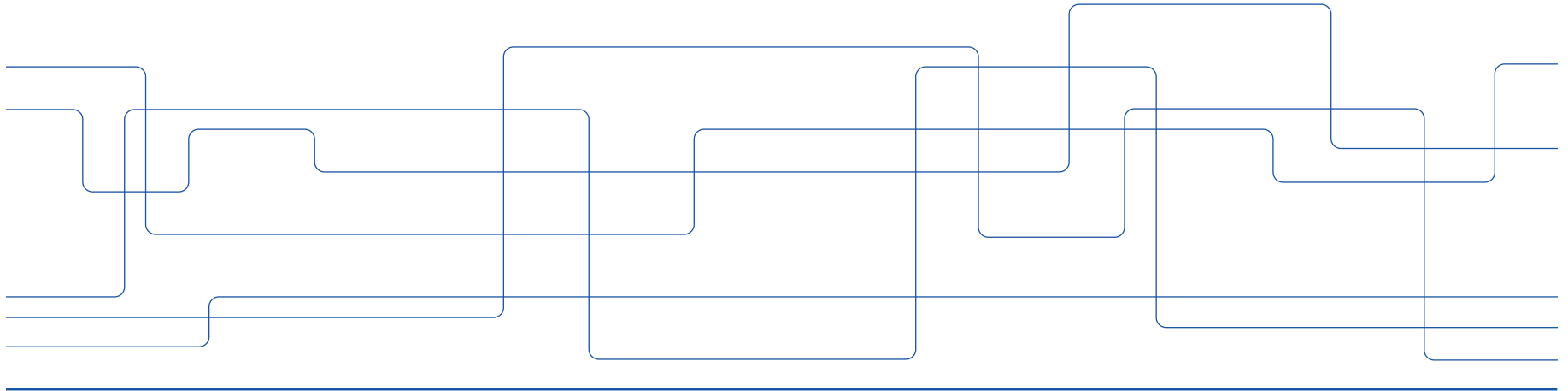


How sensitive is the estimated carbon footprint of biofuels to the LCA modelling approach?

Dr. Miguel Brandão



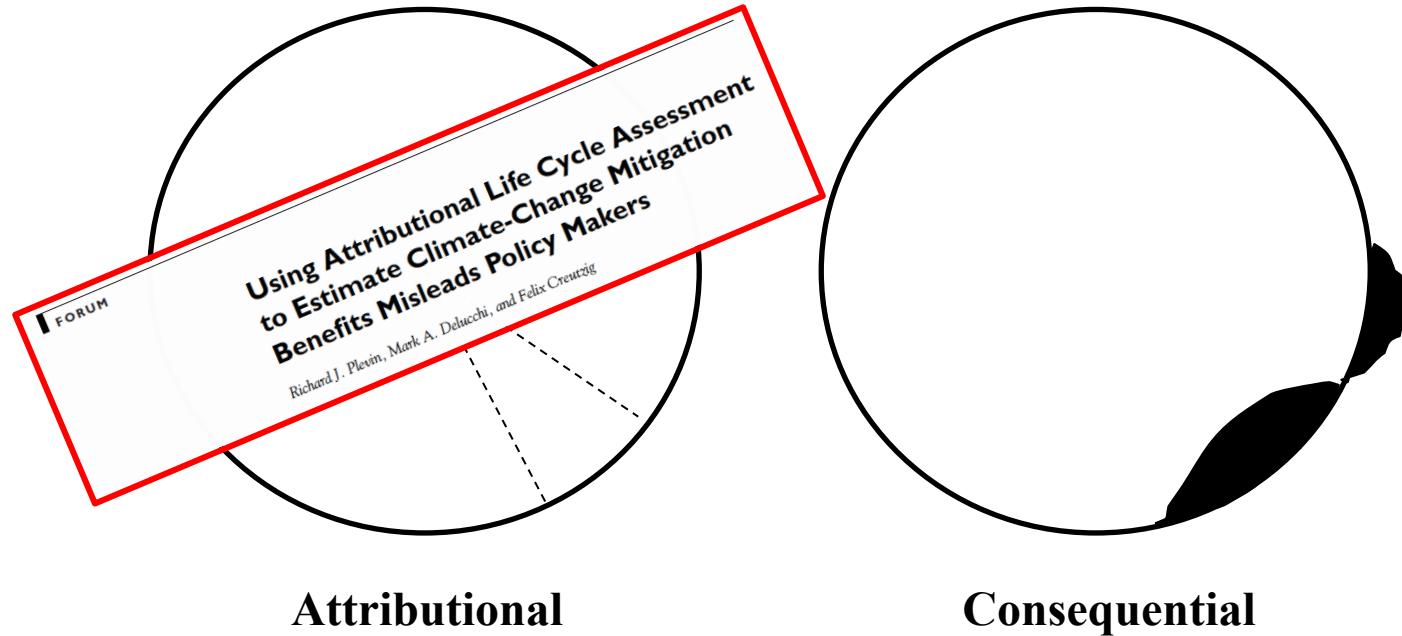


Attributional and consequential modelling

UNEP/SETAC (2011) Shonan LCA database guidance principles:

- **Attributional approach:** System modelling approach in which **inputs and outputs are attributed** to the functional unit of a product system by linking and/or partitioning the unit processes of the system **according to a normative rule**.
 - **Consequential approach:** System modelling approach in which activities in a product system are linked so that **activities are included in the product system** to the extent that they are expected to change **as a consequence of a change in demand** for the functional unit.
-

Attributional and consequential modelling



Source: Weidema (2003)

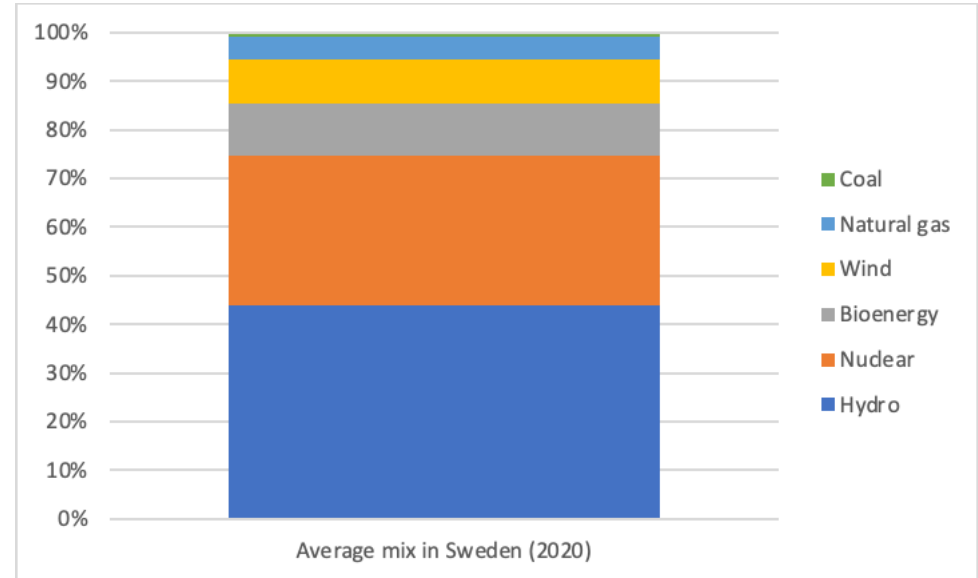


The main differences between attributional and consequential models

| | Attributional | Consequential |
|-------------------------------|--|---|
| Market modelling (supply mix) | Average | Marginal |
| Co-production | Rule-based allocation (e.g. according to economic value) | Substitution (ISO compliant as allocation is avoided) |

The standard assumption in LCA

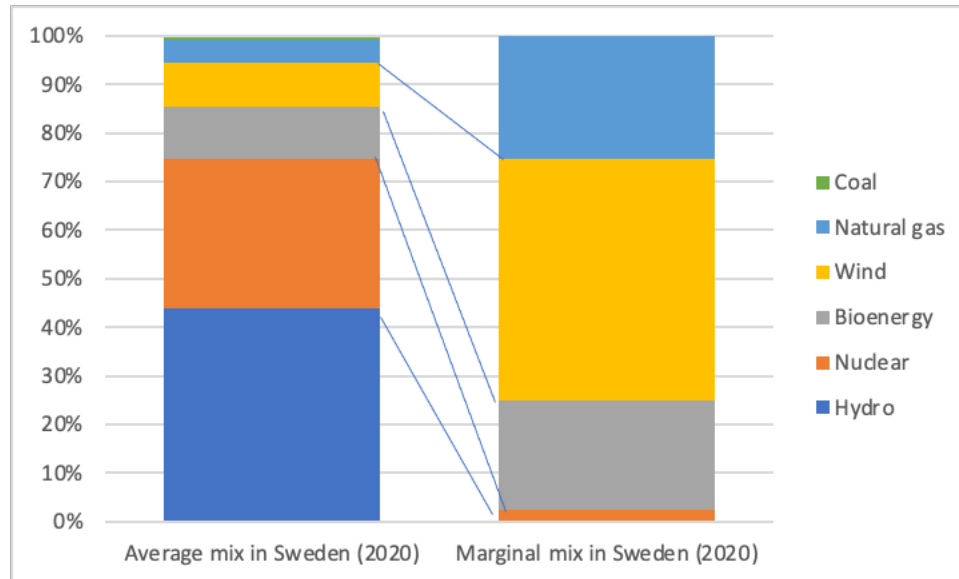
Fully elastic supply –
Current suppliers are
affected in proportion to
their current
market share



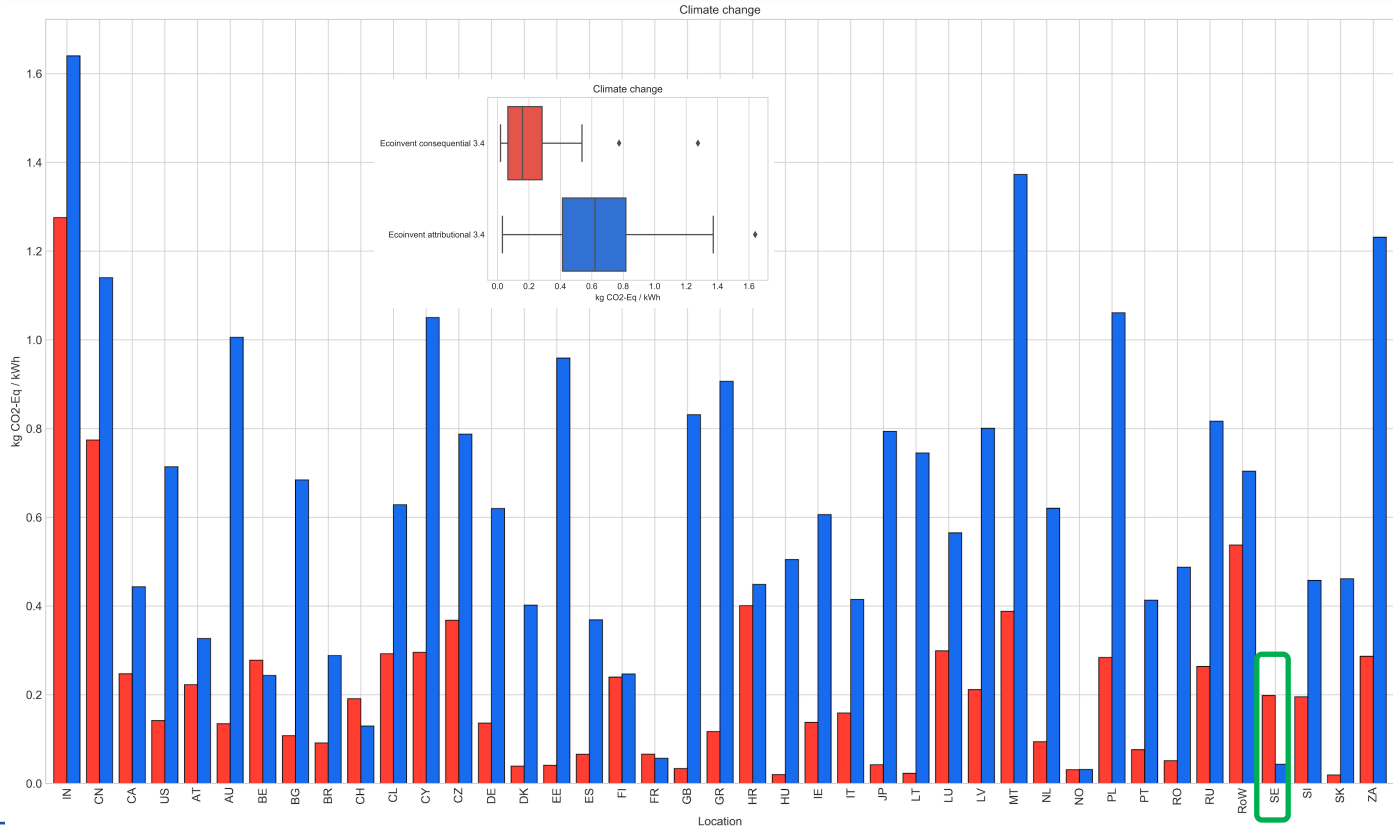
Source: Vandepaer et al. (2019)

Three situations that demand deviations from the standard assumption

1. Constrained suppliers: no changes in supplier production → Shift to alternative suppliers
2. Constrained markets: no changes in total production → Consumption changes (+1-1=0)
3. Co-product supply: no changes in consumption → Substitution of marginal product (-1)



Does it make a difference? The case for electricity



Source: Vandepaer et al. (2019)

Does it make a difference? The case for iLUC

Existing land

| Output | Flow | Unit |
|---------------------|------|---------|
| Land already in use | a1 | ha*year |
| Inputs | | |
| None | | |
| Emissions | | |
| None | - | |

Land use changes

| Output | Flow | Unit |
|-----------------------------|------|---------|
| Expansion | a2 | ha*year |
| Resource inputs from nature | | |
| Transformation from... | b1 | ha |
| Transformation to... | b2 | ha |
| Emissions | | |
| e.g. CO2 | b3 | kg |

Intensification

| Output | Flow | Unit |
|--------------------------|------|---------|
| Intensification | a | ha*year |
| Inputs from technosphere | | |
| Diesel for traction | c1 | MJ |
| N-Fertiliser, as N | c2 | kg |
| Emissions | | |
| e.g. CO2 | c3 | kg |

Reduced consumption

| Output | Flow | Unit |
|---------------------|------|---------|
| Reduced consumption | a4 | ha*year |
| Inputs | | |
| n.a. | | |
| Emissions | | |
| n.a. | - | |

Land market activity

| Output | Flow | Unit |
|--------------------------|--------------------|---------|
| Land | $\sum_{i=1}^4 a_i$ | ha*year |
| Inputs from technosphere | | |
| Land already in use | a1 | ha*year |
| Expansion | a2 | ha*year |
| Intensification | a3 | ha*year |
| Reduced consumption | a4 | ha*year |

Wheat LCA activity (1 ha yr)

| Output | Flow | Unit |
|--------------------------------|--------|---------|
| Wheat | 7,296 | kg |
| Inputs from technosphere | | |
| Land | 1.15 | ha*year |
| Diesel for traction | 3,306 | MJ |
| N-Fertiliser, as N | 198 | kg |
| P-Fertiliser, as P2O5 | 46 | kg |
| K-Fertiliser, as K2O | 84 | kg |
| Emissions | | |
| CO2 fossil (diesel combustion) | 245 | kg |
| N2O | 4.15 | kg |
| Resources | | |
| CO2 biogenic from air | 11,370 | kg |

8

iLUC

Agriculture

In summary

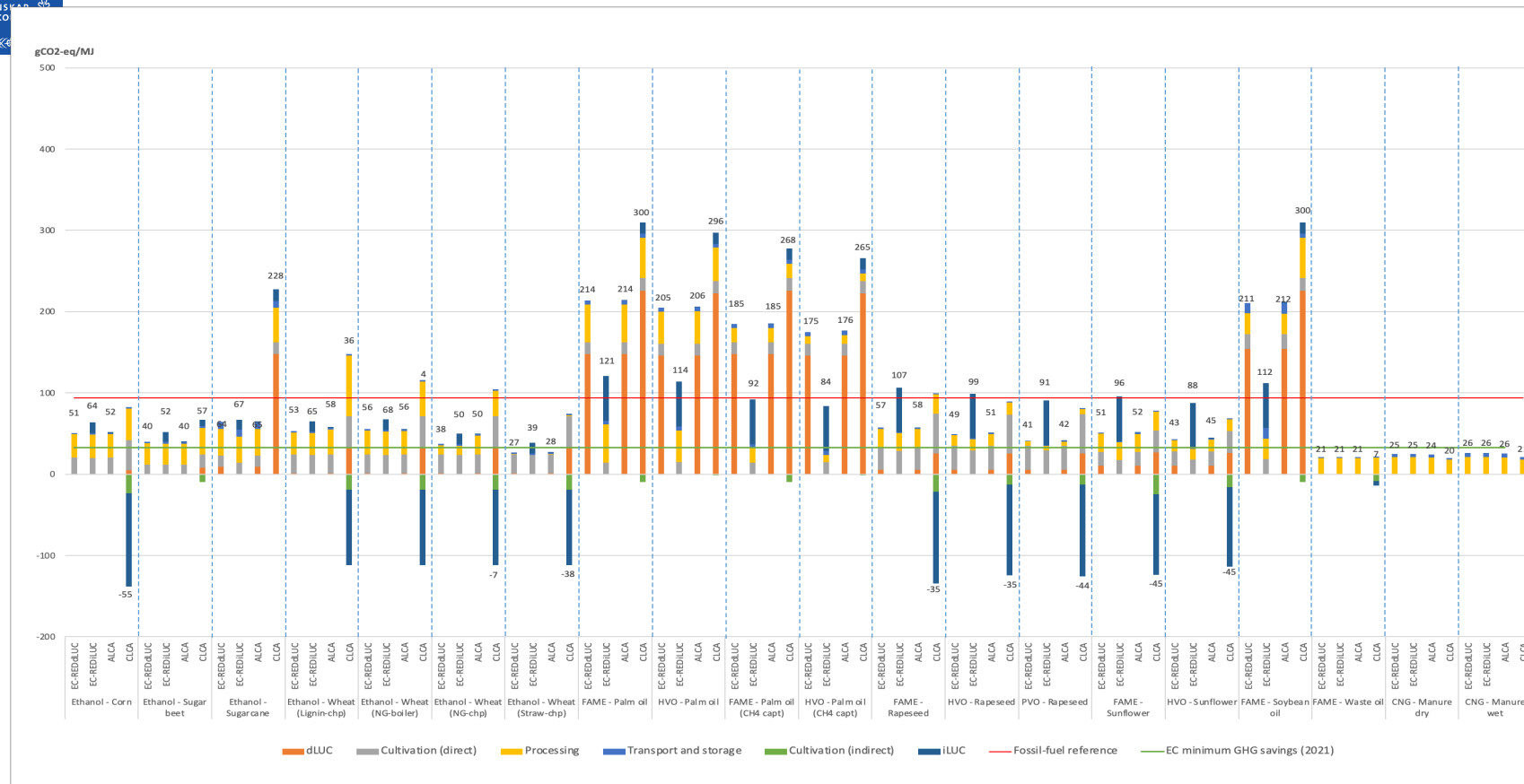
Attributional iLUC modelling includes the effects of:

- Using existing land
- Expanding existing land
- Intensification of existing land

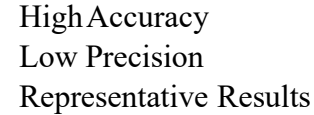
Consequential iLUC modelling includes the effects of:

- ~~Using existing land~~ (constrained supplier)
- Expanding existing land
- Intensification of existing land

What is the difference in outcome? The case for biofuels

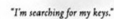


Source: Brandão, Azzi, Novaes, Cowie (submitted)



It is better to be approximately right than precisely wrong."

Tribus and El-Sayed (1982)





Outlook: (C)LCA for decision support

- LCA's relevance for policy support growing
 - Several international developments and ongoing initiatives → better methods, databases, software
 - Lack of consensus → increasing harmonisation needed in LCA practice for robustness and reproducibility
 - LCA of biofuel systems
 - Not necessarily better than the fossil fuels/materials/chemicals they replace
 - (C)LCA helps us in identifying the best and worst systems
 - May still play a role in climate change mitigation
 - Message for policy makers: promote the good system, discourage the bad and ugly
 - Methodological choices determine results → delimitation of system boundary and indirect effects
 - "All models are wrong, but some are useful" → **non-shifting of burdens**
(Box and Draper, 1987)
-



THANK YOU!

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