IAM COMPACT Study 7

Dietary shift to lower animal protein consumption

September 12, 2023

Outline

Motivation and the Model

Motivation

Literature has analyzed how a transition to healthy diets can benefit health, biodiversity, land use, and climate (Lancet-EAT)

But...

- ⋆ it is unclear how this transition will occur
- ⋆ the system-wide effects that could derive from this transition

We'll study the **FVV** diet, ie., a more sustainable diet where the animal protein is reduced, either becoming **F**lexitarian, **V**egetarian, or **V**egan.

Objective

1. Create a model to deal with the uncertainty of the scenario projections
2. Study the following effects:
   - SDG 2: Alimentation
   - SDG 3: Health
   - SDG 6: Water management
   - SDG 13: Emissions
   - SDG 15: Land use

Objective

1. Create a model to deal with the uncertainty of the scenario projections
2. Study the following effects:
   - SDG 2: Alimentation
     - Macronutrients consumption
   - SDG 3: Health
   - SDG 6: Water management
   - SDG 13: Emissions
   - SDG 15: Land use

Objective

1. Create a model to deal with the uncertainty of the scenario projections
2. Study the following effects:
   - SDG 2: Alimentation
   - SDG 3: Health
     - Premature deaths due to AP
   - SDG 6: Water management
   - SDG 13: Emissions
   - SDG 15: Land use

Objective

1. Create a model to deal with the uncertainty of the scenario projections
2. Study the following effects:
   - SDG 2: Alimentation
   - SDG 3: Health
   - SDG 6: Water management
     - Water consumption (total)
     - Water consumption by crop and livestock
     - Irrigated and Rainfed water demand
   - SDG 13: Emissions
   - SDG 15: Land use

Objective

1. Create a model to deal with the uncertainty of the scenario projections
2. Study the following effects:
   - SDG 2: Alimentation
   - SDG 3: Health
   - SDG 6: Water management
   - SDG 13: Emissions
     - GHG emissions
     - CH_4 agricultural emissions
     - N_2O agricultural emissions
   - SDG 15: Land use

Objective

1. Create a model to deal with the uncertainty of the scenario projections
2. Study the following effects:
   - SDG 2: Alimentation
   - SDG 3: Health
   - SDG 6: Water management
   - SDG 13: Emissions
   - SDG 15: Land use
     - Area of forest, pasture, cropland, and other land
     - Re-forestation
     - Cropland management (area and fertilizer demand)
     - Crop loss due to AP
     - Carbon stock

Assumptions

1. Each person decides to become FVV independently but is influenced by 3 factors:
   - Social pressure weight
   - Percentage of the population following the FVV diet by 2100
   - Peak year when the majority of the population will shift

2. Once a person decides to follow the FVV diet, will stick to this decision for the rest of the century

Assumptions

1. Each person decides to become FVV independently but is influenced by 3 factors:
   - Social pressure weight (Ex. 20)
   - Percentage of the population following the FVV diet by 2100
   - Peak year when the majority of the population will shift

2. Once a person decides to follow the FVV diet, will stick to this decision for the rest of the century

Assumptions

1. Each person decides to become FVV independently but is influenced by 3 factors:
   - Social pressure weight (Ex. 20)
   - Percentage of the population following the FVV diet by 2100 (Ex. 70%)
   - Peak year when the majority of the population will shift

2. Once a person decides to follow the FVV diet, will stick to this decision for the rest of the century

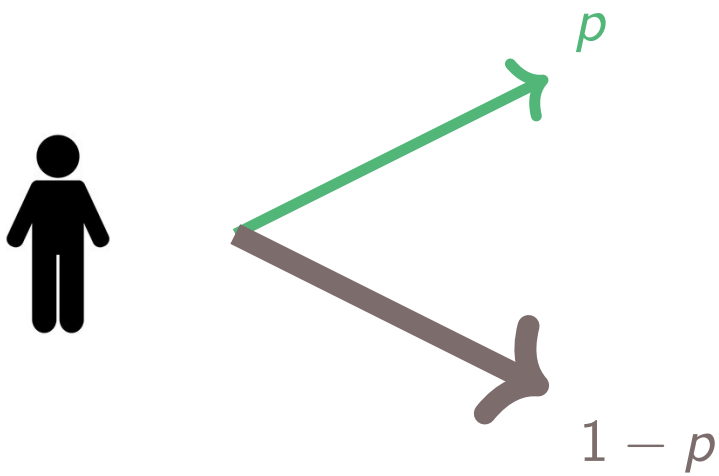
Assumptions

1. Each person decides to become FVV independently but is influenced by 3 factors:
   - Social pressure weight (Ex. 20)
   - Percentage of the population following the FVV diet by 2100 (Ex. 70%)
   - Peak year when the majority of the population will shift (Ex. 2050)

2. Once a person decides to follow the FVV diet, will stick to this decision for the rest of the century

The model

Binomial distribution with probability p

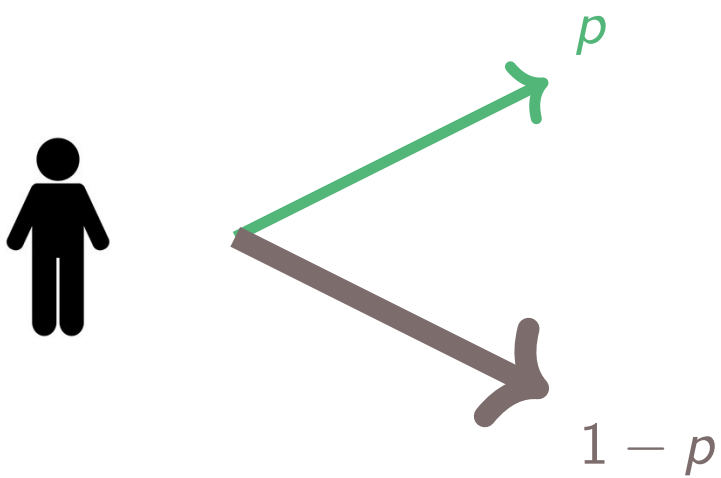


Where the probability p is influenced by

- ⋆ Social pressure weight
- ⋆ Percentage of the population following the FVV diet by 2100
- ⋆ Peak year when the majority of the population will shift

The model

Binomial distribution with probability p

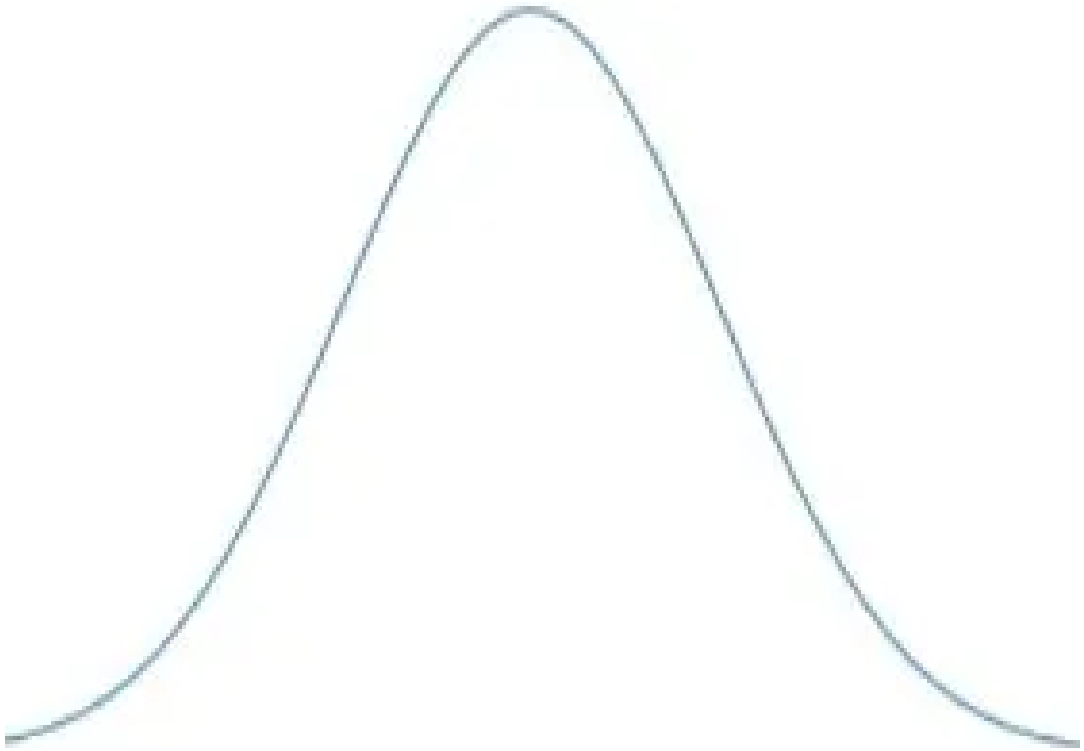


Where the probability p is influenced by

- ⋆ Social pressure weight → Exogenous
- ⋆ Percentage of the population following the FVV diet by 2100
- ⋆ Peak year when the majority of the population will shift

Uncertainty considerations

Each factor value is randomly chosen from a Normal Distribution $N(\mu, \sigma)$



Uncertainty considerations

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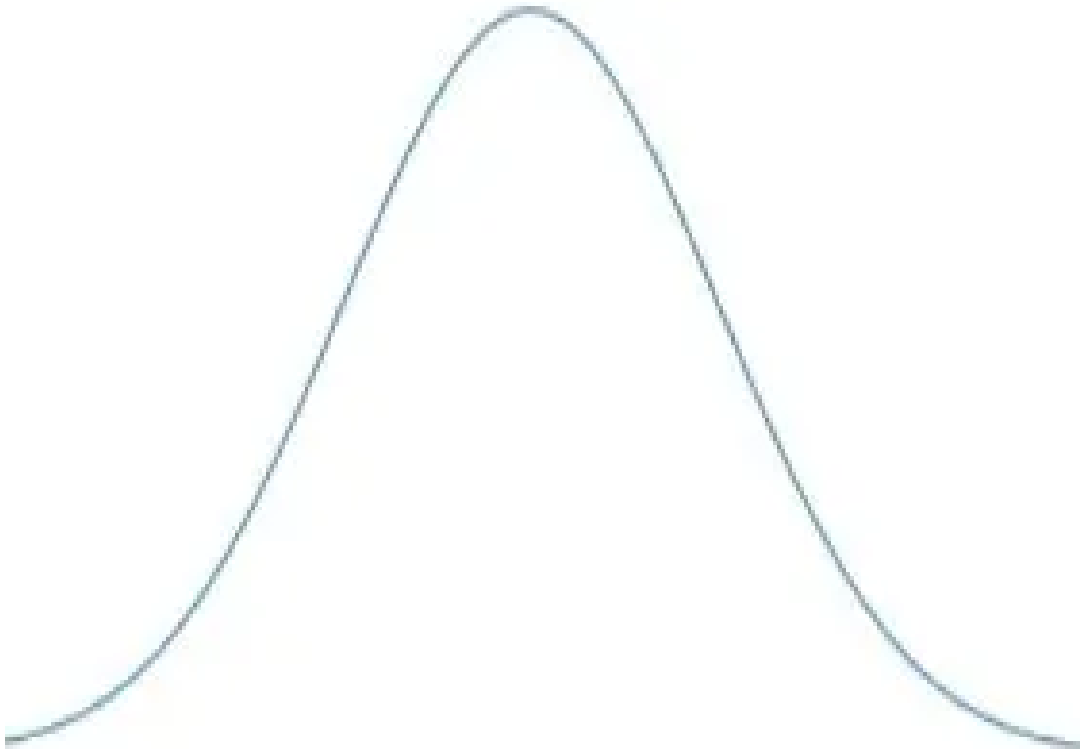
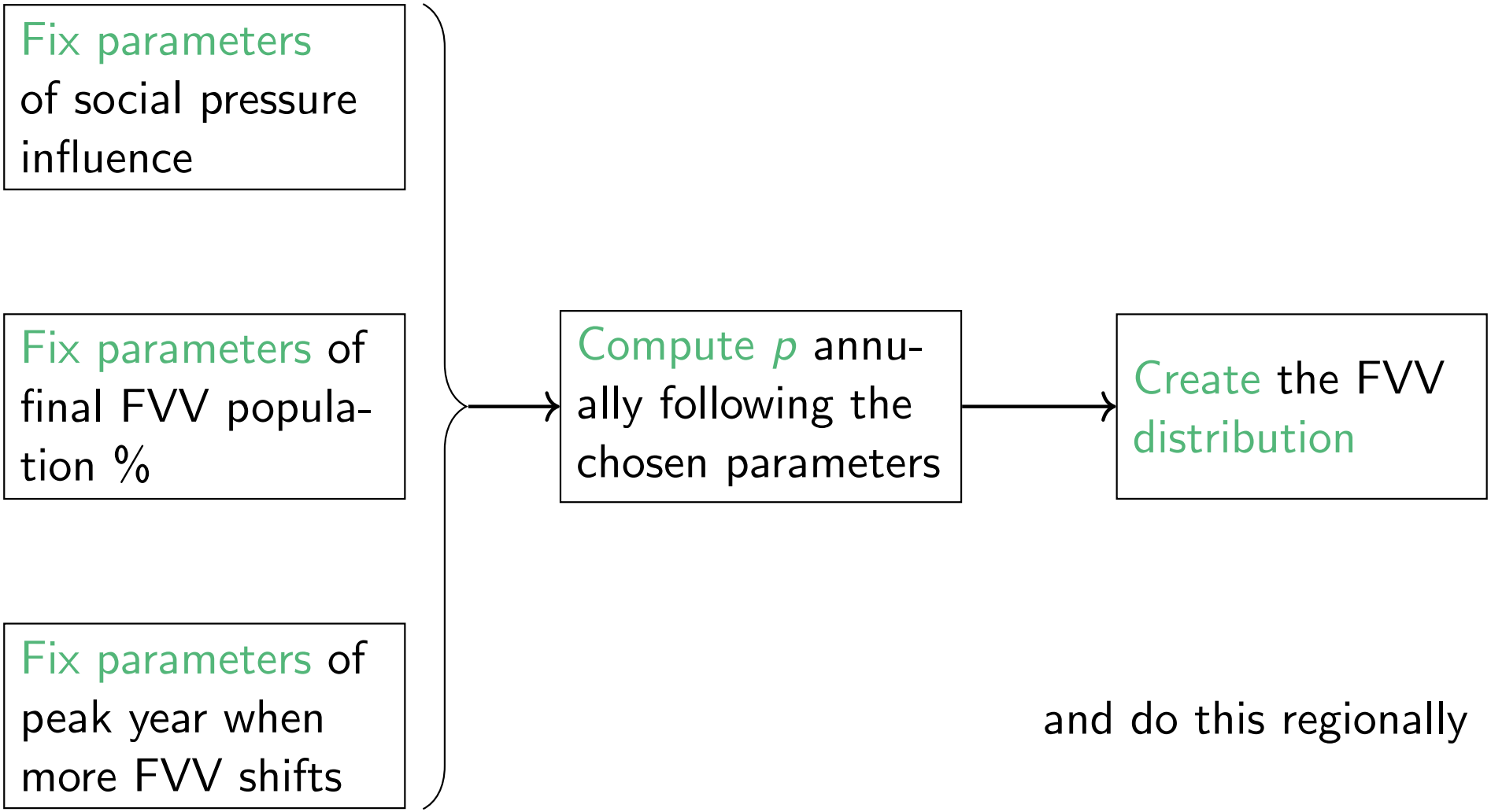
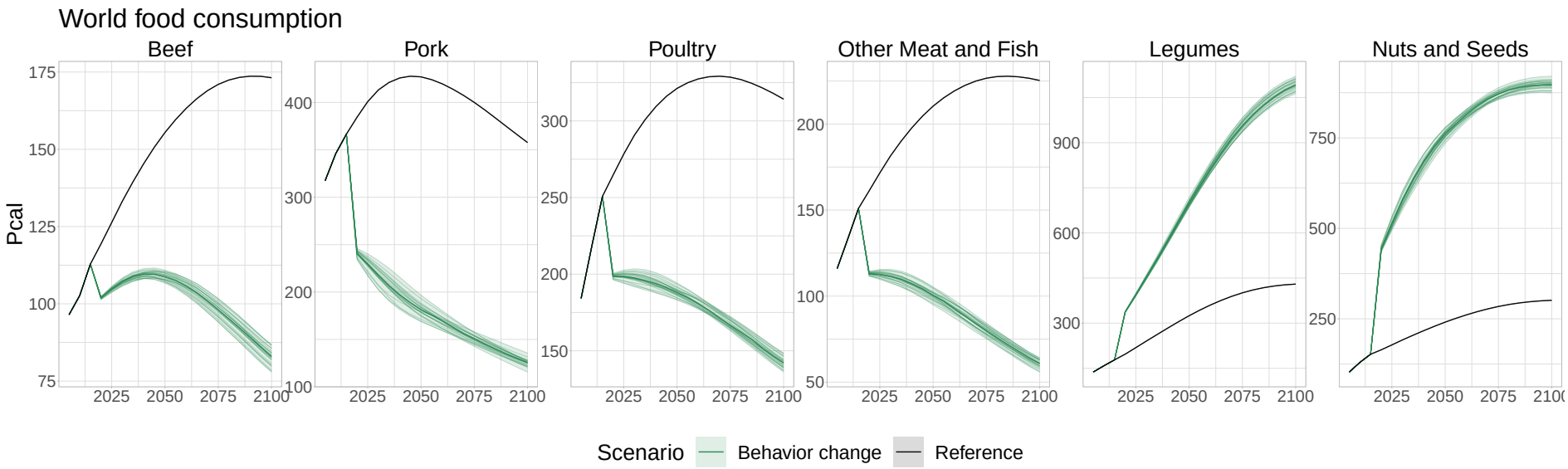


Recap

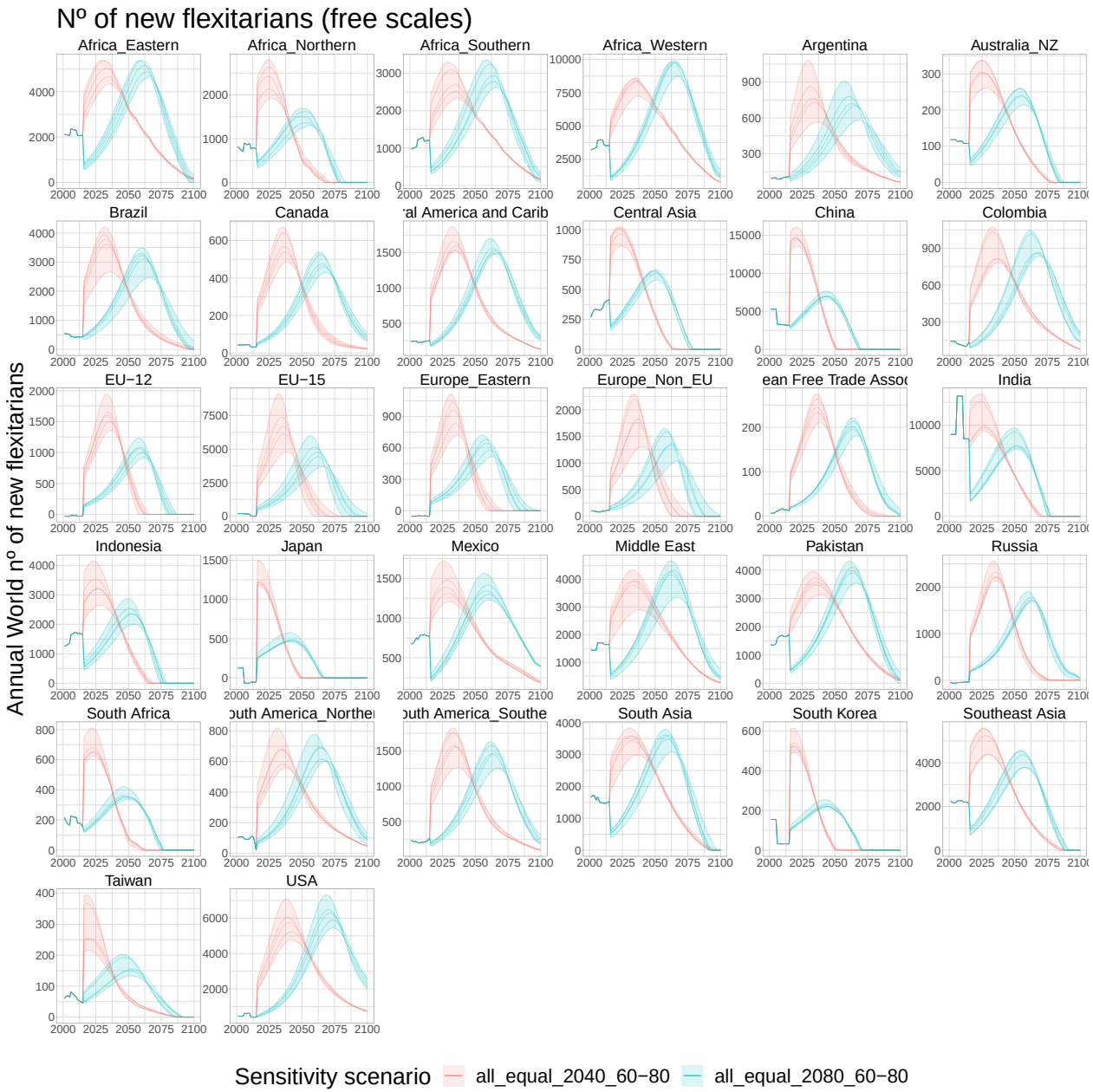


and do this regionally

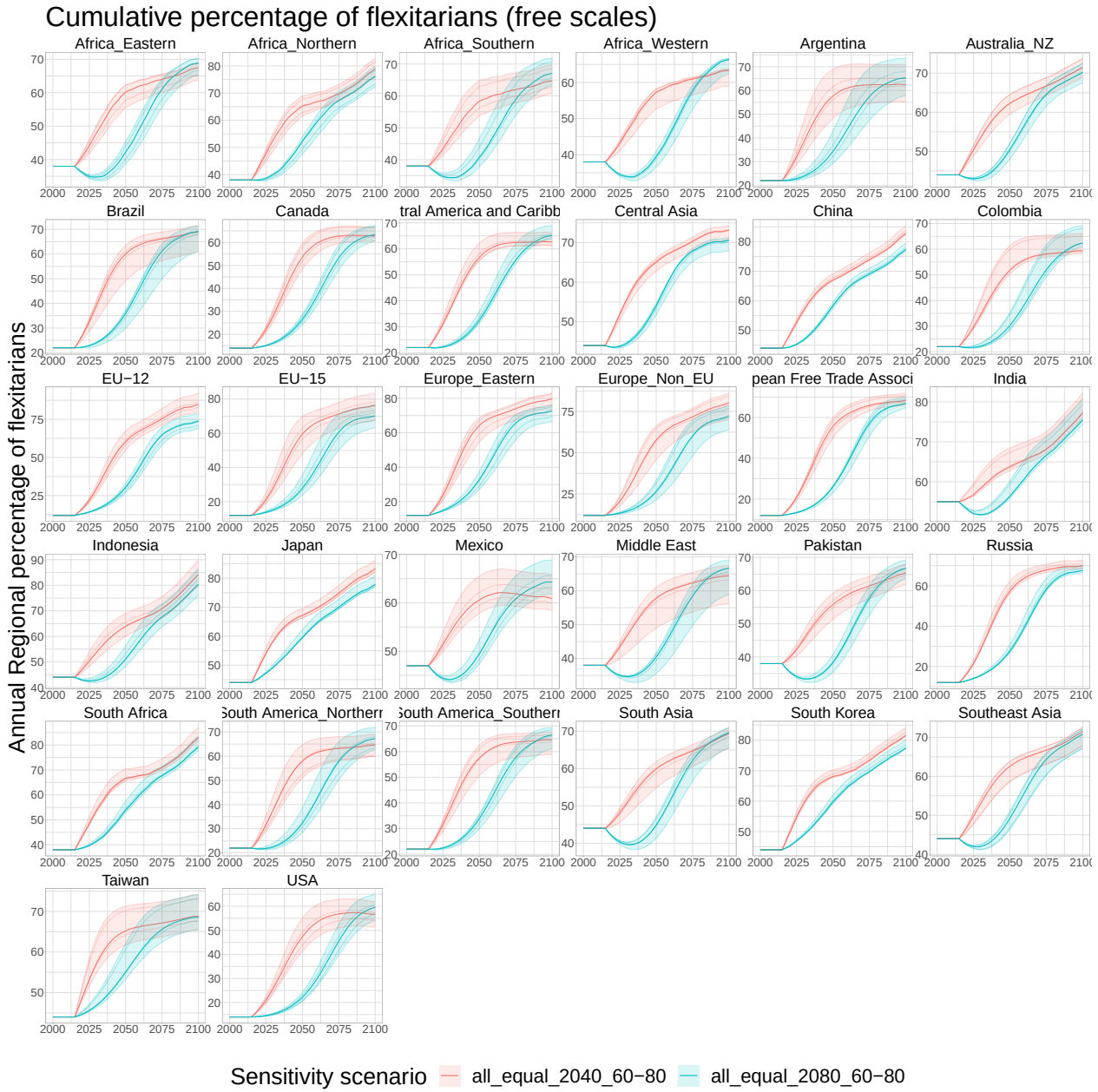
Example


World food consumption
Beef
Pork
Poultry
Other Meat and Fish
Legumes
Nuts and Seeds
Pcal
175
150
125
100
75
400
300
200
100
300
250
200
150
200
150
100
50
900
600
300
750
500
250
2025
2050
2075
2100
Scenario
Behavior change
Reference

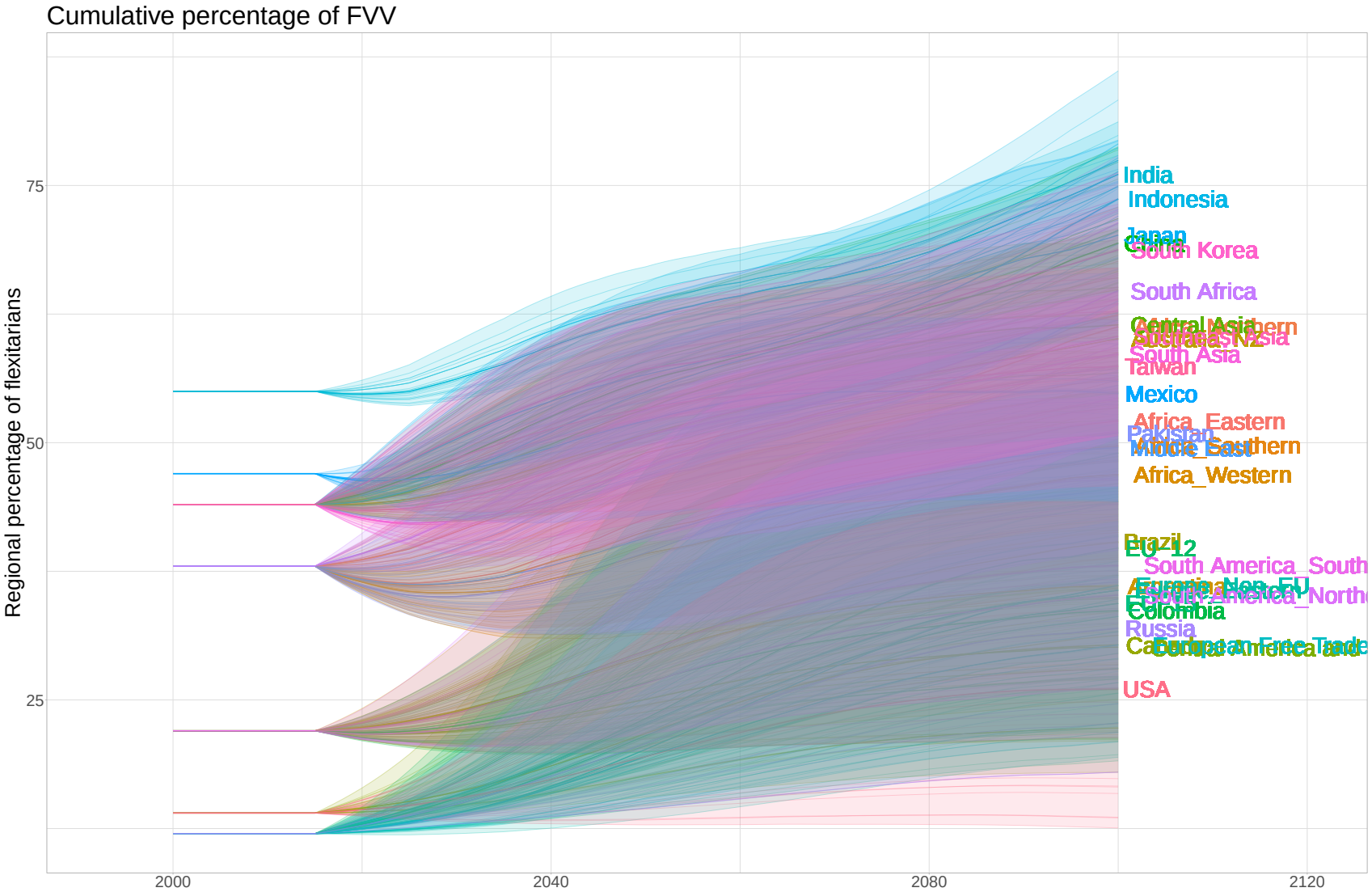
Example


Nº of new flexitarians (free scales)
Annual World nº of new flexitarians
Africa_Eastern
Africa_Northern
Africa_Southern
Africa_Western
Argentina
Australia_NZ
Brazil
Canada
Central Asia
China
Colombia
EU−12
EU−15
Europe_Eastern
Europe_Non_EU
India
Indonesia
Japan
Mexico
Middle East
Pakistan
Russia
South Africa
South Asia
South Korea
Southeast Asia
Taiwan
USA
2000 2025 2050 2075 2100
Sensitivity scenario
all_equal_2040_60−80
all_equal_2080_60−80

Example

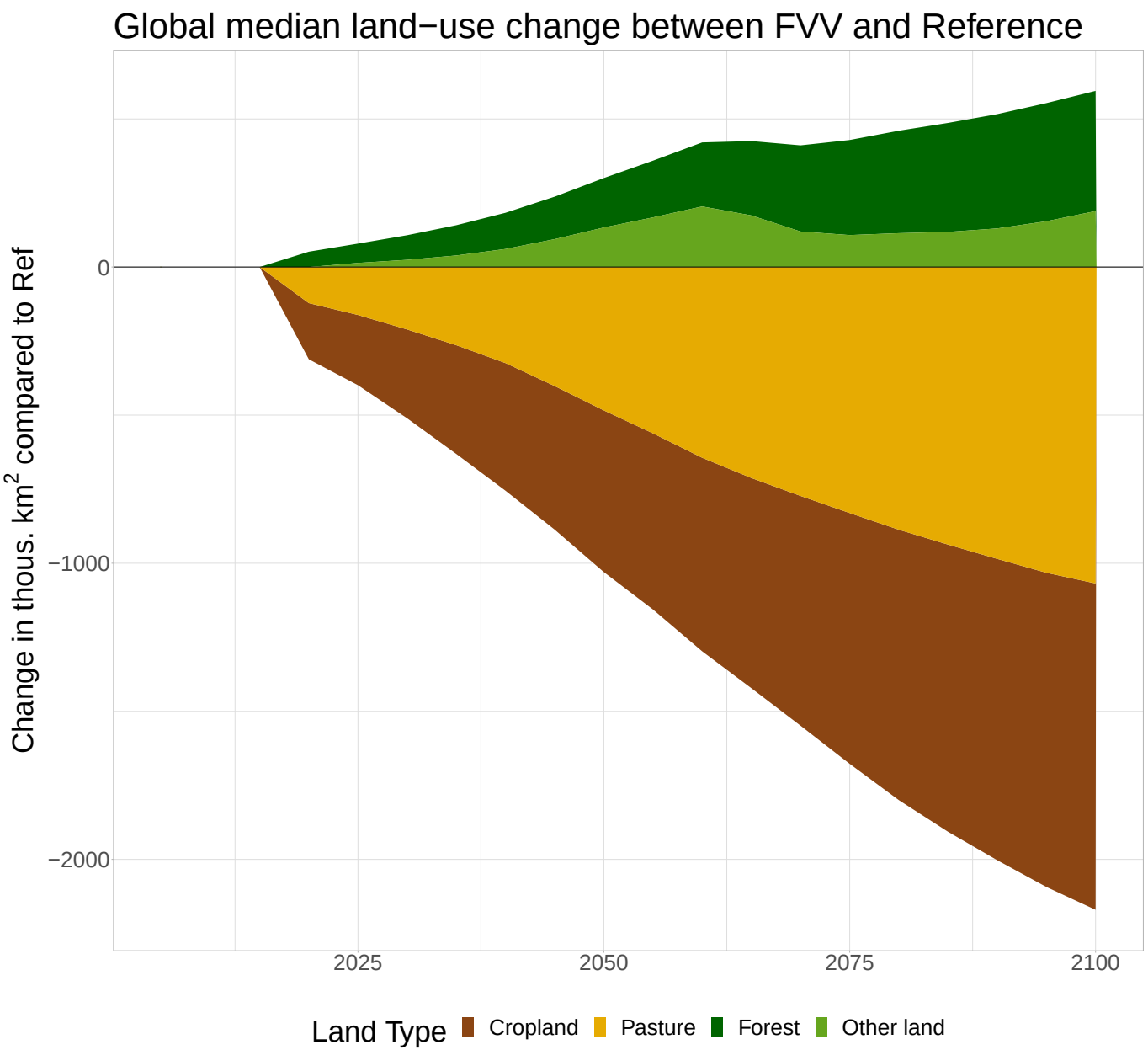

Cumulative percentage of flexitarians (free scales)
Annual Regional percentage of flexitarians
Africa_Eastern
Africa_Northern
Africa_Southern
Africa_Western
Argentina
Australia_NZ
Brazil
Canada
tral America and Caribb
Central Asia
China
Colombia
EU−12
EU−15
Europe_Eastern
Europe_Non_EU
pean Free Trade Associ
India
Indonesia
Japan
Mexico
Middle East
Pakistan
Russia
South Africa
South America_Northern
South America_Southern
South Asia
South Korea
Southeast Asia
Taiwan
USA
Sensitivity scenario
all_equal_2040_60−80
all_equal_2080_60−80

Example

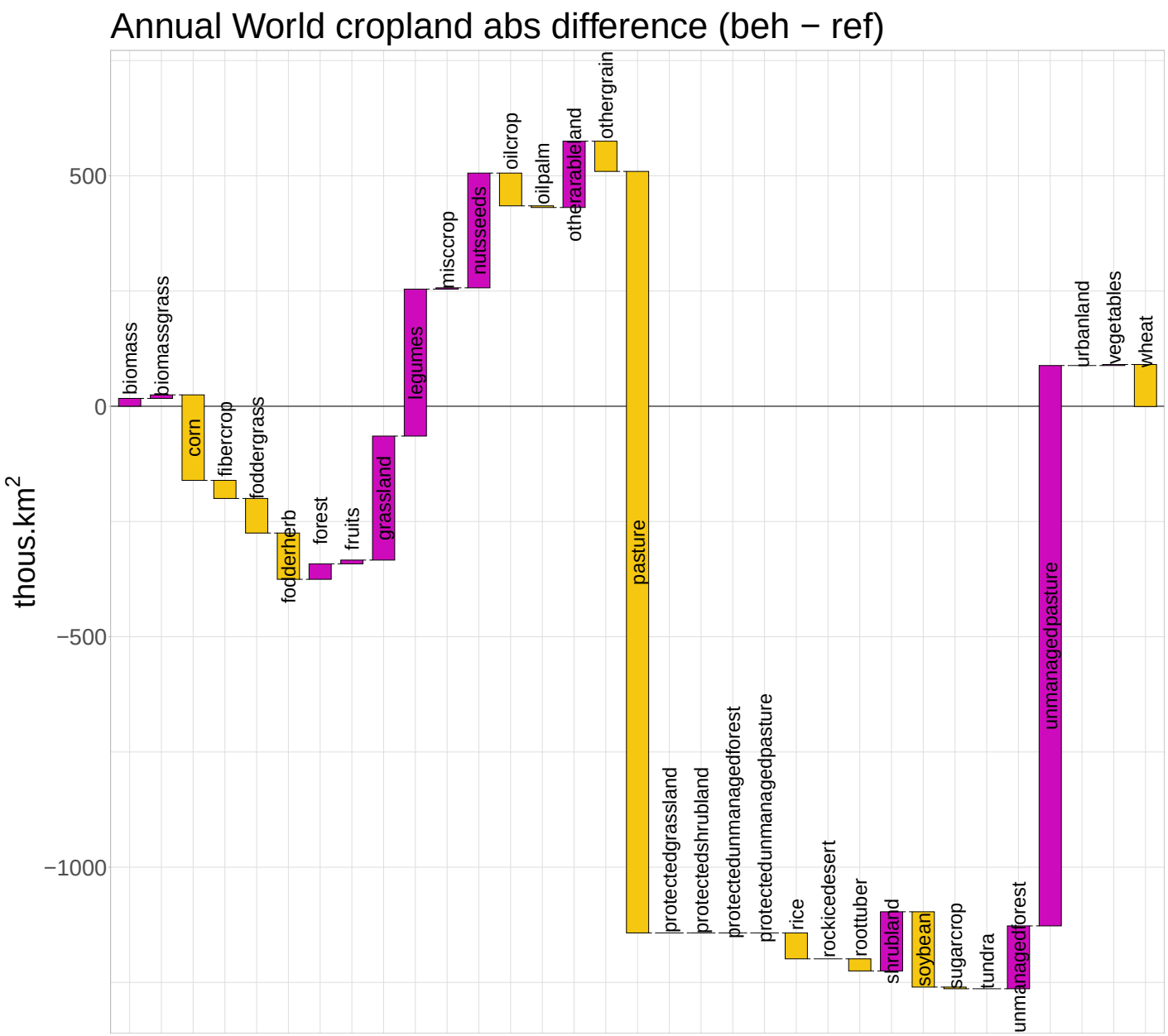

Cumulative percentage of FVV
Regional percentage of flexitarians
75
50
25
2000
2040
2080
2120
India
Indonesia
Japan
South Korea
South Africa
Central Asia
South Asia
Taiwan
Mexico
Africa_Eastern
Pakistan
Middle East
Africa_Western
Brazil
EU-12
South America_South
Colombia
Russia
USA

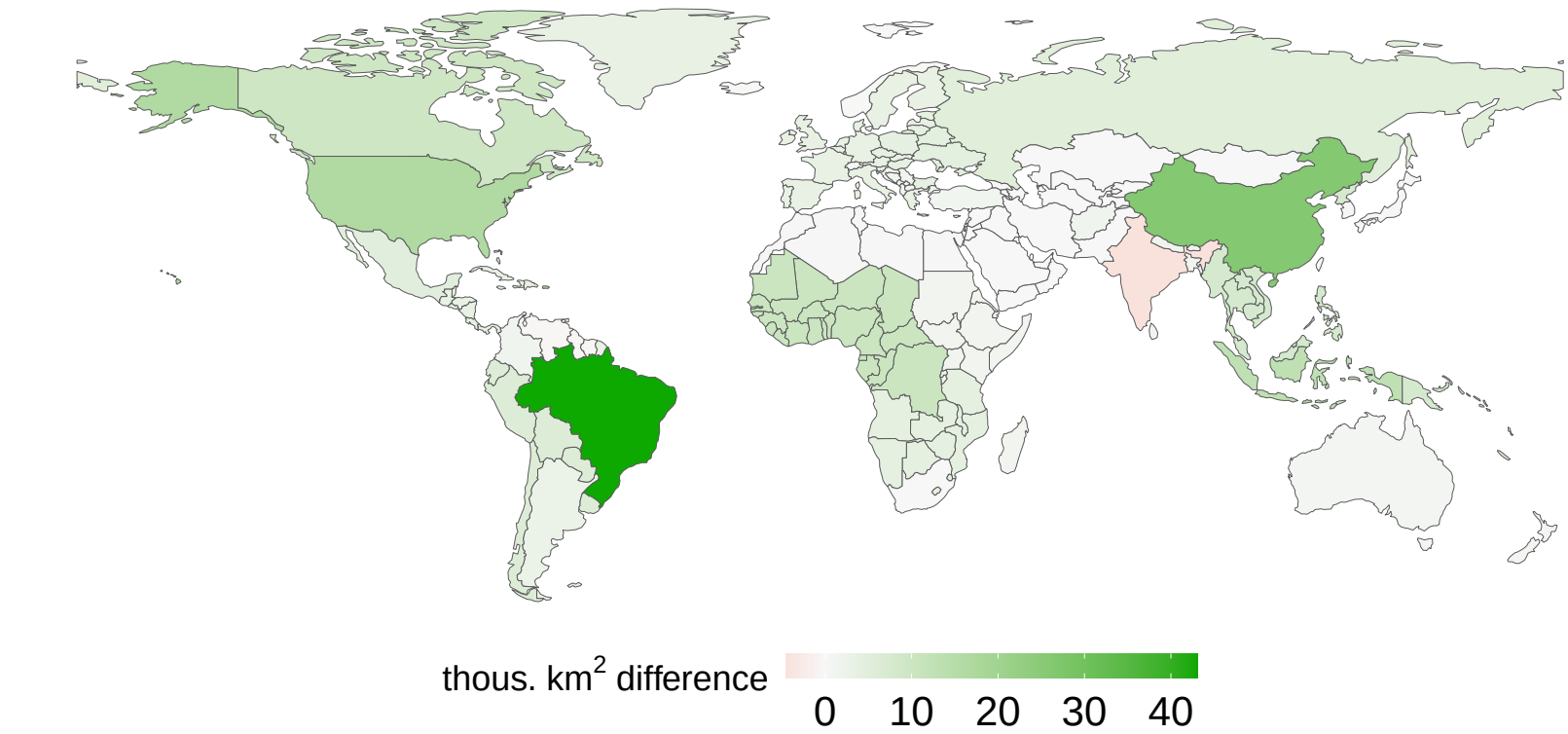
System-Wide Effects

Land use


Global median land−use change between FVV and Reference
Change in thous. km^2 compared to Ref
0
−1000
−2000
2025
2050
2075
2100
Land Type
Cropland
Pasture
Forest
Other land

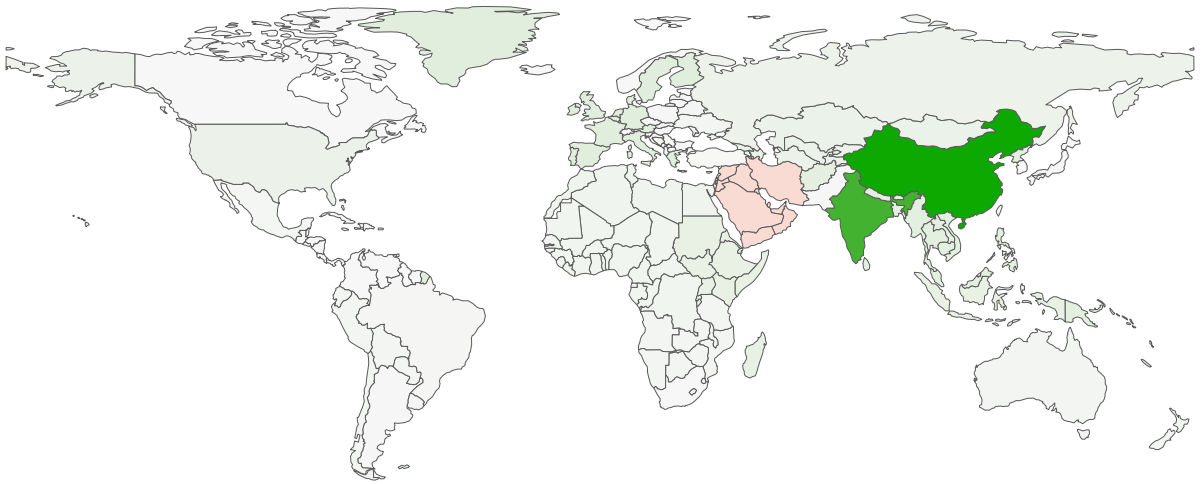
Cropland management

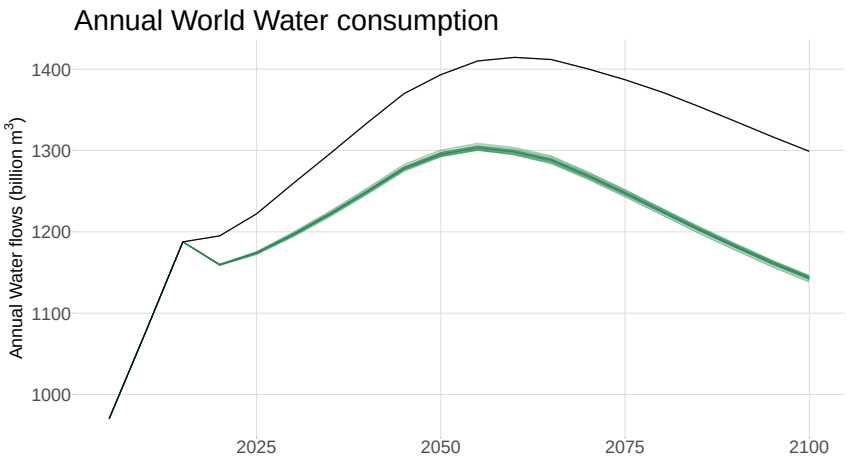



Re−forestation (abs difference) in 2030
thous. km2 difference
0
10
20
30
40

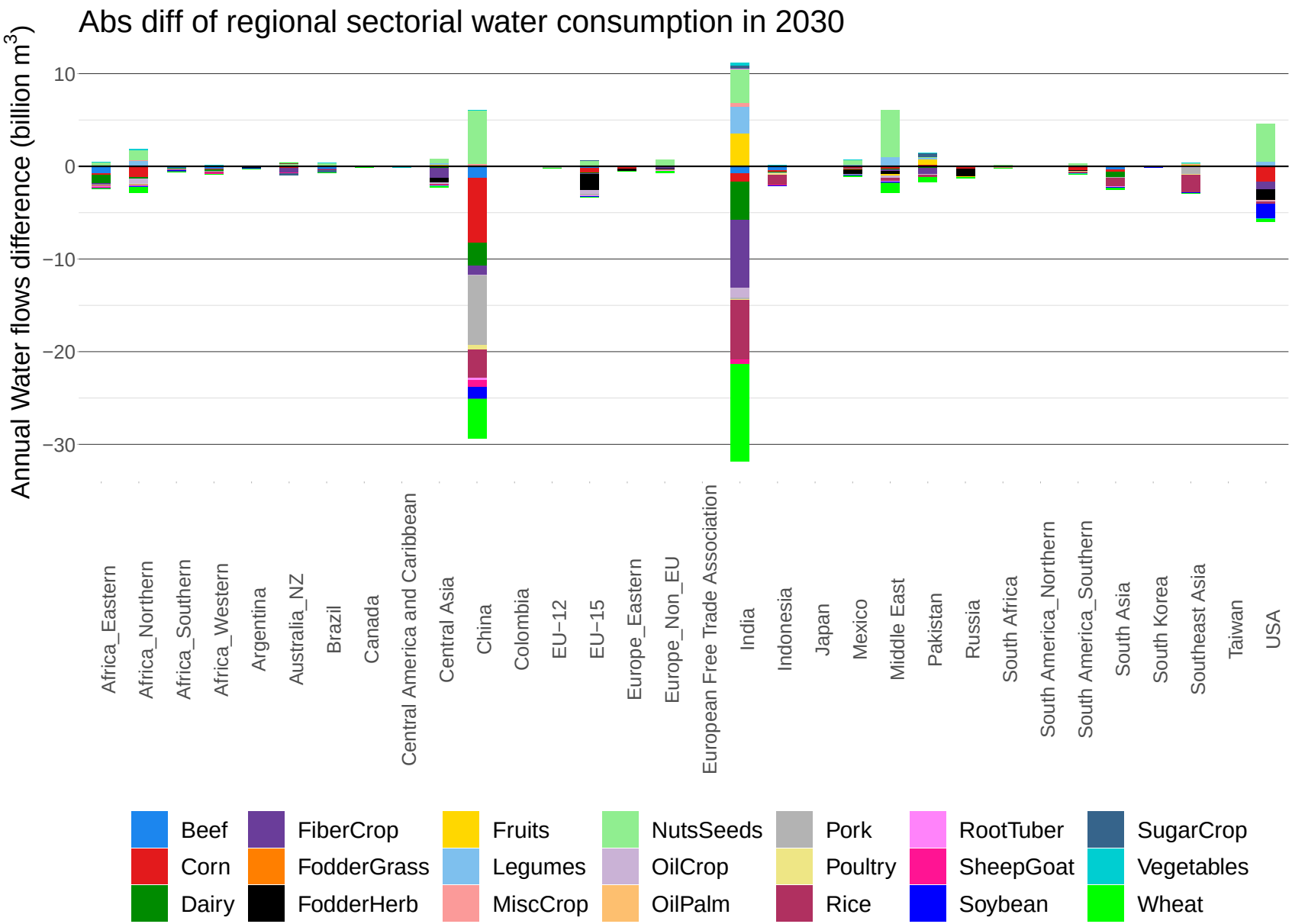
Water consumption

Annual water consumption abs difference in 2030



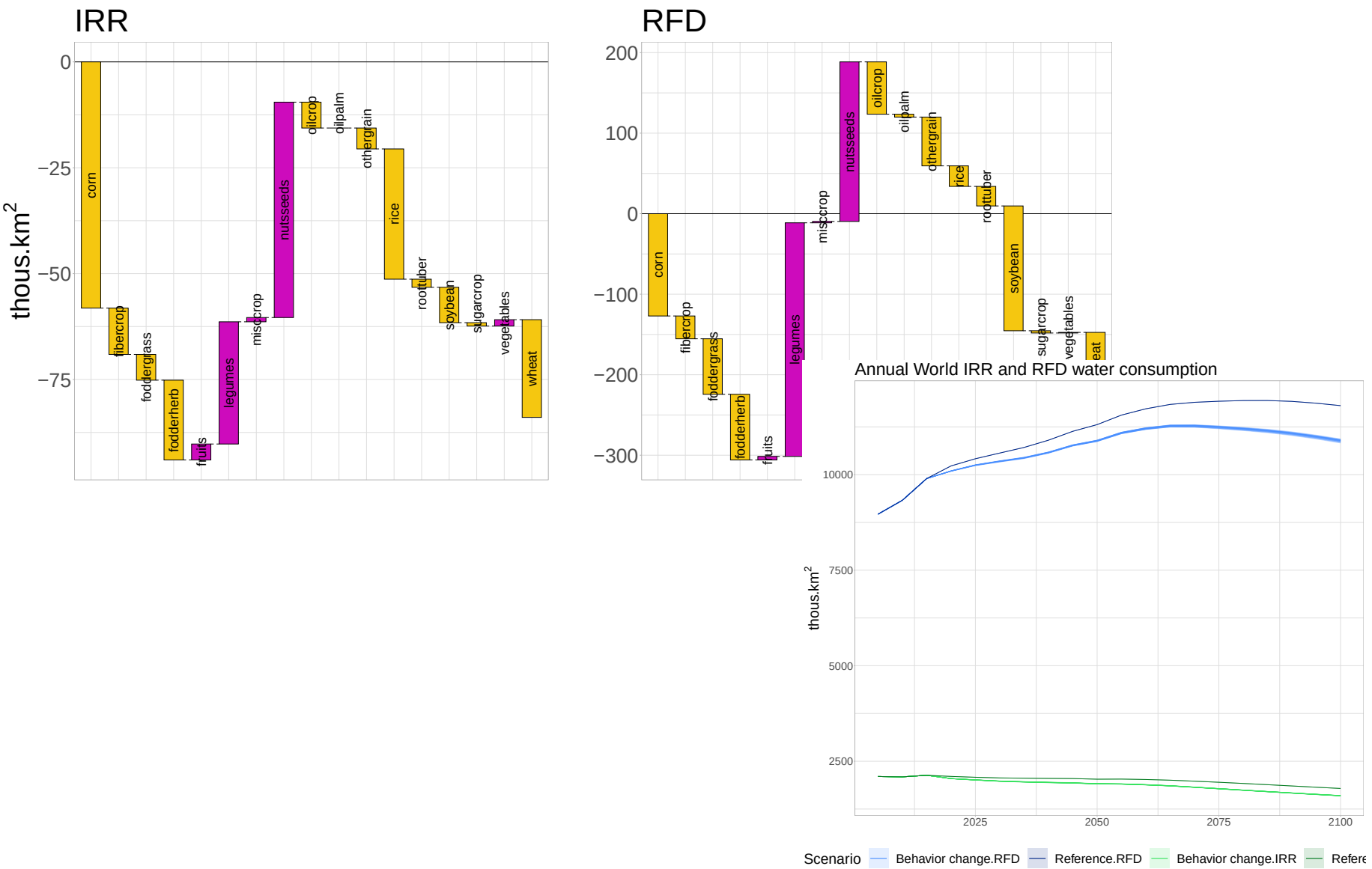


Water consumption by crop and livestock

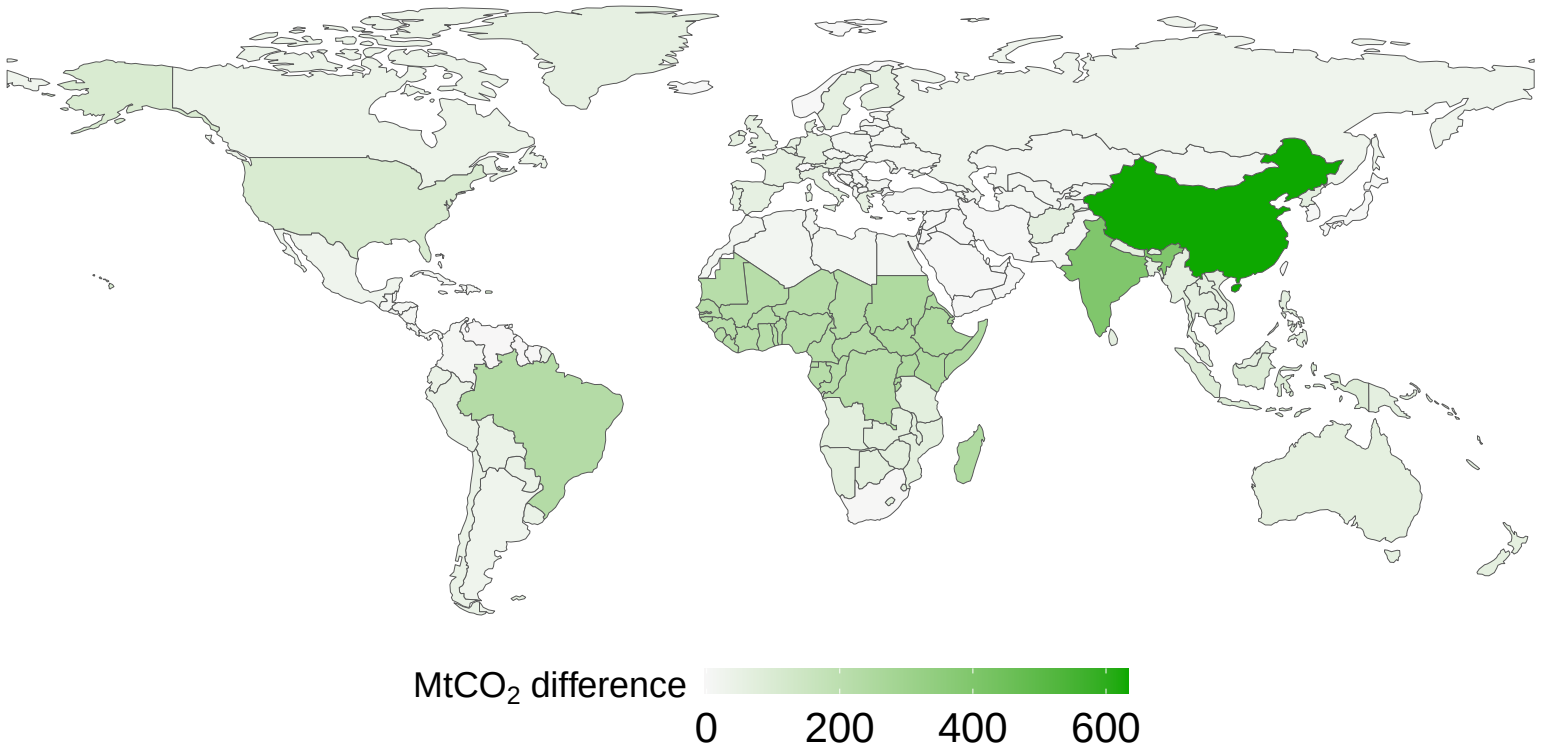


Irrigated and Rainfed water demand

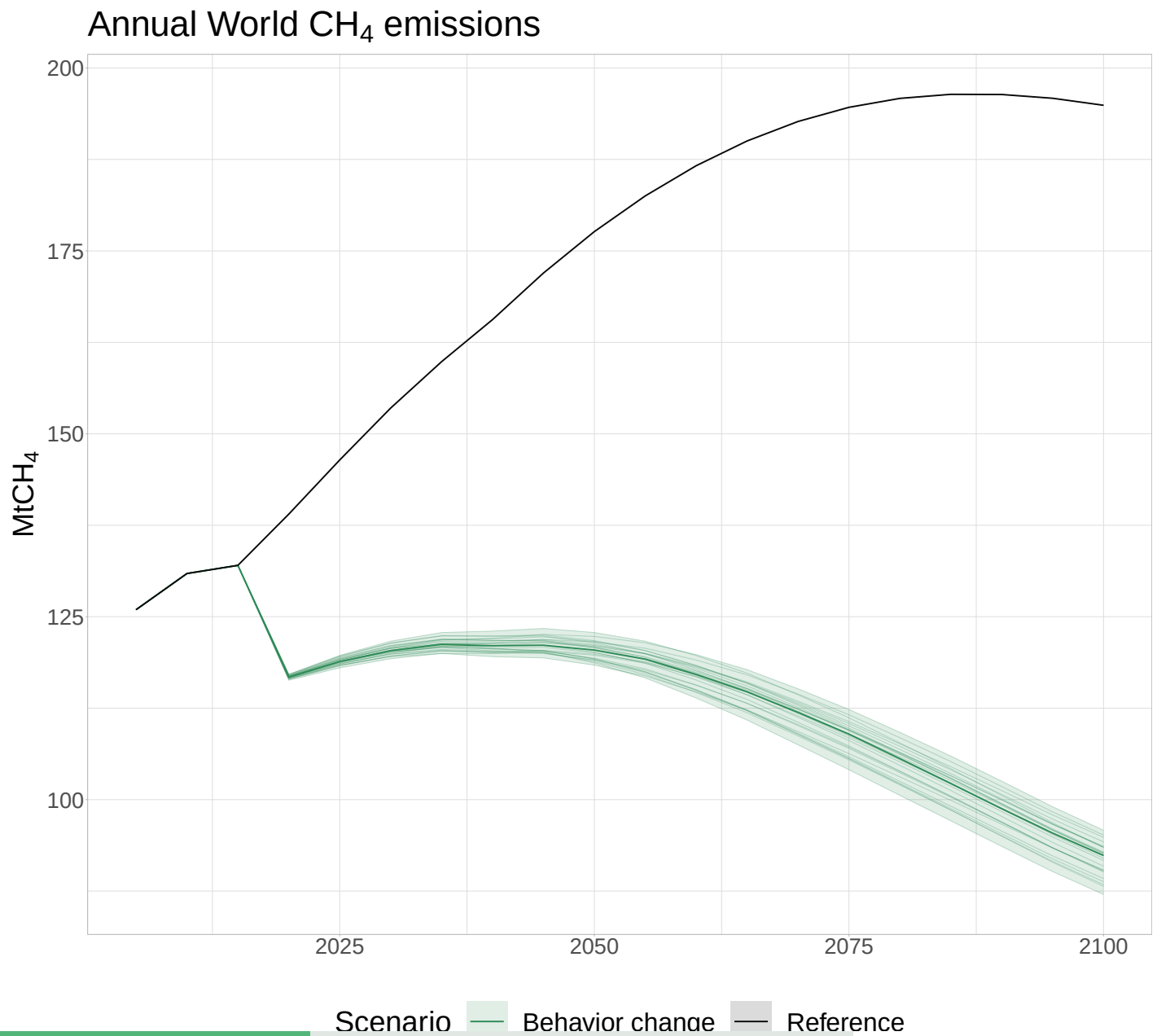
Annual World IRR and RFD abs difference (beh.change − ref)



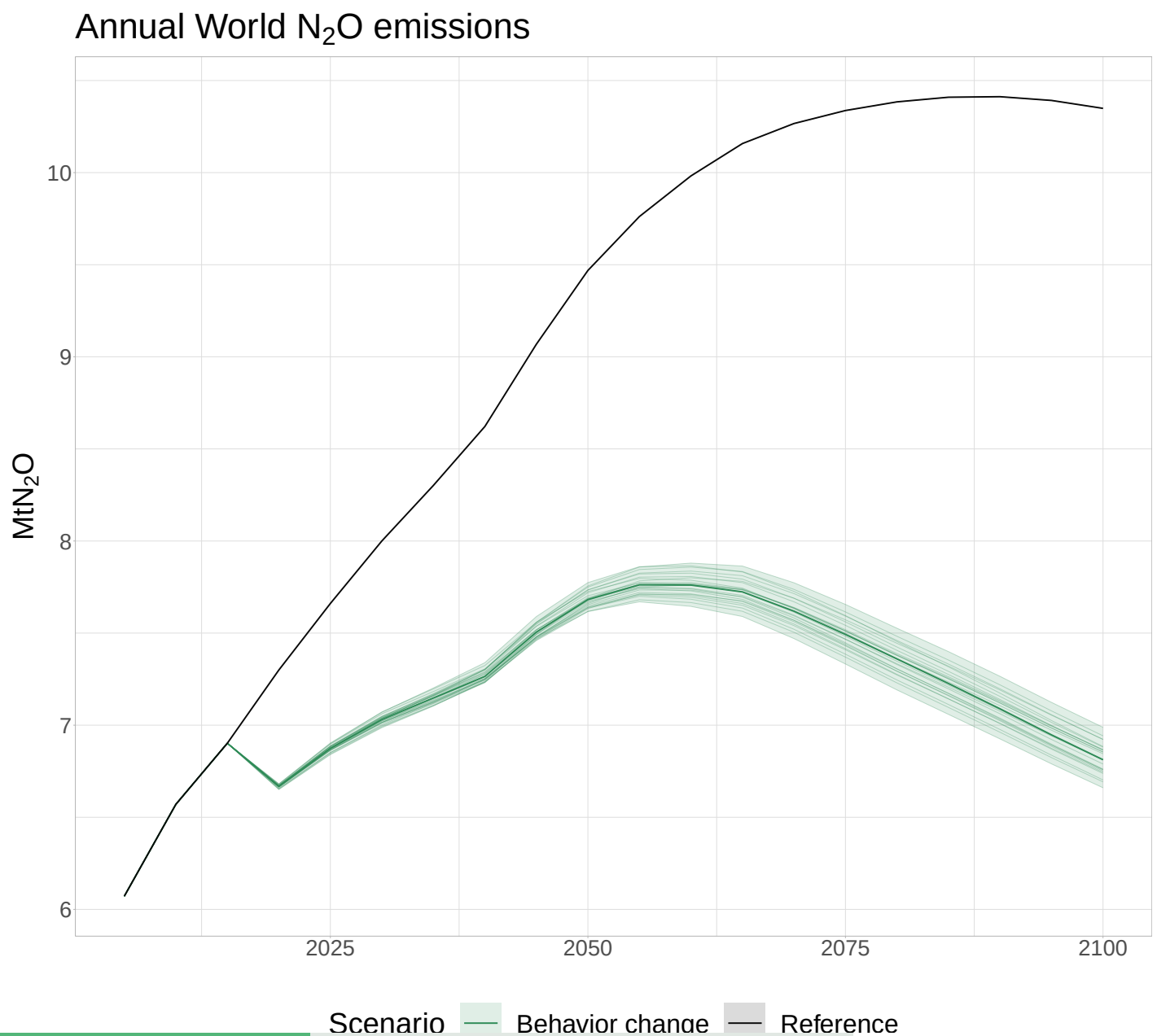
Abs GHG avoided emissions in 2030



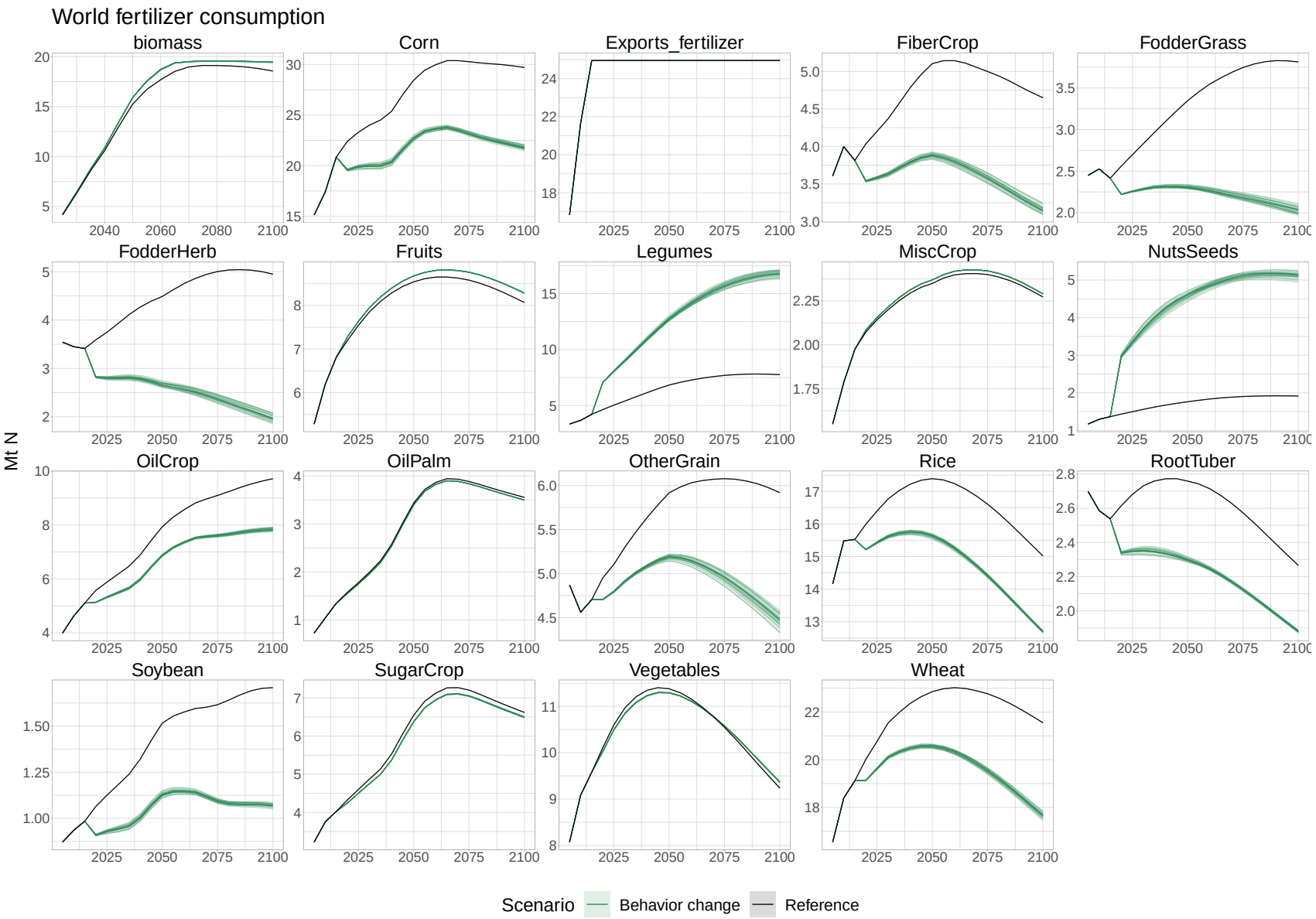
CH4 agricultural emissions



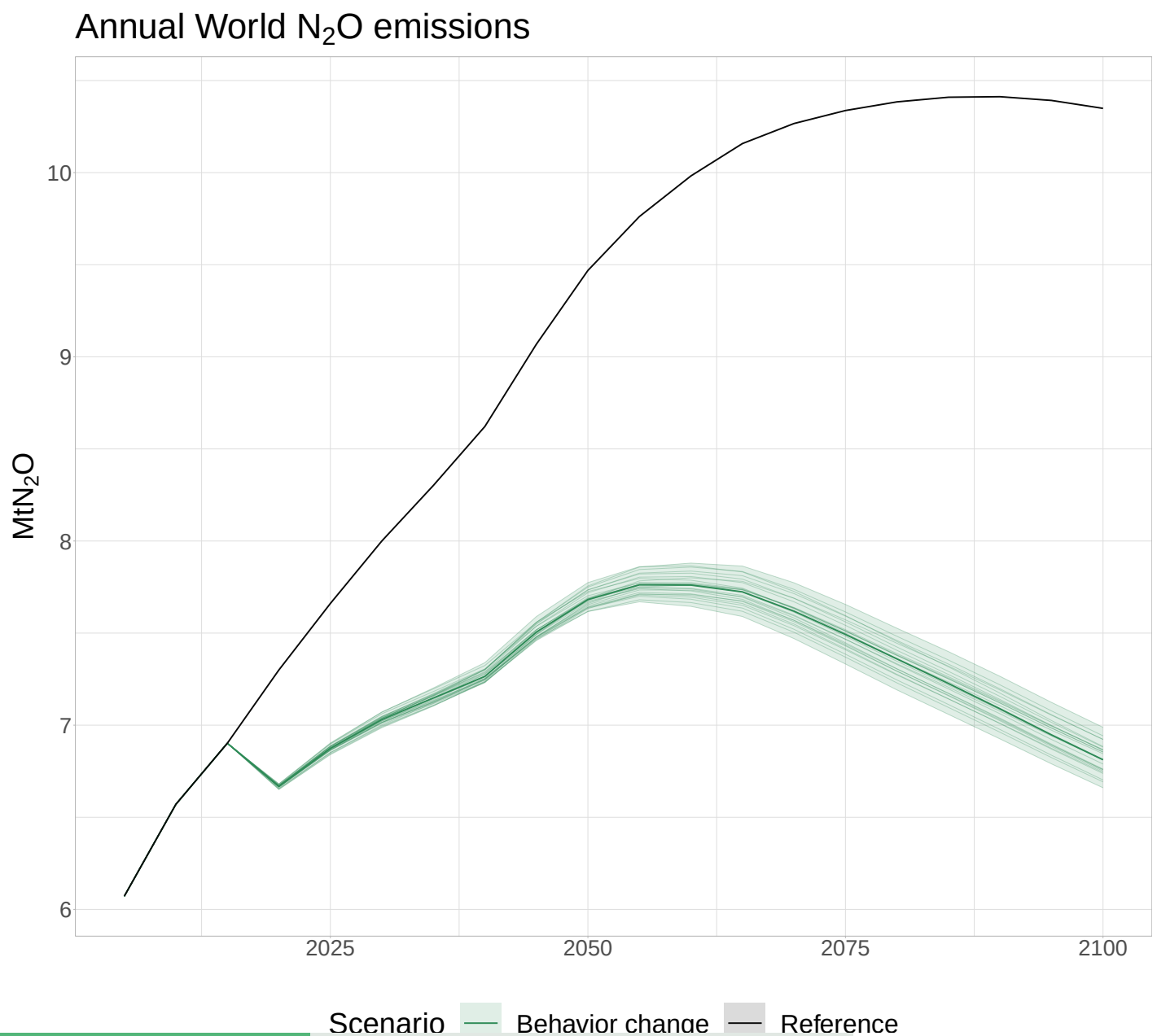
N2O agricultural emissions



N fertilizer consumption

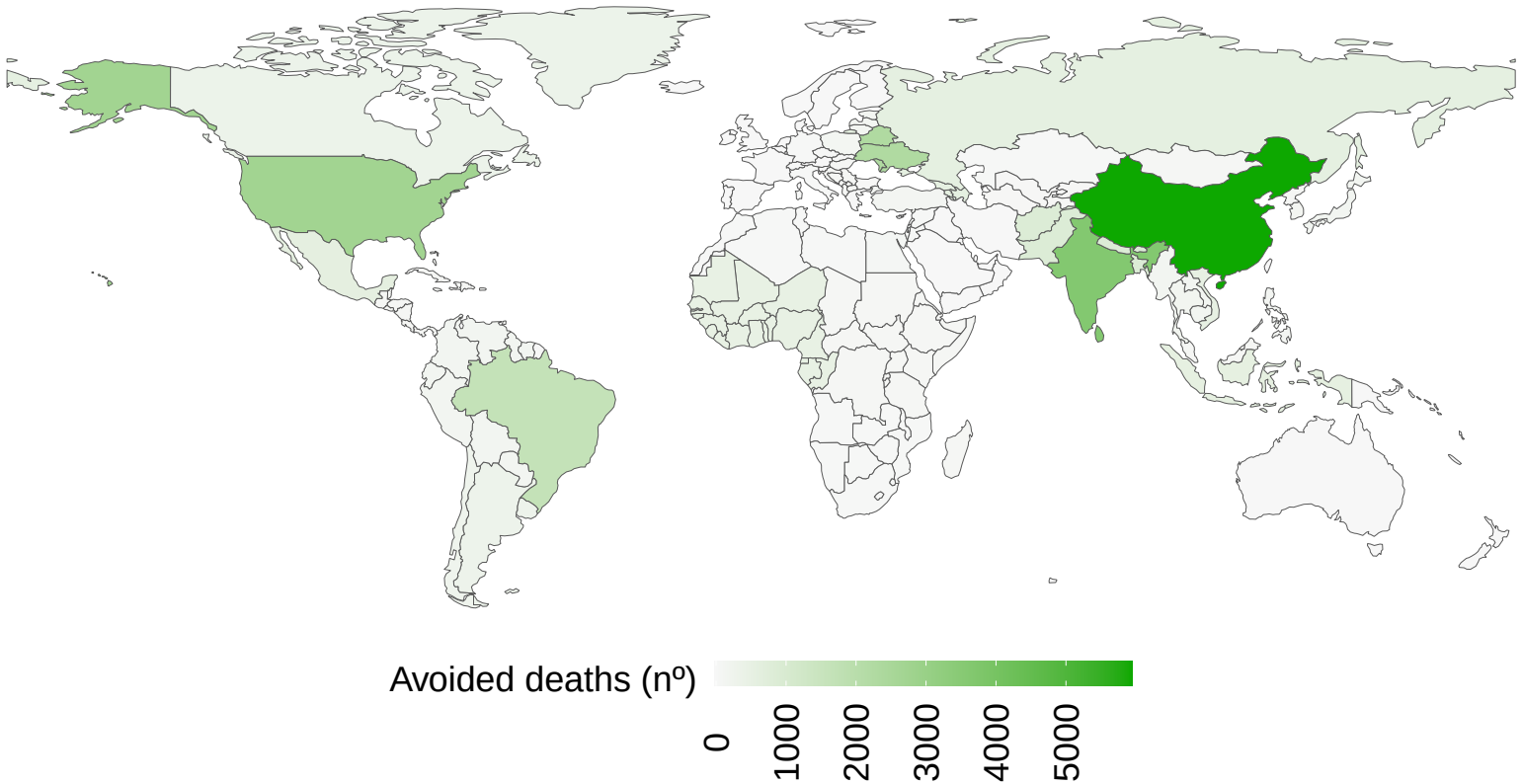


LUC CO_2 emissions

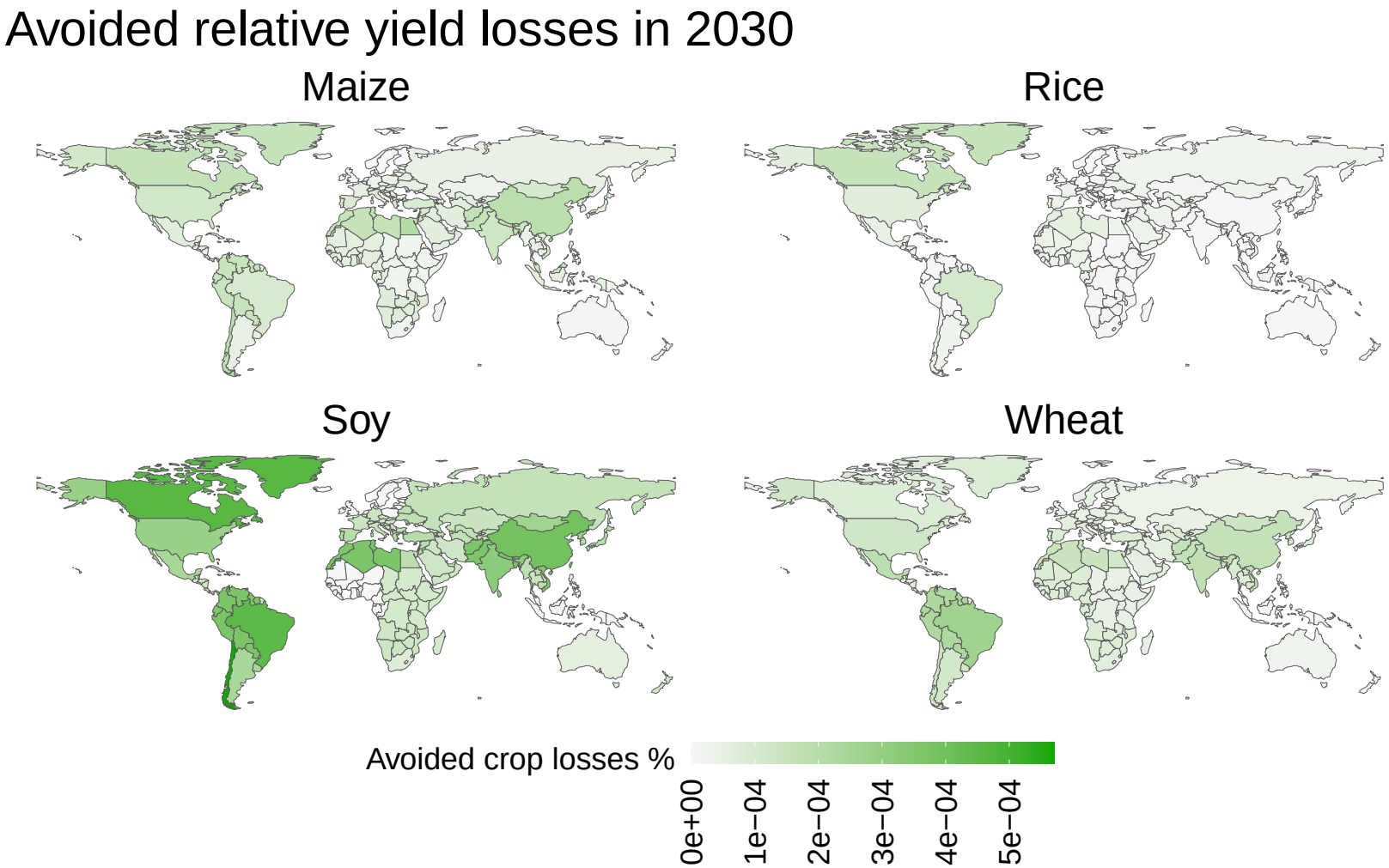


Avoided premature deaths due to AP

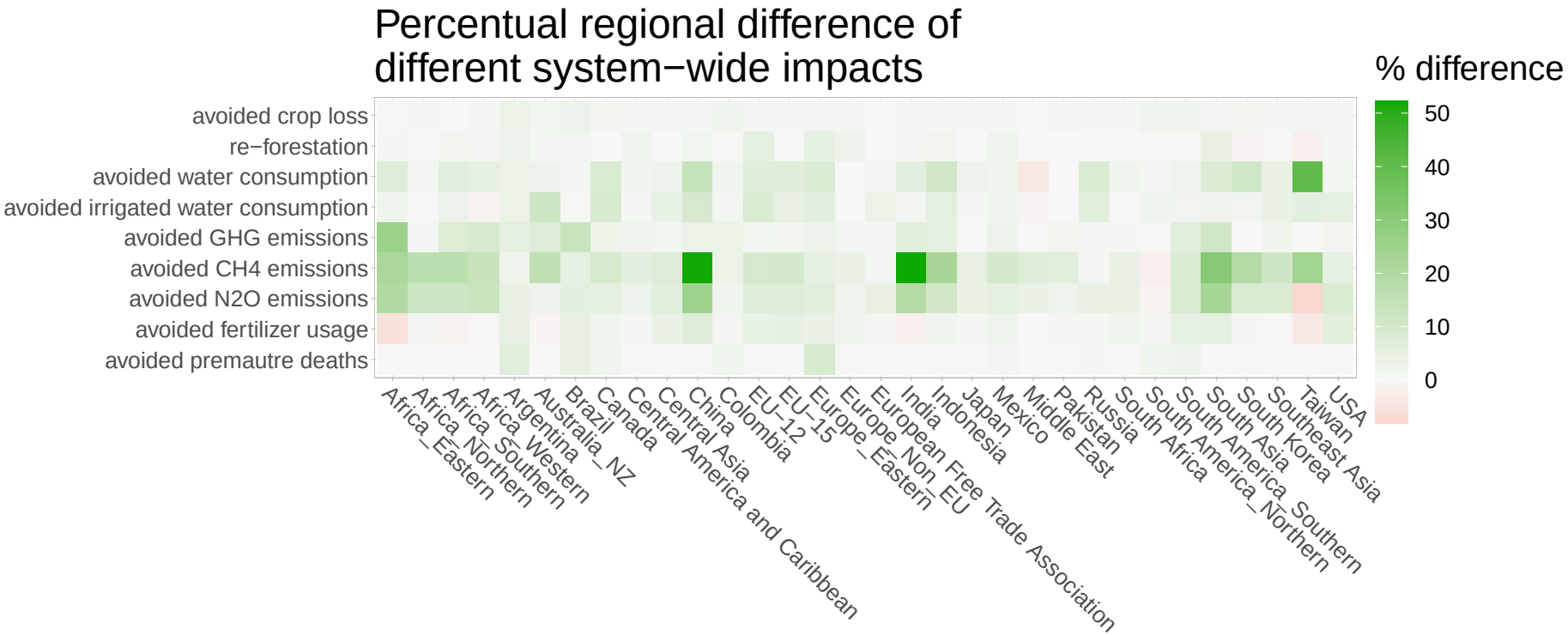
Annual avoided deaths in 2030



Crop loss due to AP



Summary of the main system-wide impact



Future Work and Discussion

Discussion

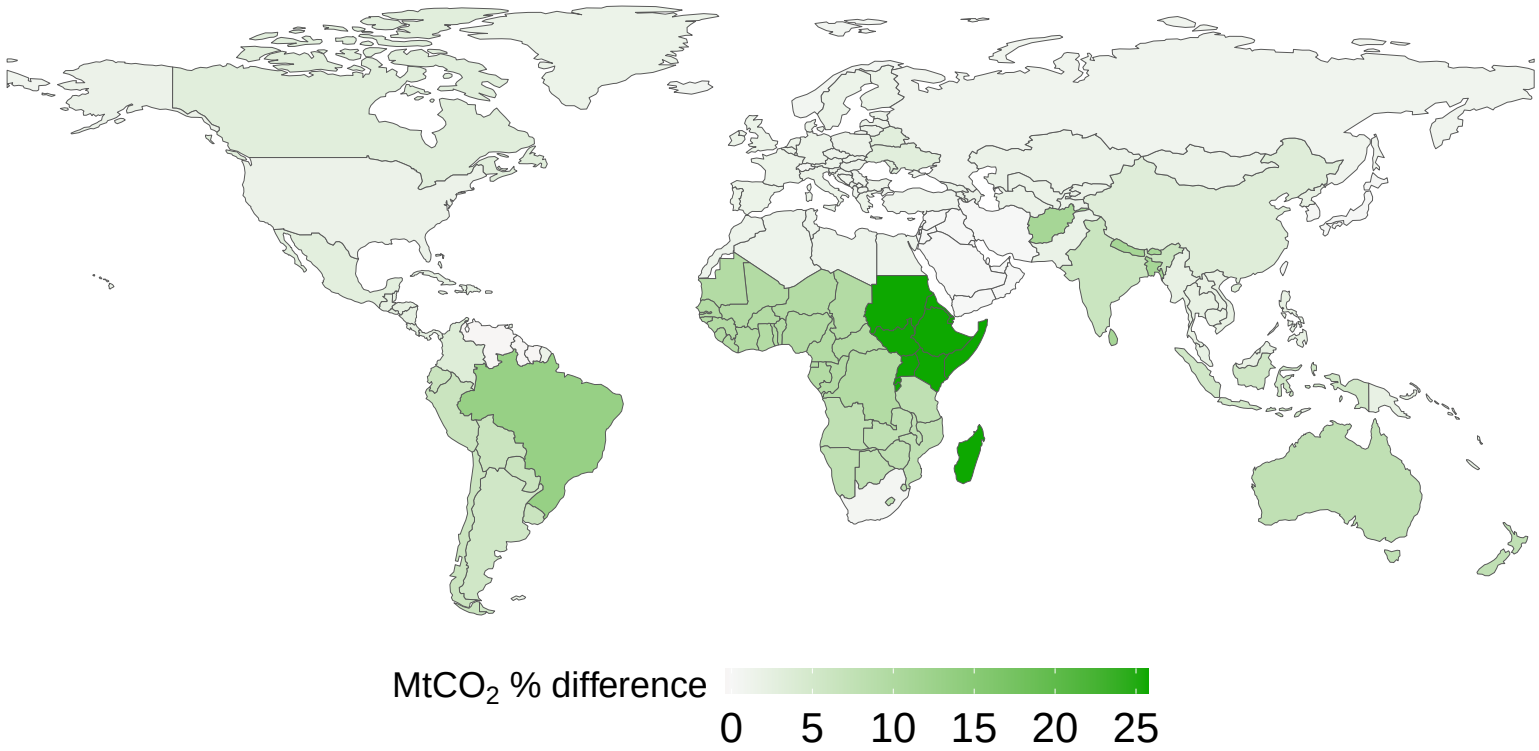
- Does it make sense nutritionally speaking the FVV diet? (Reducing animal protein and increasing nuts and legumes)
- Does it make sense the cropland area dynamic?

Future work

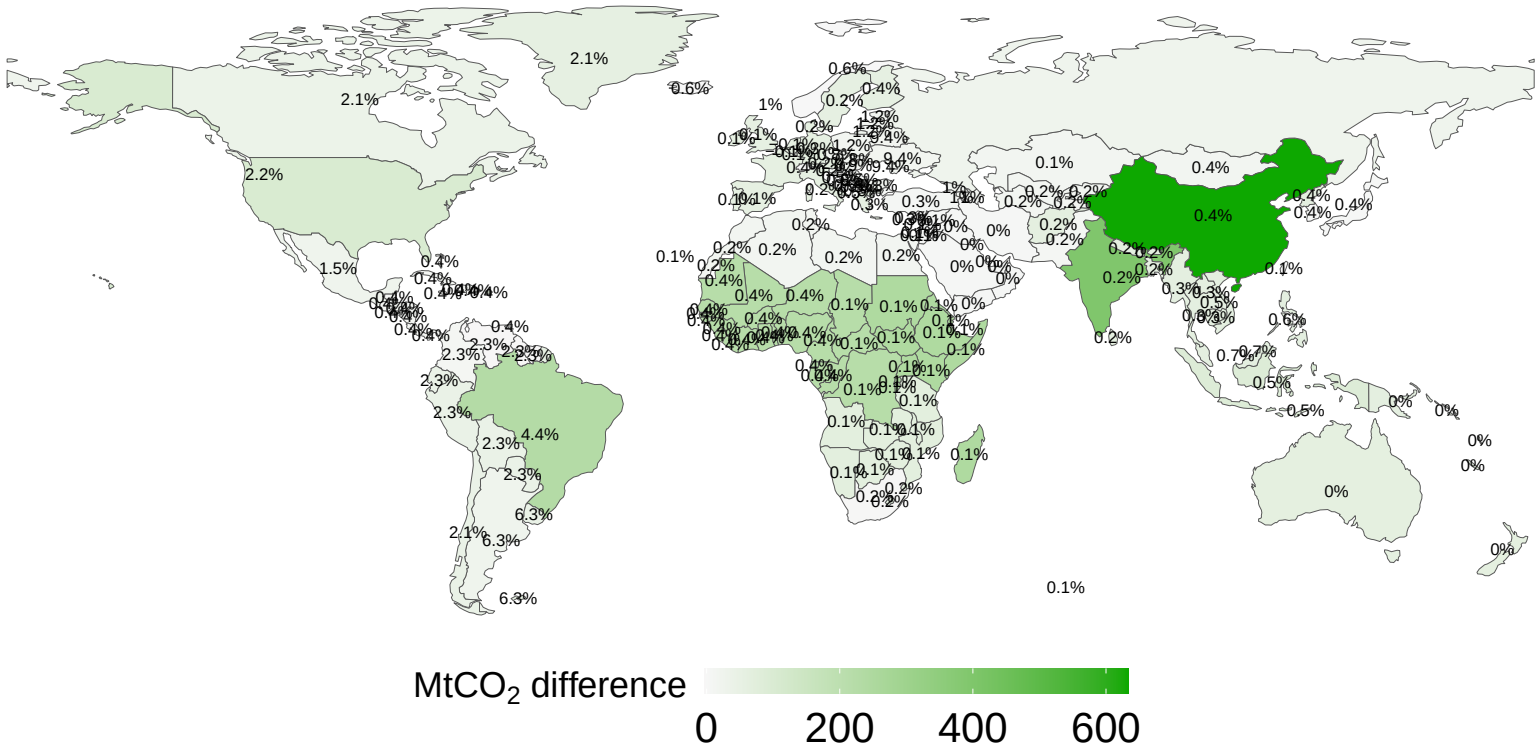
- ⋆ Study nutritional values and other system-wide impacts.
- ⋆ Consider additional regional sensitivity and study the derived system-wide effects.
- ⋆ Do a similar study for trade (with VWT) and transport. Maybe simplified?

Motivation and the Model

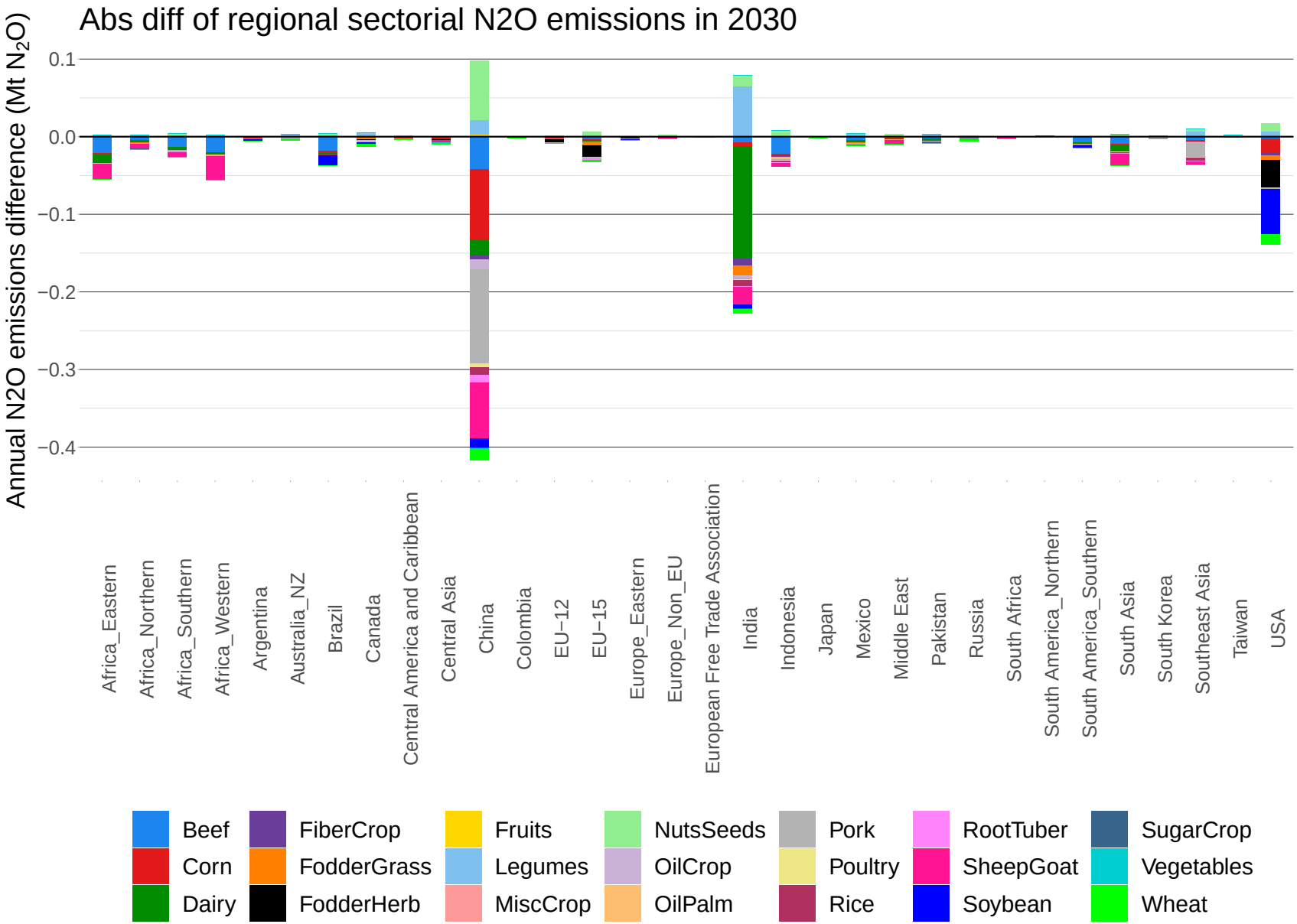
Per diff regional GHG emissions in 2030



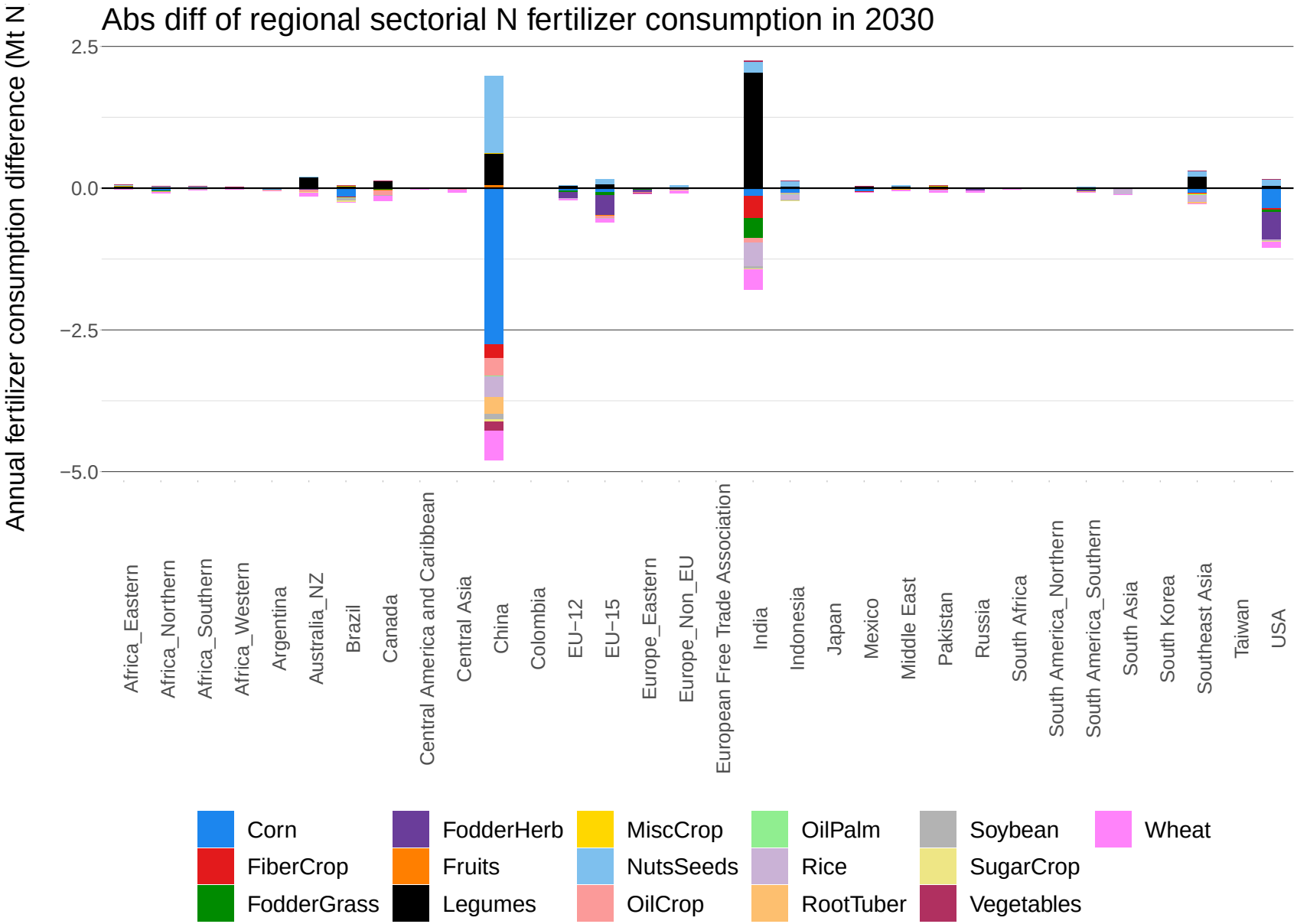
Abs GHG avoided emissions in 2030



N_2O agricultural emissions

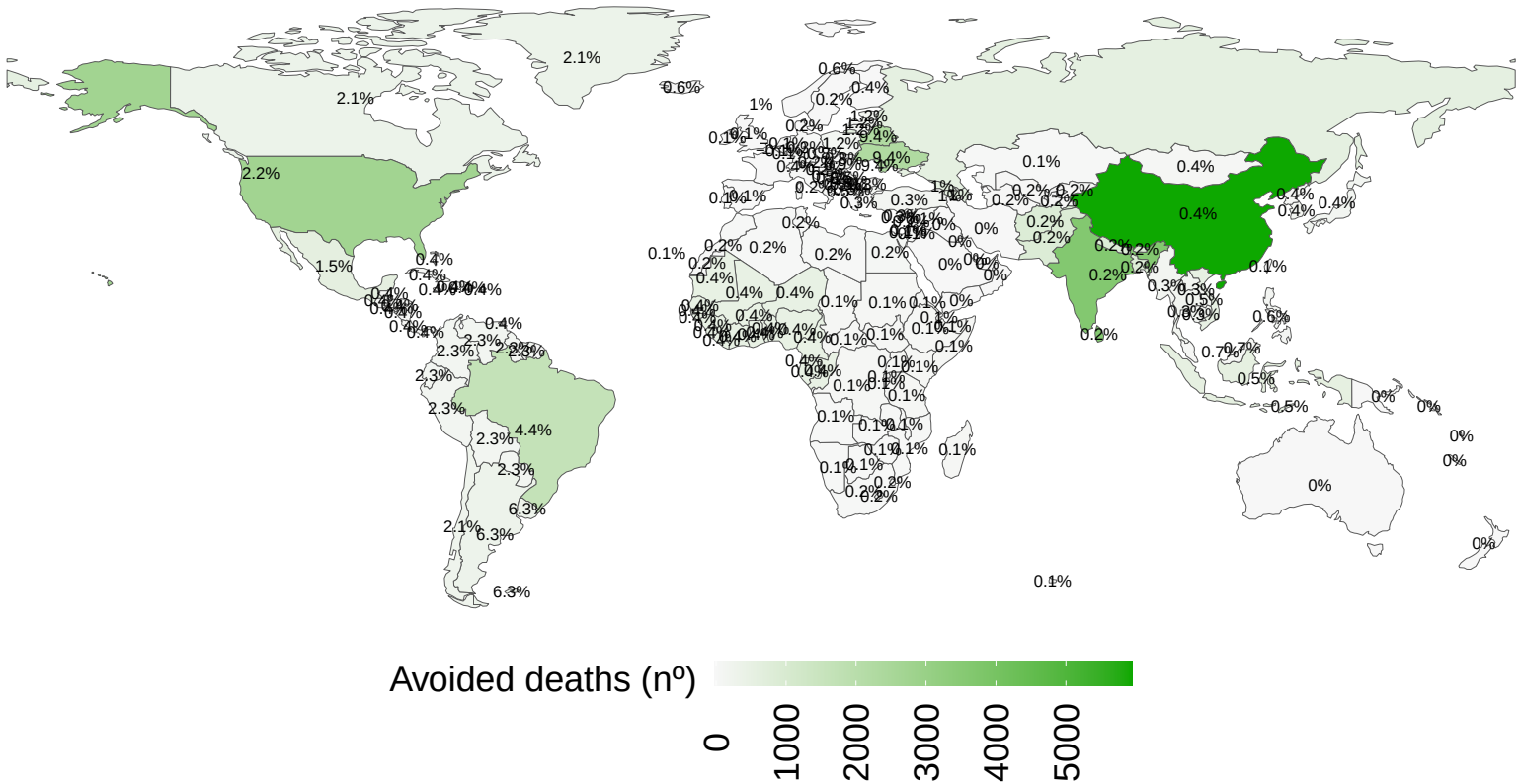


N fertilizer usage



Avoided premature deaths due to AP

Annual avoided deaths in 2030



Avoided premature deaths due to AP

Annual avoided deaths in 2030