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Environmental assessment of alternatives to fossil-based mulching plastics and peat substrate in greenhouse tomatoes

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Goal & Scope

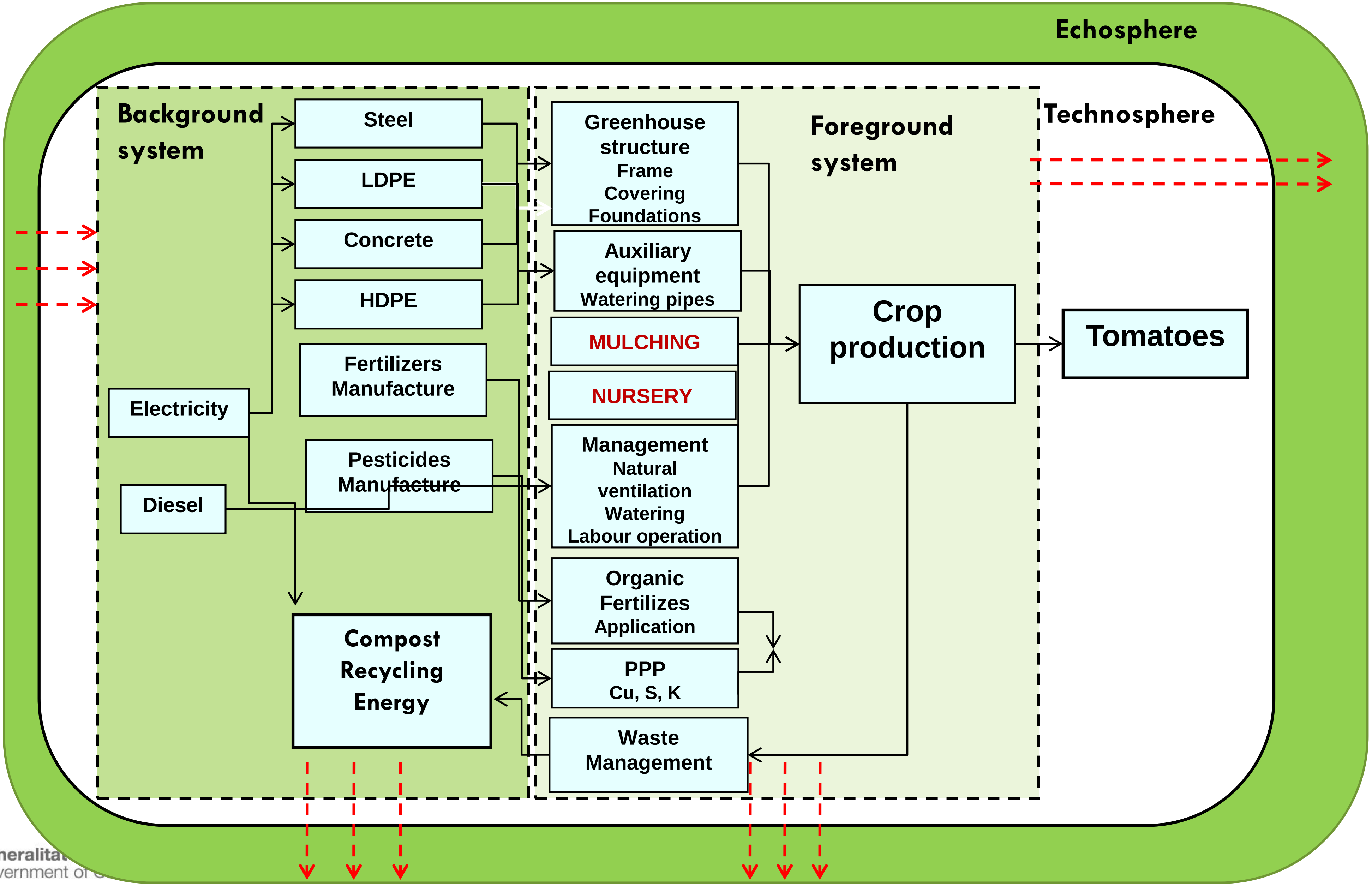
- ✓ **Functional unit:** 1 ton organic cherry tomato (*Creativo*)
- ✓ **Reference flow:** 1 ha

- ✓ **Location:** Almeria, Spain

- ✓ **Methodology:** Environmental Footprint v 3.0.

- ✓ **Specifications:** Steel “parral” greenhouse
  - *Reference (contentious) scenario*: fossil-based plastic mulching and peat substrate in nursery
  - *Alternative scenario*: starch-based bioplastic mulching and horse manure & green forest waste compost

System boundaries



Life cycle inventory data for 1 ha cherry tomato

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Inputs	Quantity	Units
Water for irrigation (well, deionised, rain)	5000	m^3/ha
Tomato seedlings	18000	units/ha
Peat (30 g peat/seedling, density 100kg/m^3 dry loose peat) **or Compost**	5.4	m^3/ha
Mulching LDPE **or Bioplastic**	194.25 **or 186**	kg
Solarization LDPE	175	kg
Electricity (operating windows, water pumps)	866.7	kWh
Copper sulfate PPP	3.75	kg
Sulfur PPP	125	kg
Potassium hydroxide PPP	0.2	kg
Sheep manure as N fertilizer	134	kg
Green waste compost fertilizer	160	kg
Machinery use	1	ha

Life cycle inventory data for 1 ha cherry tomato

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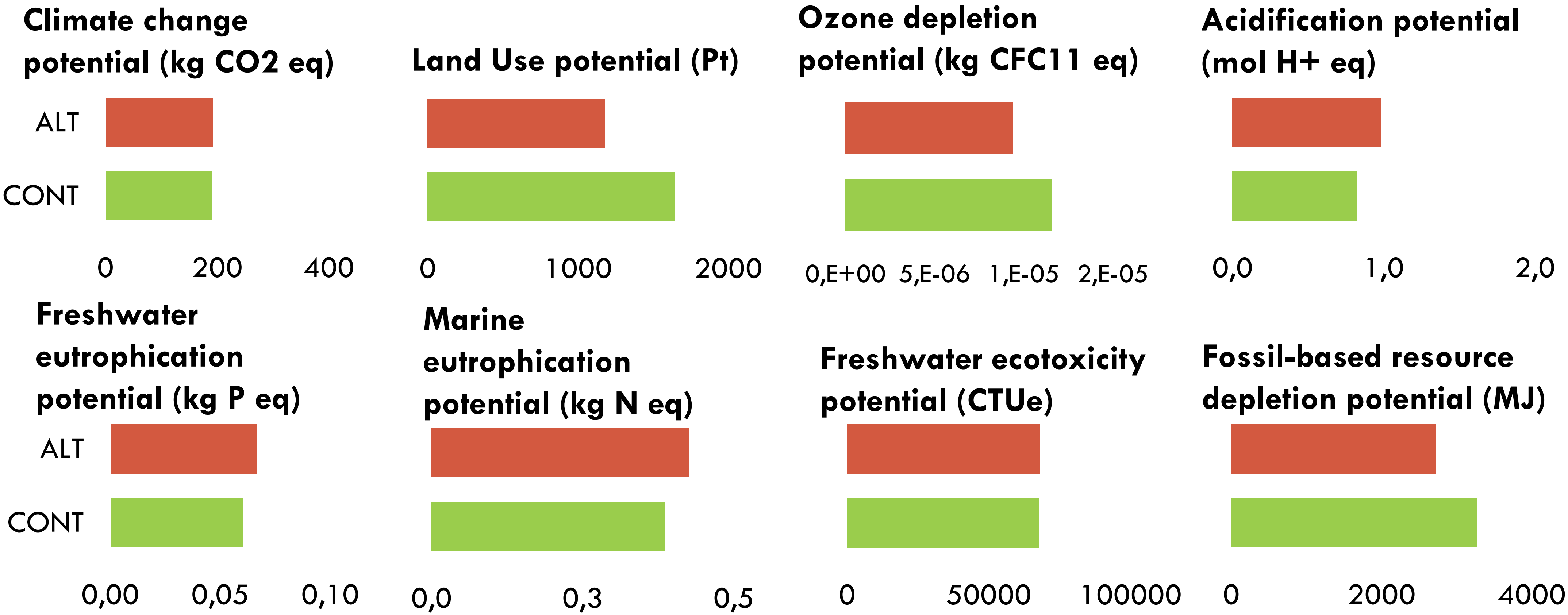
	Outputs (emissions)	Quantity	Units
Air	Ammonia	13.95	kg
	Nitrogen oxides	11.26	kg
	Dinitrogen monoxide	5.28	kg
	Copper	6.25	kg
	Sulfur	0.19	kg
Water	Nitrate	0	kg
	Phosphorus	0.000000056	kg
Soil	Copper	56.25	kg
	Sulfur	1.69	kg

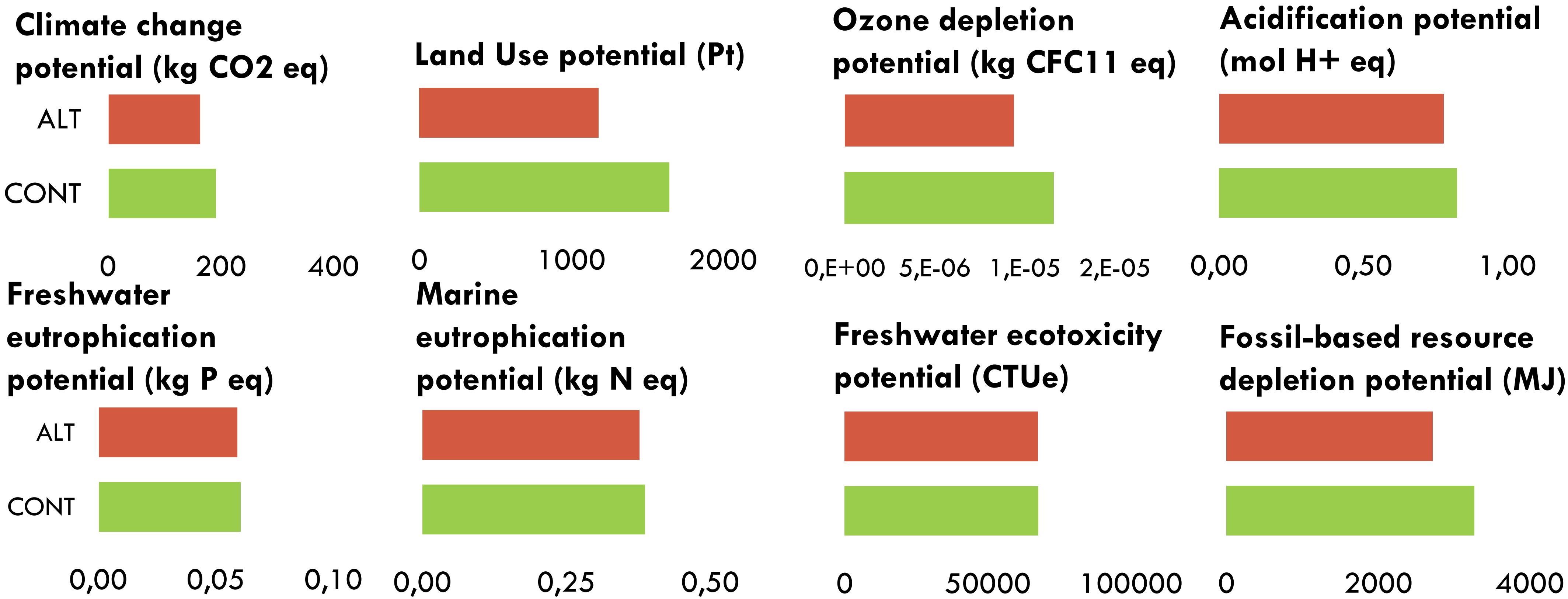
RESULTS

Fossil-based plastic (CONT) vs Bioplastic (ALT) in tomato prod.



- No clear "winner" in terms of environmental performance.
- **Better performance** in Land use, Ozone depletion & Fossil-based resource depletion
- The thickness of bioplastic (25um) is a major factor.
- **Hotspots in bioplastic prod.:** Manufacturing feedstock and polymerization

Peat (CONT) vs Compost (ALT) in tomato prod.



- No clear "winner" in terms of environmental performance.
- **Better performance** in Land use, Ozone depletion, Fossil-based resource depletion
- **Hotspots in compost production:** Transport of forest residues and diesel consumption across most categories
- Emissions from compost contribute to climate change, acidification, marine eutrophication

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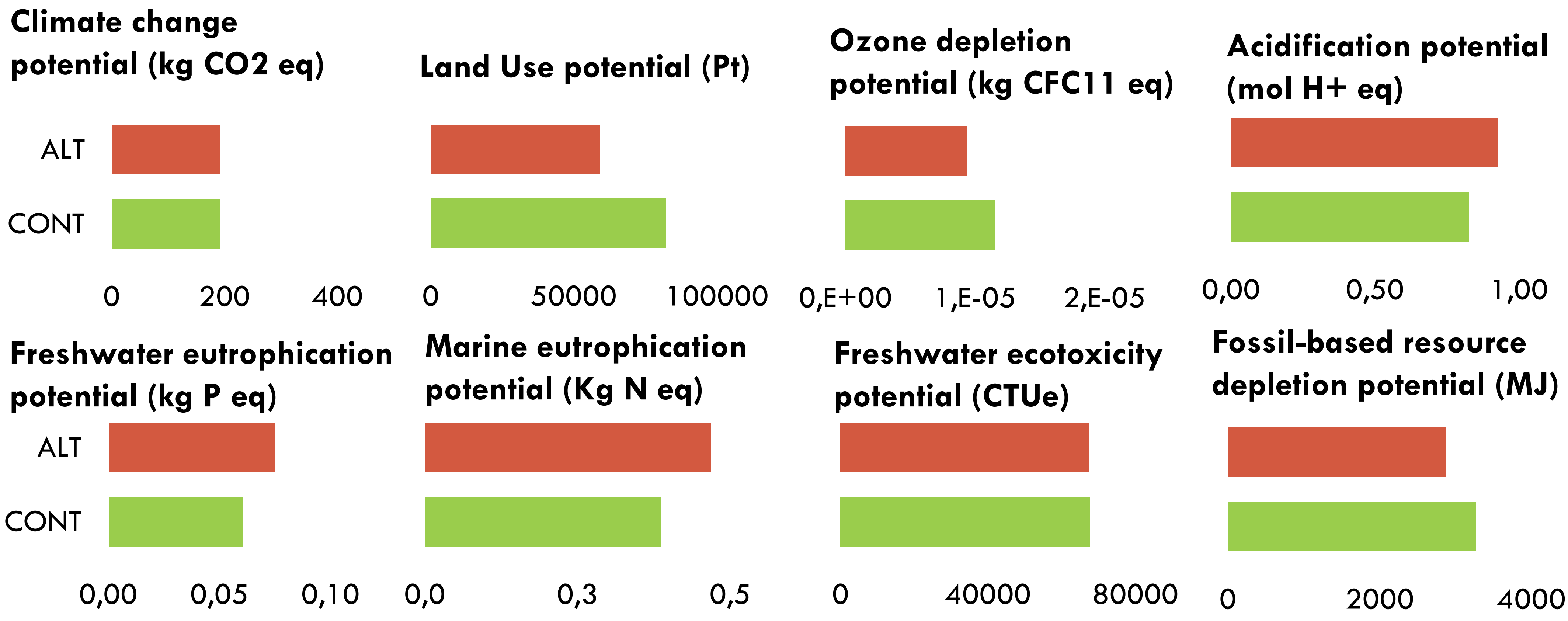
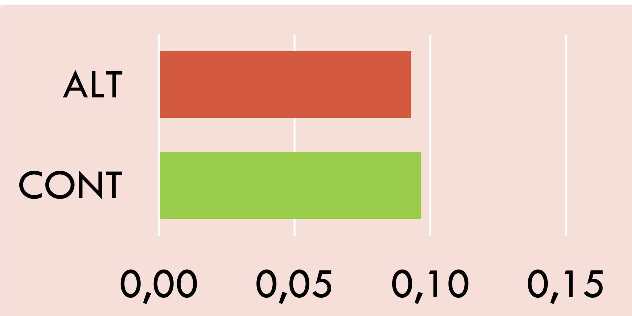
Substituting both alternatives in tomato prod. (bioplastic & compost growing media)





- Normalized and weighted results show that the alternative and contentious scenarios are along the same magnitude, with ALT slightly lower.

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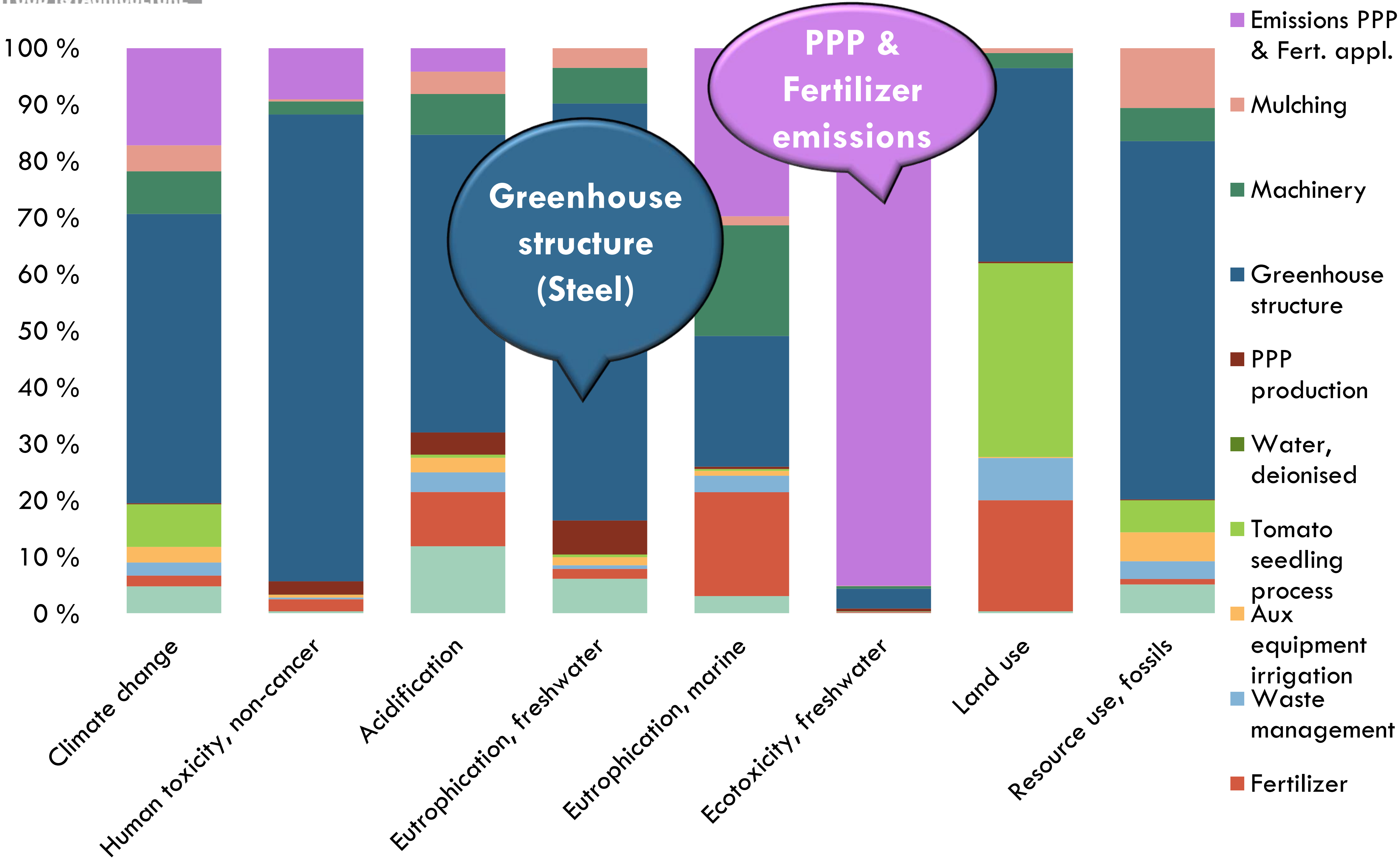
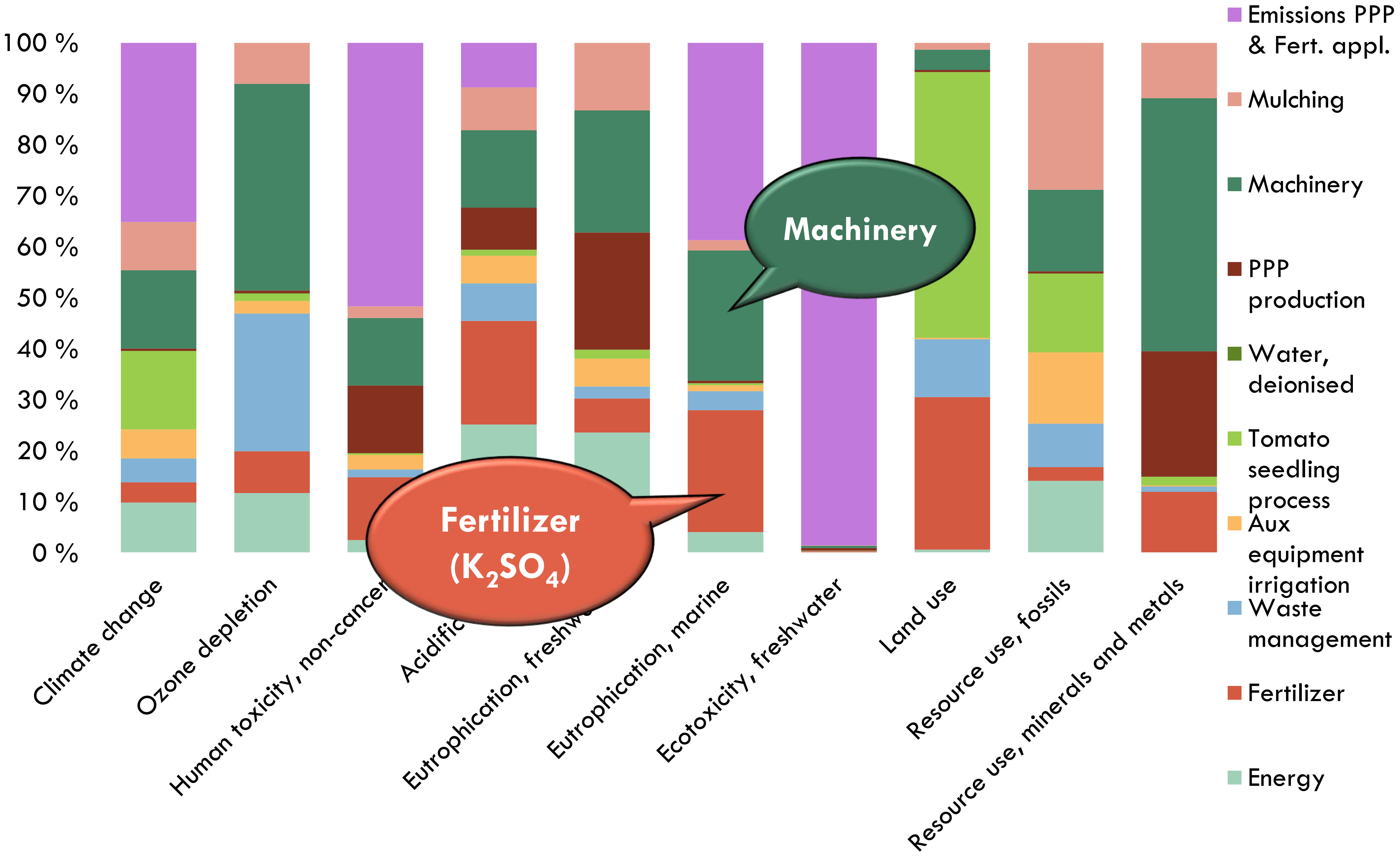
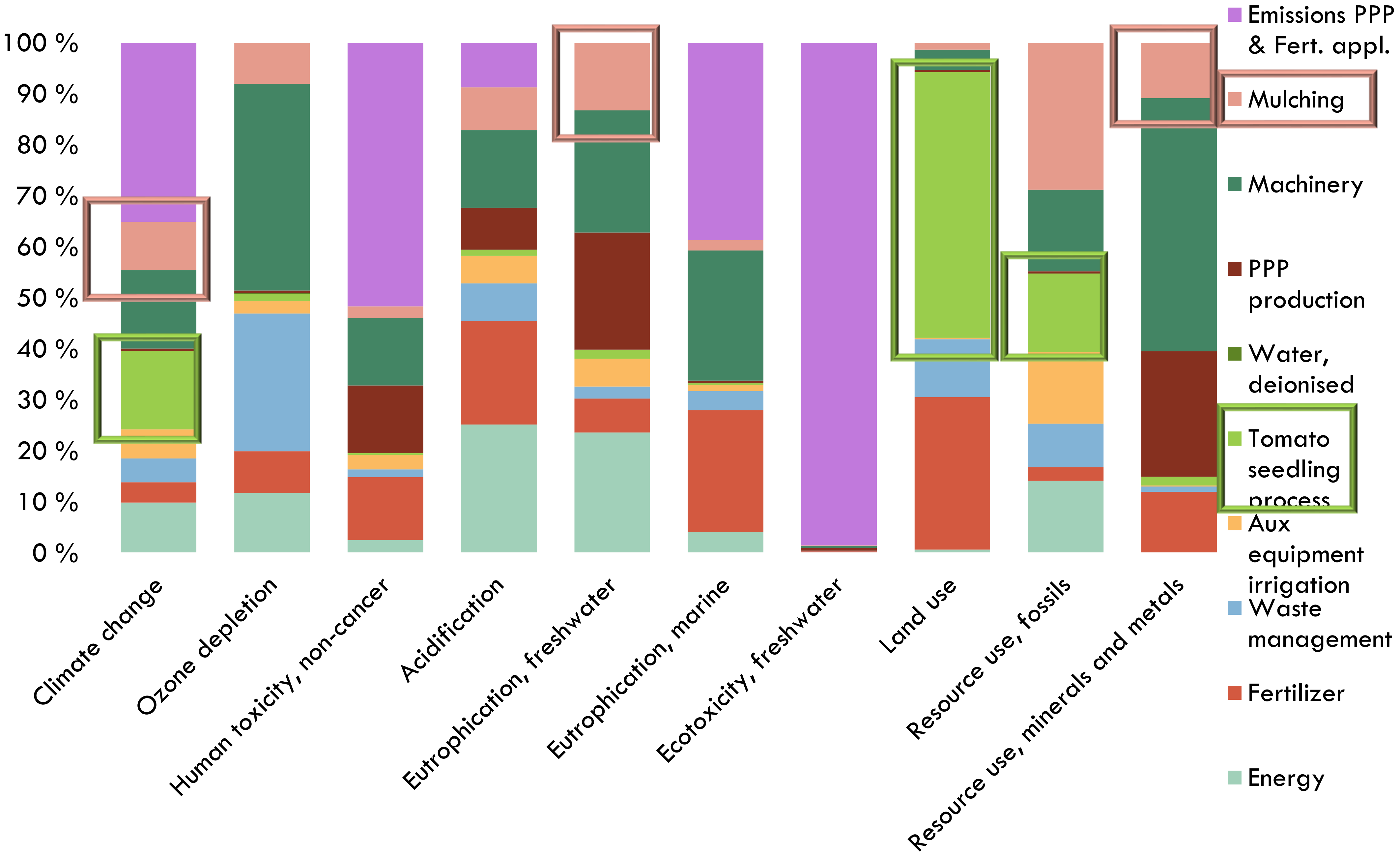
Contribution Analysis: Contentious scenario



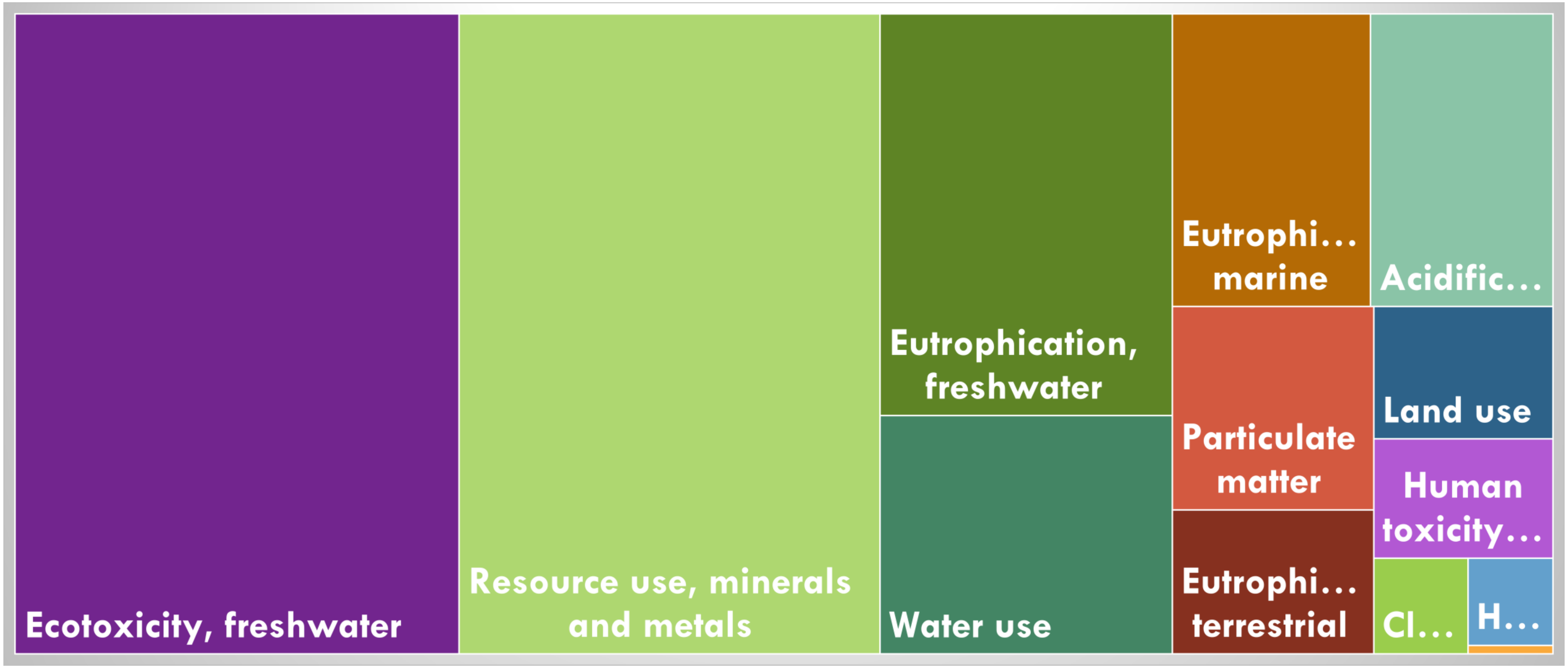
Contribution Analysis: Contentious scenario: excluding greenhouse infrastructure



Contribution Analysis: Contentious scenario: excluding greenhouse infrastructure



Normalization & weighting of impacts: Alternative scenario



- Impacts dominated by Copper ecotoxicity, one of the contentious inputs assessed in ORG+

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Conclusions

Important issues and improvements:

- **Where the starch for the bioplastic comes** from is very important (organic or conventional potatoes; virgin starch or residual starch from potato processing)
- **Thickness of the bioplastic film** has a large influence on results, can we reduce thickness even more?
- We used **general emission factors** for compost and bioplastic degradation, this can be improved if we have information on **composition**
- Assumption: **similar quality and density** of peat and compost with 1 m3 peat = 1 m3 compost (?)
- Impacts related to **microplastics** and **general plastic pollution** (e.g. impacts on human toxicity, ecotoxicity, ecosystem services) are **not yet modelled in LCA**
- **Biodiversity** impacts not estimated here, harvesting of peat could have a high effect (this forms part of my PhD research)

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Extra slides in case

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Conclusions

- **Major contentious inputs** for **both scenarios were:** greenhouse structure, copper PPP, fertilizer production & emissions, machinery
- The contentious inputs **PEAT and PLASTIC** mulch can have major contributions **to Resource depletion-fossil, Land use & Climate change.**
- **Alternative inputs** show better performance in **Land use, Ozone depletion and Resource depletion-fossil impact, but** have **high** impacts in **eutrophication**

a

Characteristic	Film
Thickness (microns)	40
Density of Bioplast (g/cm3)	1,24
Film mass per ha of film (kg/ha film)	496
Film mass per ha of land covered with film (kg/FU)	297,6
Composition (Two types of layers: A & B)	
Mass of layer A: Bioplast 400Elit (Thermoplastic starch-based polymer, TPS) (kg/FU)	119,0
Mass of layer B:	
Bioplast 400D (kg/FU)	174,9
Carbon black colouring (kg/FU)	3,6

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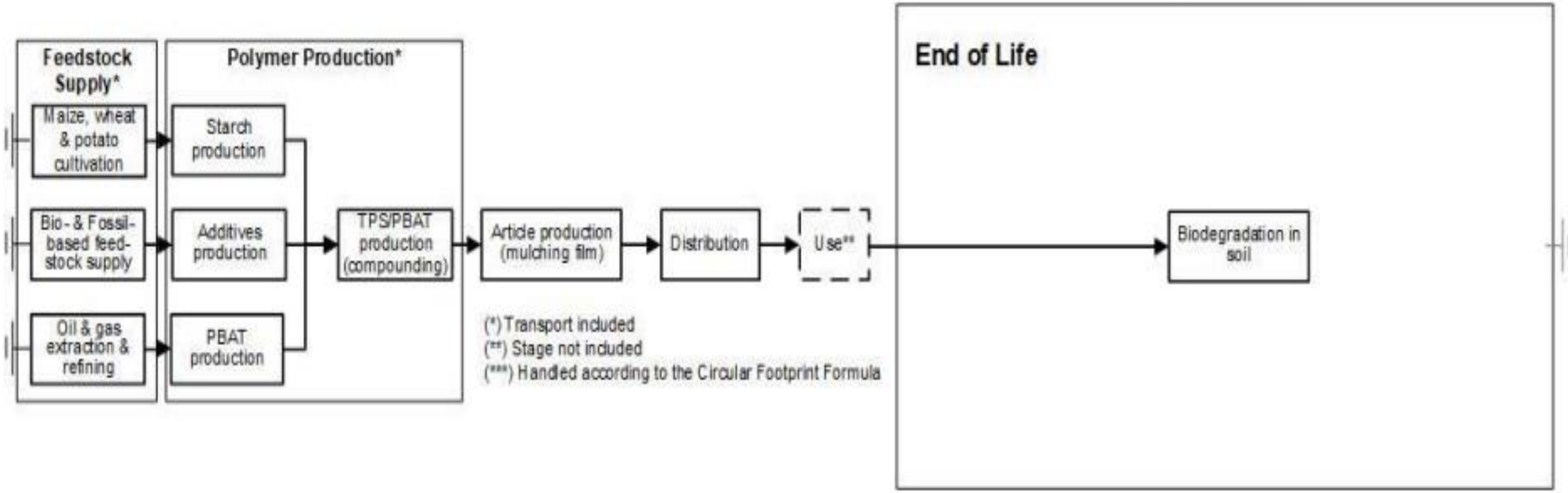
- ✓ **Functional unit:** 1 ha field (0,6 ha of mulched land) "providing mulching to one hectare of agricultural land in Europe, cultivated with horticulture crops (e.g. melon, strawberry, zucchini etc.), for a period corresponding to an average growing season (i.e. four to five months). (Source: Nessi et al., 2020)

- ✓ **Methodology:** Environmental Footprint v 3.0.
- ✓ Followed guidance and default factors for all stages in Nessi et al. (2020), but used the characteristics of the specific biopolymer (next slide)



Contribution Analysis: Alternative scenario: excluding greenhouse infrastructure