

Including the land use and land-use change emissions in the life cycle assessment of agricultural products

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Introduction

- ❑ Land use and land use change (LULUC) emissions and removals
 - Carbon stocks in living biomass
 - Carbon stocks dead organic matter (DOM)
 - Carbon stocks soil organic carbon (SOC)
- ❑ 42% of global GHG emissions from agriculture are caused by LULUC
- ❑ Accounting of LULUC emissions in LCA is challenging
 - Complex and dynamic nature
 - Gaps in internationally recommended approaches



Methodological framework

- A mass-balanced based approach with temporal allocation for a fixed time period to allocate the net LULUC

$$GWP_{LULUC,i} = AF_i \times (\Delta C_t \times CF + CH_{4,org} \times CF) \text{ (kg CO}_2 \text{ eq.)} \quad (1)$$

- $GWP_{LULUC,i}$ is the LULUC related GWP of product i,
- AF_i represents the allocation factor of product i,
- ΔC_t represents the total changes in carbon stock,
- $CH_{4,org}$ emissions from organic soil,
- CF is the factor to convert units into kg CO₂ eq., i.e., 44/12 for kg C and 29.8 for kg CH₄.

$$\Delta C_t = (S_{CL-CL} \times \Delta C_{CL-CL}) + (S_{OL-CL} \times \Delta C_{OL-CL}) \text{ (kg C/ ha)} \quad (2)$$

- S_{CL-CL} is the share of crop land remaining crop land,
- ΔC_{CL-CL} represents the changes in carbon stock on crop land remaining crop land,
- S_{OL-CL} is the share of other land converted to crop land
- ΔC_{OL-CL} represents the changes in carbon stock on of other land converted to crop land.

CL-CL: Cropland remaining cropland

CL-OL: Other land converted to cropland

Methodological framework (Cot'd)

$$\Delta C_j = \Delta C_{lb} + \Delta C_{DOM} + \Delta C_{SOC} \text{ (kg C/ ha)} \quad (3)$$

- ΔC_j is the carbon stock change in CL-CL or OL-CL,
- ΔC_{lb} is the carbon stock change in living biomass contents,
- ΔC_{DOM} is the carbon stock change in dead organic matter contents,
- ΔC_{SOC} is the carbon stock change in soils contents.

$$\Delta C_{SOC} = S_m \times \Delta C_{SOC,min} + S_o \times \Delta C_{SOC,org} \text{ (kg C/ ha)} \quad (4)$$

- S_m is the share of mineral soil,
- S_o is the share of organic soil,
- $\Delta C_{SOC,min}$ is the carbon stock change in soil organic carbon from mineral soil,
- $\Delta C_{SOC,org}$ is the carbon stock change in soil organic carbon from organic soil.

- The N_2O impacts from organic soils are included as the fossil impacts.

Allocation of C stock changes to products

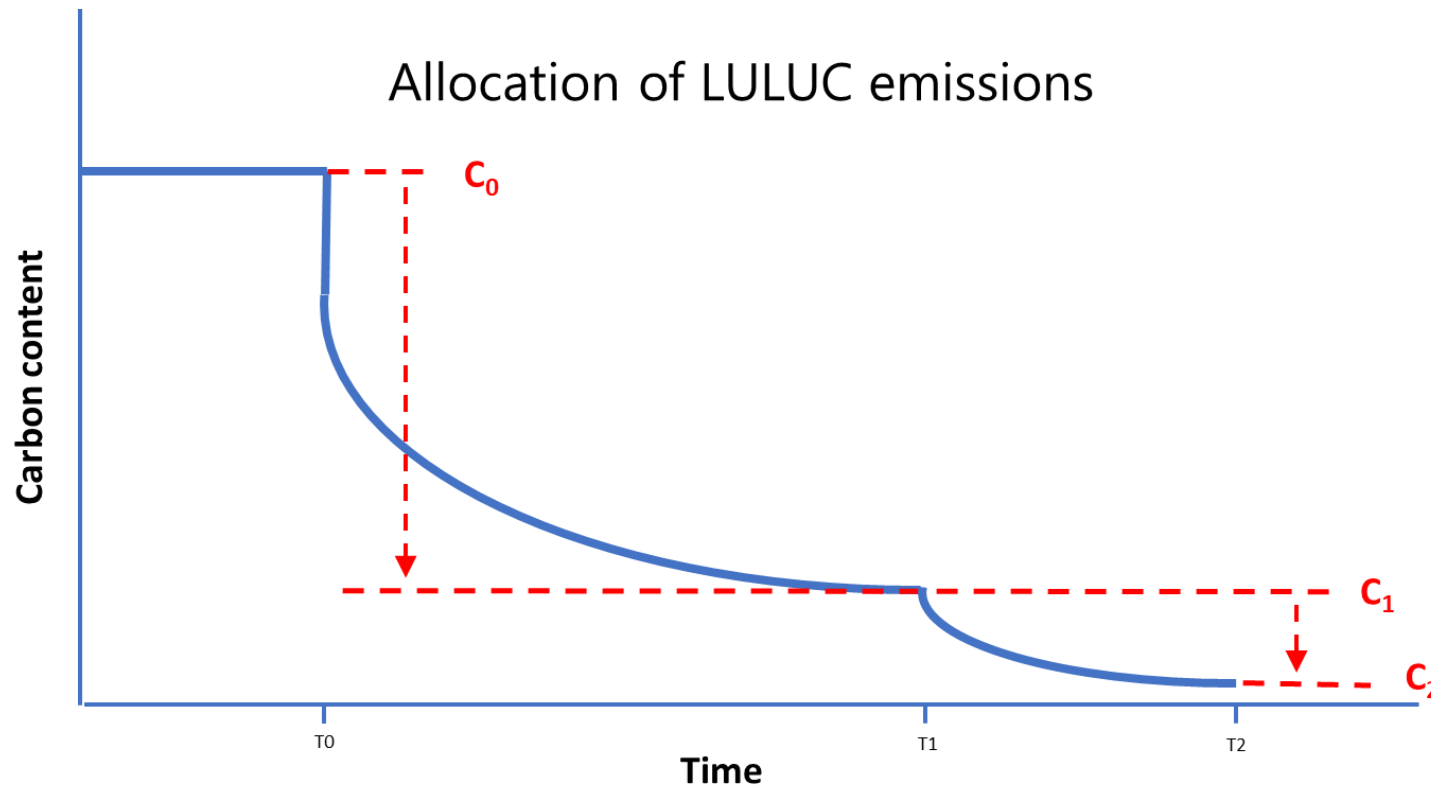


Figure 1: Allocation of C stock changes to agricultural products

(Leinonen, 2022)

Methodological framework (Cot'd)

- Average national cropland GWP_{LULUC} emissions
 - Based on the National GHG Inventory of Finland
- Provinces of Finland – LULUC emissions for cropland
 - GWP_{LU} emissions from Luke economydctor
 - Shares of mineral and organic soils – organic soils especially in Northern Finland
- Calculated GWP_{LULUC} was included in the total GWP of:
 - Wheat
 - Barley
 - Oats
 - Peas
- System boundary: cradle-to-farm gate, FU: 1 kg
- Crop production data: Agri-footprint 6



Results and discussion

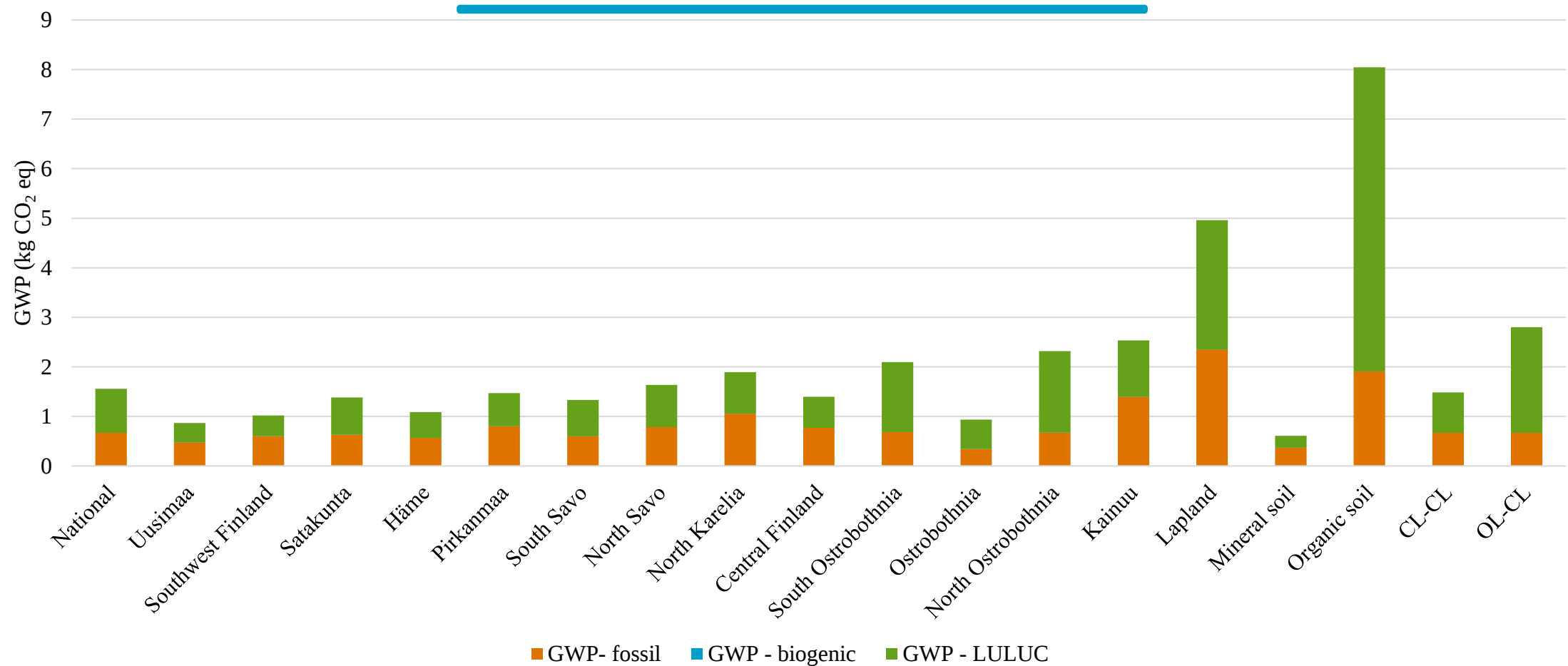


Figure 1: GWP impacts of 1kg Wheat production

Results and discussion (Cont'd)

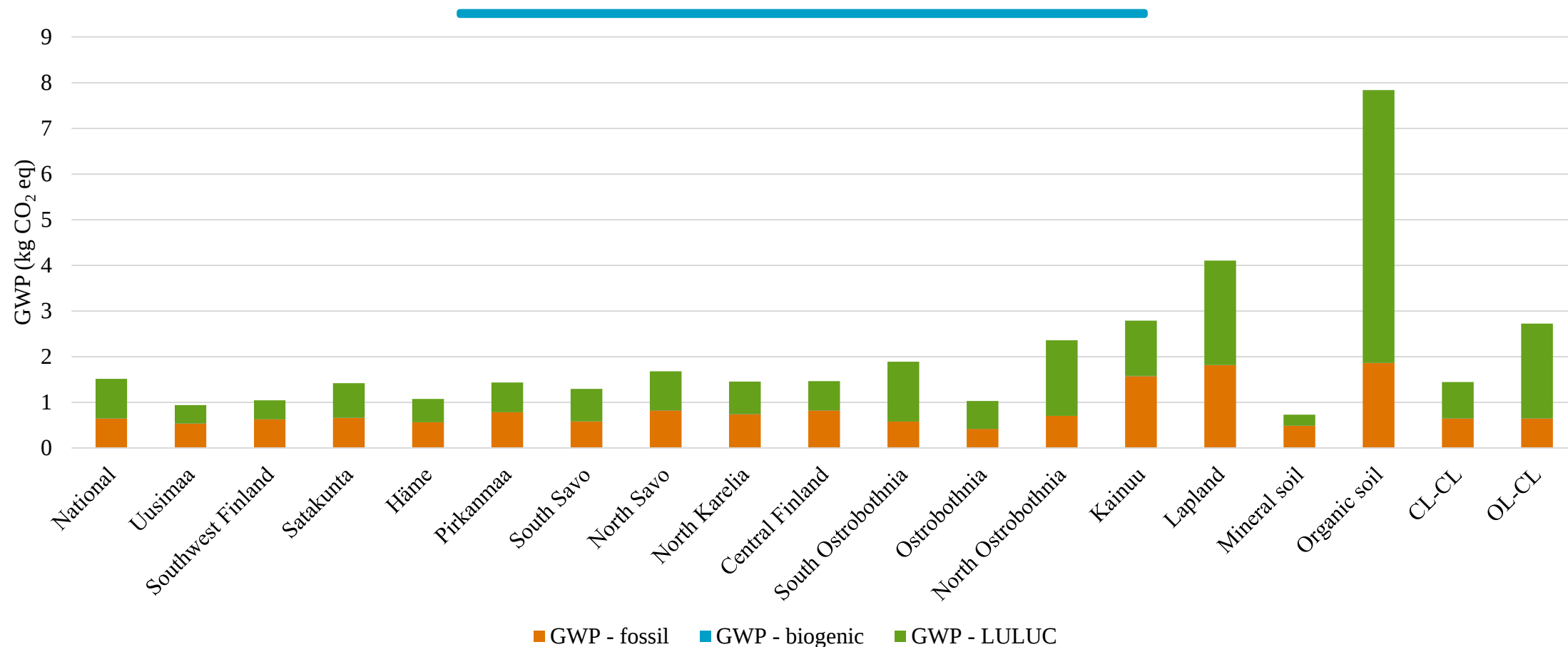


Figure 2: GWP impacts of 1kg Barley production

Results and discussion (Cont'd)

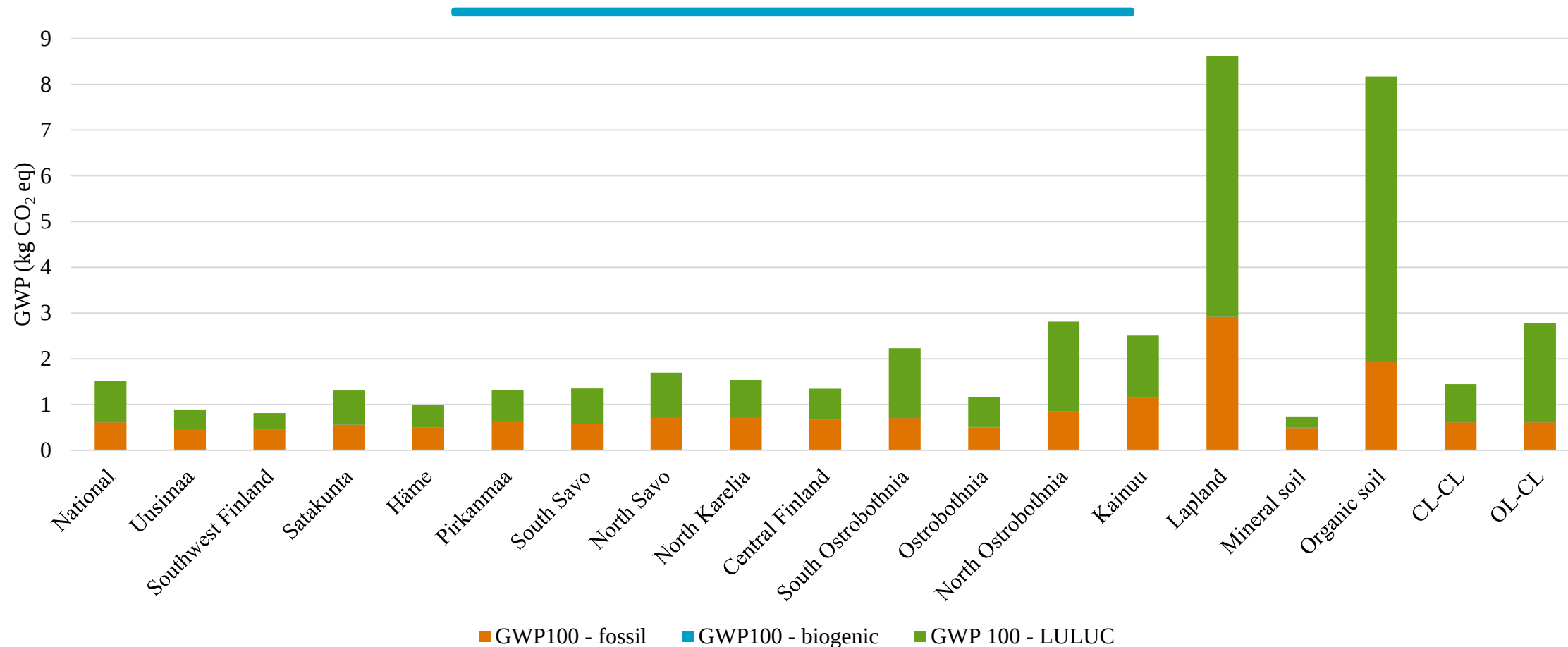


Figure 3: GWP impacts of 1kg Oats production

Results and discussion (Cont'd)

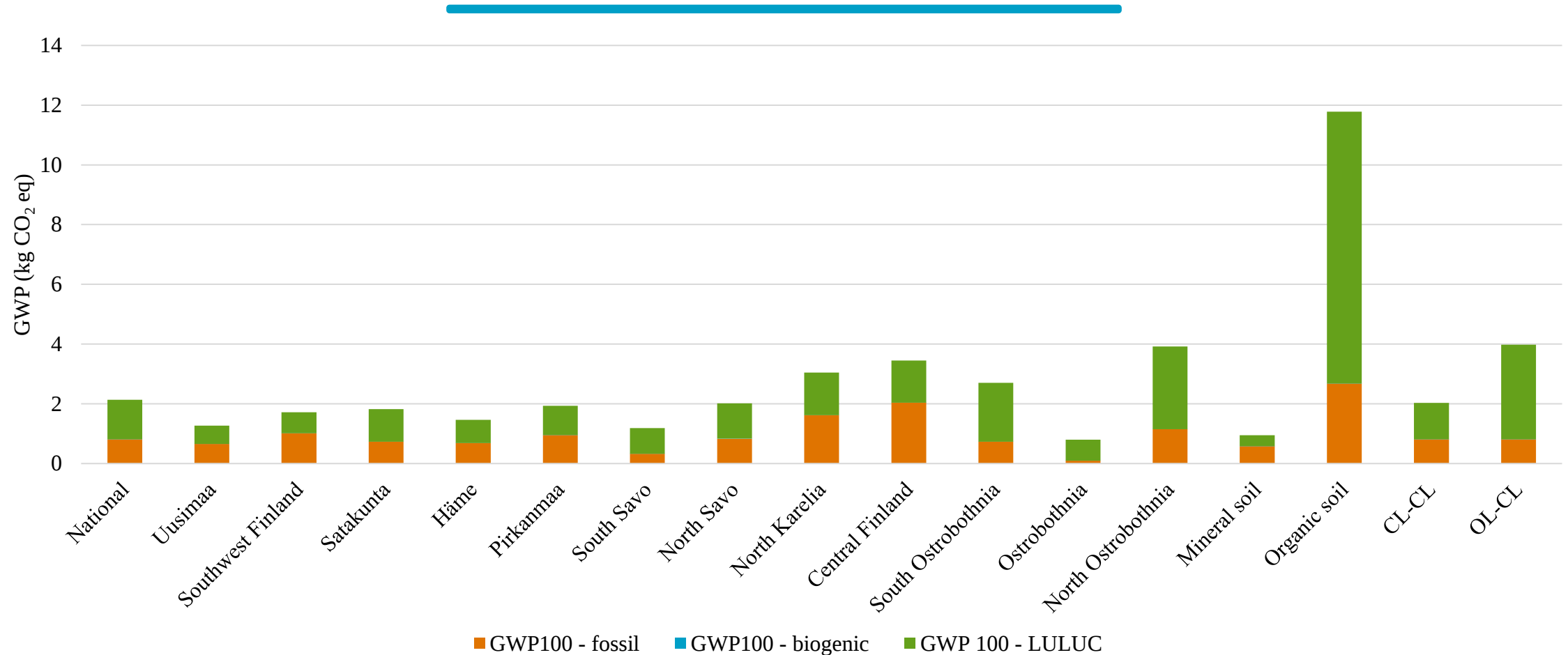


Figure 4: GWP impacts of 1kg Peas production

Conclusion

- **Critical Role of Carbon Stock Changes:** Carbon stock changes in LULUC are pivotal in shaping the GWP of agricultural food products.
- **LULUC Significance:** $\text{GHG}_{\text{LULUC}}$ emissions contributed significantly to the GWP impacts of selected crops at the national level, ranging from approximately 57% to 62%.
- **Regional Variations: Across** different regions in Finland, LULUC contributions vary widely, underscoring the regional disparities in total GWP for crops. This was mainly attributed to the uneven distribution of organic soils in Finland.
- **Type of land and soil:** Land converted to cropland exhibits substantially higher LULUC emissions compared to cropland remaining cropland while farming on organic soil yields impacts significantly higher than crop production on mineral soil
- **Role of SOC:** SOC changes were identified as the primary driver of LULUC impacts

LULUC emissions constitute a significant portion of the overall GWP associated with crop production and demonstrate sensitivity to various factors, especially the soil type.

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➤ <https://www.luke.fi/en/projects/modilca-01>

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