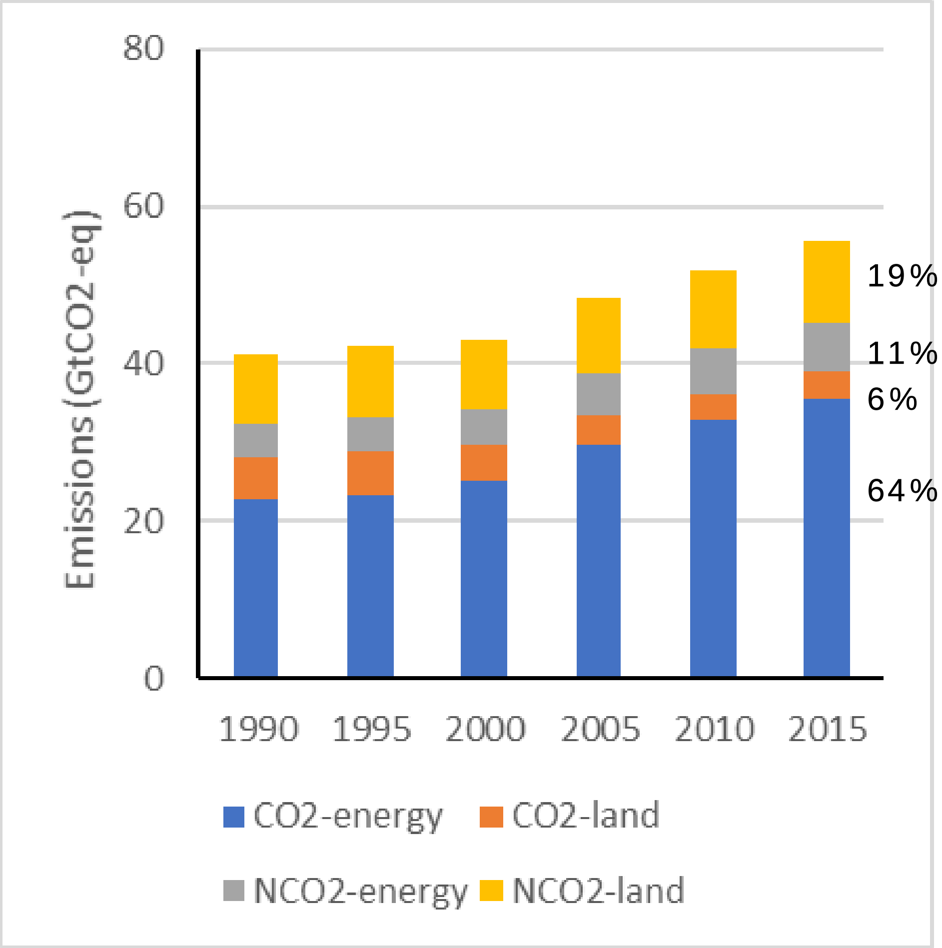
Role of land-based mitigation in long-term scenarios

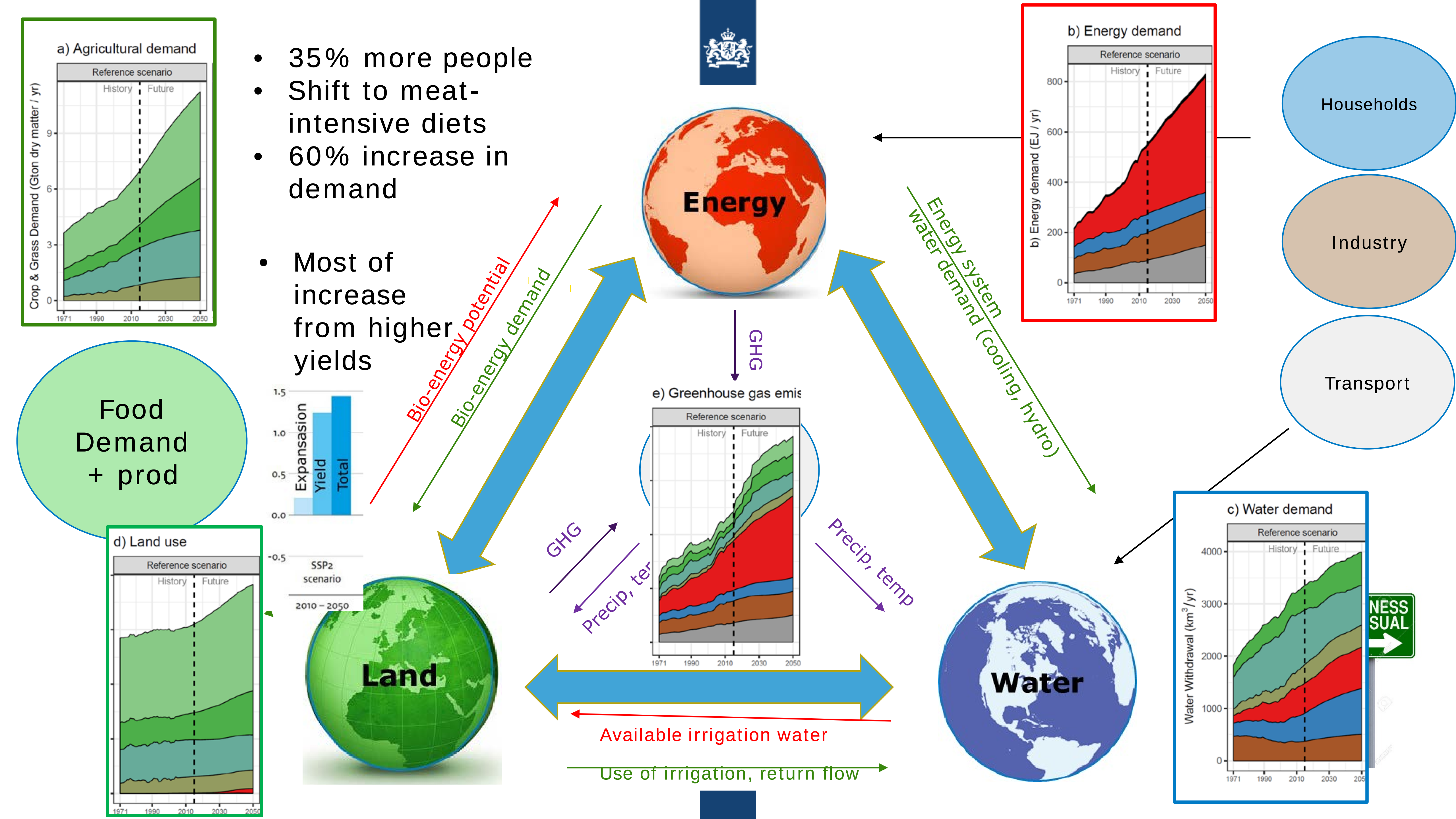
Detlef van Vuuren

@IMAGE_PBL

Emission development 1990 -2015



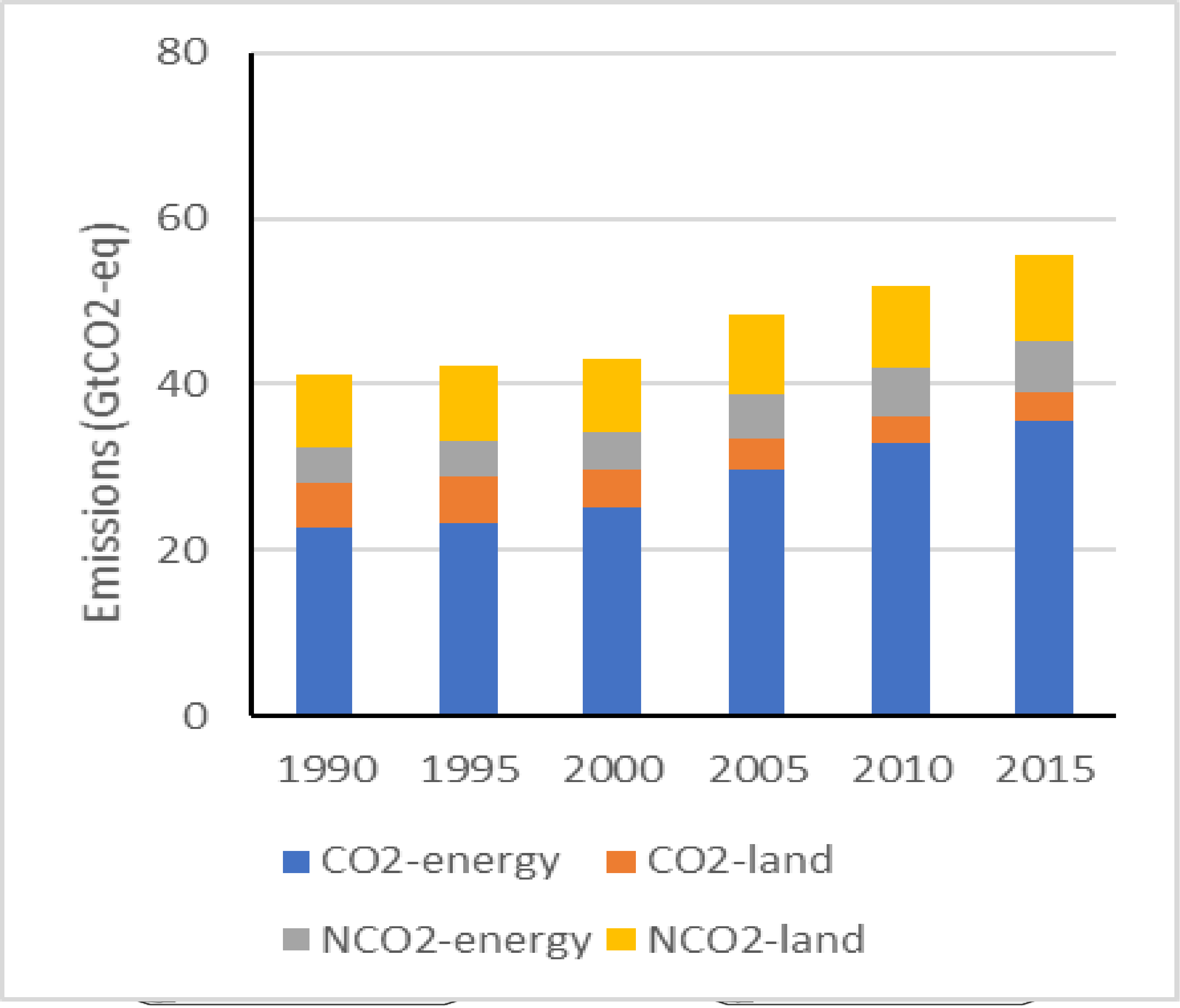
Data: CMIP6 database

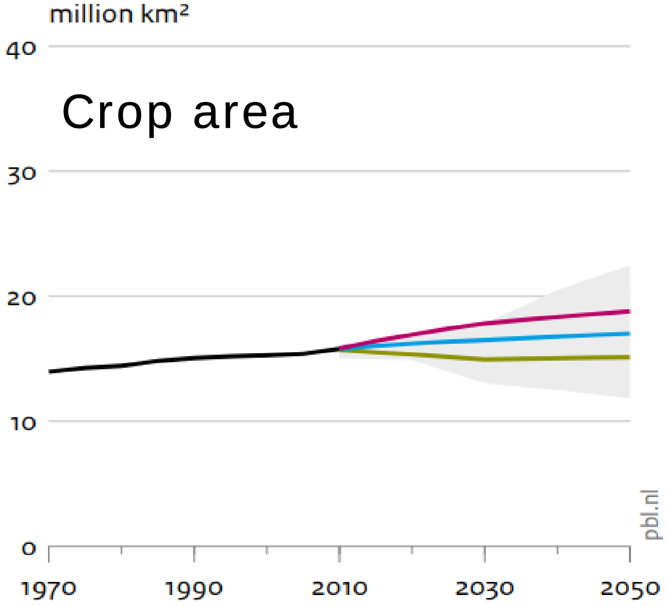


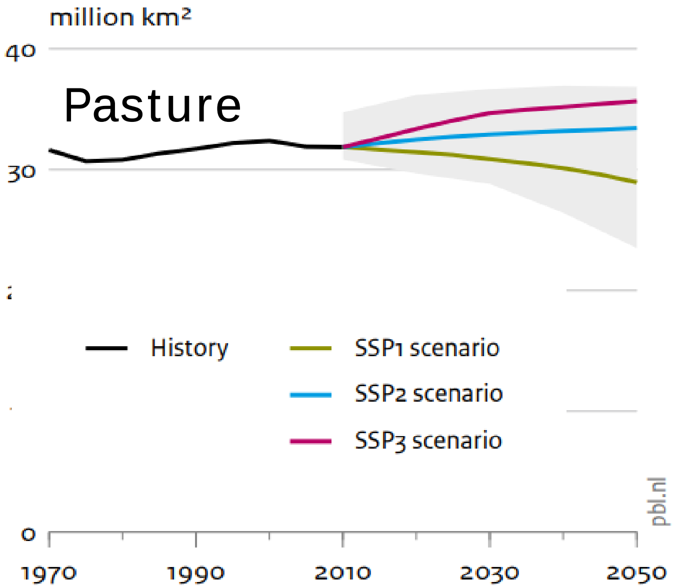
a) Agricultural demand
Reference scenario
History
Future
Crop & Grass Demand (Gton dry matter / yr)
35% more people
Shift to meat-intensive diets
60% increase in demand
Most of increase from higher yields
Expansasion
Yield
Total
SSP2 scenario
2010 – 2050
Food Demand + prod
d) Land use
Bio-energy potential
Bio-energy demand
Energy
GHG
e) Greenhouse gas emis
Land
Water
Available irrigation water
Use of irrigation, return flow
Precip, temp
b) Energy demand
b) Energy demand (EJ / yr)
Energy system water demand (cooling, hydro)
Households
Industry
Transport
c) Water demand
Water Withdrawal (km³/ yr)

Land use consequences

Source: Doelman et al

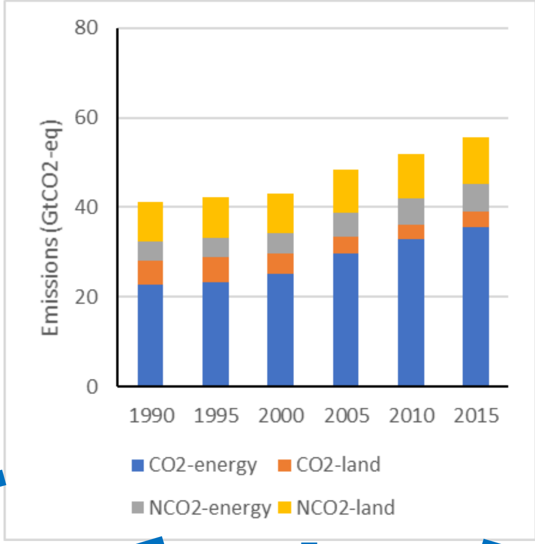






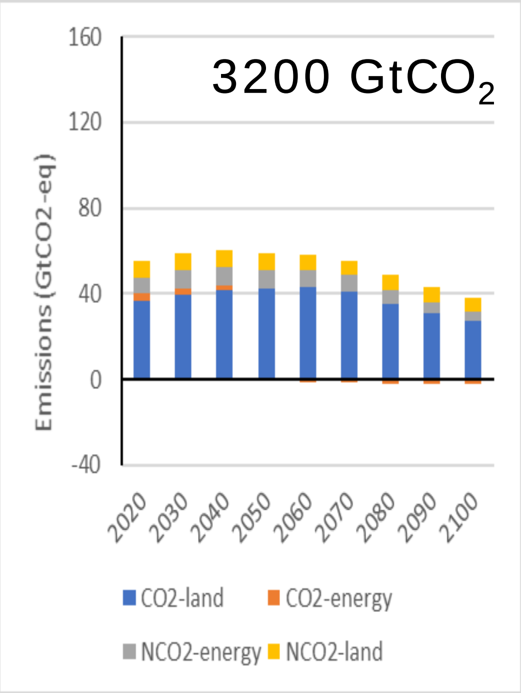
Baseline:

- Increasing share CO2-energy
- Slowly increasing non-CO2 emissions
- Land CO2 – either small decrease or become negative

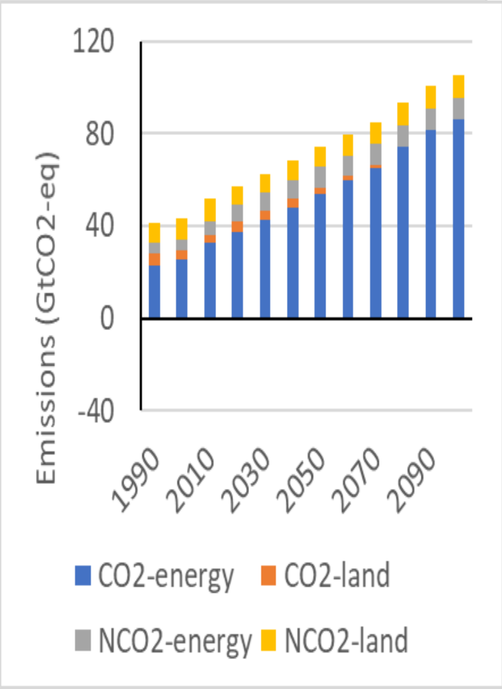


Data: CMIP6 database

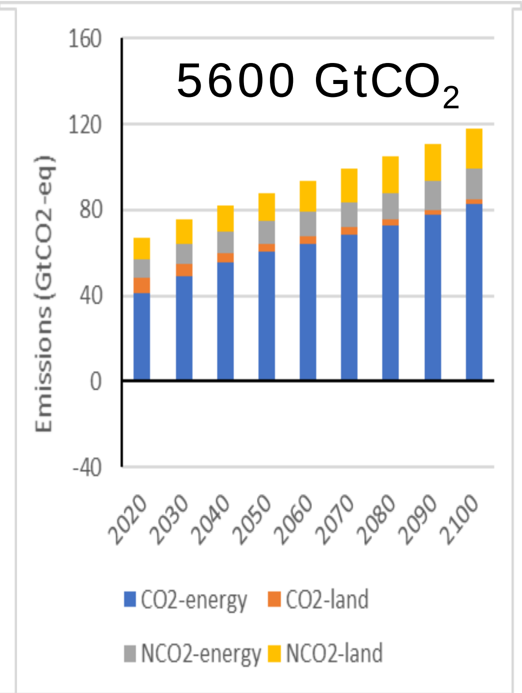
SSP1



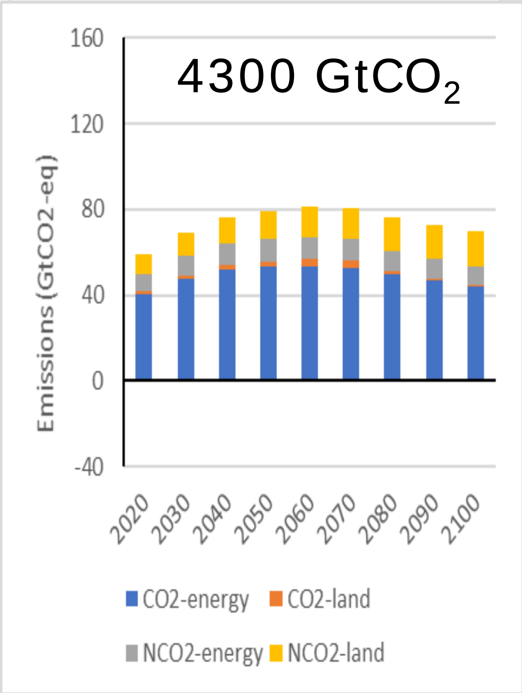
SSP2



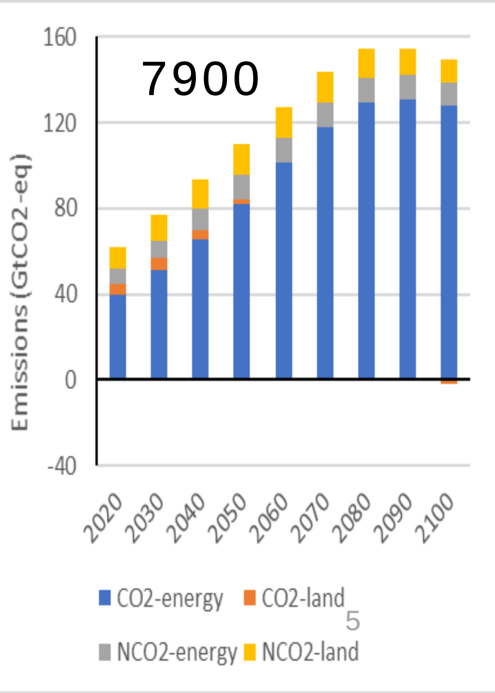
SSP3



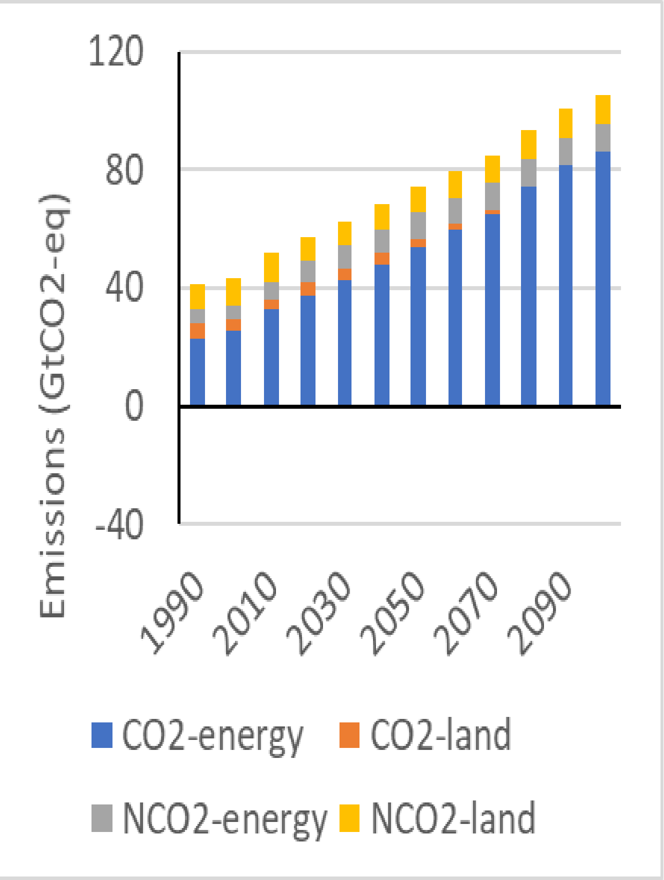
SSP4



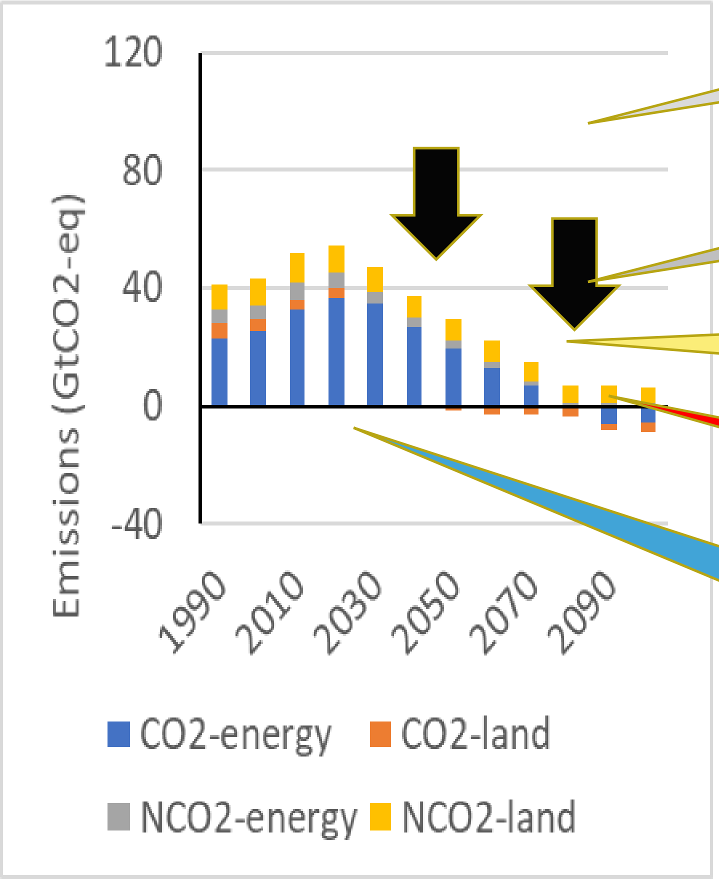
SSP5



Default response strategy



- Peak emissions shortly after 2020
- Reach zero emissions shortly after 2050
- Compensate excess emissions by negative emissions after 2050 (BECCS, Afforestation)



Limiting demand (diet change, waste loss)

Increasing agriculture efficiency

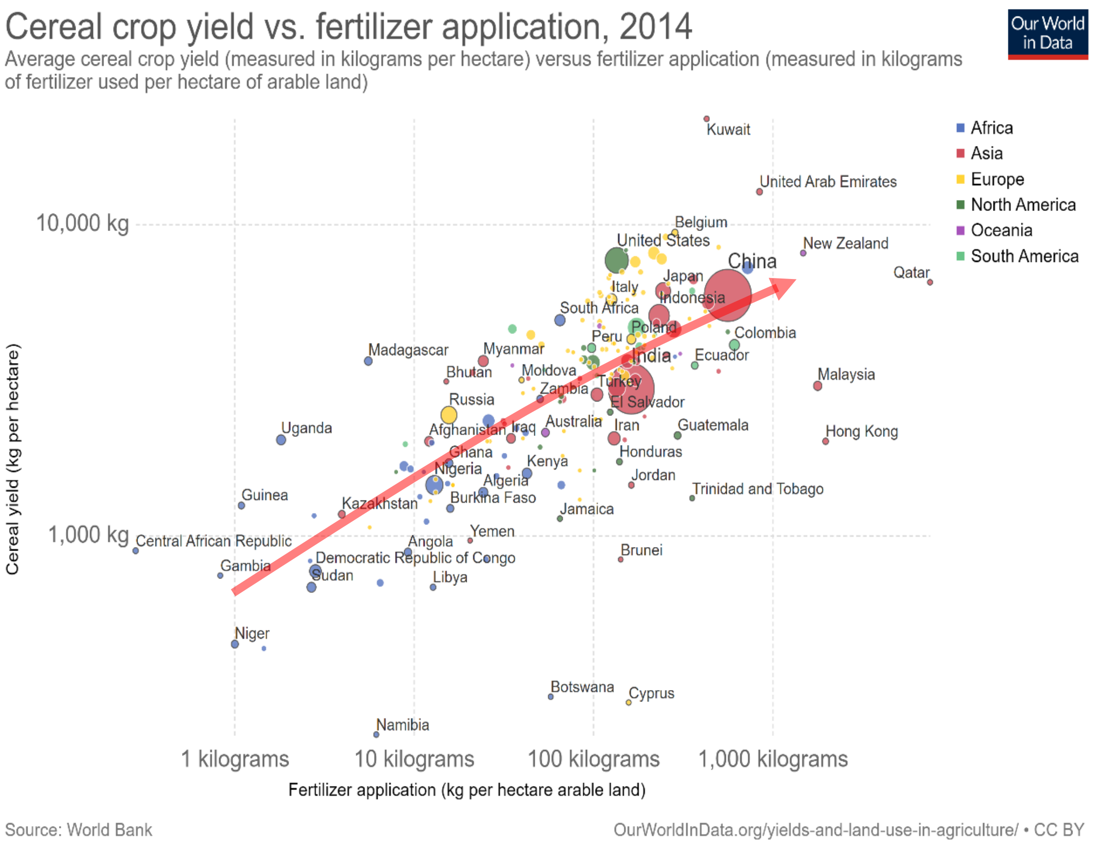
Reducing non-CO2 emissions from agriculture

Halting deforestation; reforestation

Decarbonisation of the energy system based on bio-energy

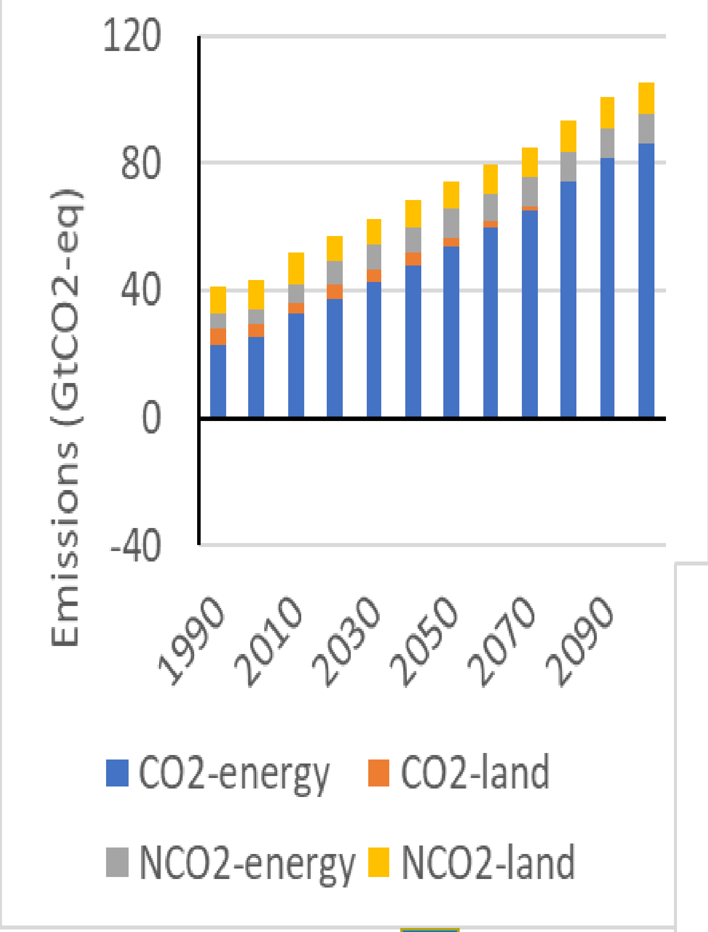
Increasing agriculture efficiency

- Sine quod non…
  - 50-60% increase in food demand
  - Room for bio-energy, afforestation



- Possible trade-offs:
  - Intensification increases inputs (energy use → CO_2, fertilizer → N_2O)
  - Intensification can lead to negative environmental impacts

Default response strategy



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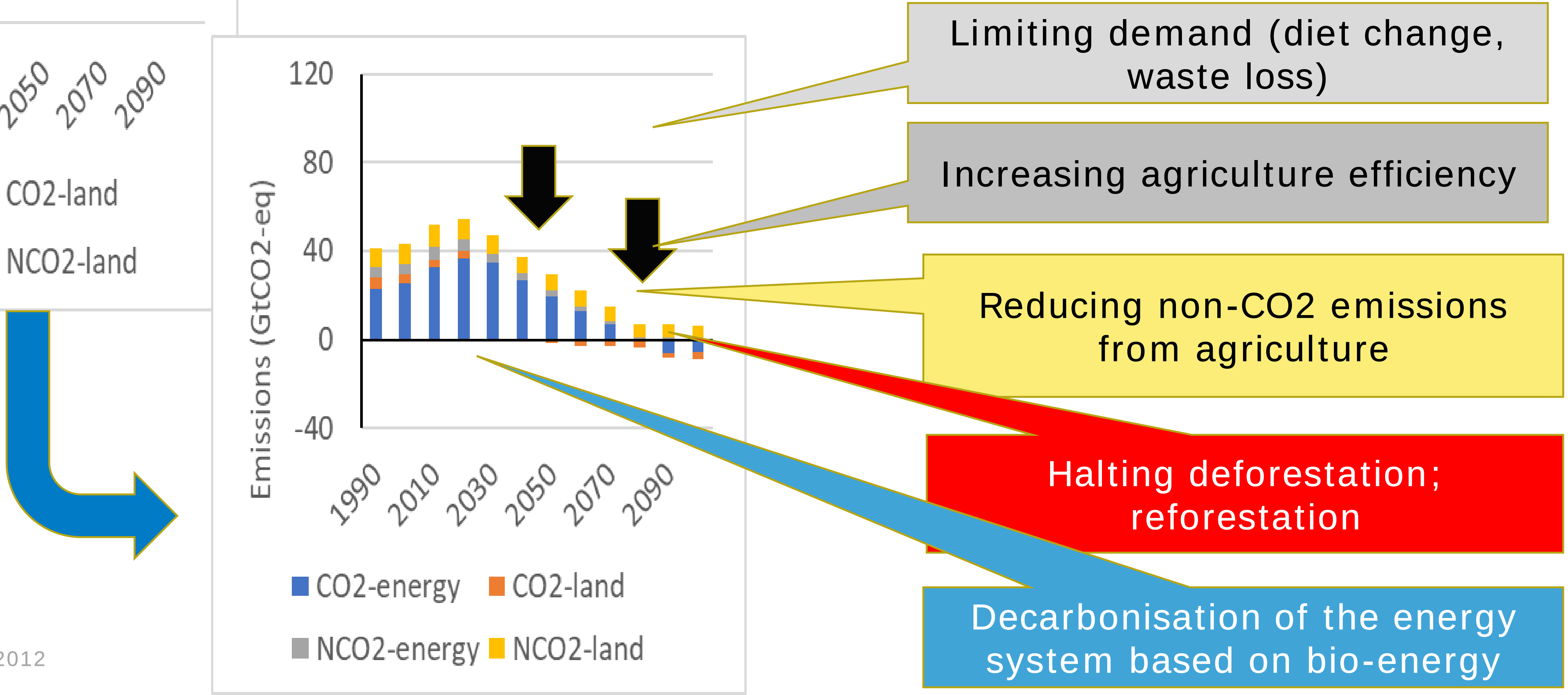
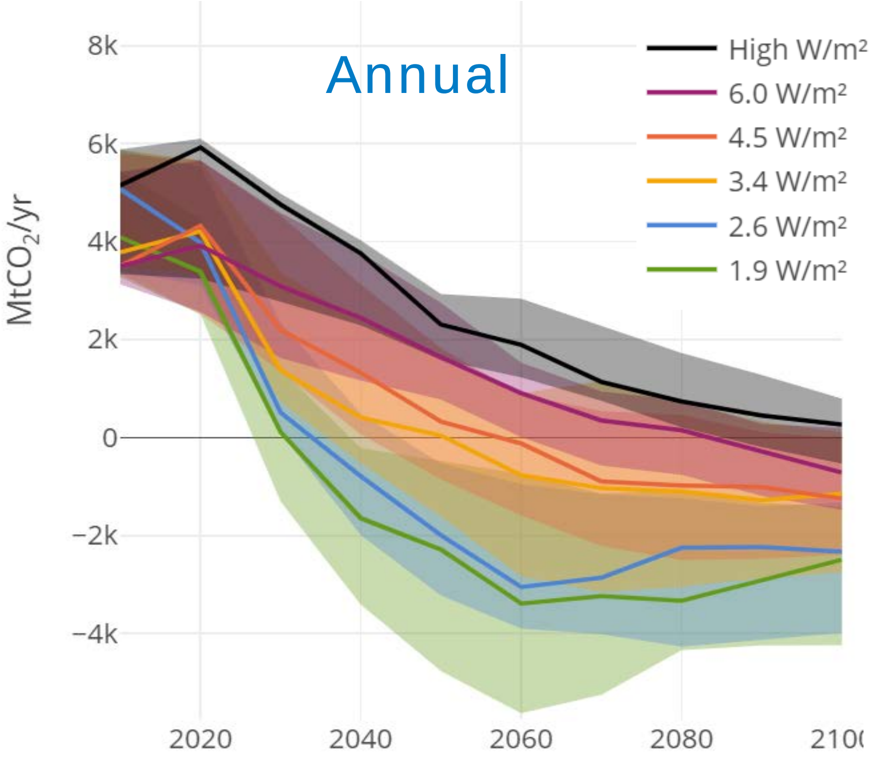
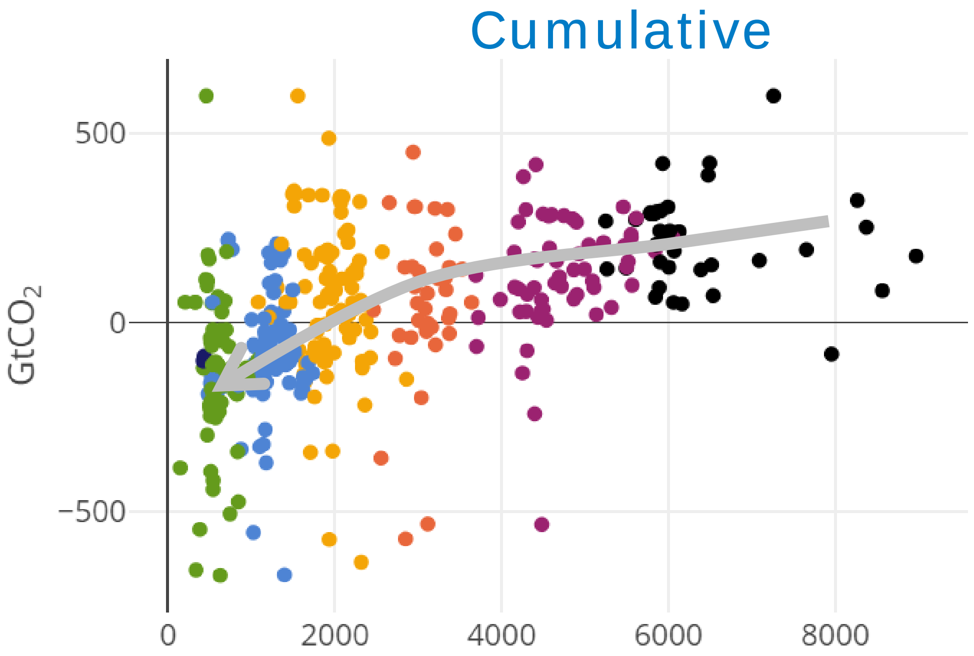


Halting deforestation; reforestation

CO_2 emissions from land-use change





About - 2 $GtCO_2$/yr or comulative 0-300 $GtCO_2$

- Possible trade-offs:
  - Competition with agriculture land (price increases)
  - Competition with bio-energy
  - Albedo impacts (boreal zones)

Source: IPCC SYR1.5 scenario database

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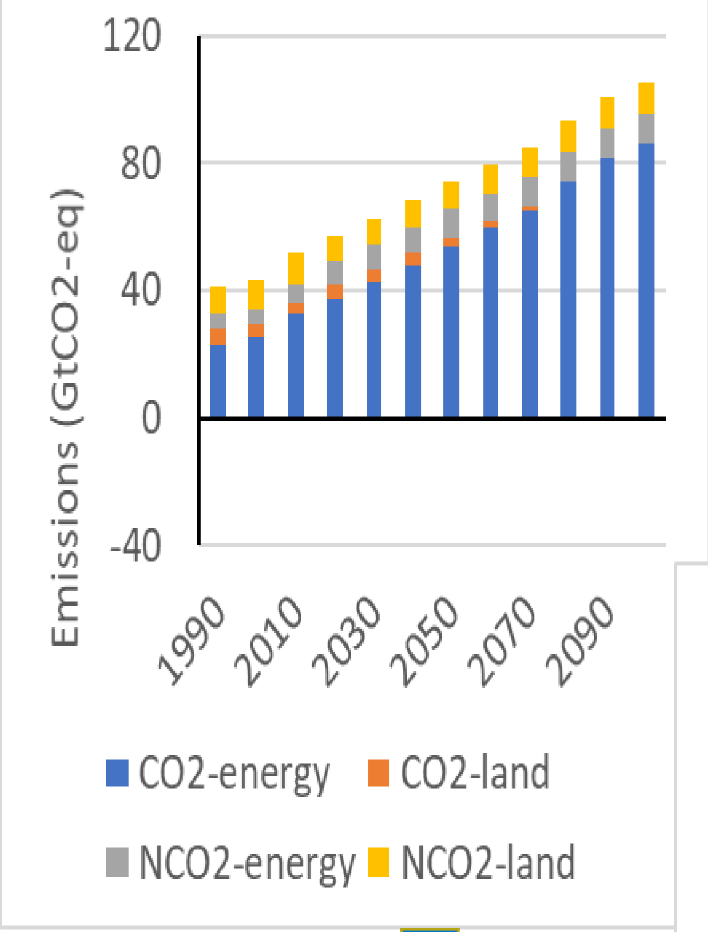
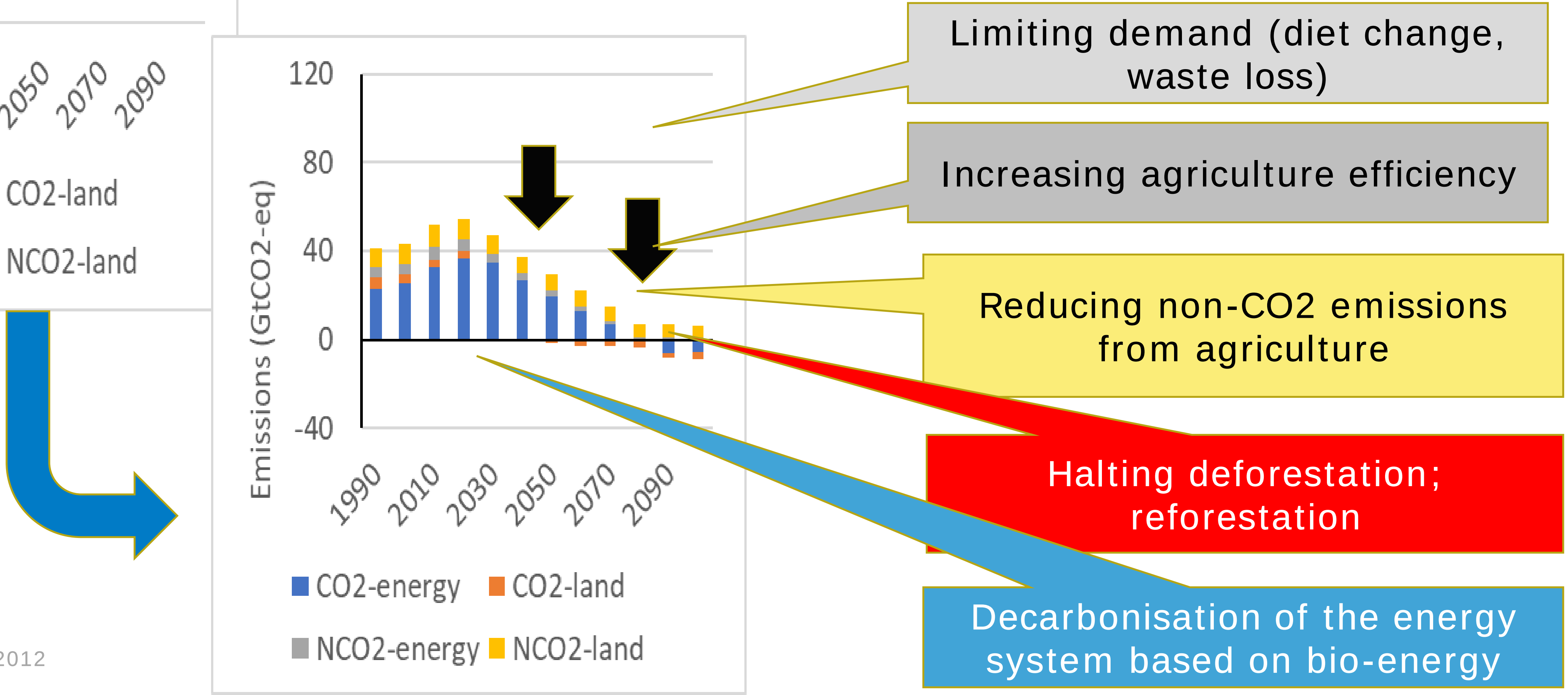
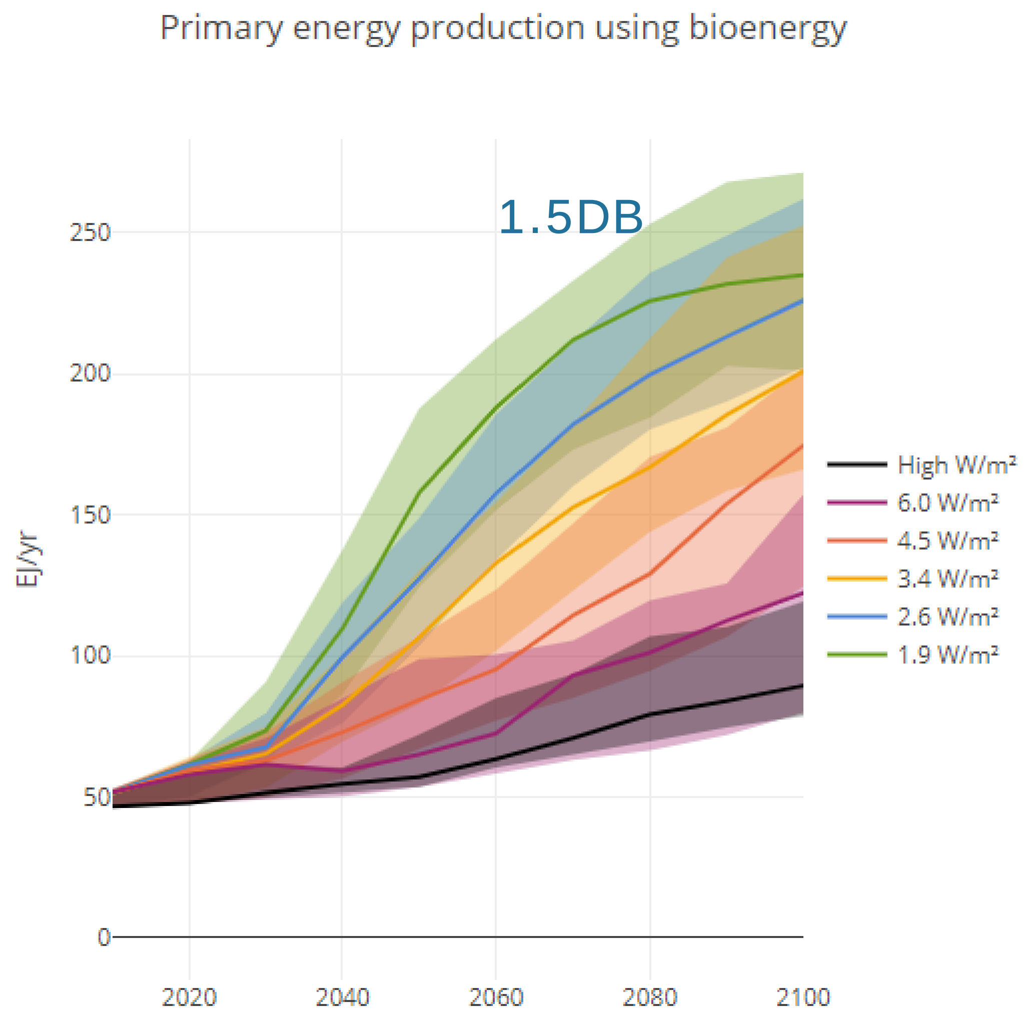
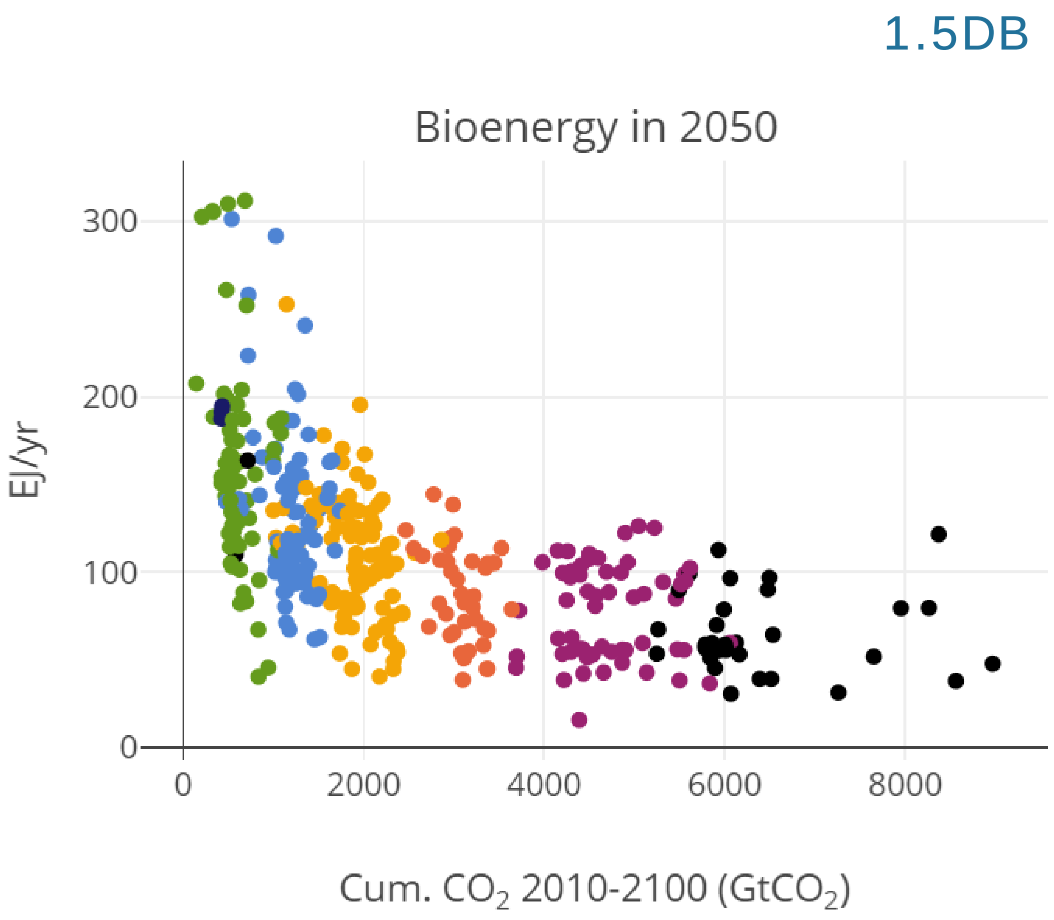




Decarbonisation of the energy system based on bio-energy



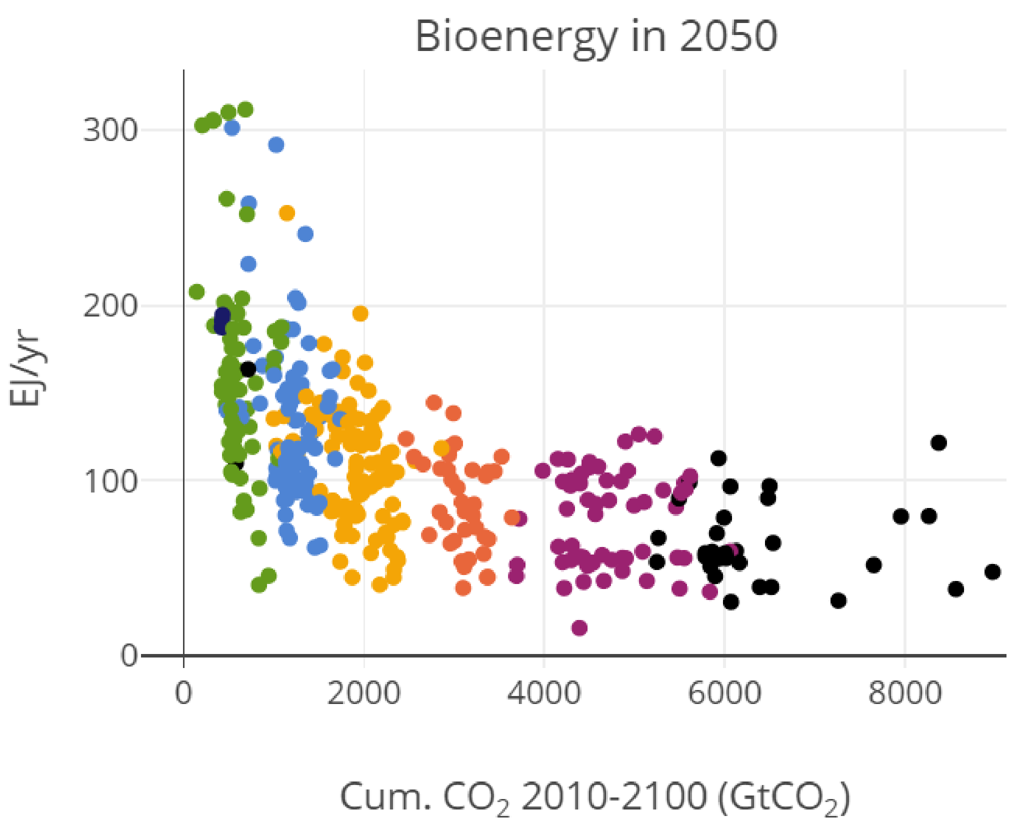


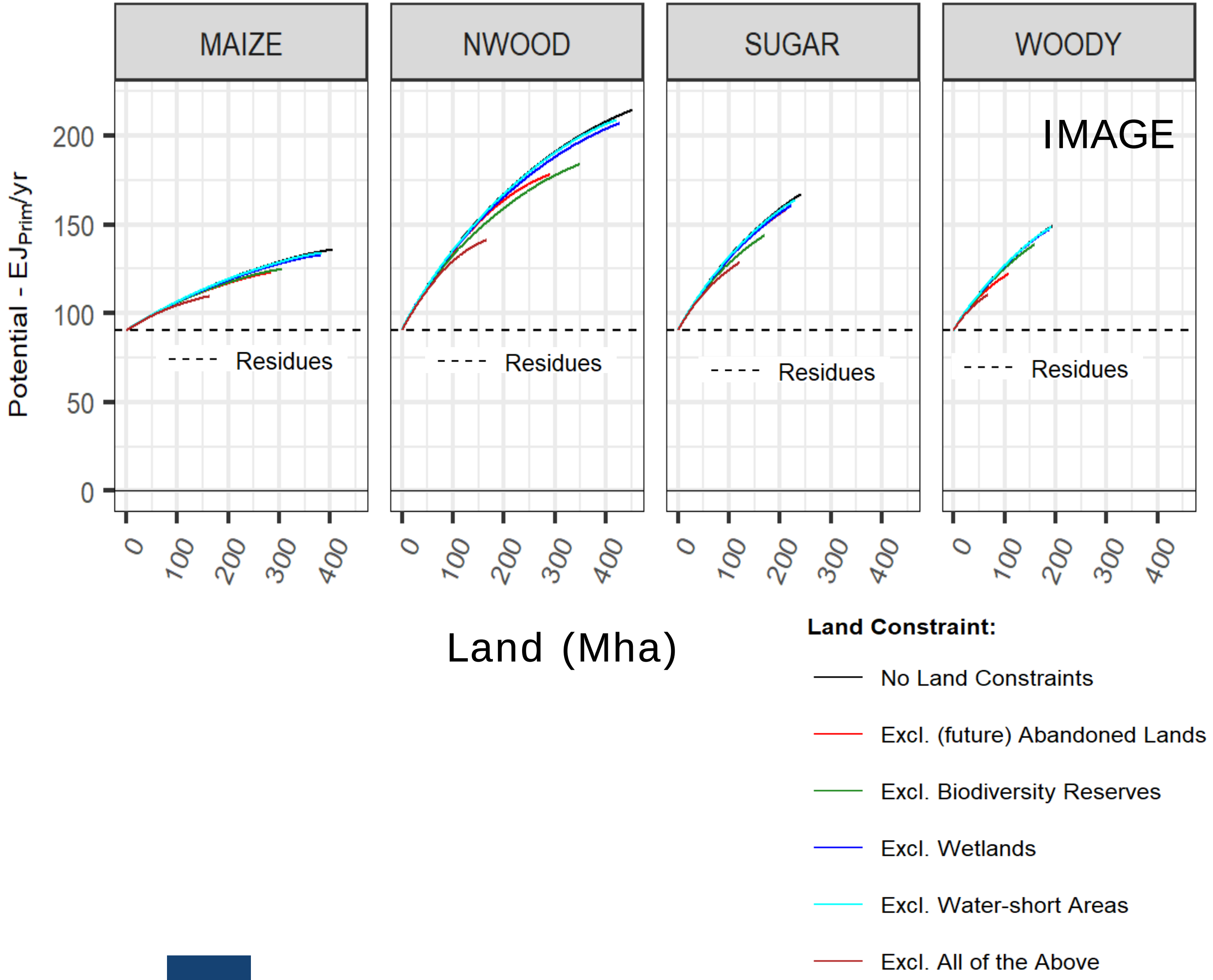
About 100-250 EJ of bio-energy demand

Source: IPCC SYR1.5 scenario database

Decarbonisation of the energy system based on bio-energy

Can we produce 200 EJ?





Source: Based on Daioglou et al

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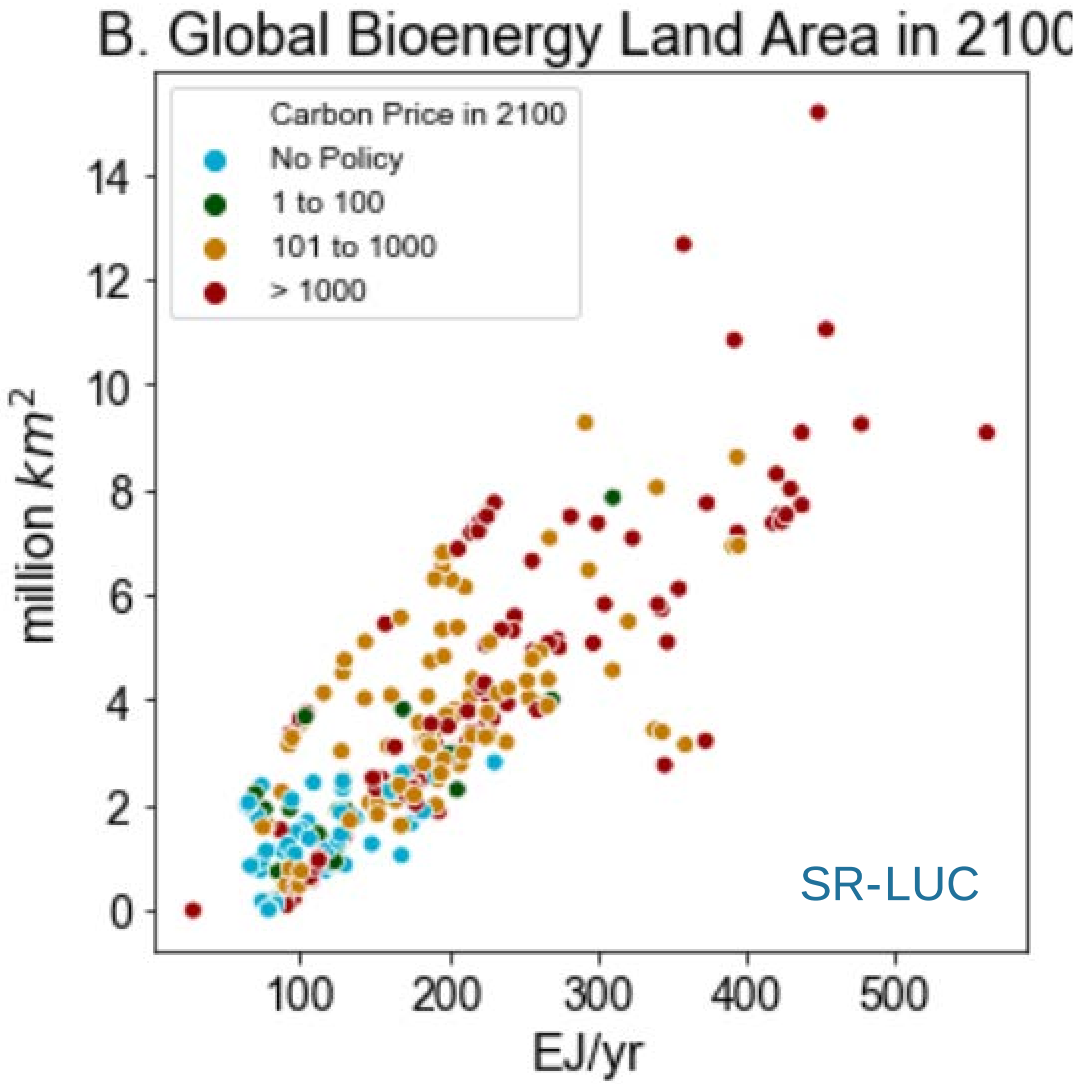
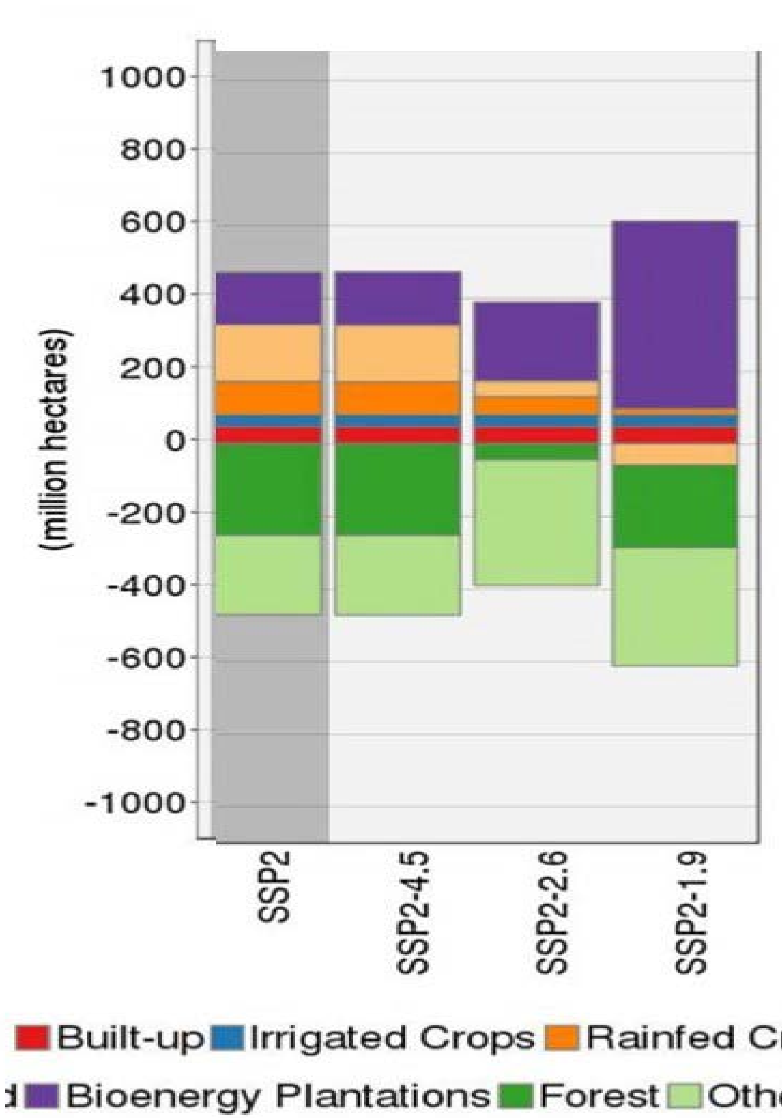
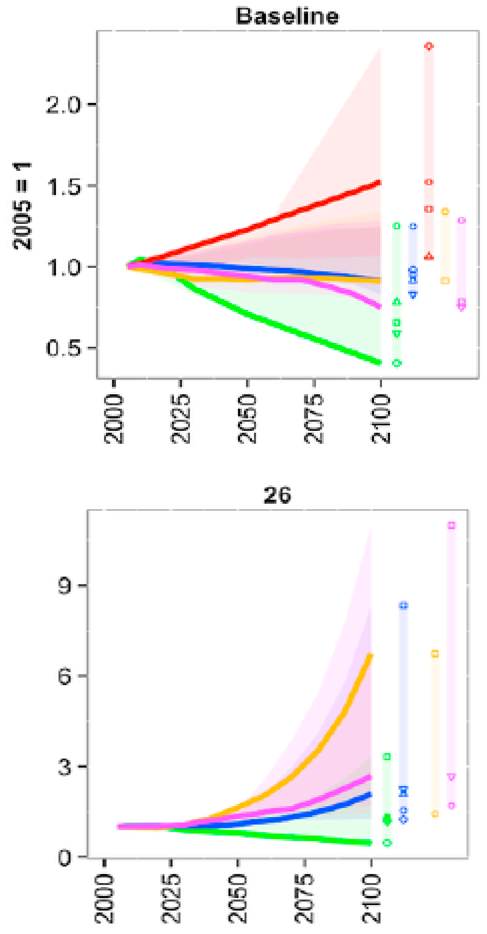


Land use



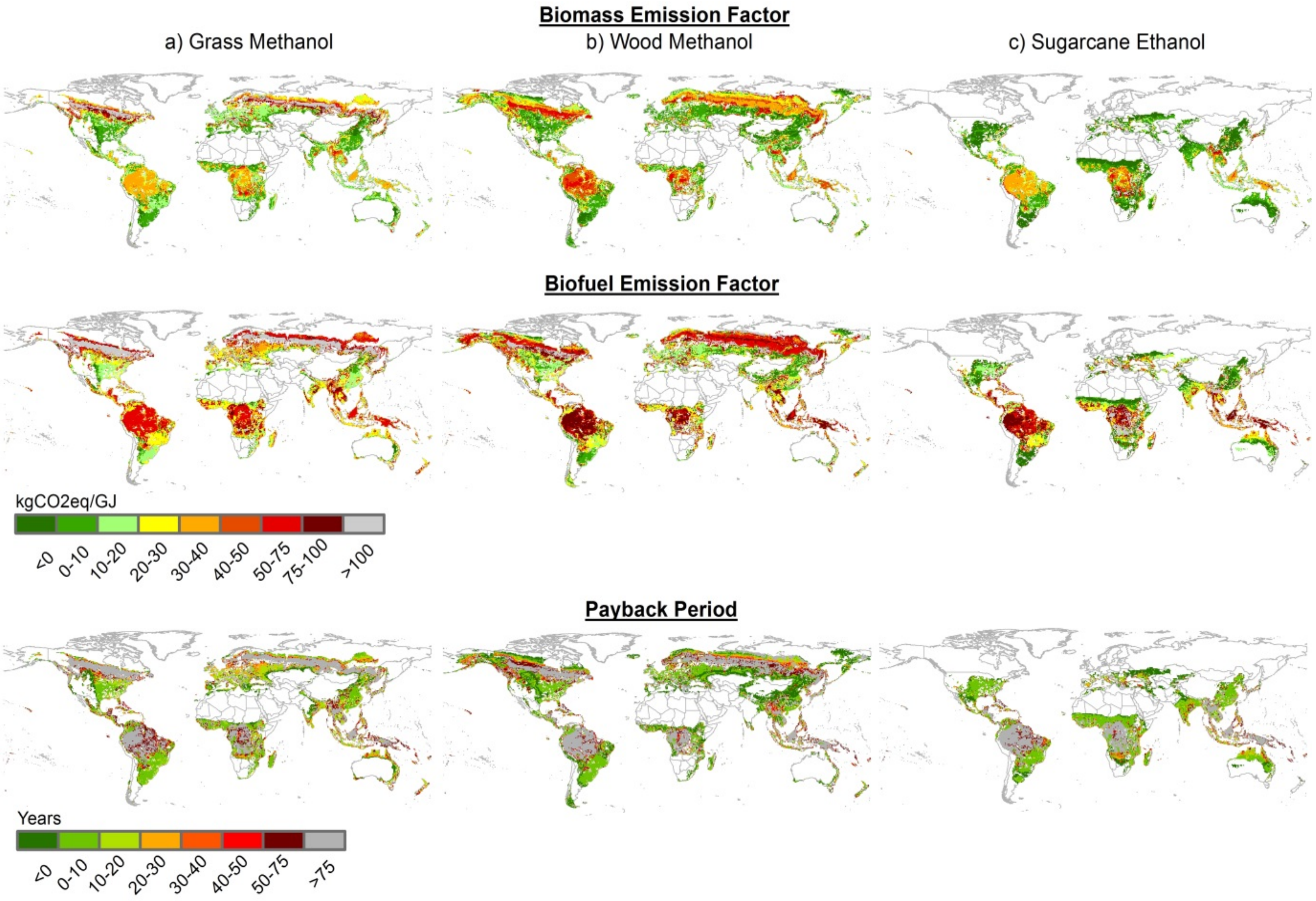
Food prices



Excl. All of the Above

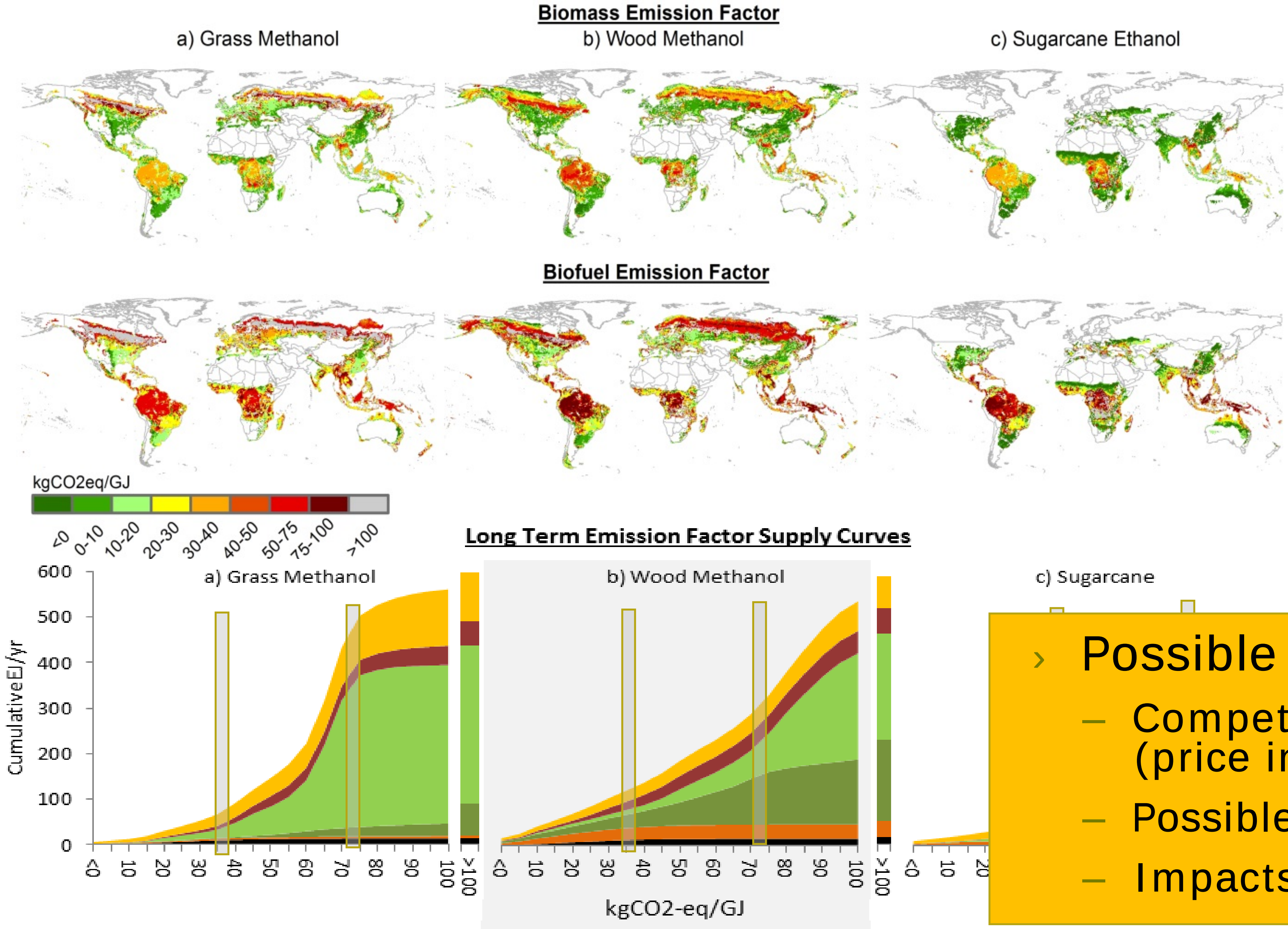
Decarbonisation of the energy system based on bio-energy

But at what costs in terms GHG?



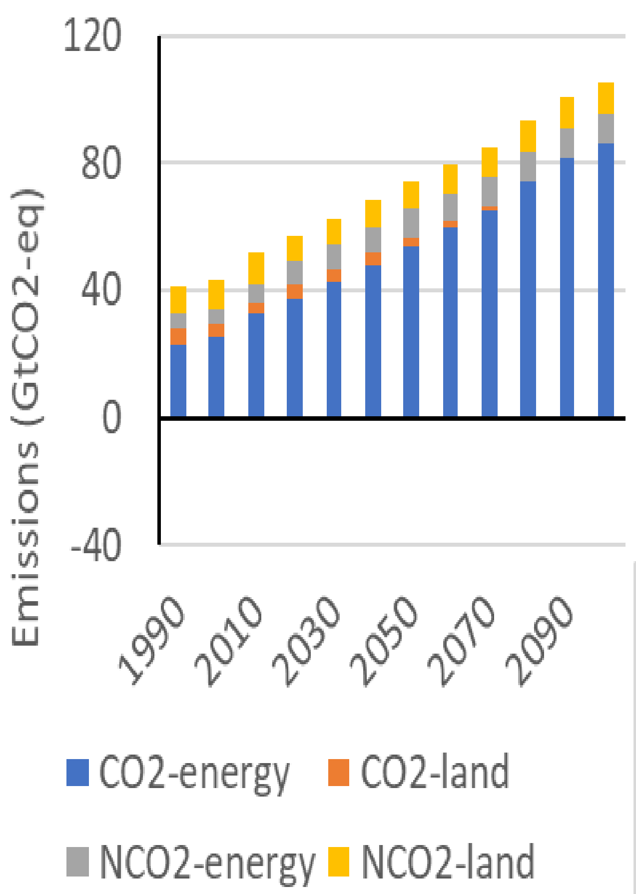
Source: Daioglou et al.

Decarbonisation of the energy system based on bio-energy



- Possible trade-offs:
  - Competition with agriculture land (price increases)
  - Possible trade-off with biodiversity
  - Impacts on GHG emissions

Default response strategy



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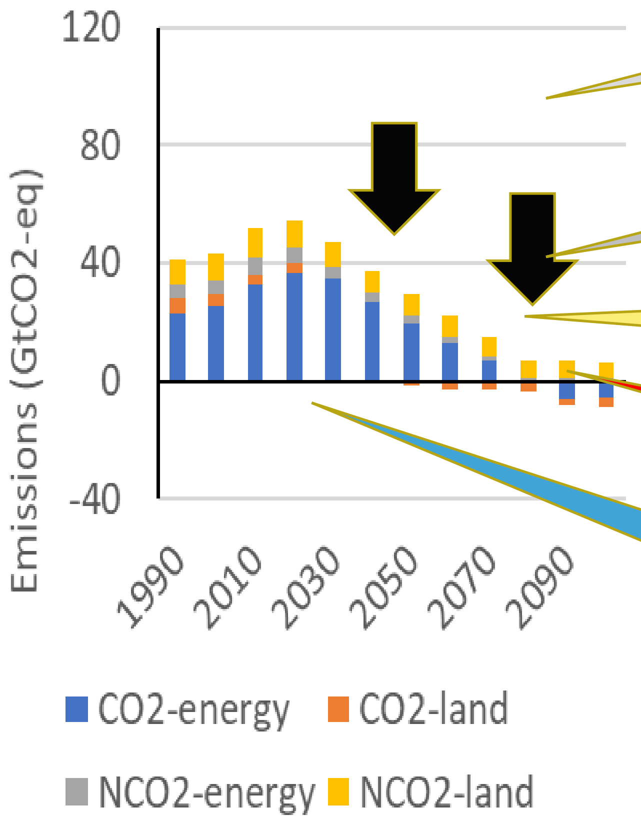

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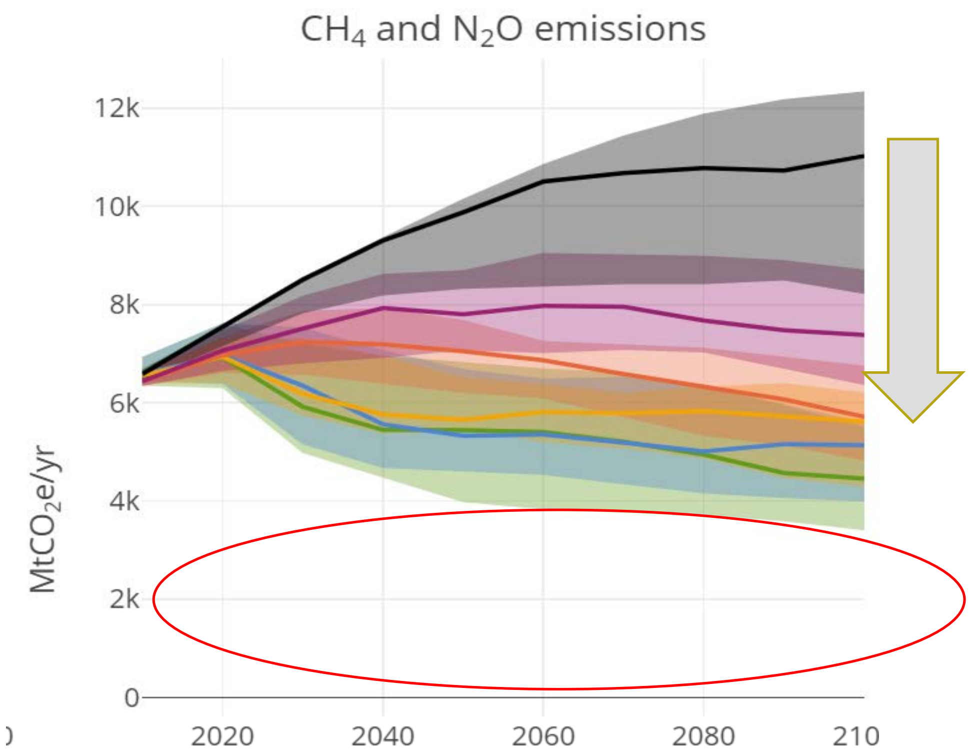
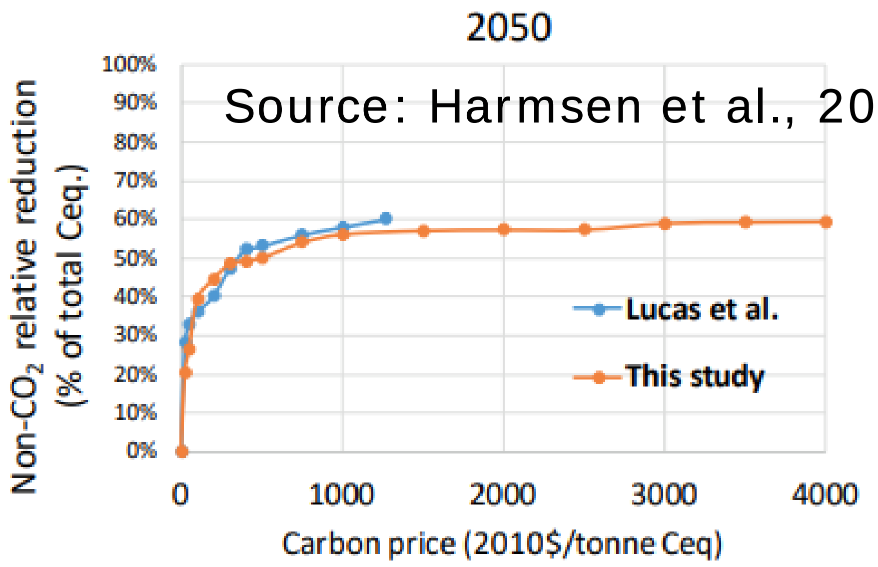


About 4-6 $GtCO_2$/yr reduction

Source: IPCC SYR1.5 scenario database



- Possible trade-offs:
  - Increase in food prices (especially if implemented poorly)

Default response strategy

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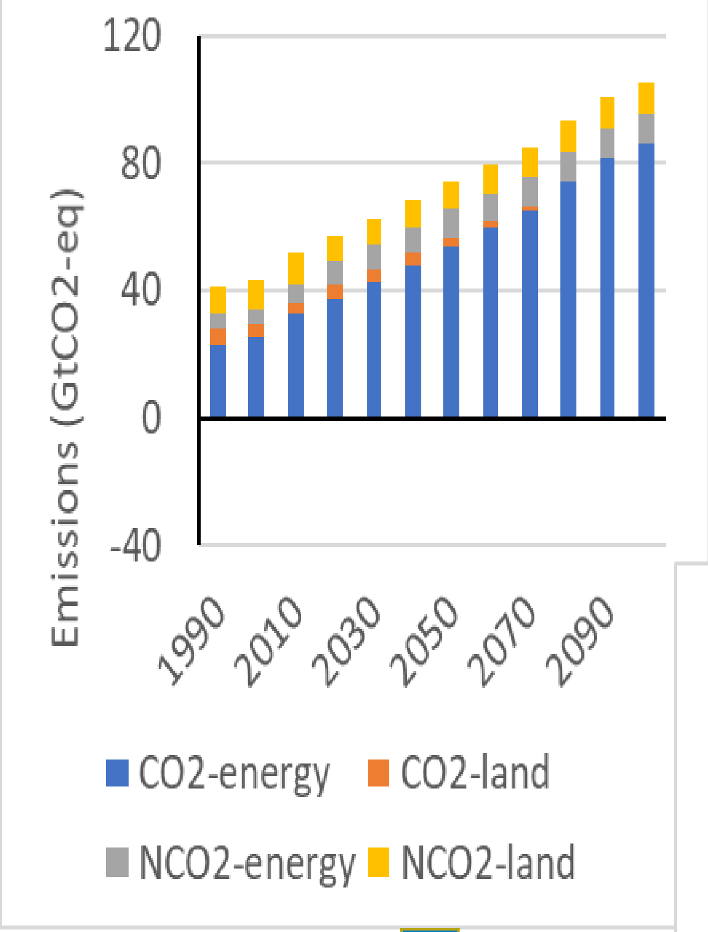

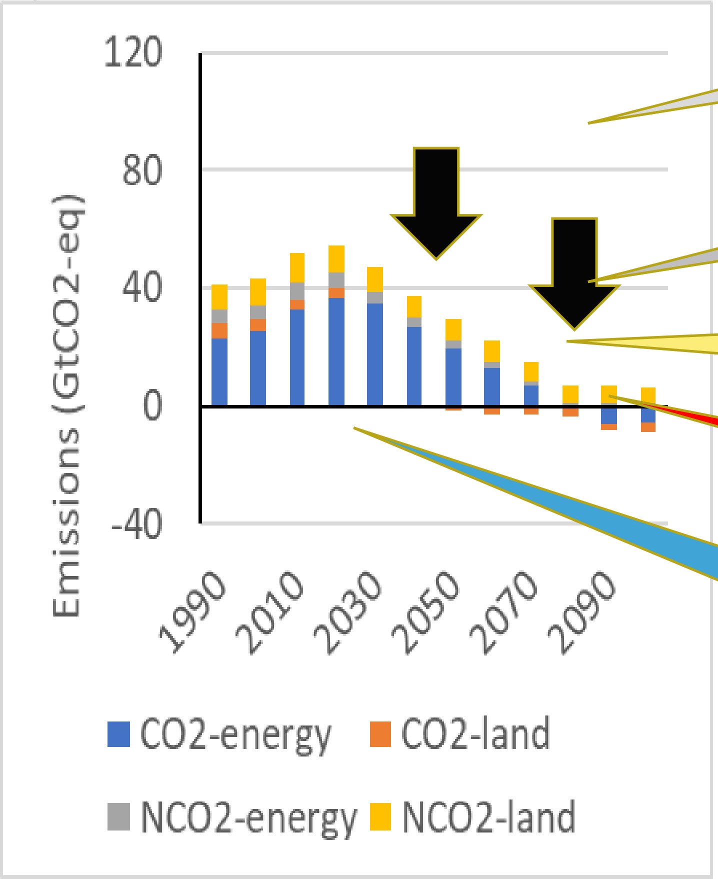

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Increasing agriculture efficiency

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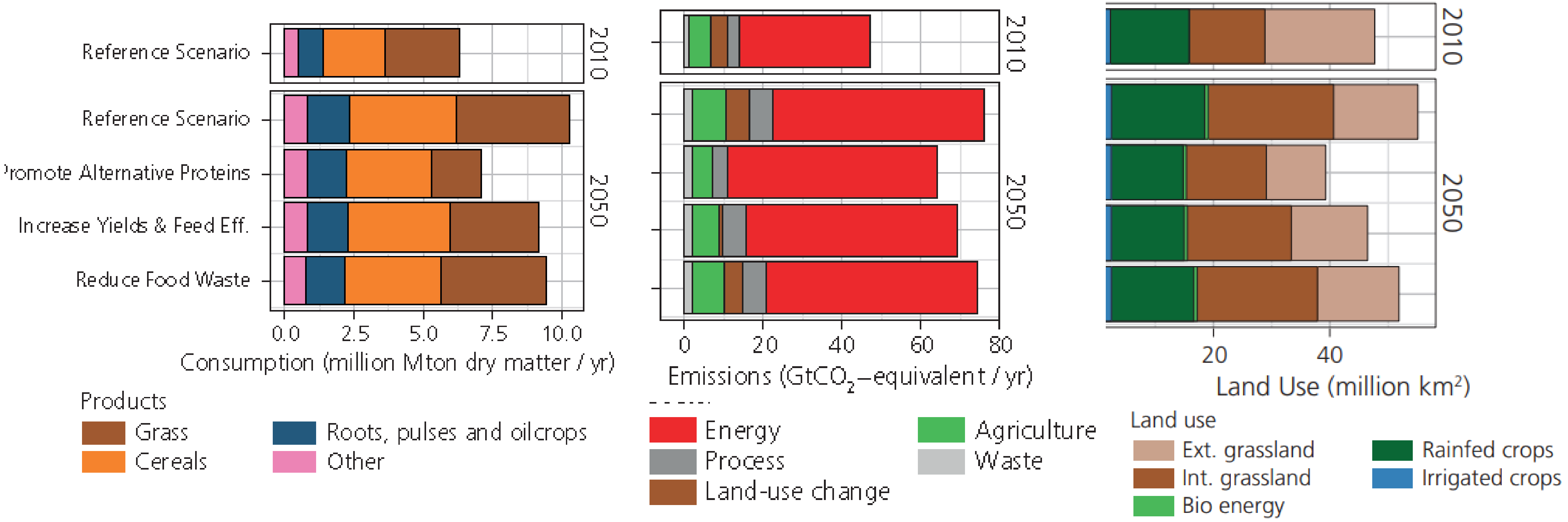
Decarbonisation of the energy system based on bio-energy

Limiting demand (diet change, waste loss)

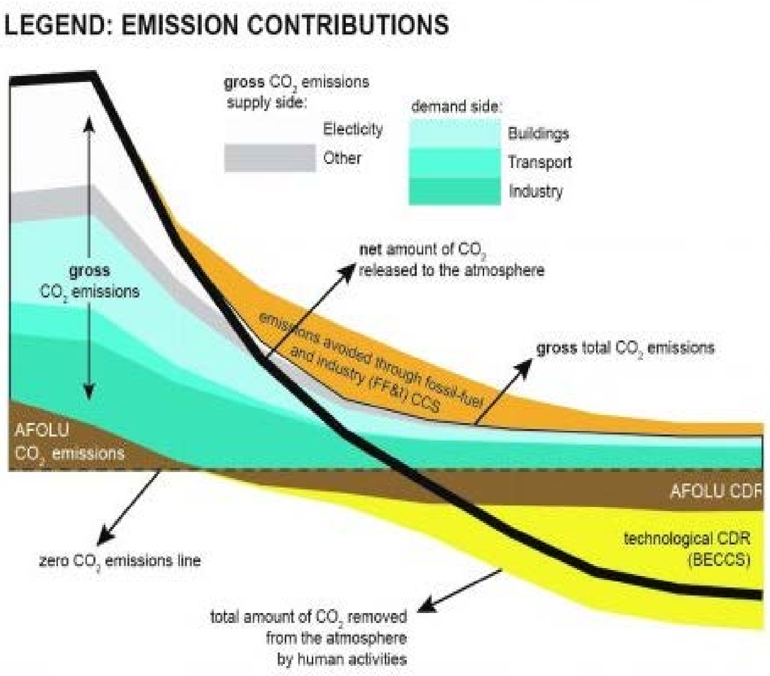
Alternative route – lifestyle change can help

In particular reducing meat consumption to healthy levels can help a lot

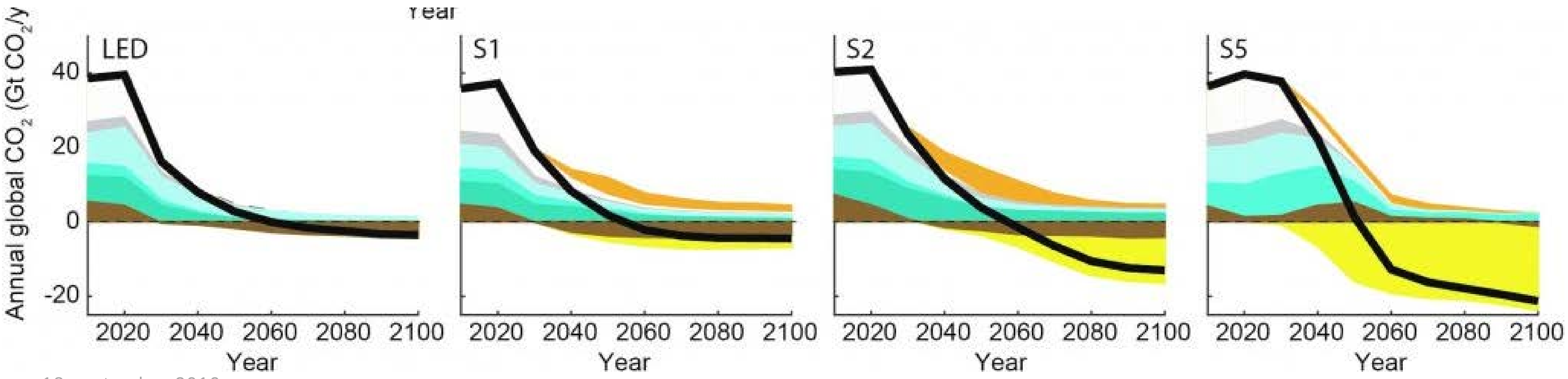


Archetypes of decarbonization pathways

- Trade-offs between different options
- Trade-offs in time



Source: IPCC SYR1.5



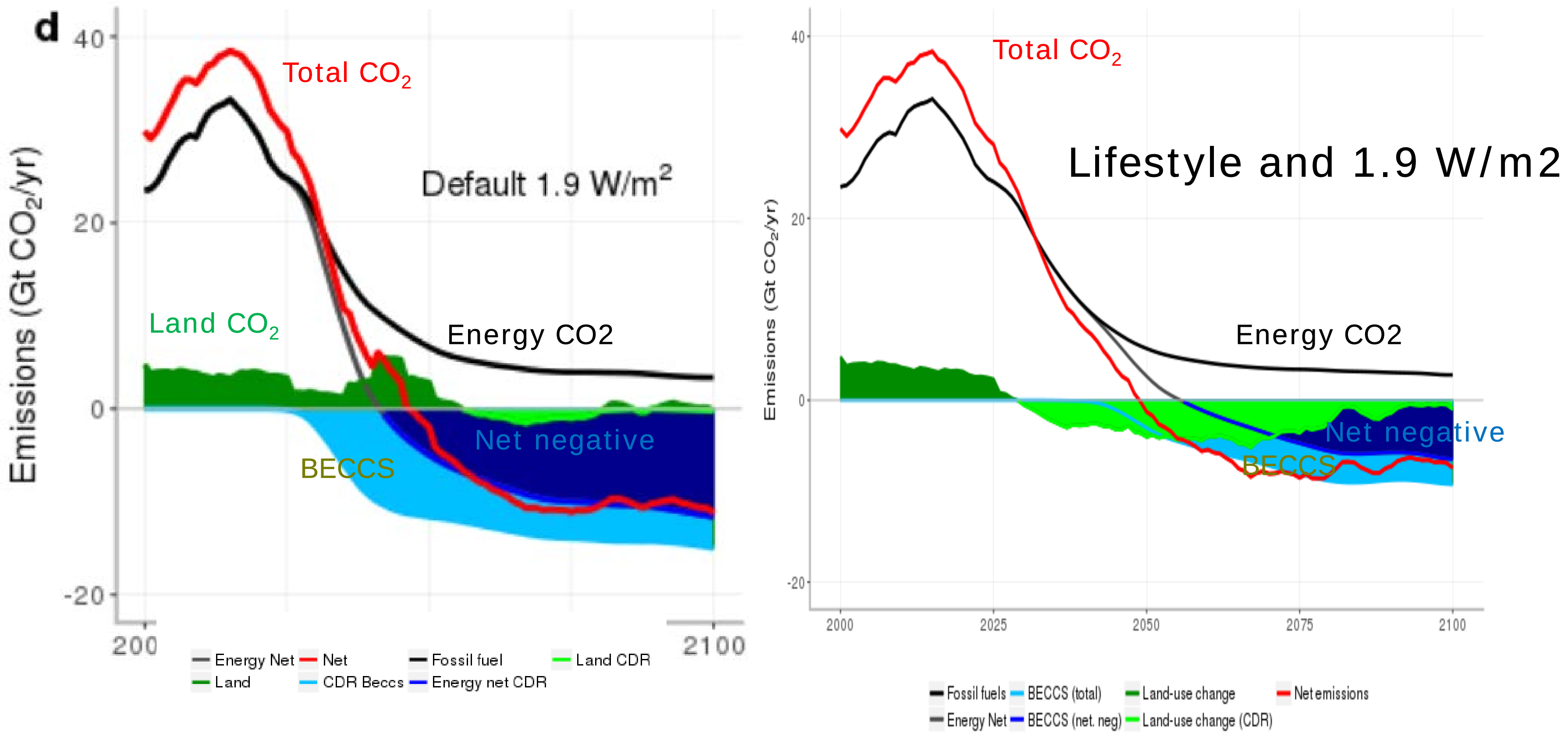
Alternative pathways

Scenario	Description
Default	Selection of technologies based on least-cost
Lifestyle change	less meat-intensive diet (conform health recommend… …nsive transport modes, less use of heating and cooling (c… …ooling reference levels) and reduction of use of several c…
Renewable electricity	Higher electrification rates in all end-use sectors, … assumptions on the integration of variable renewa… …ssion, distribution, and storage
Low non-CO2	Implementation of best-available technologies for red… …missions and complete application of cultivated meat in 2050.
Low population	Implementation of low population scenario based on SSP1 [16]
Efficiency	Rapid application of best-available technologies for energy and material use in all relevant sectors
Agriculture intensification	80% convergence to most efficient livestock system globally by 2050; Yield highest management factor in SSP1 or SSP5, achieved in 2050

i.e. 10.4 kcal/cap/day of cattle, 16.0 of pork, 32.3 of eggs, 33.2 of poultry and 13.0 kcal/cap/day of fish and seafood

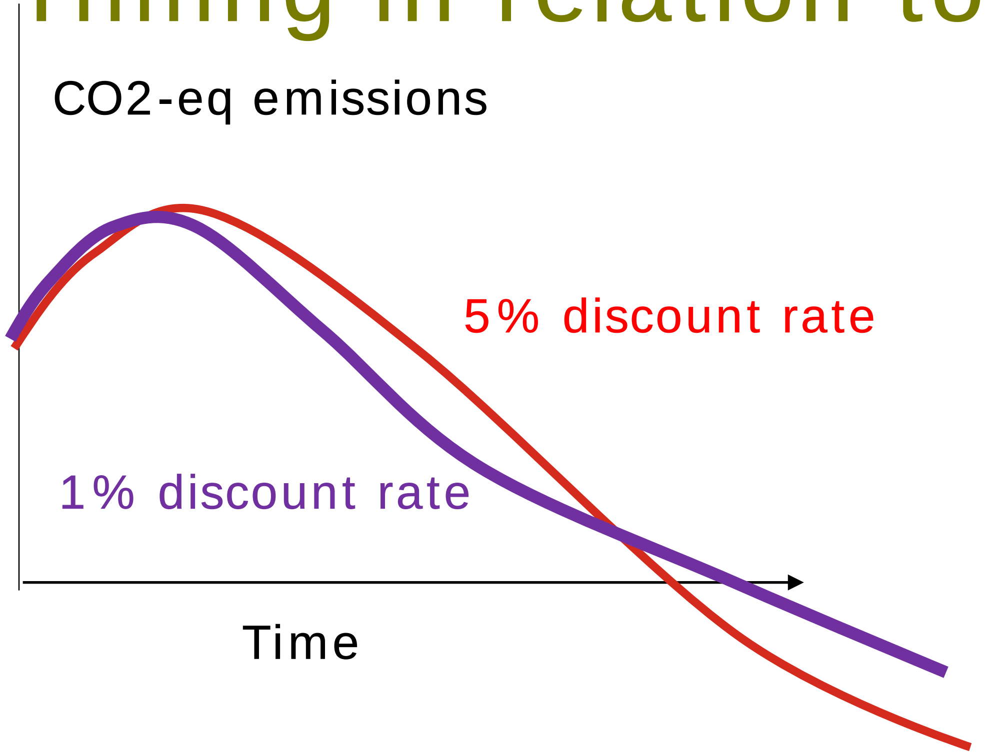
i.e. meat produced using genetically modified cells fed by soya and corn

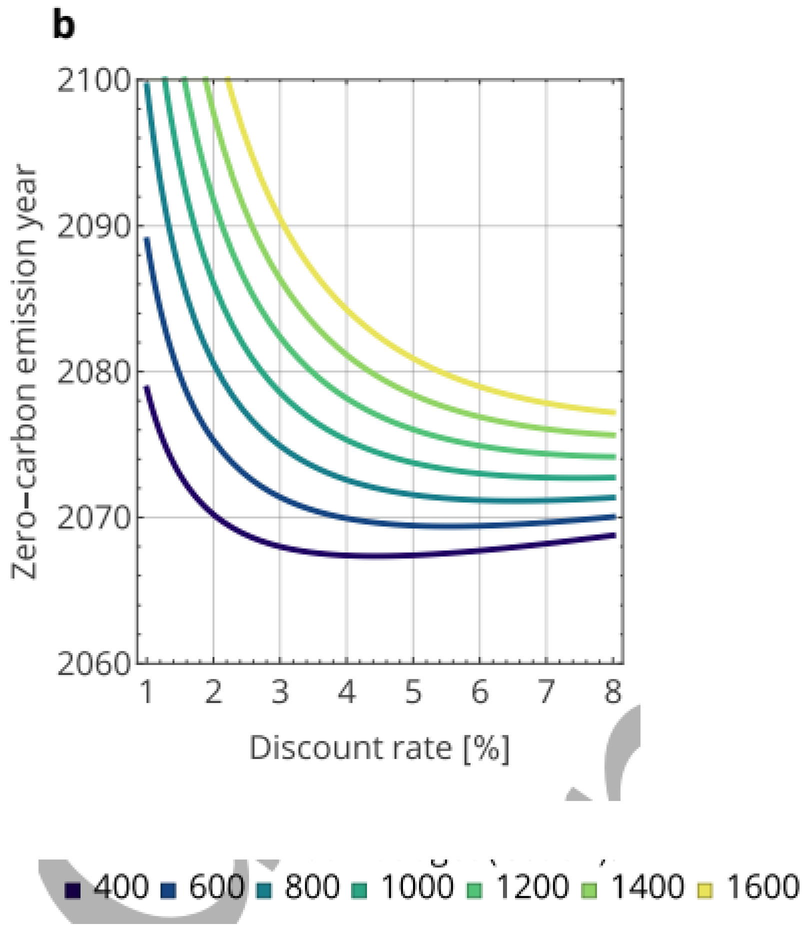
Lifestyle change: Much more sinks as a result of reforestation of current agriculture land



Source: Van Vuuren et al., 2018

Timing in relation to discounting





Source: Emmerling et al., 2019

In conclusion

- Land-based mitigation plays a critical role for deep mitigation scenario (including CDR!)
- Size and timing not fixed in stone
- Different interests (actors), trade-offs, preferences for each option
- Allows to manage (minimize) trade-offs