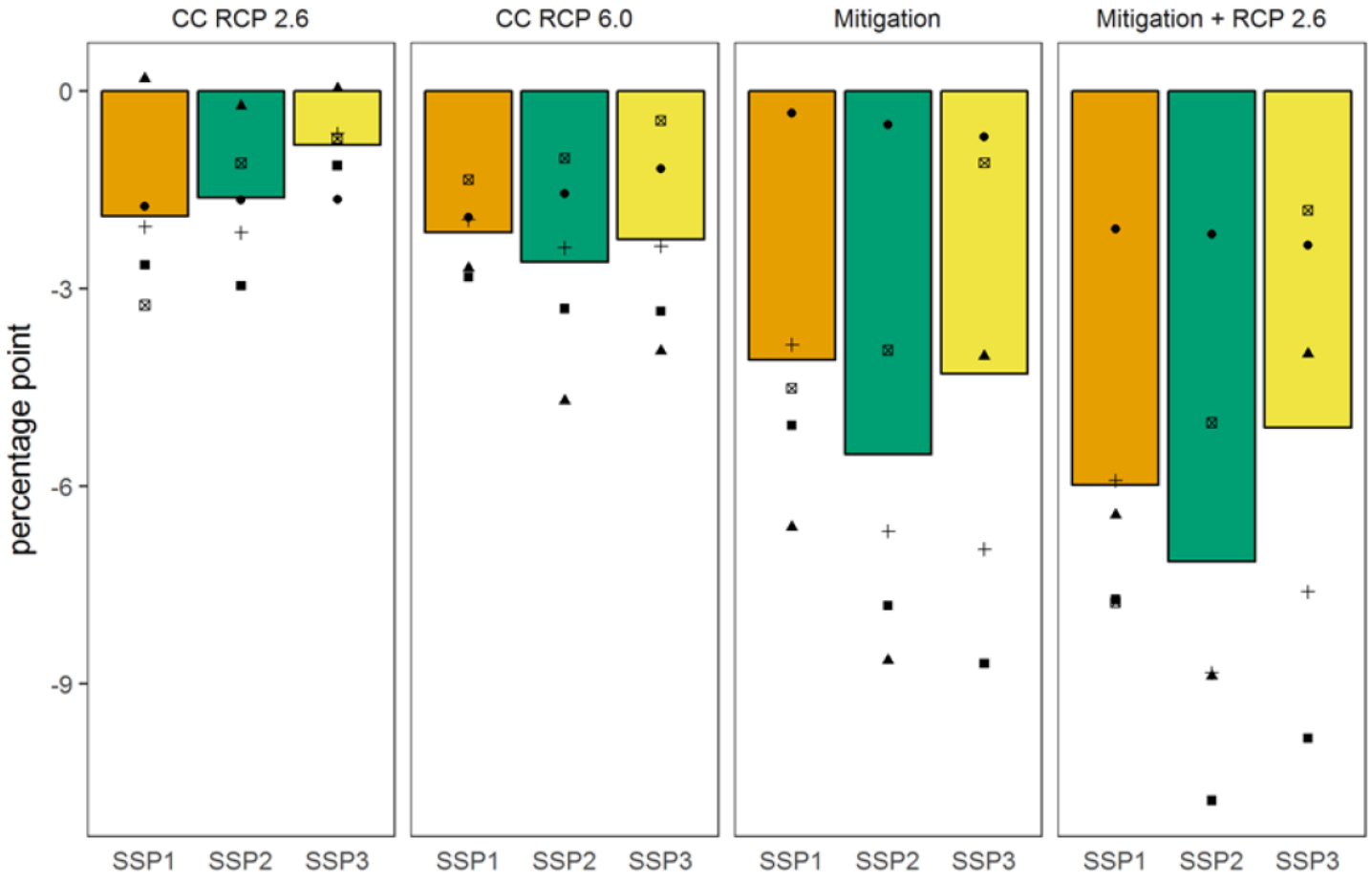
- Mitigation is defined as the necessary de-intensification of carbon emissions to achieve a 2 degree climate target
- It is generally addressed through a global greenhouse gas emission tax (i.e. typically called 'carbon tax') covering livestock and crop activities emitting non-CO2 emissions (i.e. methane and nitrous oxide)
- In order to assess the relative important of mitigation efforts and climate change, mitigation is assessed in two ways:
  - With residual climate impact effects (i.e. yield changes corresponding to an RCP2.6 climate scenario by 2050)
  - Without residual climate impact effects (i.e. no yield changes due to climate change by 2050)

Resulting Scenarios

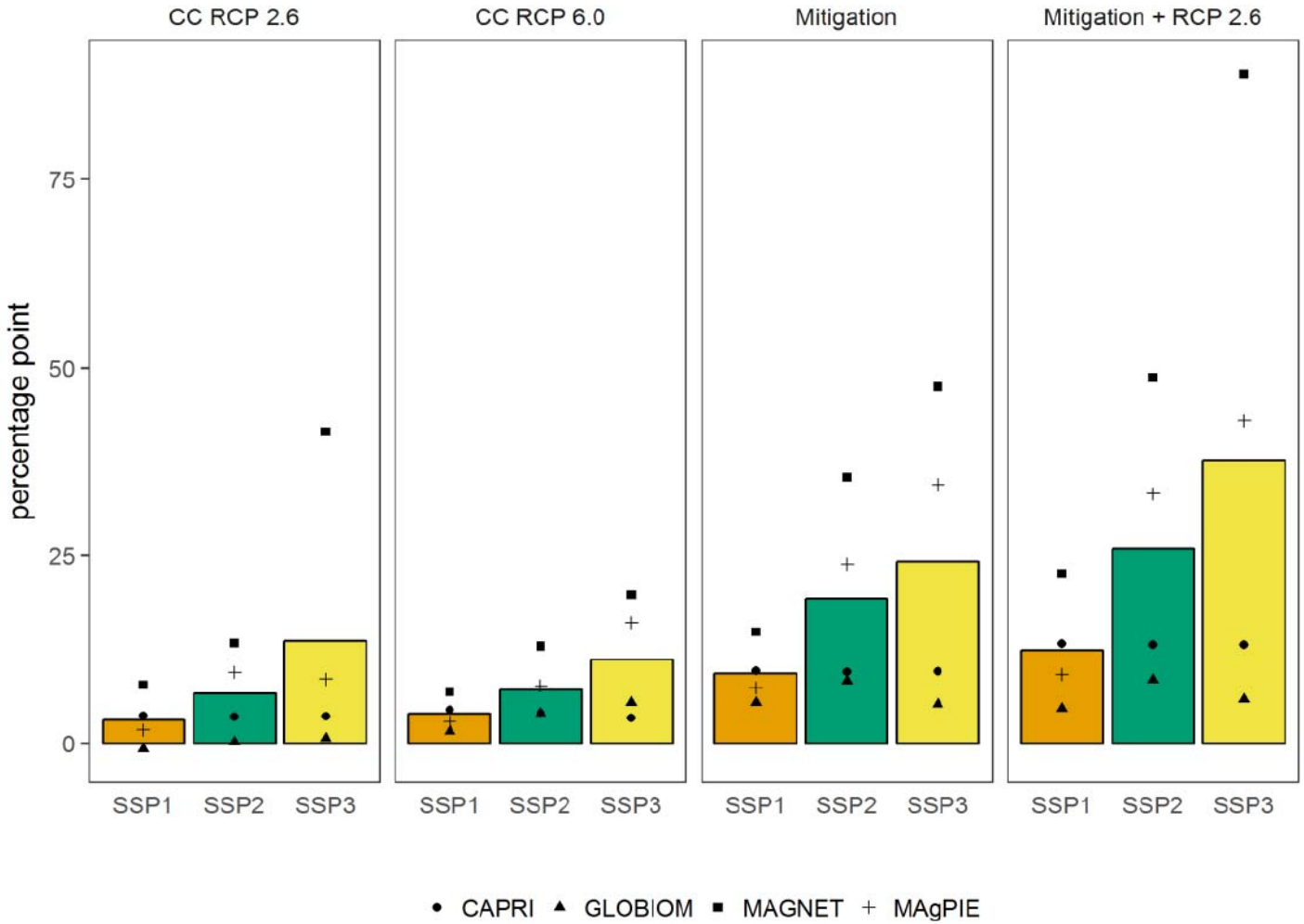
	Climate	Focus	SSP1 'Sustainability'	SSP2 'Middle of the Road'	SSP3 'Fragmentation'
			Adaptation challenge: low	Adaptation challenge: medium	Adaptation challenge: high
A	NoCC	No climate change	SSP1_NoCC	SSP2_NoCC	SSP3_NoCC
B	RCP6.0*	Climate change impacts	SSP1_CC6	SSP2_CC6	SSP3_CC6
C	NoCC	Mitigation measures for 2°C stabilization without residual climate change impacts	SSP1_NoCC_m	SSP2_NoCC_m	SSP3_NoCC_m
D	RCP2.6*	Mitigation measures for 2°C stabilization + residual climate change impacts	SSP1_CC26_m	SSP2_CC26_m	SSP3_CC26_m

* Based on a scenario with median climate impacts (across different crop model/climate model combinations) with no CO2 fertilization

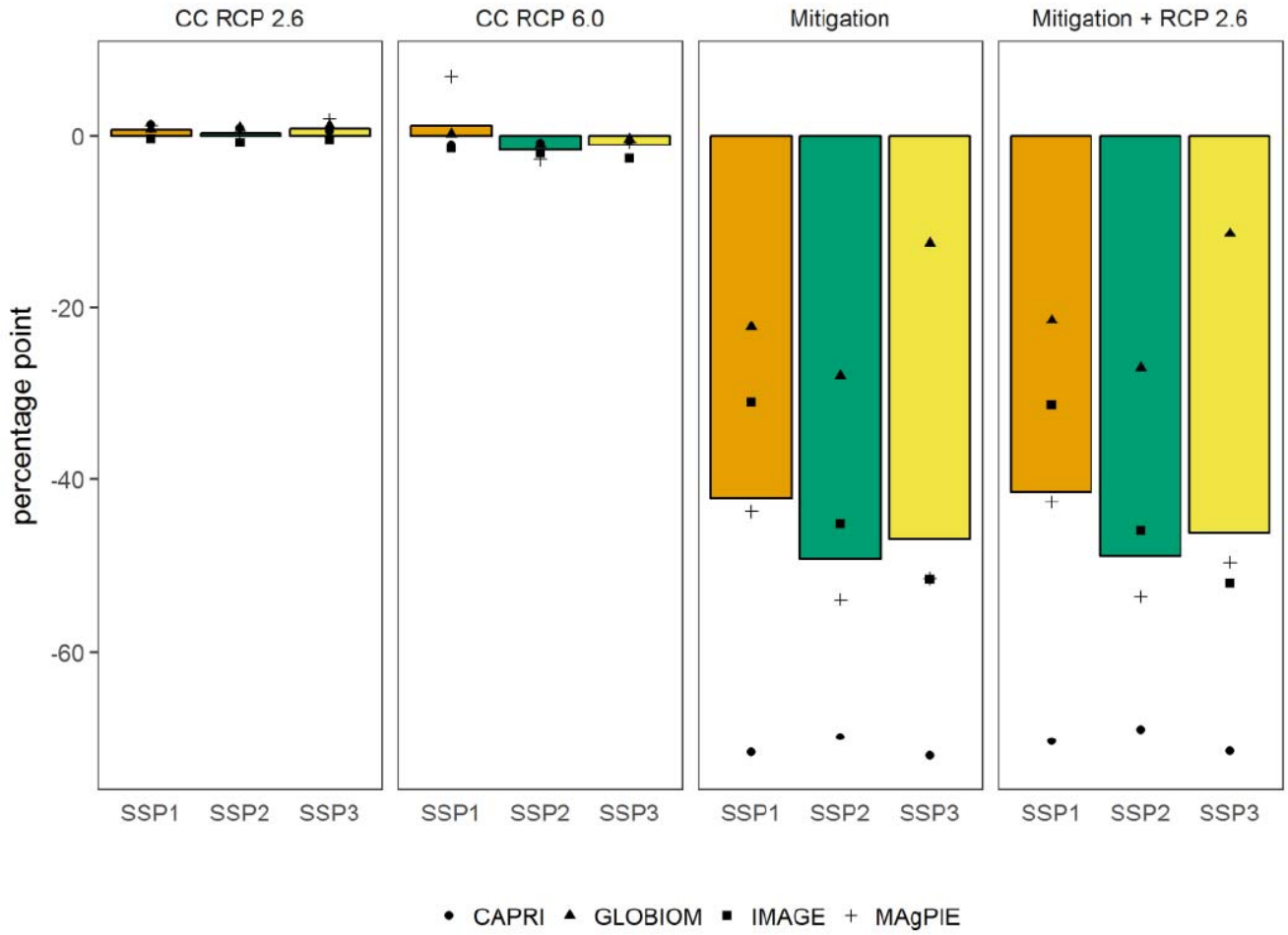
Results: global agricultural production



Results: producer prices of Ag. commodities



Results: greenhouse gas emissions (methane and nitrous oxide)



Summary findings (I)

- Already by 2050, climate change may start to have limited but noticeable impacts on agricultural yields (yield increases are 2.5% lower than without climate change, as a global average across the models applied in the study)
- If impacts of climate change on crop yields are limited and the assumptions behind the socioeconomic pathways used in the modelling hold, then the impact of mitigation policies on global production (i.e. more limited increase) and prices (i.e. higher increase) could actually be more important than the negative climate change impacts by 2050. However, this is partially due to the limited impact of the climate scenarios by 2050.

Summary findings (II)

- Climate mitigation policies designed to achieve a 2ºC target by the end of the century - such as carbon pricing - are likely to have a higher negative impact on livestock than crop production (i.e. higher carbon footprint).
- Up to 2050, demand for agricultural production will be more influenced by population and dietary choices than by economic growth.
- The study focuses only on global impacts and in-depth analysis is necessary to identify regional vulnerabilities, and to help specify adaptation and mitigation strategies for regional agricultural sectors.
- Sustainable agriculture features prominently in the climate commitments

European Commission

Thank you for your attention

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Annex: Towards a 1.5 Degree World

- Limiting global warming to 1.5ºC by the end of the century implies very stringent mitigation policies
- Livestock sector and ruminants in particular will be vital to achieve a consistent level of emission reductions, mainly through technologies that reduce emissions directly or structural changes that target livestock productivity.
- With increasing levels of mitigation efforts, model results show a trade-off with food production once the cost-effective mitigation option portfolio is exhausted.
- Agricultural mitigation efforts should be accompanied by supporting policies that enable the widespread adoption of low cost mitigation options across regions