JIRCAS – NARO SYMPOSIUM

Agriculture and climate change: from challenges to solutions

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Two Goals of Our Time

1. **Achieving Food Security**

   – 800 million chronically undernourished

   – Food production to increase 50-70% by 2050

   – Adaptation to climate change is critical

2. **Avoiding Dangerous Climate Change**

   - The ’ 2°C railguard ’ requires major emission cuts

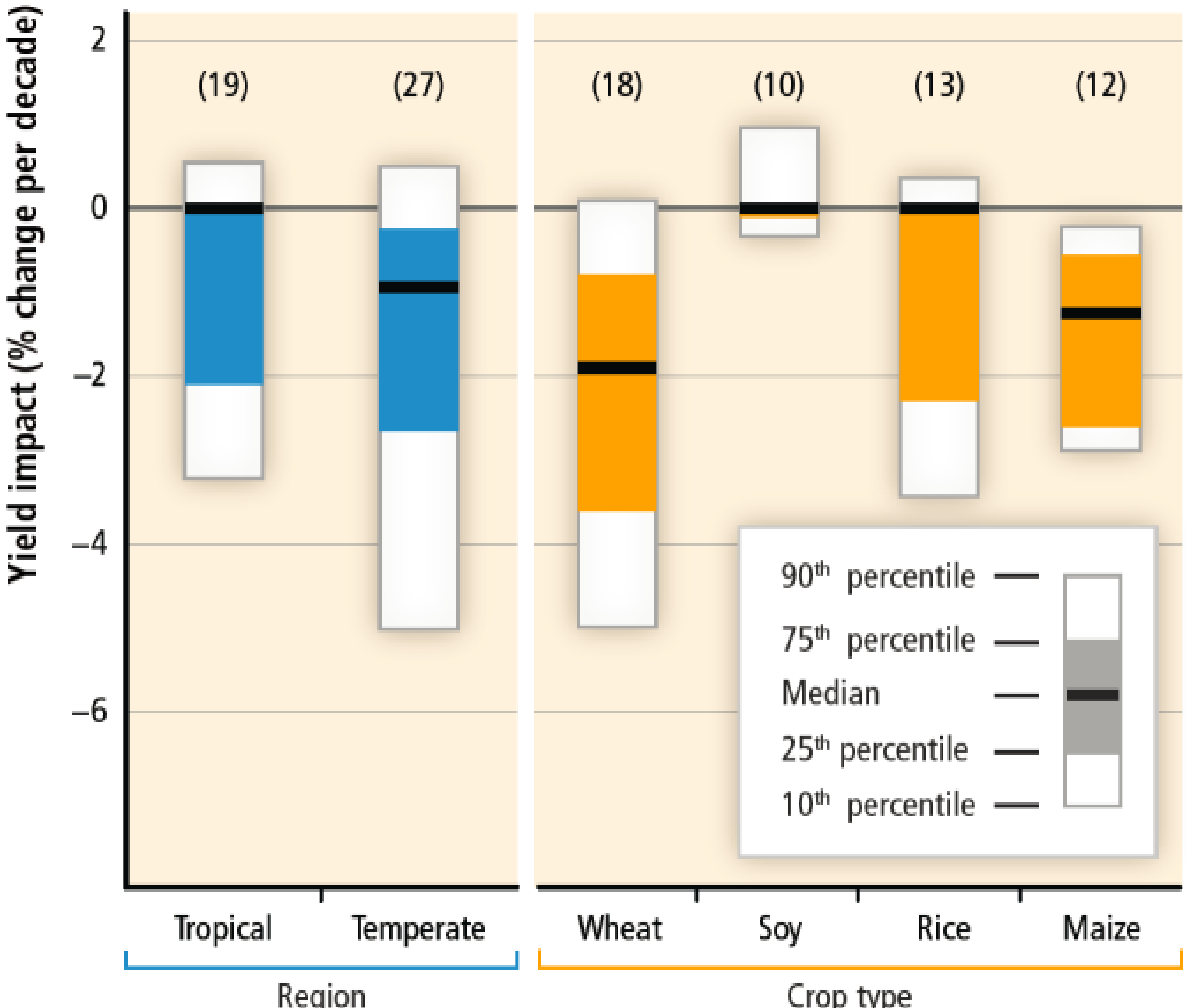
   - Agriculture and land use contribute to 24% of GHG emissions…

   …and need to be part of the solution

CLIMATE CHANGE IMPACTS

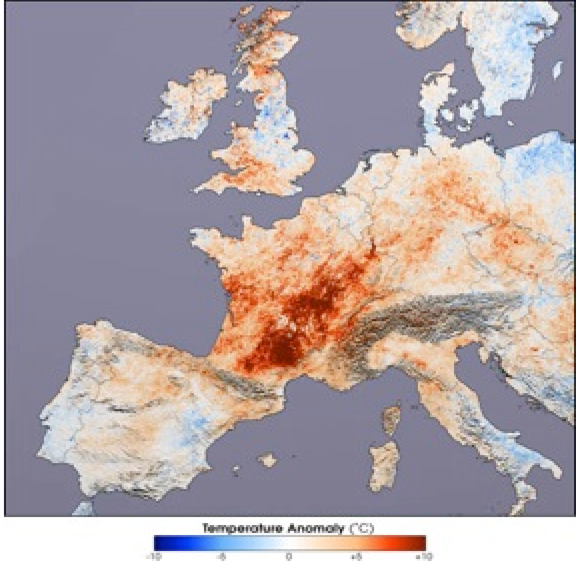
ipcc
INTERGOVERNMENTAL PANEL ON climate change

Observed impacts on crop yields (% per decade)



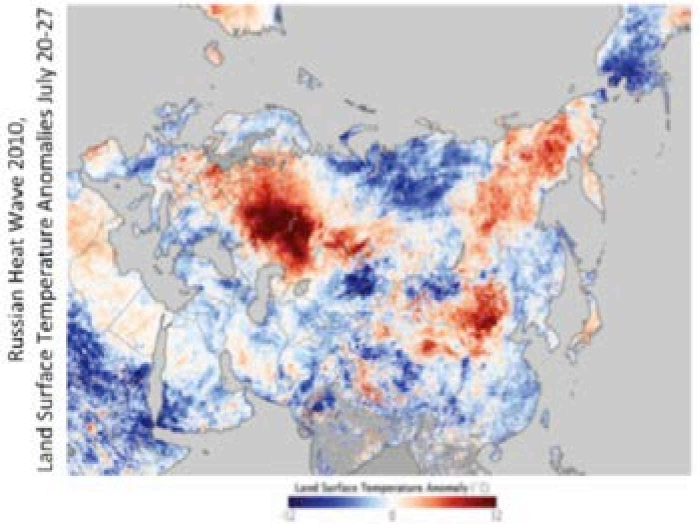
INTERGOVERNMENTAL PANEL ON climate change

Extreme climatic events since 2000: heat and drought

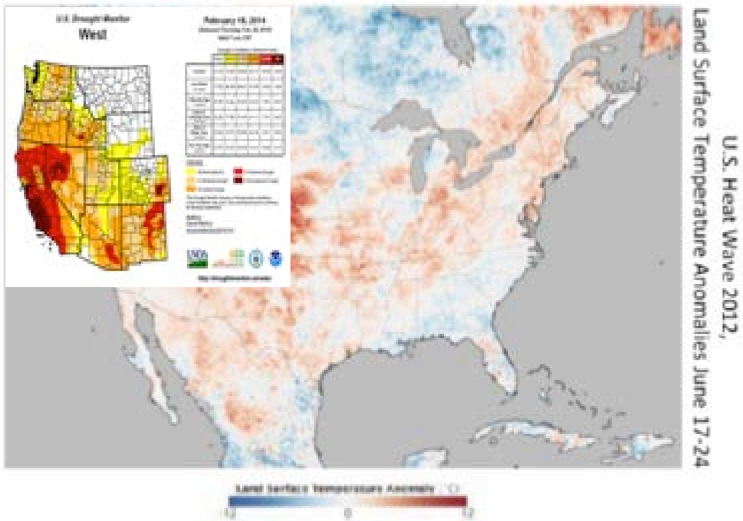


Summer 2003 Europe
(no equivalent since 1500)

Summer 2010 Russia
(no equivalent since 1500)



Summer 2012 USA



Source: NASA Earth Observatory 2012.

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Climate impacts on world food prices

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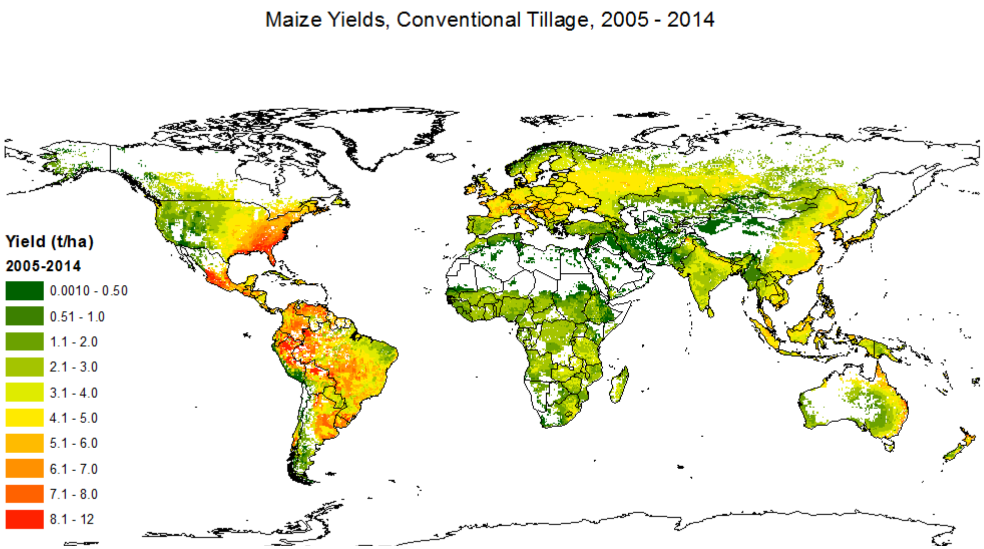
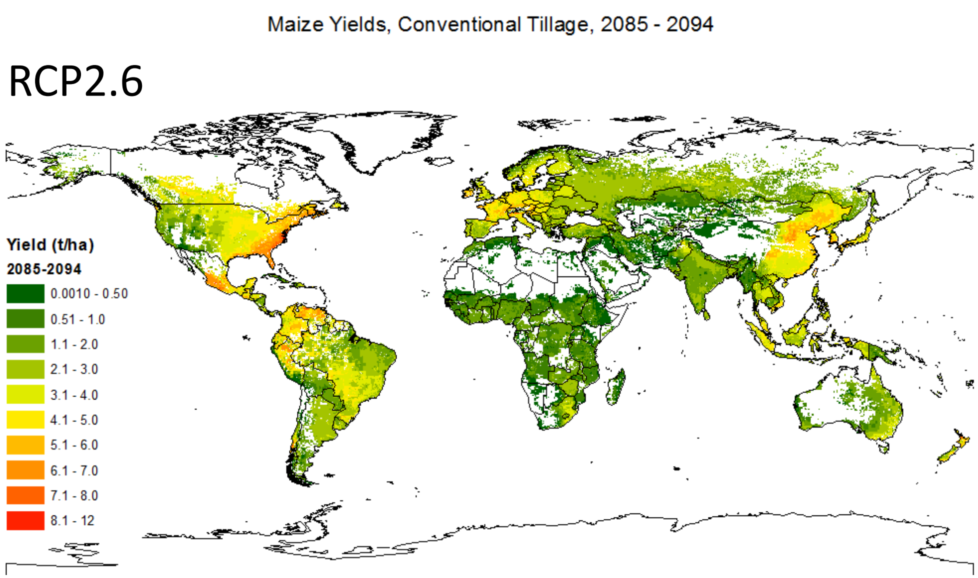
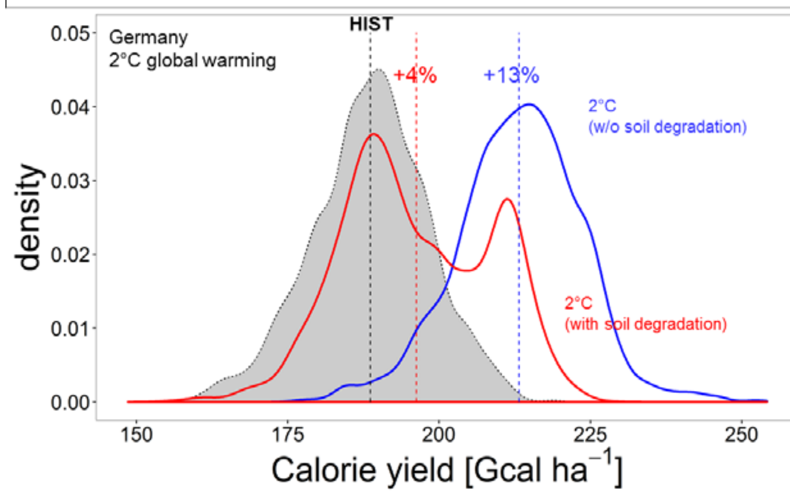
INTERGOVERNMENTAL PANEL ON climate change

Yields are increasingly impaired by combination of soil degradation and climate change



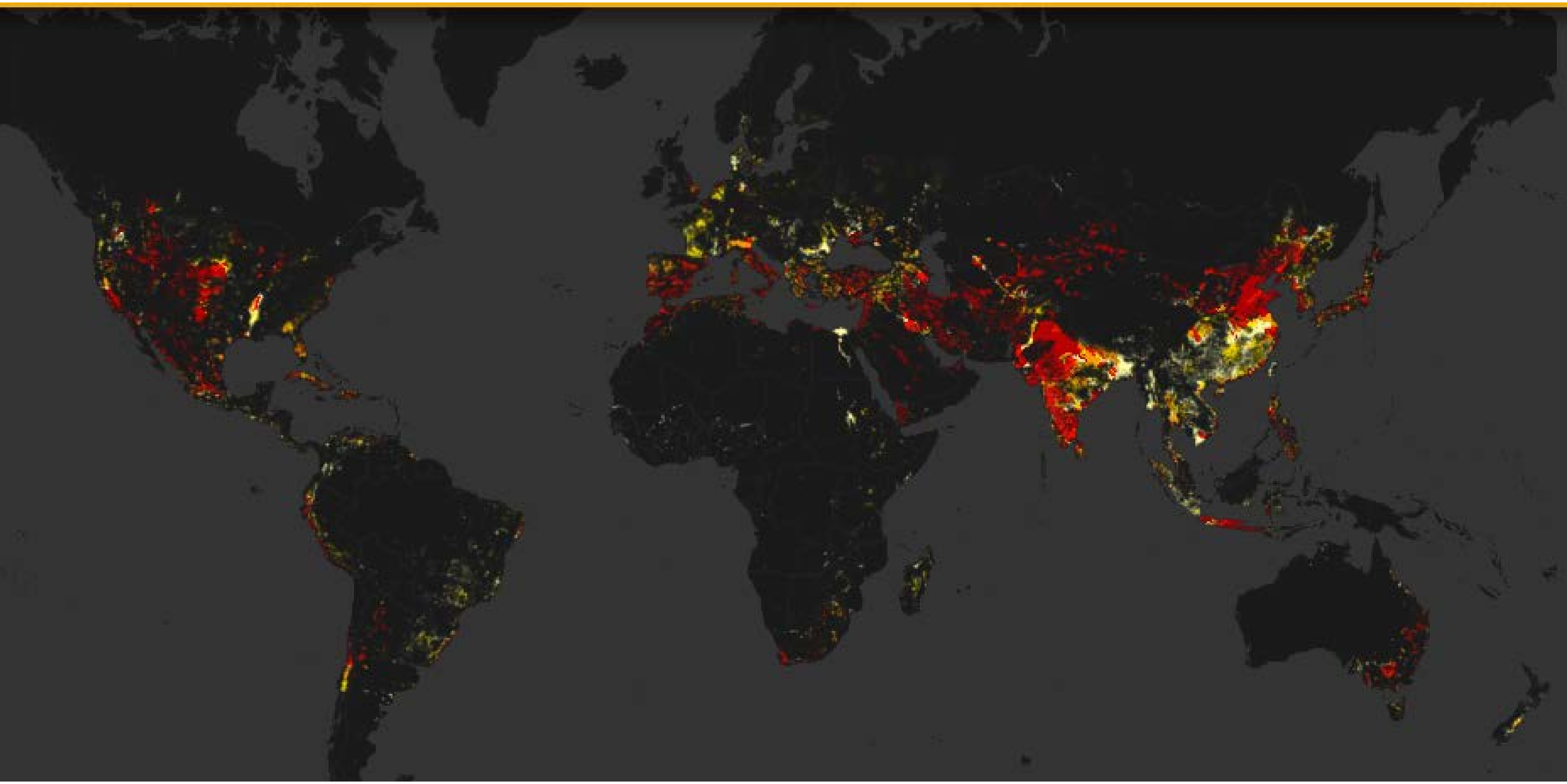
RCP2.6





(Balkovic J, Havlik P, Soussana J-F
EPIC model, dynamic soil,
RCP 2.6, IIASA, Unpublished)

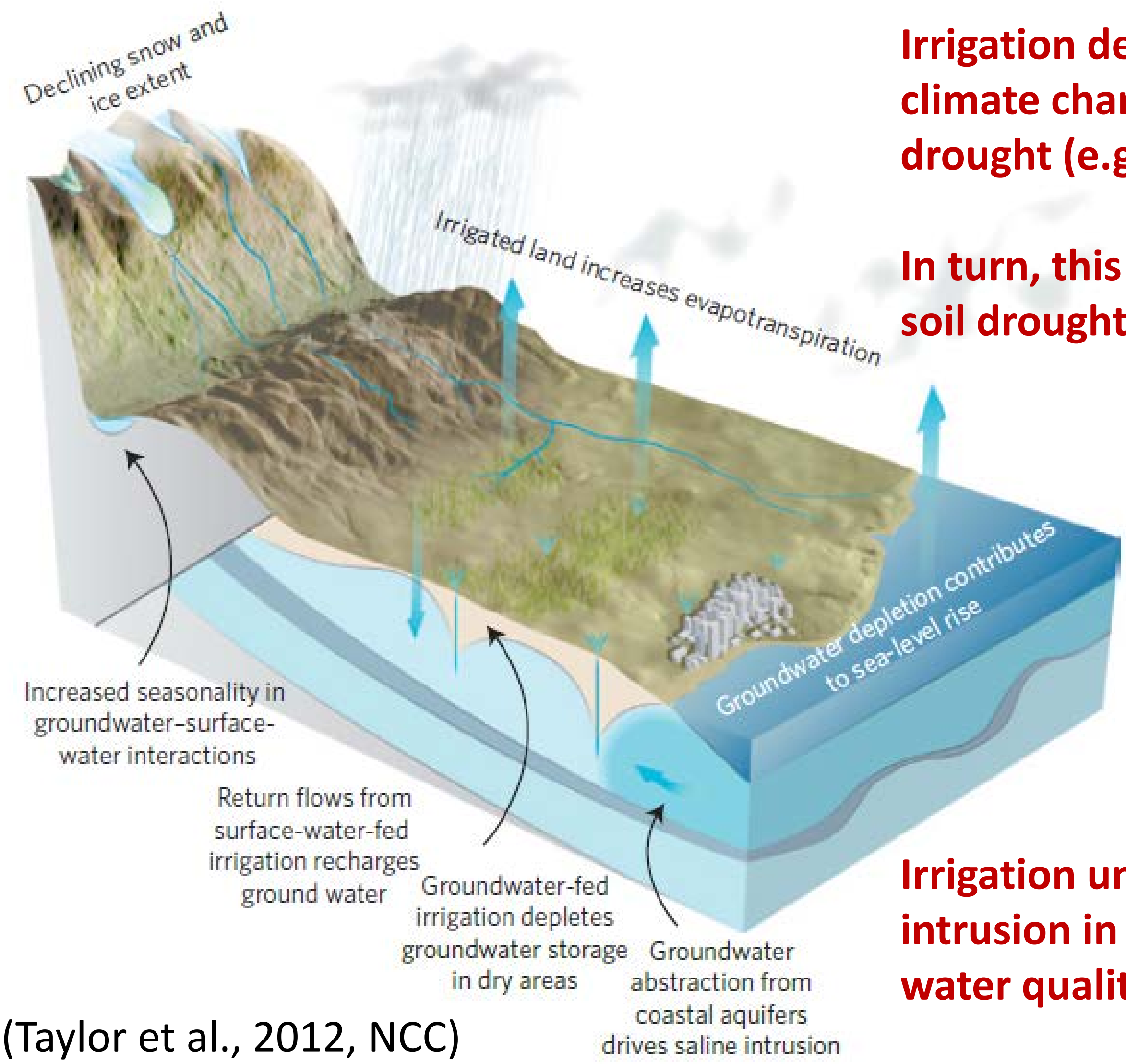
Irrigation in regions with water resources depletion



Source: World Resources Institute

http://www.wri.org/applications/maps/agriculturemap/#x=-162.42&y=17.61&l=2&v=home&d=gmia

Groundwater – climate interactions



(Taylor et al., 2012, NCC)

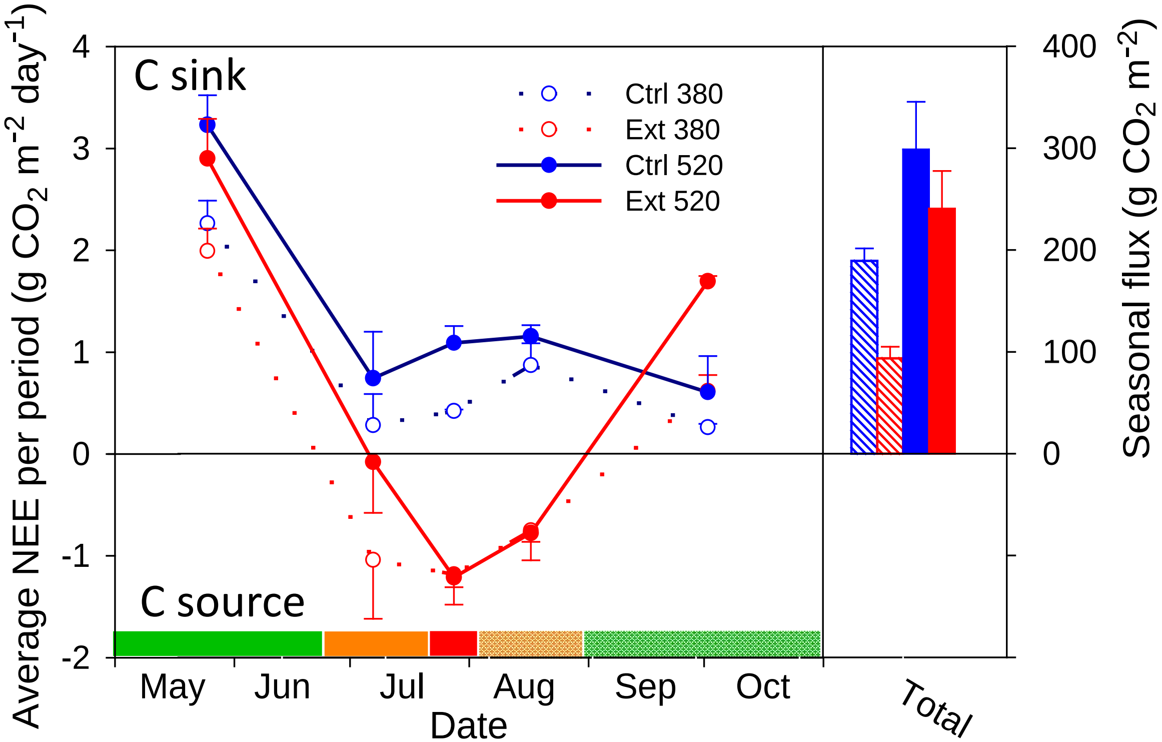
Irrigation demand usually increases under climate change, which can cause underground drought (e.g. in California),

In turn, this limits irrigated area and increases soil droughts

Irrigation under climate change drives saline intrusion in coastal aquifers, strongly reducing water quality

Elevated atmospheric CO_2 alleviates the impacts of a heat and drought extreme on grasslands

2050 A2 scenario: warming and precipitation change.
With/without summer heat and drought **extreme**; With/without **elevated CO_2** (520 ppm)



Testing interactions across drivers

(Roy, Cochard, Soussana, PNAS, 2016)

Adaptation: remote sensing, drought monitoring

- **Rapid developments in satellite imagery, e.g.:**
  - Soil moisture (microwave, SMOS)
  - Leaf area index and drought (Sentinel 2.0), global cover, 10 days return time, ca. 20 m resolution
  - Infrared imaging of drought (Thirsty project, INRA, ESA & NASA)
- **Crop and pasture monitoring to deliver near real time advice to farmers**

Sentinel 2.0 satellite

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Plant breeding for heat and drought tolerance

Crop programs in France:
from genomics to phenotyping

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amaizing

Breed Wheat

BFF Biomass For the Future

PeaMUST

RapsodyN

AKER Betterave2020

SUNRISE UNE CULTURE POUR LE FUTUR

ANR

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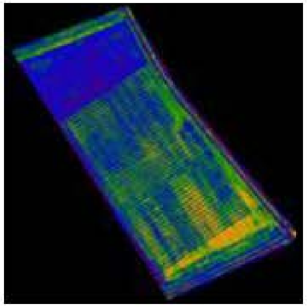
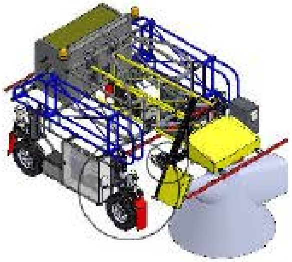
DROPS

INVESTISSEMENTS D'AVENIR

PHENOME Réseau Français Phénomique végétale FPPN





Increasing the resilience of agricultural production

Precision agriculture and modern breeding

- Anticipating risks and adapting practices (e.g. sowing dates),
- Breeding for tolerance to water stress and to high temperatures, for tolerance to flooding (without reducing production potential?)
- Precision irrigation (saving water?)

Water and soil conservation

- Integrated water management at catchment scale,
- Conservation agriculture (no-till, cover-crops, mulch, green manure, etc.),
- Crop-livestock integration, agroforestry (improved microclimate)

Diversification: increased resilience at farm scale

- Crop rotation, grass leys, permanent grasslands, specialized crops,
- Mixed cultivars, grass-legume mixtures, etc.
- Diversified landscapes (reduced pest and disease pressure)

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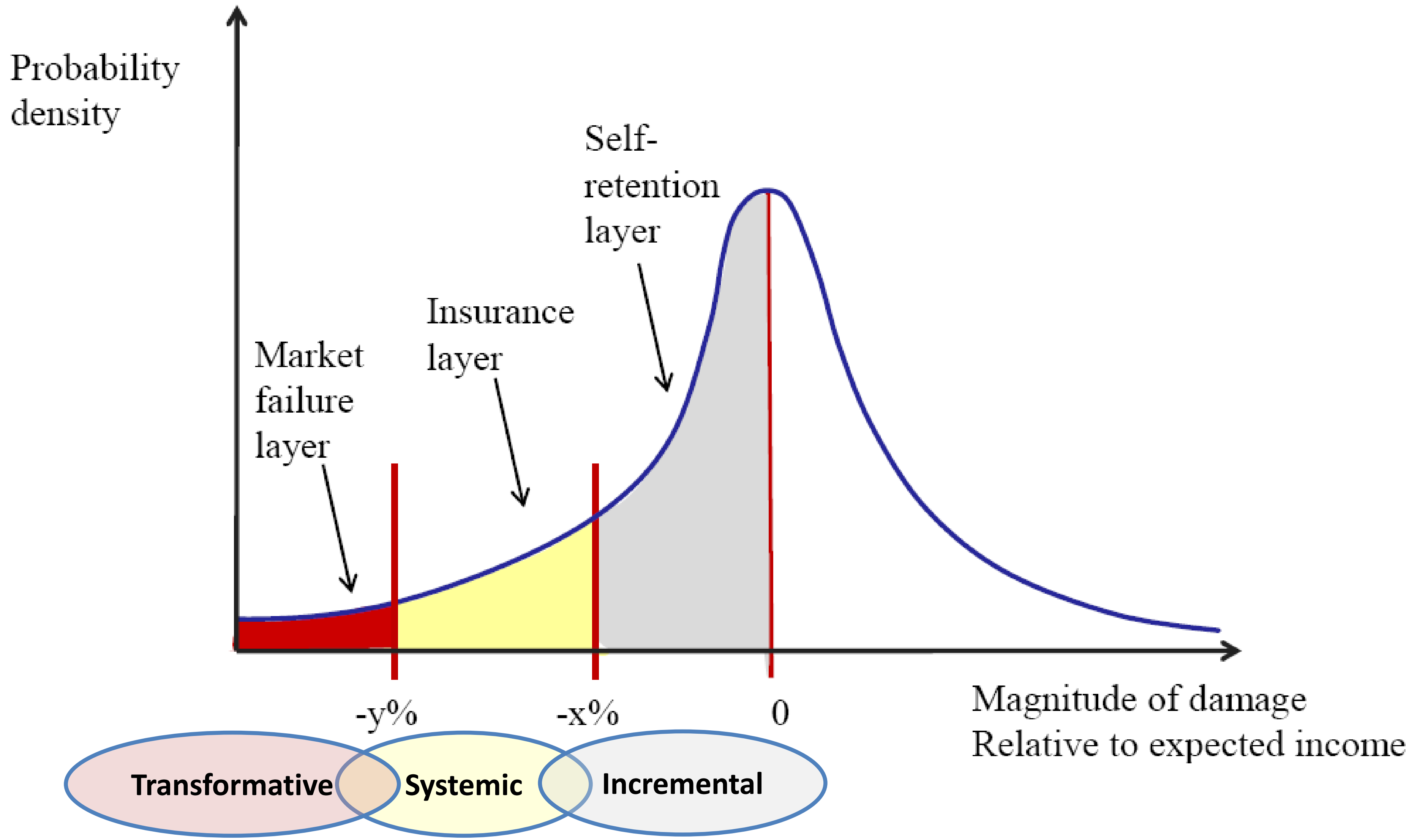
Hurricane impacts in Central America on monocultures vs. agroecological terraces

(Nicholls et al., 2015, ASD)

After Hurricane Mitch in Central America, Honduran farms under monoculture exhibited higher levels of damage in the form of mudslides (left photo) than neighboring biodiverse farms featuring agroforestry systems, contour farming, cover crops, etc. (right photo)

Transition in adaptation strategies: layering risk



Transitions in types of adaptation

Agoecology?

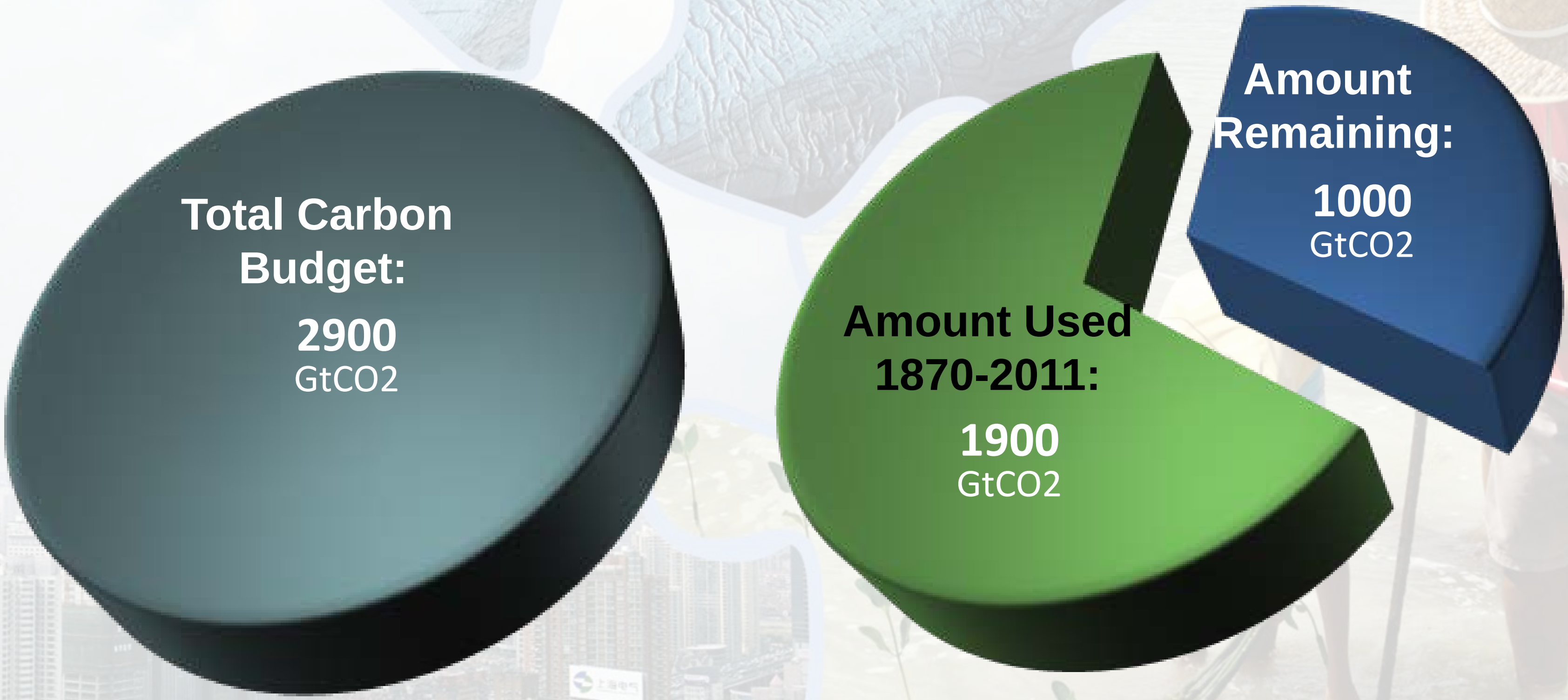
Precision agriculture?

(Cattaneo, OECD, 2011
& Vermeulen et al., 2014, PNAS)


Reducing GHG emissions
FROM AGRICULTURE

The window for action is rapidly closing

65% of our carbon budget compatible with a 2° C goal already used



AR5 WGI SPM

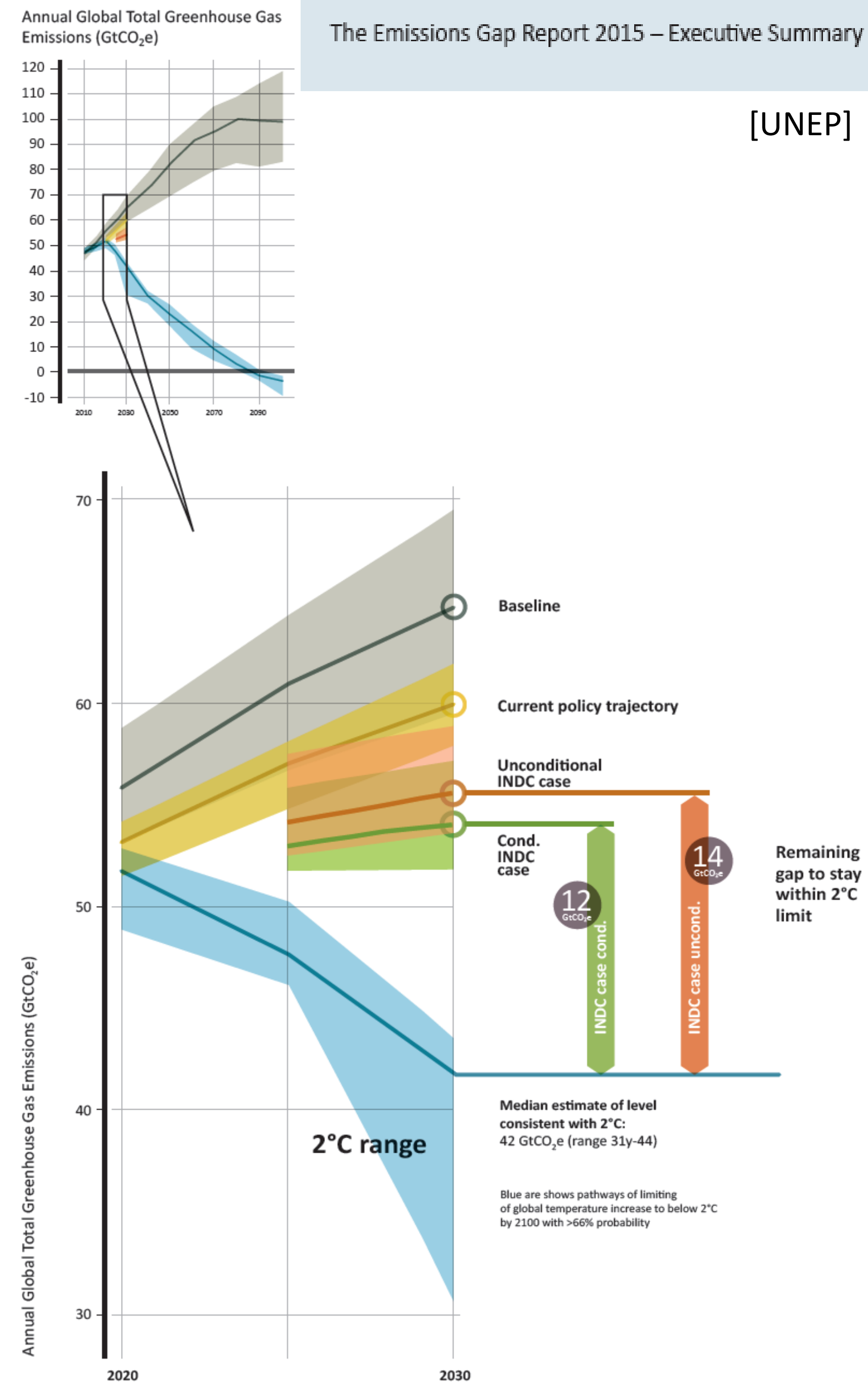
A large gap in emissions reduction by 2030 for 2° C

- By 2030, a gap of 12 Gt CO_{2e} with conditional INDCs prevents reaching the targeted +2℃ maximum global warming threshold

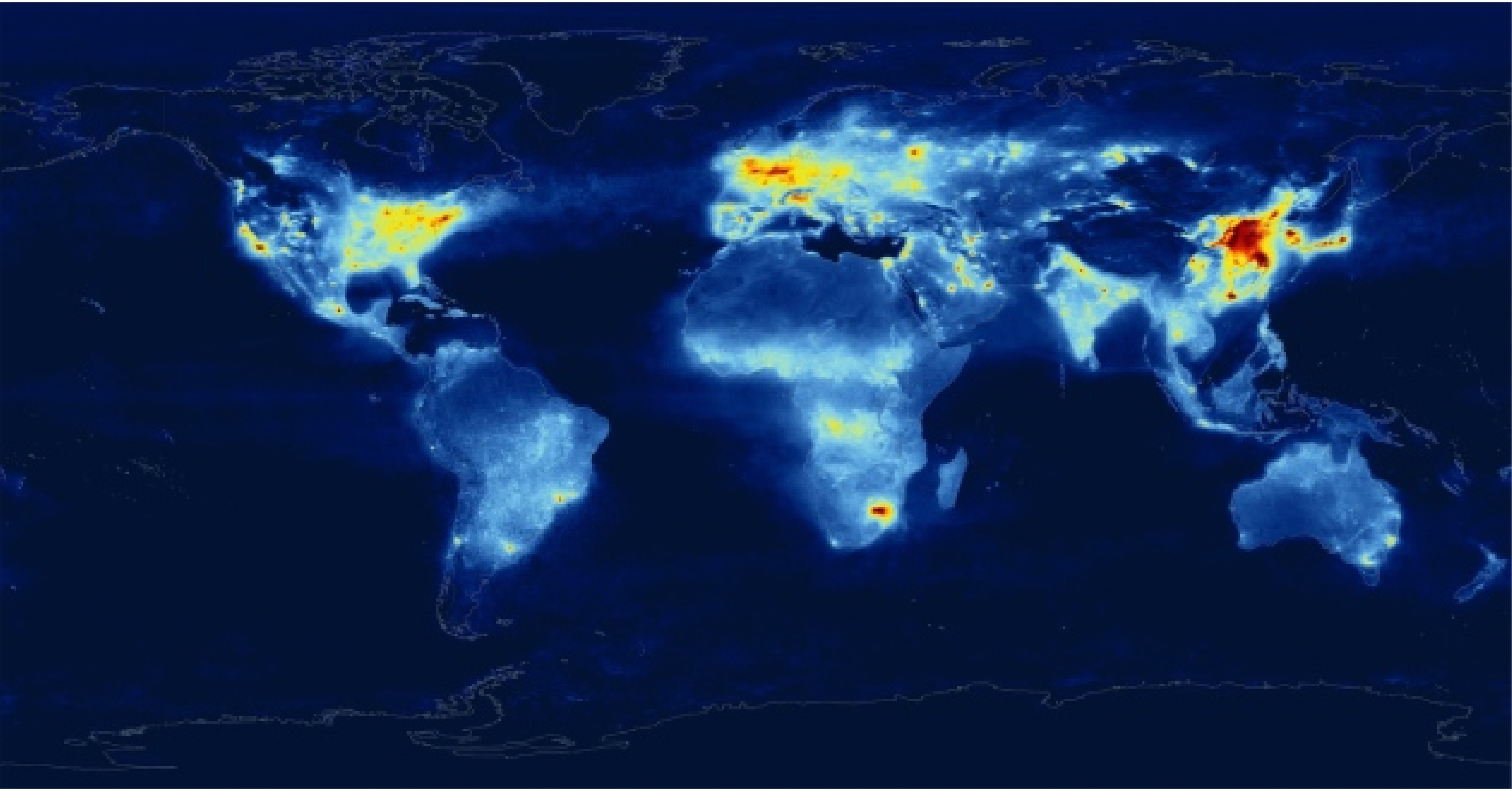
- 129 countries include the AFOLU sector in their INDCs (Intended Nationally Determined Contributions)
  - **At least 25% of total committed GHG mitigation** ***[as estimated by the International Institute for Applied Systems Analysis, IIASA]***

The Emissions Gap Report 2015 – Executive Summary

[UNEP]

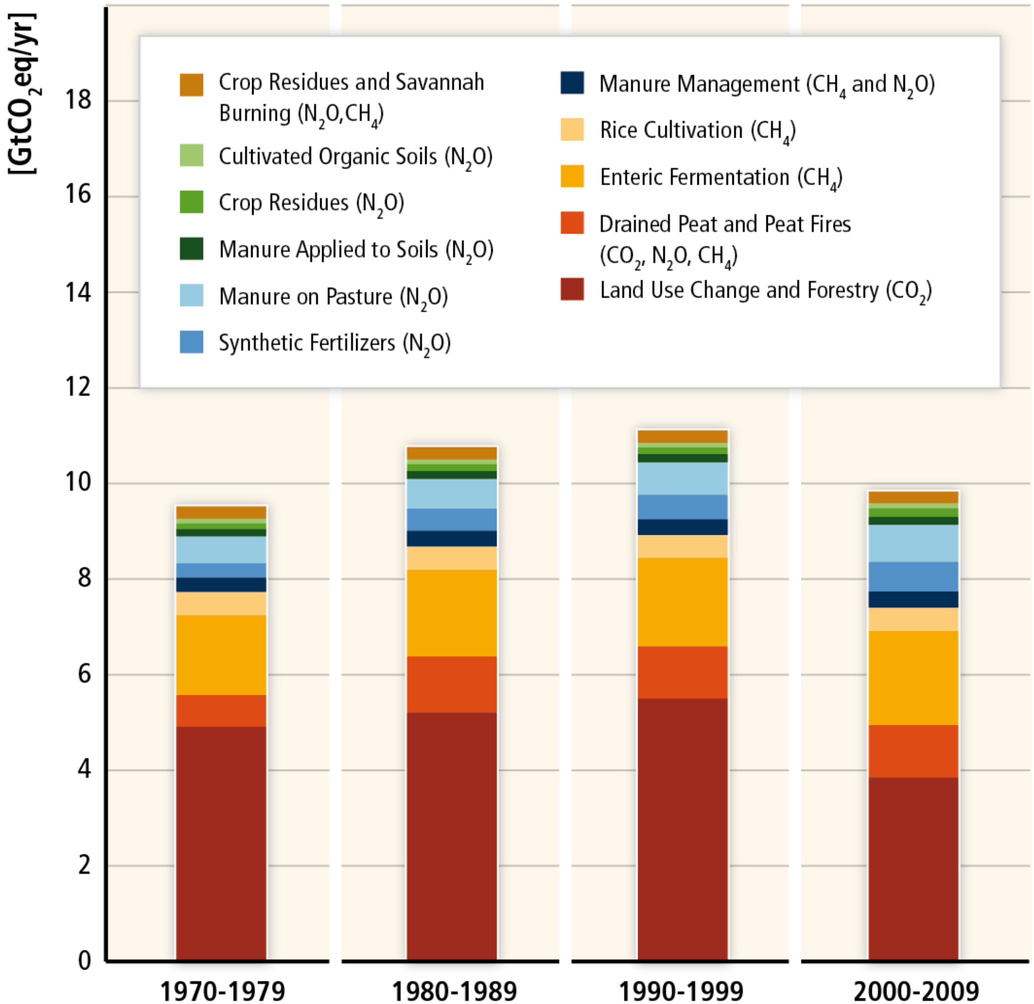


Agriculture, forestry and land use change contribute to 24% of global GHG emissions



Remote sensing of N_2O emission hot-spots

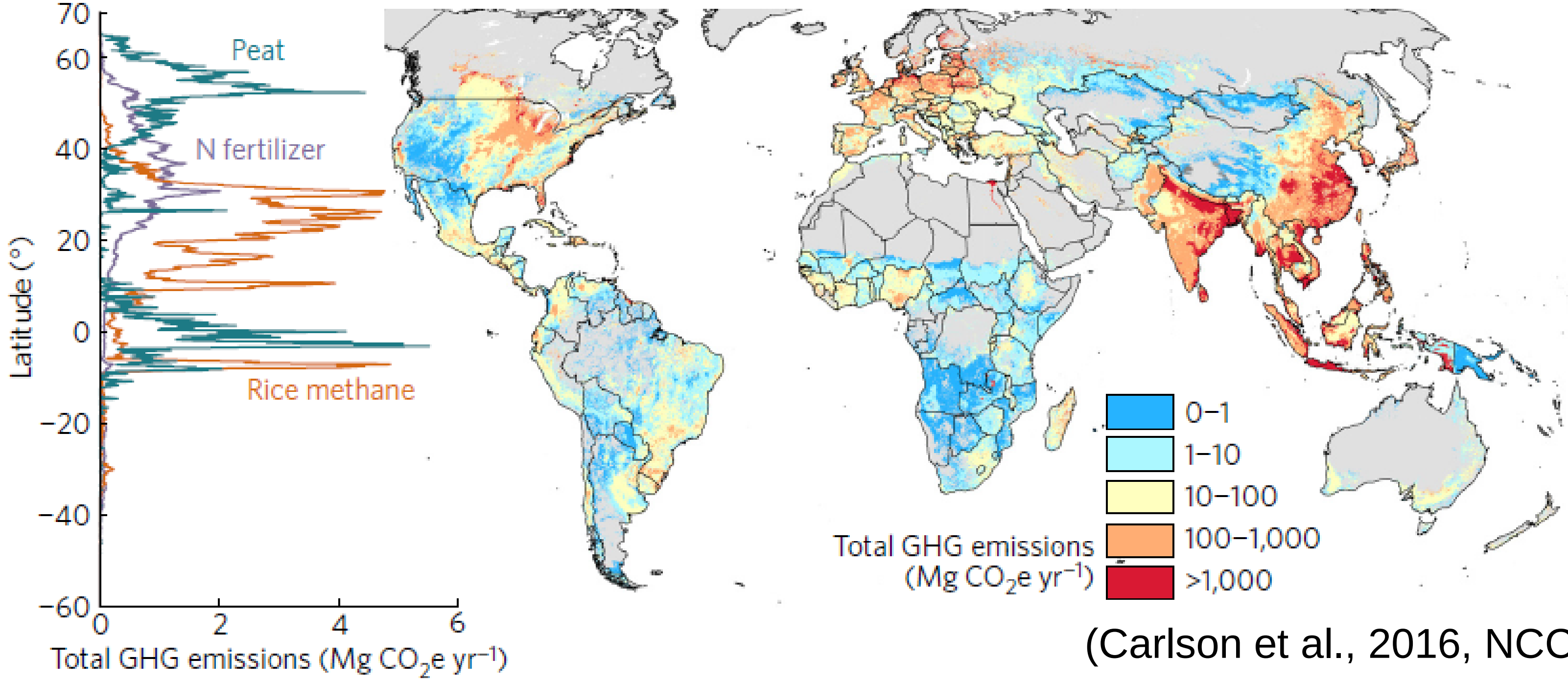
Agricultural emissions are increasing, but *net* forestry CO_2 emissions have fallen recently



- AFOLU accounts for 24% of total anthropogenic GHG emissions
- AFOLU is the only sector where net emissions fell in the most recent decade
- Whilst agricultural non-CO_2 GHG emissions increased, *net* CO_2 emissions fell, mainly due to decreasing deforestation, and increased afforestation rates

IPCC WGIII AR5

Peatland drainage: one third of global cropland GHG emissions



(Carlson et al., 2016, NCC)

Climate change impacts

Warming -> Loss of bog

Drainage and warming -> Lowered water table -> Increased soil CO_2 and reduced CH_4

AFOLU mitigation options:

SUPPLY SIDE

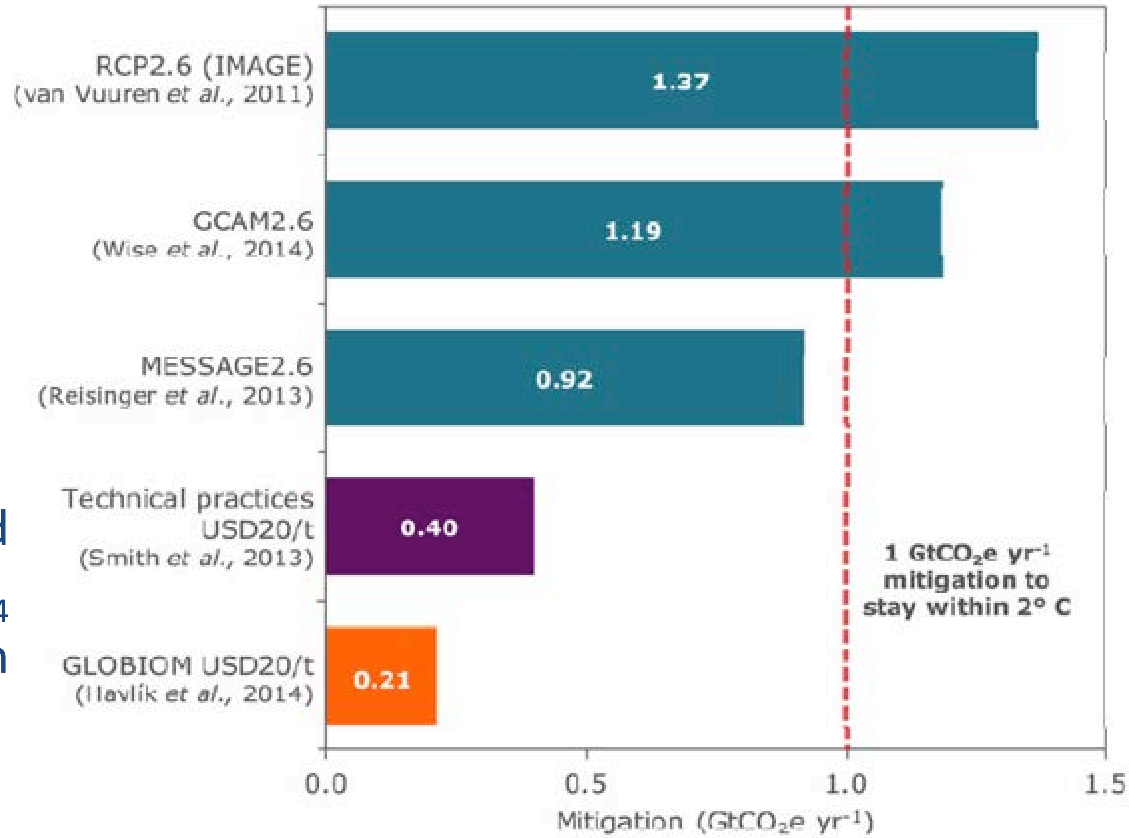
Livestock mgmt. Cropland mgmt. Int. systems Forestry

… and bioenergy

DEMAND SIDE

Dietary change
Improvement in the food chain
Use of wood products

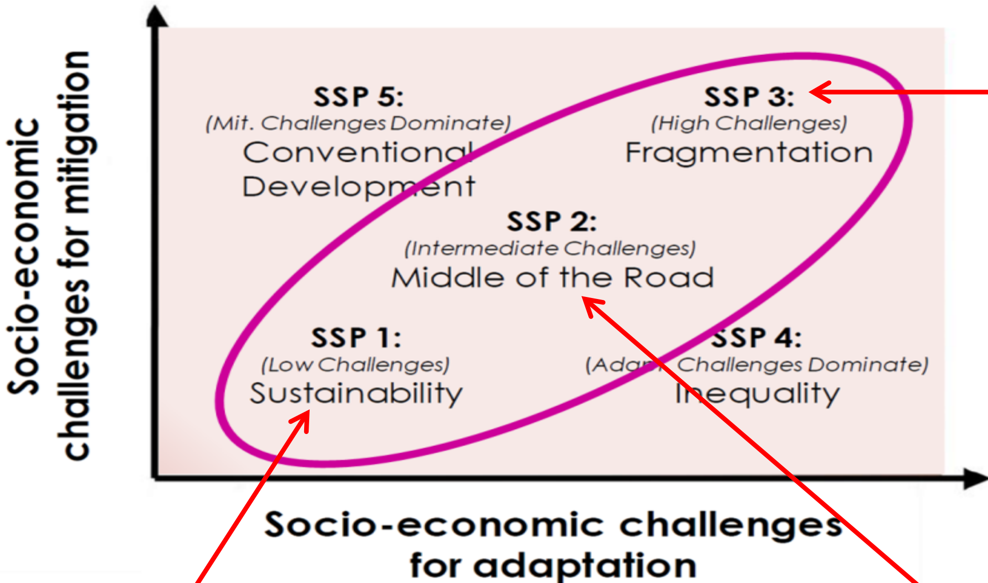
Staying withing 2°C cannot be achieved by the agriculture sector by 2030 using only methane and N_2O mitigation



N_2O and CH_4 mitigation

(Wollenberg et al., 2016, GCB)

Shared socio-economic pathways 1-3

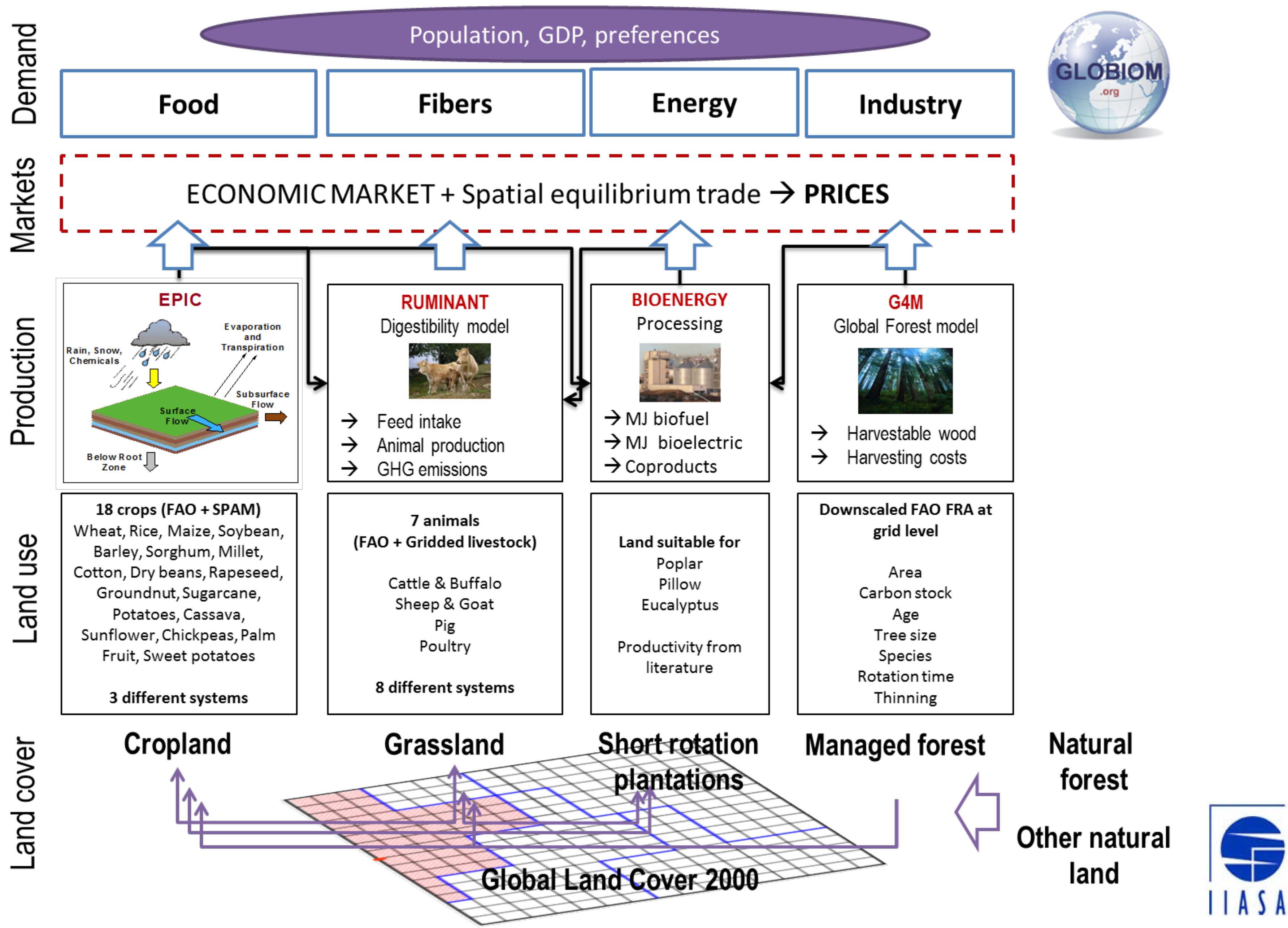


SSP3 is a fragmented world characterized by strongly growing population and important regional differences in wealth with pockets of wealth and regions of high poverty. Unmitigated emissions are high, low adaptative capacity and large number of people vulnerable to climate change. Impact on ecosystems are severe.

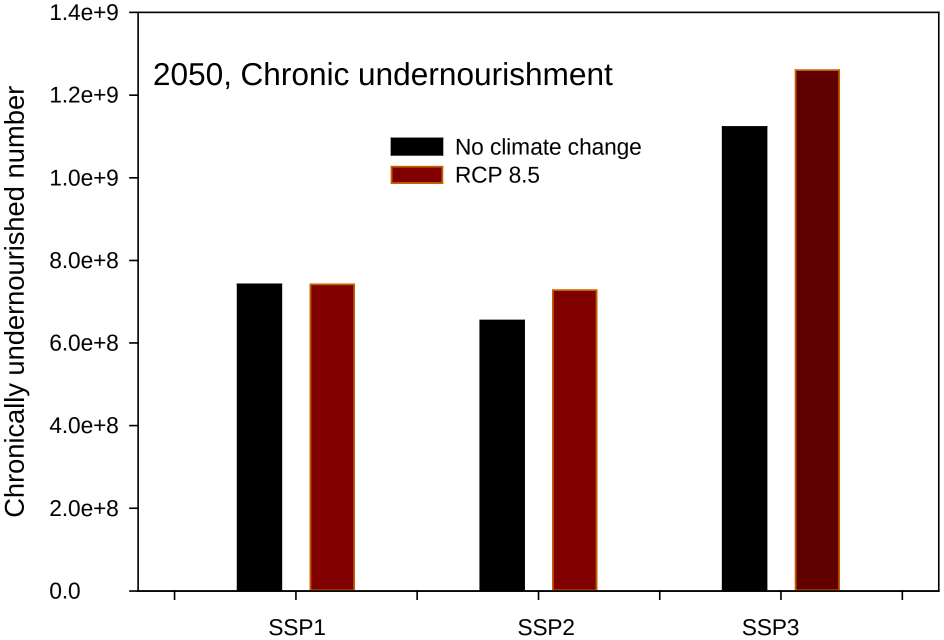
SSP1 is the sustainable world with strong development goals that include reducing fossil fuel dependency and rapid technological changes directed towards environmentally friendly processes including yield-enhancing technologies.

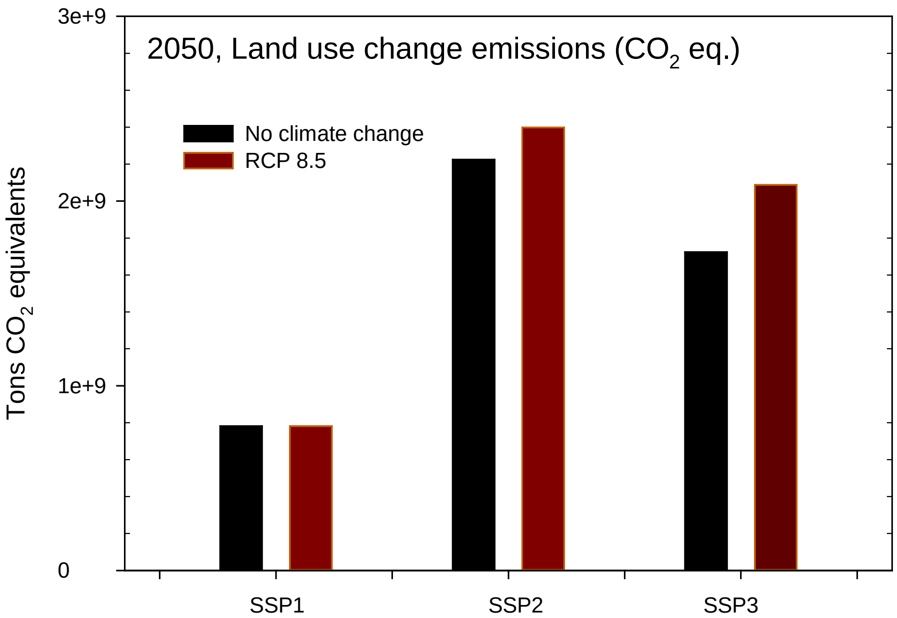
SSP2 is the continuation of current trends with some effort to reach development goals and reduction in resource and energy intensity. On the demand side, investments in education in not sufficient to slow rapid population growth. In SSP2 there is only an intermediate success in addressing vulnerability to climate change.

GLOBIOM (IIASA)

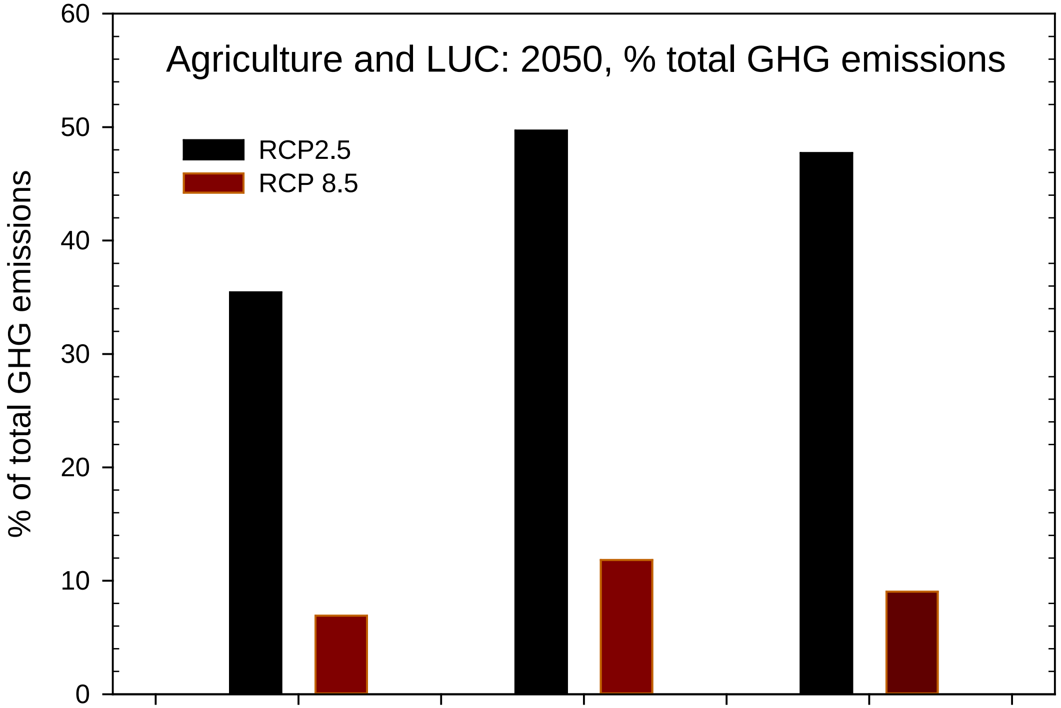


Food security and land use change projections for 2050





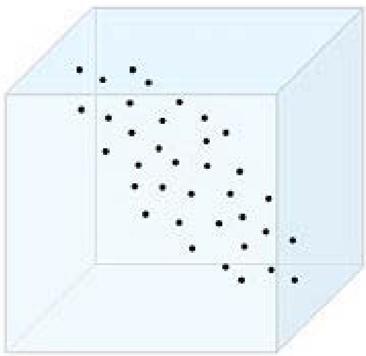
Global food system emissions may prevent climate stabilization



SocioEconomic Pathways

SSP1 SSP2 SSP3

Identifying a solution space for 2050



Model runs with 500,000 random draws of drivers and wedges

Criteria for solutions by 2050: satisfy food demand and meet the 2°C target

Global change drivers	Solution wedges
Land degradation	GHG abatement
Climate change	Soil carbon sequestration
Biofuels	Primary production
Westernized diets	Livestock efficiency
Overconsumption of food	Diets (less animal food)
Undernourishment	Reduced food wastes

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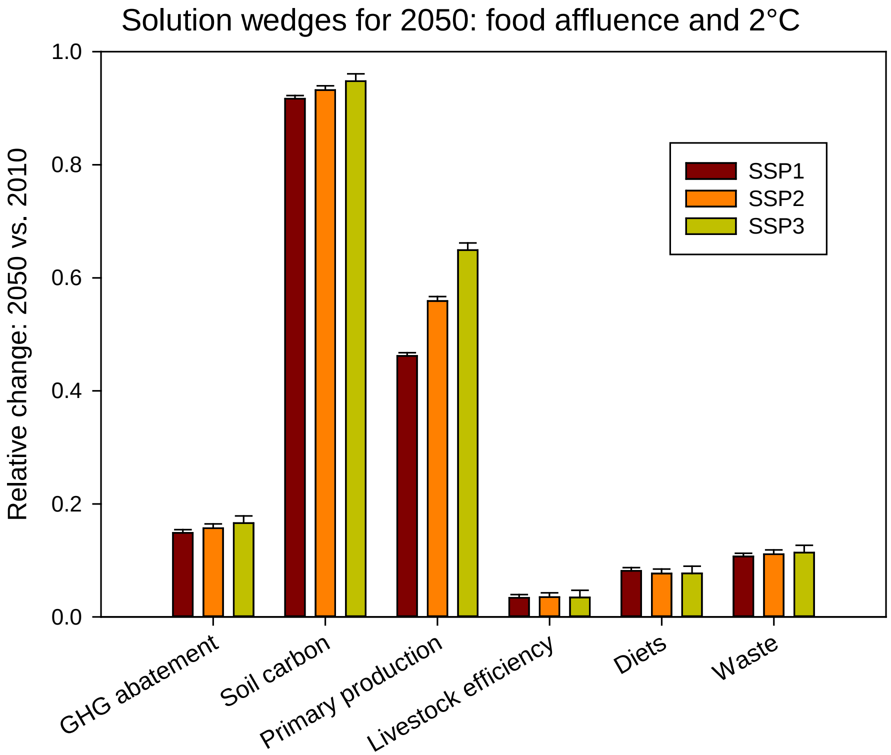
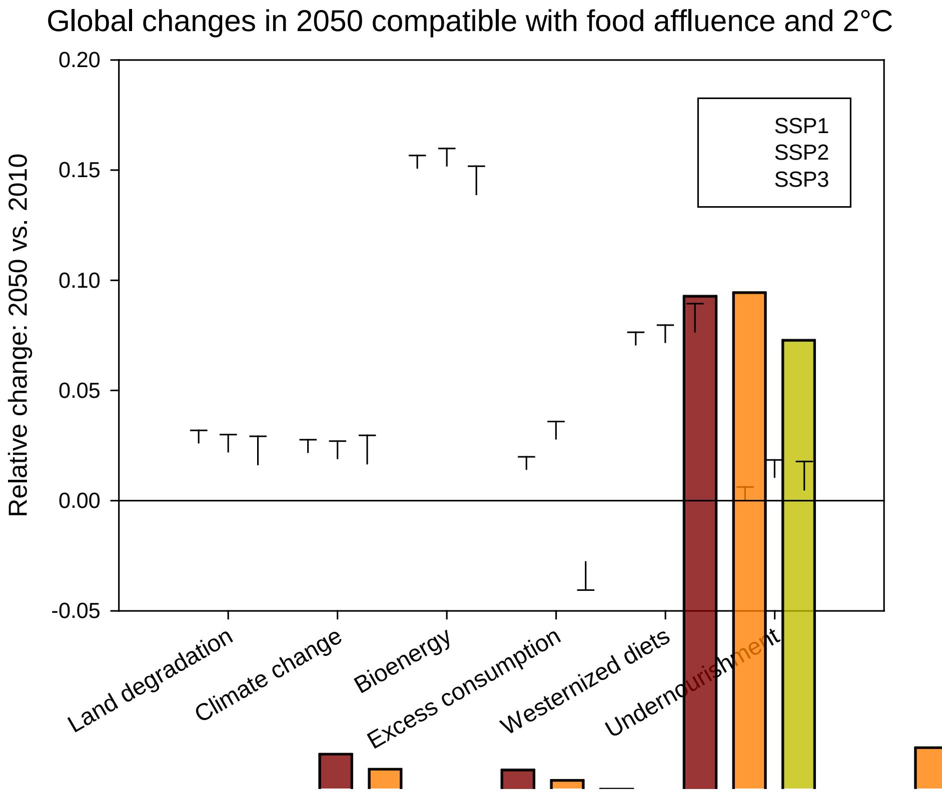
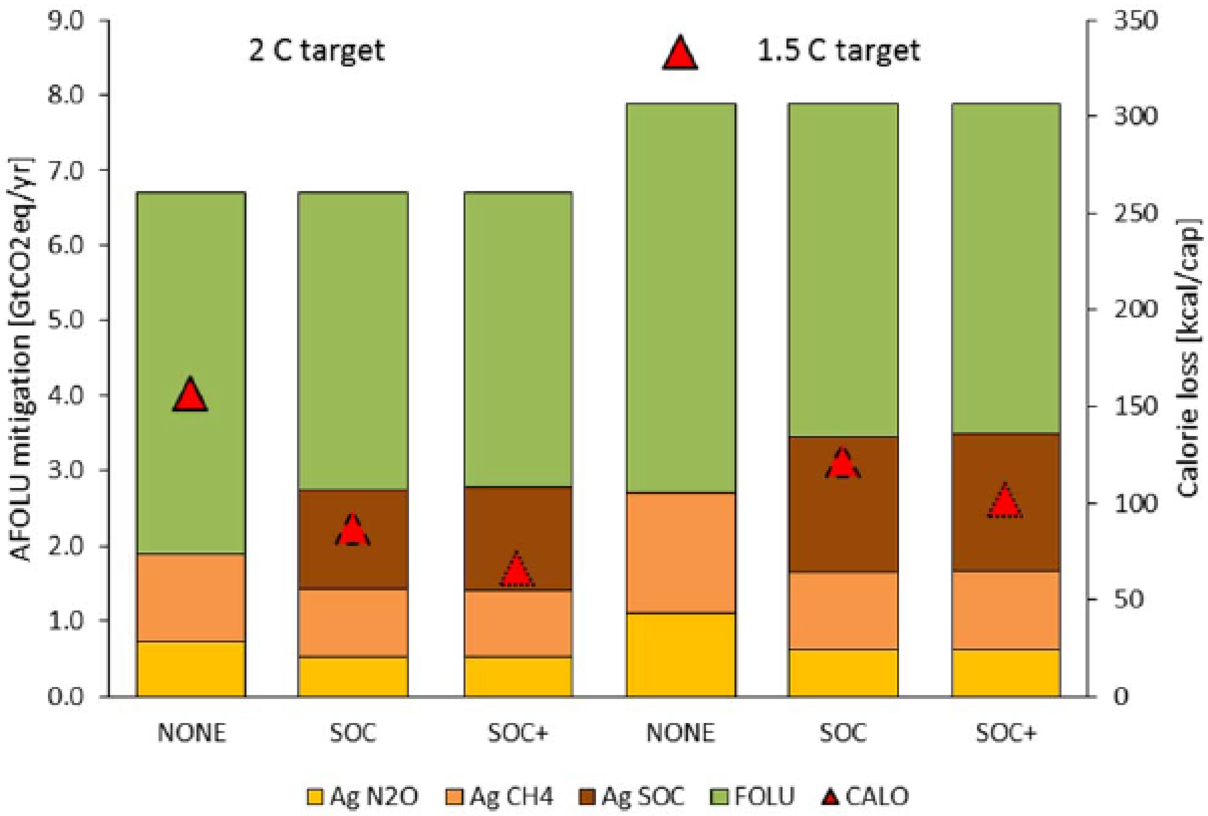
Which solutions can satisfy global food demand and the 2°C target by 2050?





(Soussana, Ben Ari et al., in prep.)

Soil carbon sequestration alleviates the negative impacts of mitigation policies on food security



SOC, soil organic C sequestration; SOC+, including its benefits for yields

(Frank et al., ERL, in revision)

IIASA

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What is « The 4 per 1000 initiative : Soils for food security and climate » ?

=> A multi-stakeholder Initiative launched by France at COP21 with the support of FAO

⇒One of the 6 initiatives of the Agriculture focus of the Lima – Paris Action Agenda (LPAA)

⇒ 1 objective: increase soil fertility thanks to carbon sequestration in soils

=> 3 major outcomes:

- **Improve food security**
- **Adapt** agriculture to climate change
- **Mitigate** GHG emissions

Agricultural practices for soil carbon sequestration

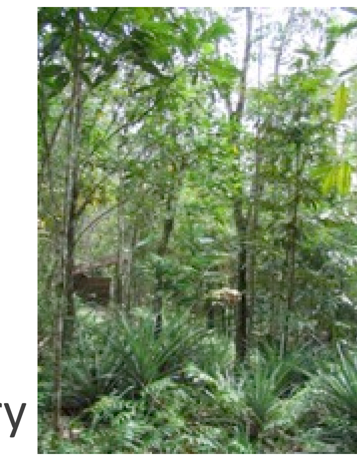
Conservation tillage

Integrated soil fertility management

Rangeland Management

Water management

Agroecology



Agroforestry

Organic fertilizers

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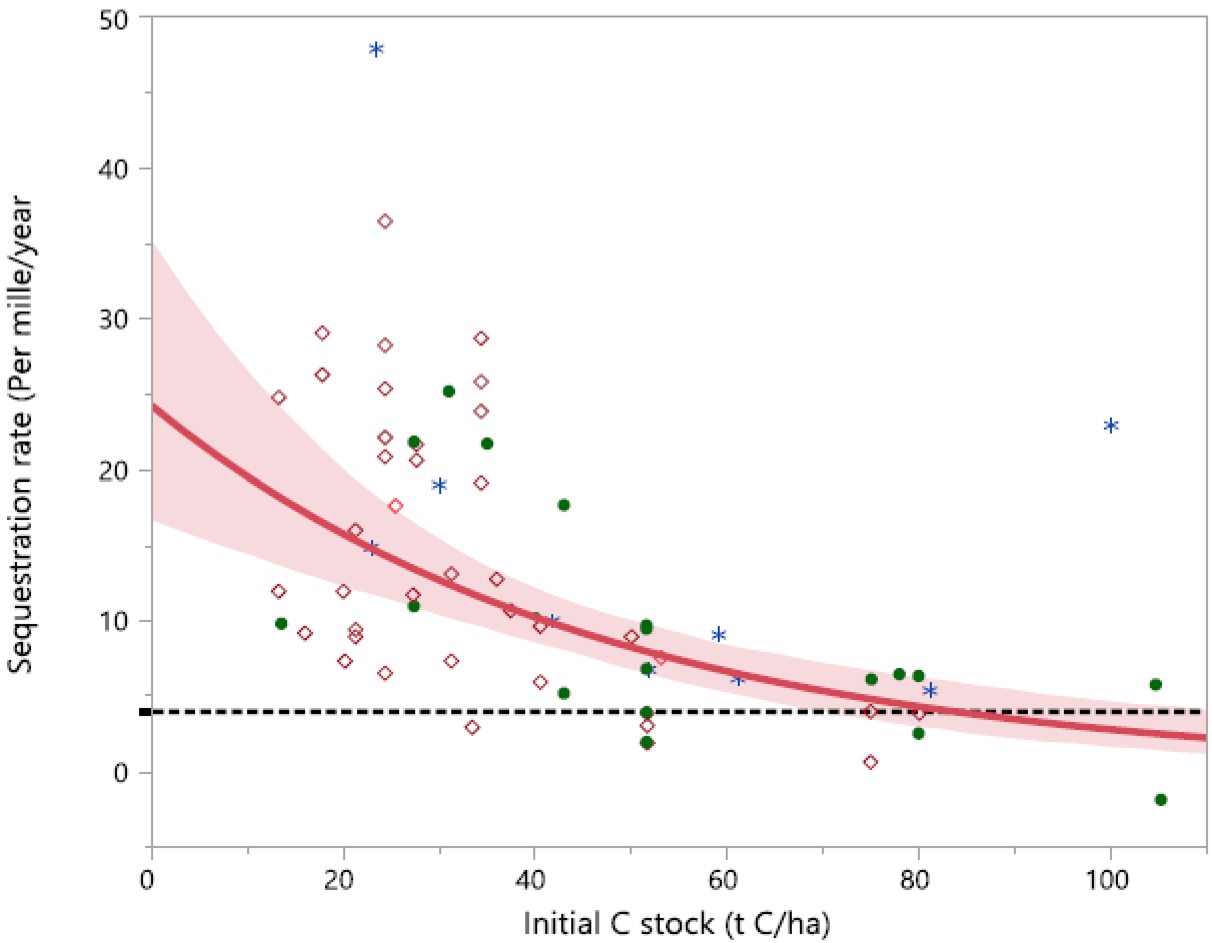
4 PER 1000 SOILS FOR FOOD SECURITY AND CLIMATE

A 4 per 1000 annual rate of SOC sequestration has often been observed,or exceeded, in long-term arable field trials

..but the rate declines with initial SOC stock



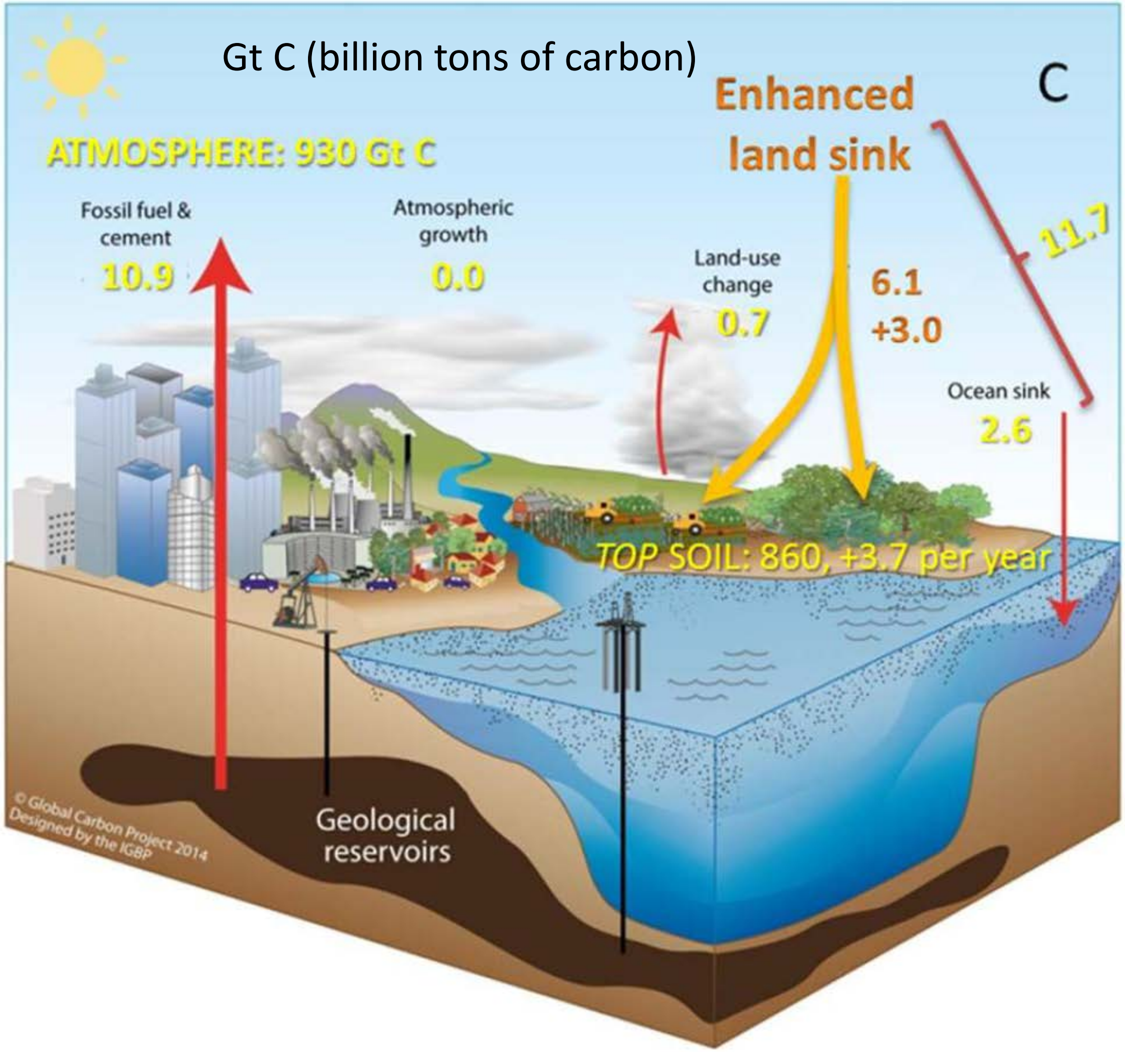
(Minasny et al., 2017)

Combining global aspirations for soils (4/1000) and for tropical forests: potential for atmospheric CO_2 stabilization in 2030-40

Measures:

- halting deforestation & forest degradation,
- reforestation & agroforestry,
- Agricultural soil management
- Desertified & salinized soil restoration

Total soil carbon sequestration at 3.7 Gt C/yr, i.e. 0.4% of top soil C stock (860 GtC)



(Soussana et al., submitted)

From challenges to solutions

- **The *nexus* between food security, land degradation, water and climate change creates a critical long-term risk for humankind**
- **Science is a foundation for smart decisions on climate change**
- **The research agenda should focus on options for *solutions*, while also informing the public, and supporting the policy process**
- **This is no simple task and it requires increased European and international collaboration**

JIRCAS-NARO, August 31, 2017

Thank you for your attention!

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