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Climate-induced Change in Crop Yields:

A General Equilibrium Analysis of Macroeconomic Impacts and Costs & Benefits of Adaptation

Miles Perry,
European Commission, Institute for Prospective Technological Studies

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Presentation Overview

- **Climate change impacts & CGE models**
  - **Multisector Analysis**
- **From impacts to adaptation: focus on agriculture**
  - **Moving into Adaptation**
  - **Preliminary Results**
  - **Caveats & Next Steps**

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Multisector Climate Change Impact Analysis

- **IPTS has been involved in several climate impact projects as economic analyst**

ClimateCost
PESETA

Climate Models
[run by climate scientists]

Sector-specific Impacts
[performed by sector specialists]

e.g.
River floods Crop yields
Sea-level Rise Human Health

Economic Analysis
[by IPTS]

Sectoral impacts used as shocks to macroeconomic (CGE) model

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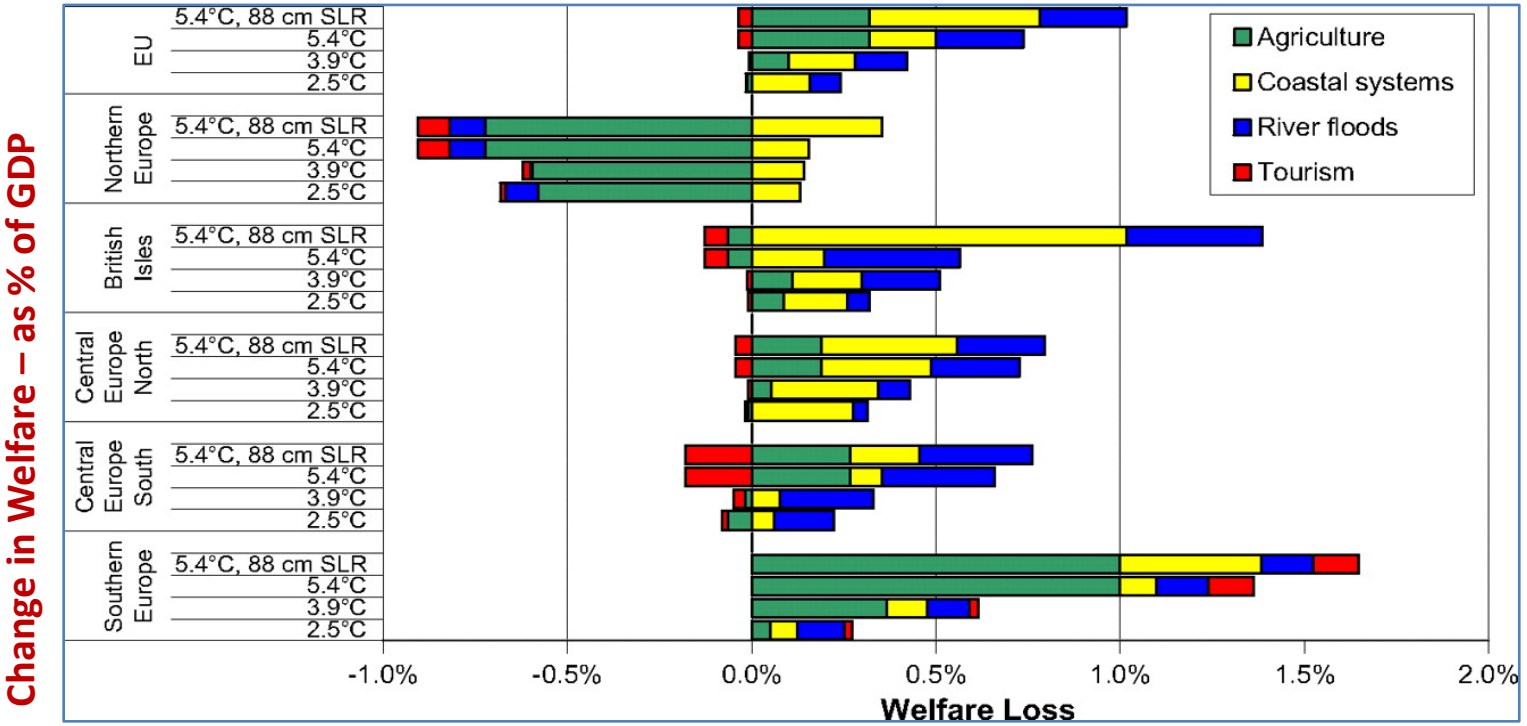
Multisectoral CGE enables joint analysis of different impacts



Source: Results of PESETA project

Advantages:

- **Places a (speculative) monetary value on climate change damages**
- **Provides a common framework for comparing different effects**
  e.g. how to compare yield loss, floods etc.?

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Adaptation

IPTS continues to perform climate impact analysis

PESETA2 report coming soon
feat. forest fires, tourism, human health, energy

BUT WHAT ABOUT ADAPTATION?

- **By how much does adaptation reduce damages?**
- **How much does adaptation cost?**
- **& when is adaptation cost effective?**

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Modifying CGE Model for Adaptation

Crop yield changes with & without adaptation
were produced by Universidad Politécnica de Madrid*
as part of the PESETA project

without Adaptation:

farmers employ only costless adaptations to climate change (e.g. planting dates)

with Adaptation:

farmers adjust irrigation &/or fertiliser application as required by new climate

* Yield changes derived from 2080 climate scenario & DSSAT-based crop modelling
See Iglesias A *et al.* (2011) Adapting Agriculture to Climate Change. *Economía Agraria y Recursos Naturales* 11 2

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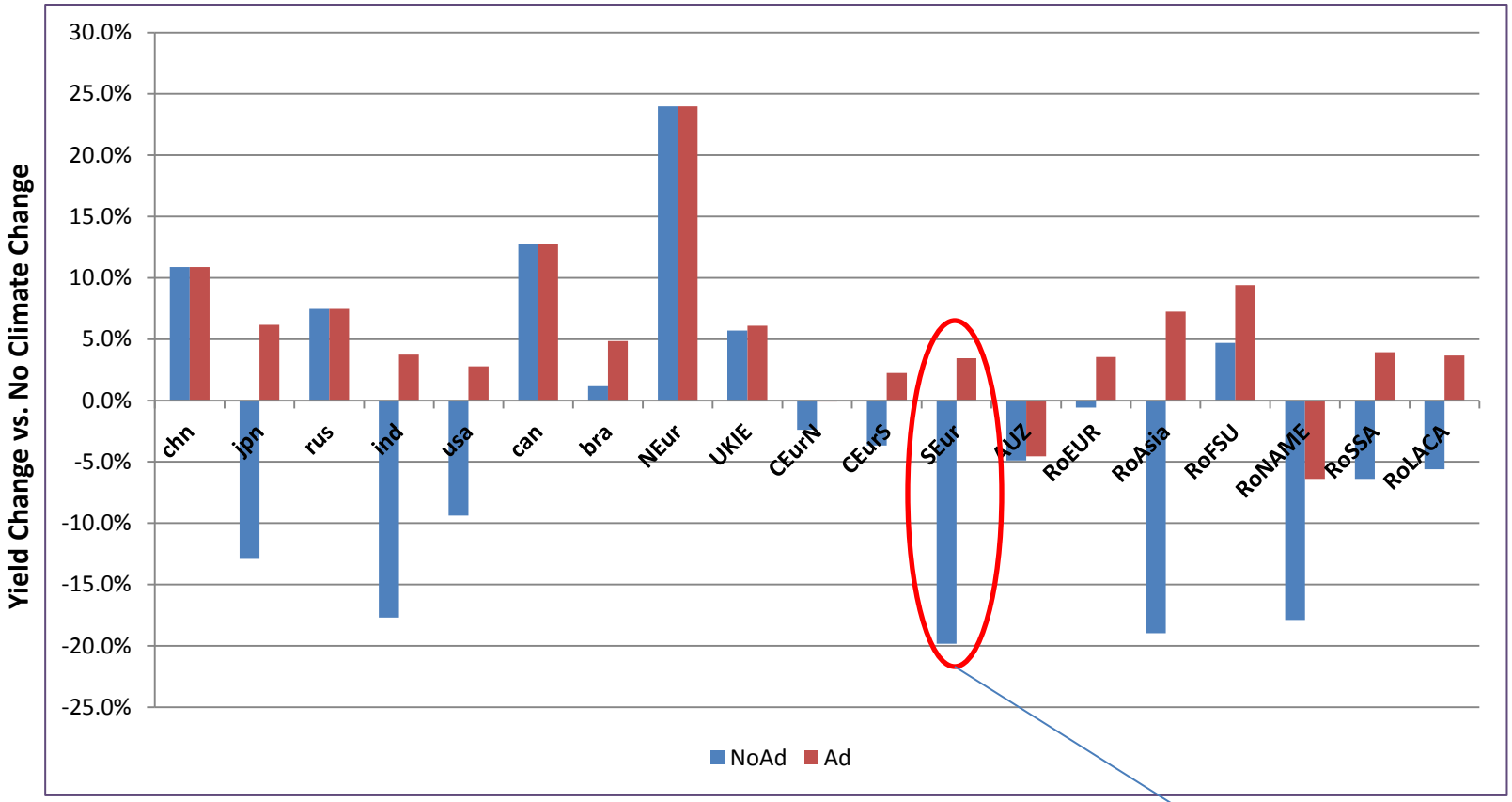
Crop Yields with/without Adaptation



Adaptation consists of
Irrigation &/or Additional Fertiliser
Provided sustainability conditions allow

Other CGE Model Changes

- **Climate Change affects crop yields**
  as per previous slide
- **Cost of Irrigation estimated**
  as an increase in capital requirement
- **Physical Limit on Irrigation imposed**
  Irrigation can expand up to "severe water stress" threshold
- **Allow endogenous technology choice**
  Options are Adapt (and pay for it) vs. Don't Adapt

Rationale: estimate cost & benefit of adaptation then let model decide

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Illustration of Adaptation Choice

No Climate Change – only one technology available

Input Costs		Output Value	
Fertiliser	€5		
Irrigation	€5		
Other	€5		
Total Cost	***€15***	***Total Output***	***€15***

Unit Cost = (€15 / € 15) = 1

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Illustration of Adaptation Choice II

With Climate Change – model chooses Adaptation provided it is cost effective

No Adaptation

Input Costs		Output Value
Fertiliser	€5	
Irrigation	€5	
Other	€5	
Total Cost	***€15***	***Total Output*** ***€12***

Adaptation

Input Costs		Output Value
Fertiliser	€7	
Irrigation	€7	
Other	€5	
Total Cost	***€19***	***Total Output*** ***€16***

~~Unit Cost = (€15 / € 15) = 1~~

Unit Cost = (€15 / € 12) = 1.25

Unit Cost = (€19 / € 16) = 1.19

In this illustration:

- **Climate change increases unit cost**
- **But cost increase is lower with Adaptation technology**
- **Therefore chooses Adaptation**

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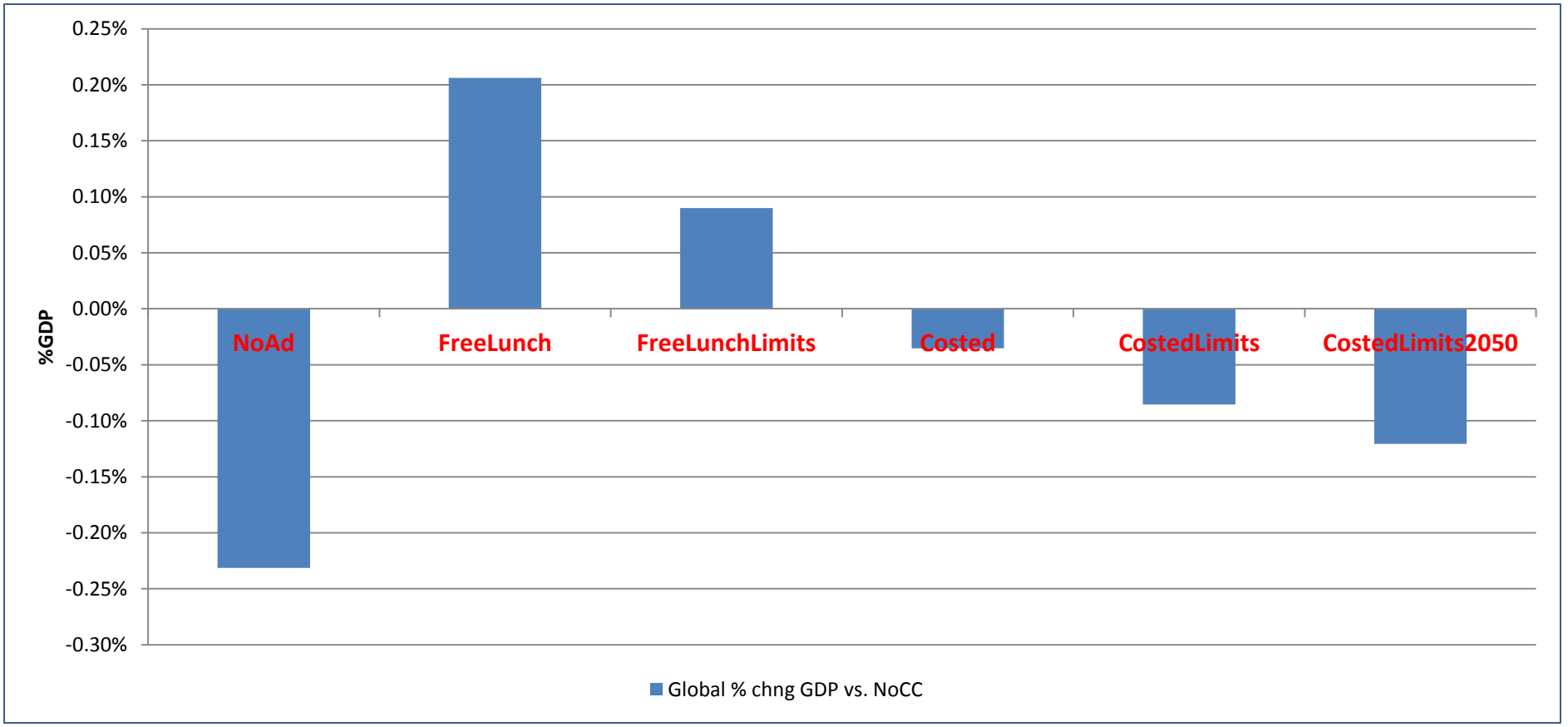
Results – 2080 Climate, Comparative Static Analysis



Adaptation can reduce damages substantially

But

Attention must be paid to the costs & limits of adaptation options

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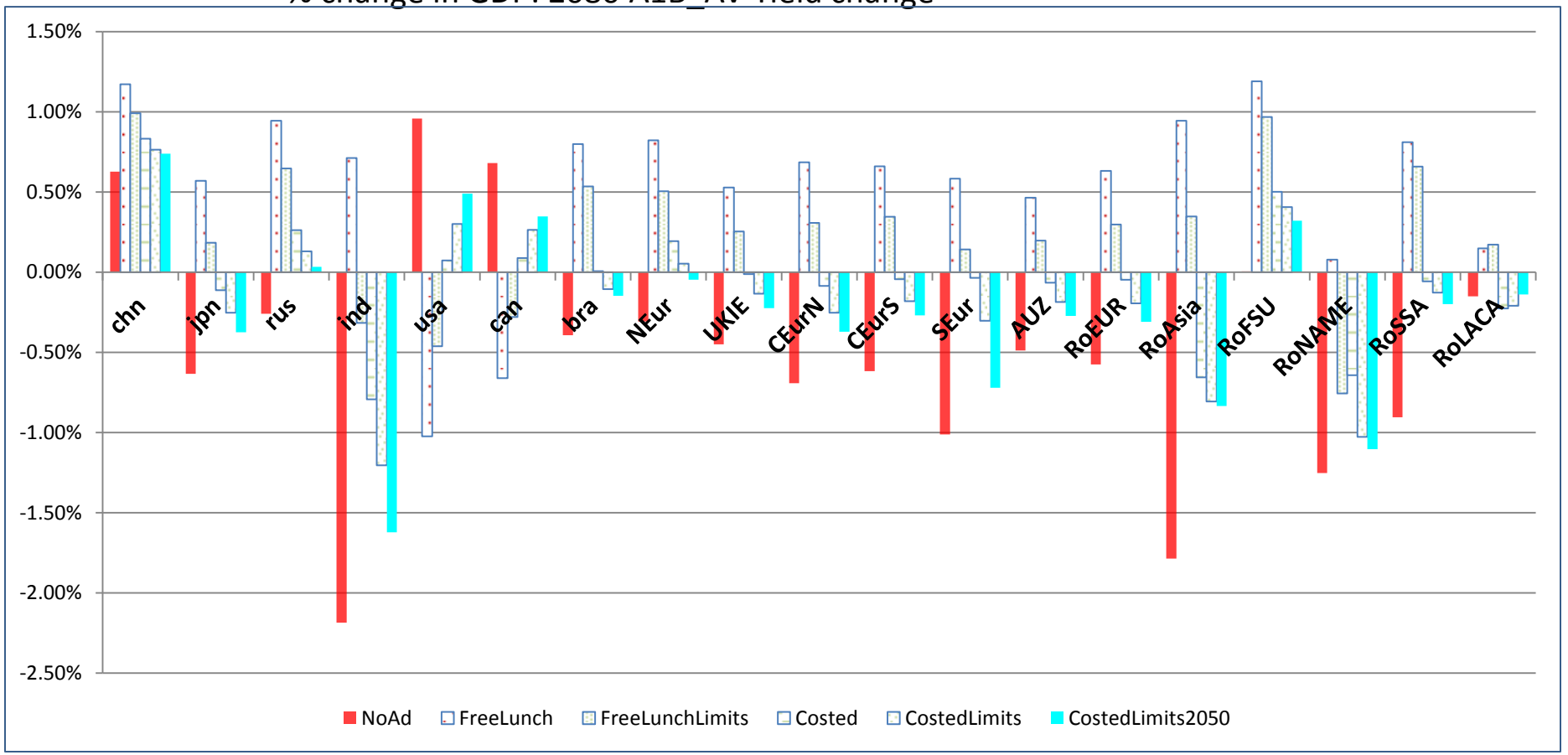
Results – by region



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Results Summary

When 2080 climate is imposed on today's economy…

- No Adaptation: Global GDP loss equivalent to around 0.2% of GDP.
  - >1% in India, Southern Europe, Asia, North Africa.

- "Free" adaptation gives global *gain* of 0.2% of GDP
  - but net result negative once cost & sustainability limits considered (-0.1% GDP)

- Results allow comparison of capital cost with and without adaptation

  - Adaptation sends $10bn additional capital (net) to agriculture sector

  - $0.5bn in sub-Saharan Africa, $2bn in India, $9bn in Rest of Asia (excl. China)

  - Some regions require less capital as adaptation shifts global production (China, Russia, Canada)

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Limitations and next steps

- Costs and sustainability limits are speculative at this stage
- Analysis is comparative static – need to switch to dynamic economic model
- Need to move to multiple sectors (not just agriculture)

  data requirements considerable

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Agriculture Data II
Sustainability Conditions

Condition	Action	Effect on Crop Productivity
rainfall index >800	**Irrigation** – increase in the **total** amount of water to compensate potential yield reduction	Potential negative impacts are **completely compensated**
600 < rainfall index < 800 AND Irrigation infrastructure and technology already developed	**Irrigation** – increase in **half** of the amount of water to compensate potential yield reduction	Potential negative impacts are **compensated by one half**
Rainfall index < 600 OR irrigation and water management systems are already developed	**Irrigation** – no further increase in water for irrigation	Potential negative impacts are **not compensated**
Countries with low environmental protection standards	**Fertiliser** – increase in total N fertiliser application	Potential negative impacts are **compensated by 50%**
Countries with high environmental protection standards	**Fertiliser** – no increase in total N fertiliser application	Potential negative impacts are **not compensated**