

# LCA OG CIRKULARITET: KLIMA- OG MILJØAFTRYK VED NY FØDEVAREPRODUKTION

# MARIE TRYDEMAN KNUDSEN

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- Seniorforsker ved Institut for Agroøkologi ved Århus Universitet og medlem af Klimarådet
- Agronom og ph.d. i livscyklusvurderinger af fødevarer
- Klima- og miljømæssig bæredygtighed af fødevarer og landbrugssystemer, hvor jeg primært bruger livscyklusvurderinger (LCA).

# VORES LCA OG SYSTEMANALYSE TEAM



# PROJEKTER I VORES LCA TEAM

SYSTEMANALYSE og LIVSCYKLUSVURDERING (LCA) af:

- Klimavenlig, sund og bæredygtig kost (SustainOrganic, Kostrådsprojekt)
- Grøntsagsproduktion (ClimateVeg)
- Husdyrproduktionssystemer (PATHWAYS, Pork 4.0, EFFORT, GroBeat, Kalv ved Ko)
- Cellulært kød og mælk (CleanPro)
- Skovlandbrug og integrerede landbrugssystemer (MIXED, OUTFIT)
- Bioraffinering og grønt protein (GreenEggs, GreenVALLeys, GrassTools)
- Alternative økologiske gødninger (ClimOptic)
- Tørvejorde og alternative vækstmedier (Peatwise, BioSubstrate)
- Alternativ emballage (SinProPack)
- Cirkulært landbrug og klimaregnskaber på bedriftsniveau (CIRKULÆR)
- Metodemæssig udvikling omkring f.eks. kulstoflagring og biodiversitet (MIXED etc.)





# PROJEKTER I VORES LC

## SYSTEMANALYSE og LIVSCYKLUSVURDERING

- Klimavenlig, sund og bæredygtig kost (Sus)
- Grøntsagsproduktion (ClimateVeg)
- Husdyrproduktionssystemer (PATHWAYS, Pork, Energi, Grøn, Ved Ko)
- Cellulært kød og mælk (CleanPro)
- Skovlandbrug og integrerede landbrugssystemer (MIXED, OUTFIT)
- Bioraffinering og grønt protein (GreenEggs, GreenVA)
- Alternative økologiske gødninger (ClimOptic)
- Tørvejorde og alternative vækstmedier (reatv)
- Alternativ emballage (SinProPack)
- Cirkulært landbrug og klimaregnskaber på bed
- Metodemæssig udvikling omkring f.eks. kulstoflagring

Hvad er klima- og miljøpåvirkningen per ha og per kg produkt?

Hotspots og forbedringsmuligheder

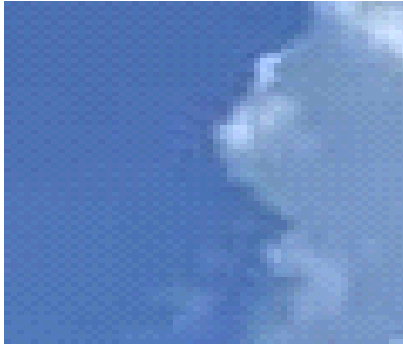
Hvordan er det estimeret?

Hvad er de metodemæssige udfordringer?

Hvordan kan de løses?

# MILJØPÅVIRKNING FRA FØDEVAREPRODUKTION

Klimapåvirkning



Næringsstofberigelse



Jord og kulstoflagring



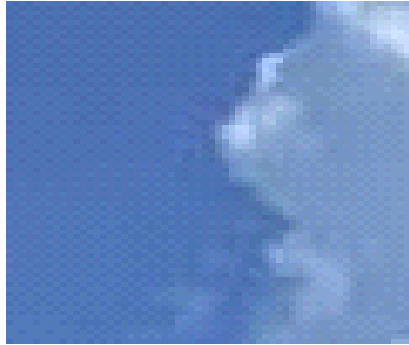
Økotoxicitet

Biodiversitet



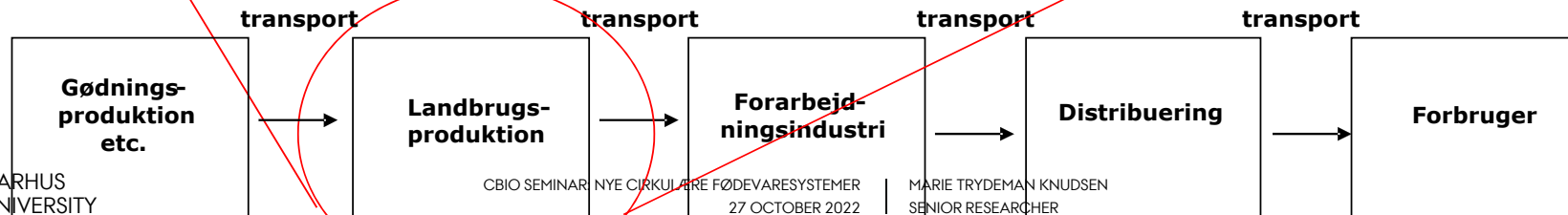
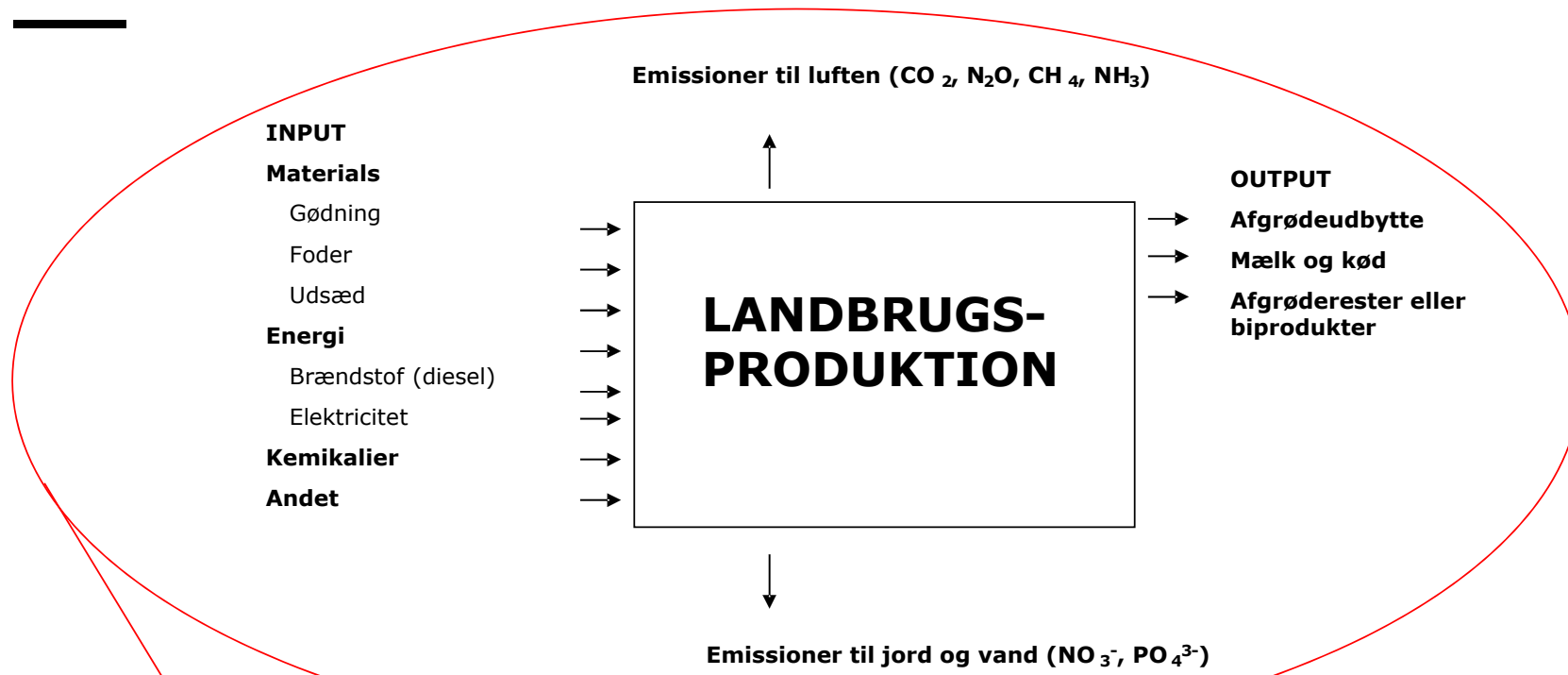
# KLIMAPÅVIRKNING FRA FØDEVARER?

Klimapåvirkning

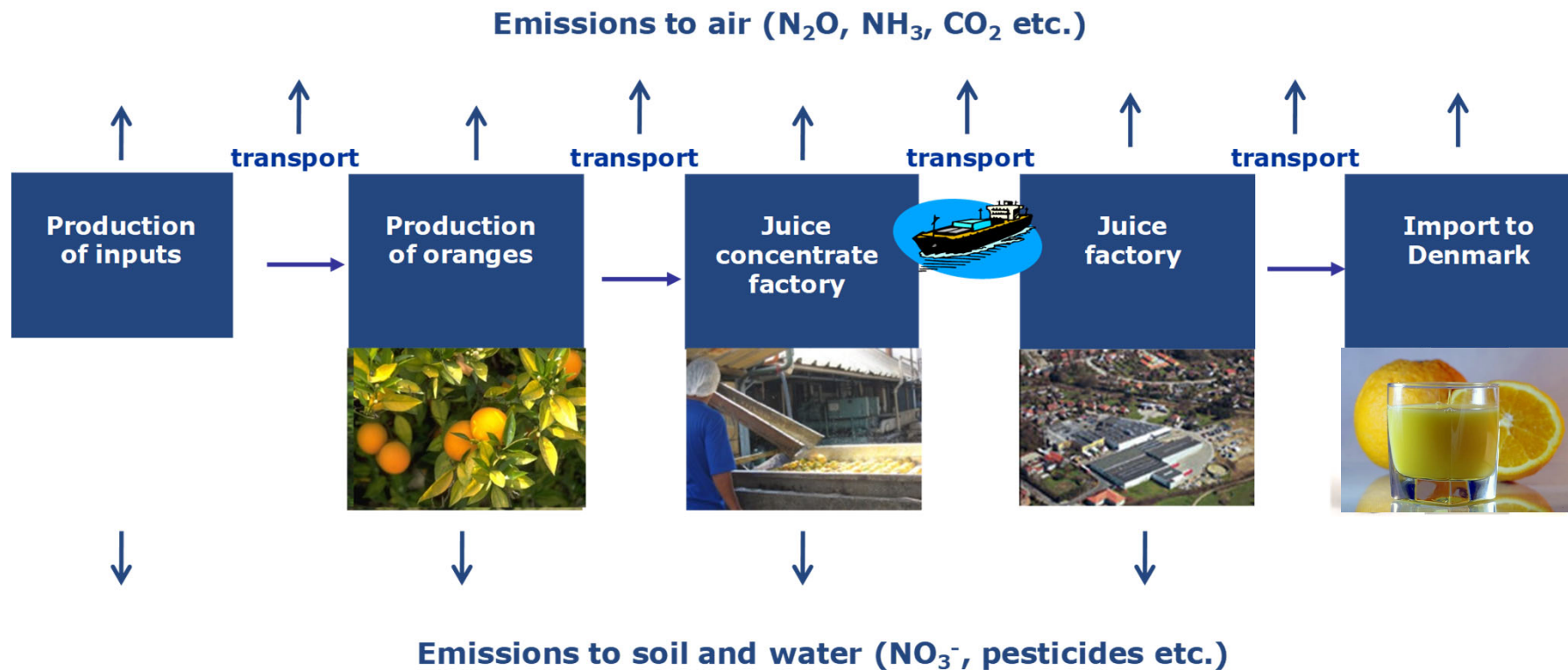


20-30% af vores  
totale klimaaftryk

# LIVSCYKLUSVURDERING



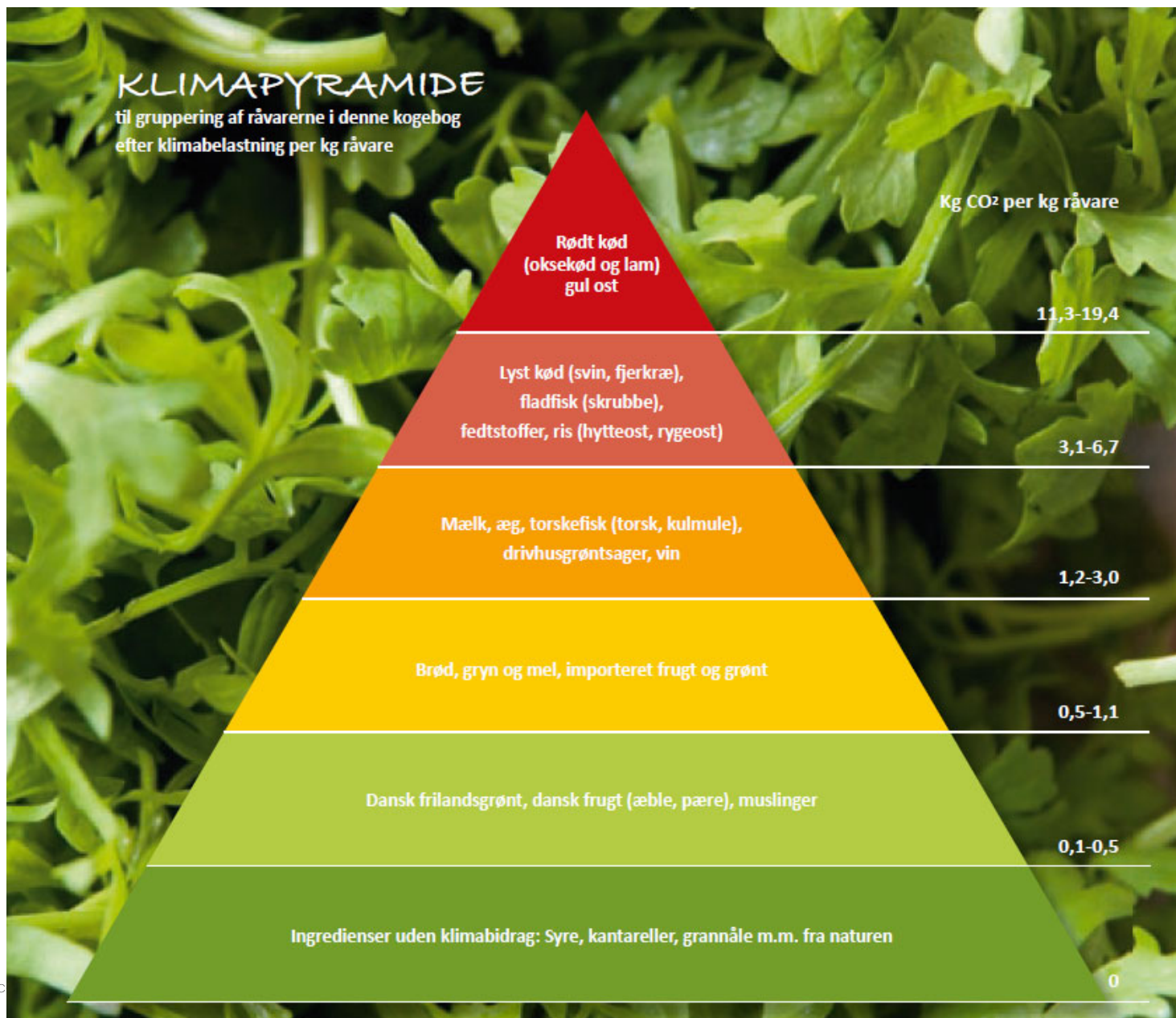
# EKSEMPEL: LIVSCYKLUSVURDERING AF APPELSINJUICE





# KLIMAPYRAMIDE

til gruppering af råvarerne i denne kokebog  
efter klimabelastning per kg råvare



# LCA-TANKEGANGEN

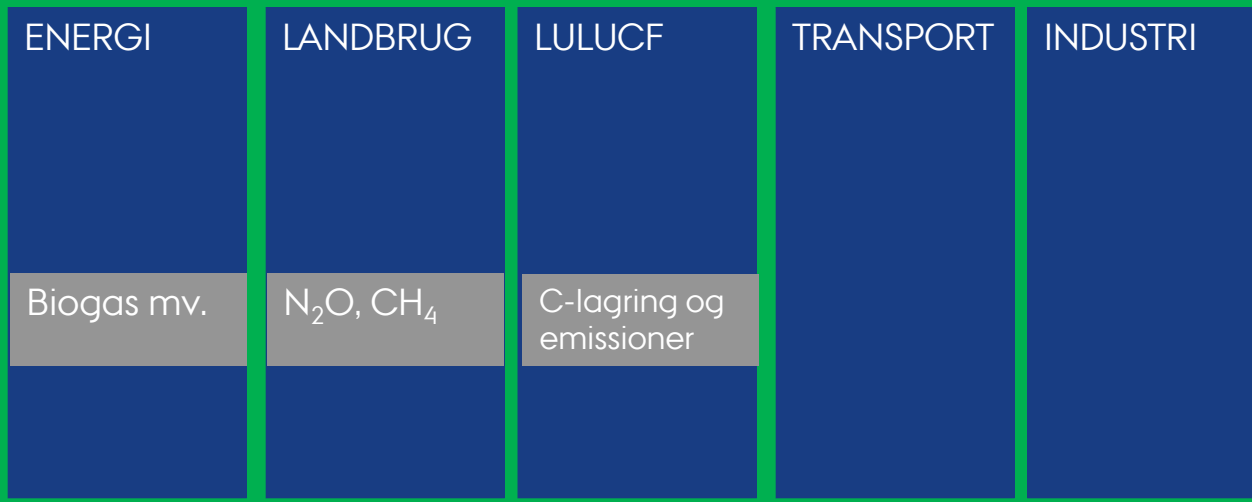
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- At se på hele systemet – så man reducerer klima- og miljøpåvirkningen i systemet uden at skabe nye miljøproblemer andre steder i systemet
- Dokumentation af mulighederne for at reducere klimapåvirkning fra fødevarer, landbrugssystemer og alternative produkter
- Identifikation af hotspots – størrelsen af emissioner og kulstoflagring i forhold til hinanden og set i sammenhæng med resten af systemet
- Sammenligning af forskellige systemer

# SYSTEMGRÆNSER

GLOBALE

NATIONALE



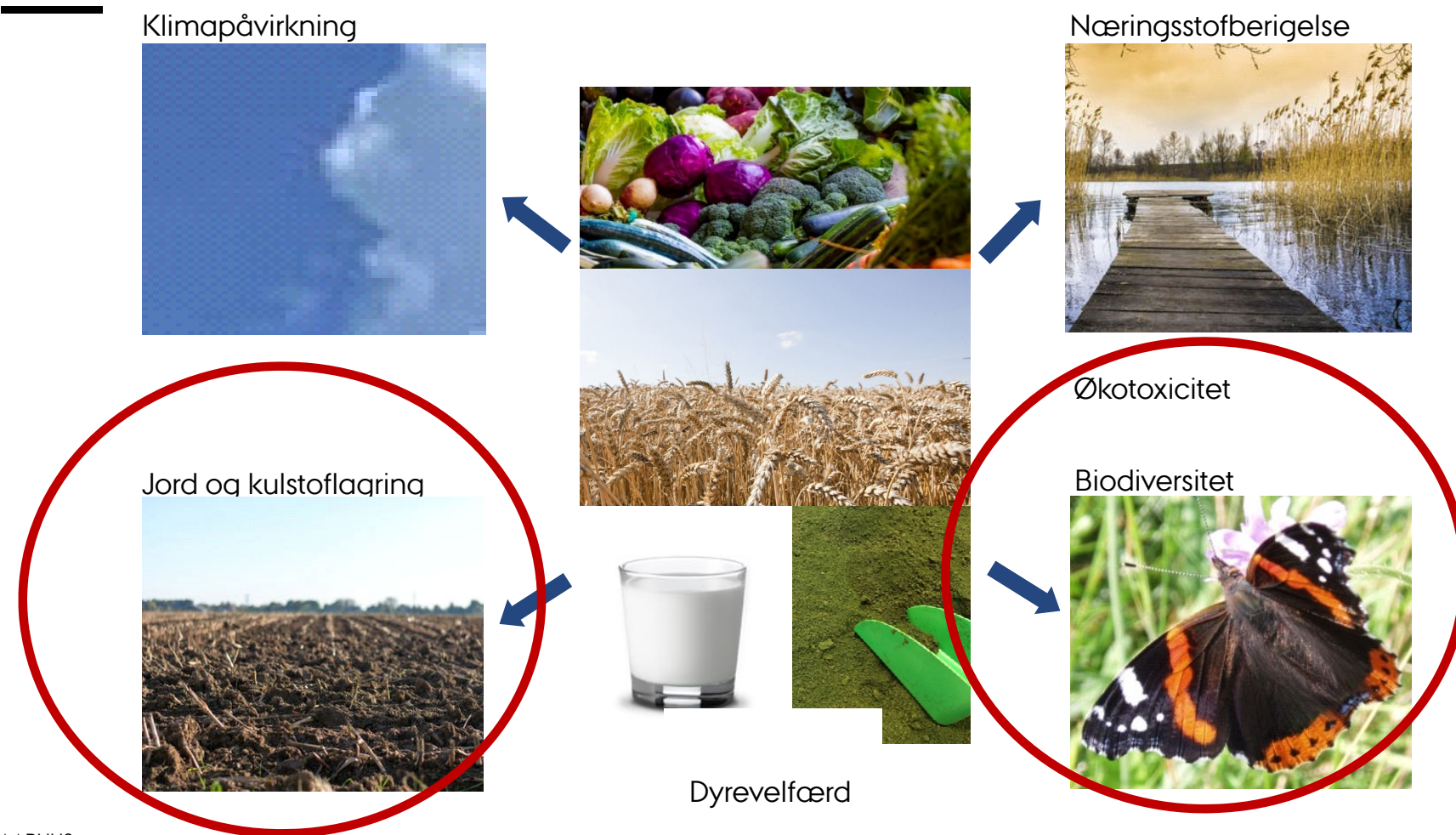
Soja og palmeolie



# MILJØPÅVIRKNING FRA FØDEVAREPRODUKTION



# MILJØPÅVIRKNING FRA FØDEVAREPRODUKTION



# EKSEMPEL: HAVRE-PROTEINKONCENTRAT I BRØD, PASTA MV.

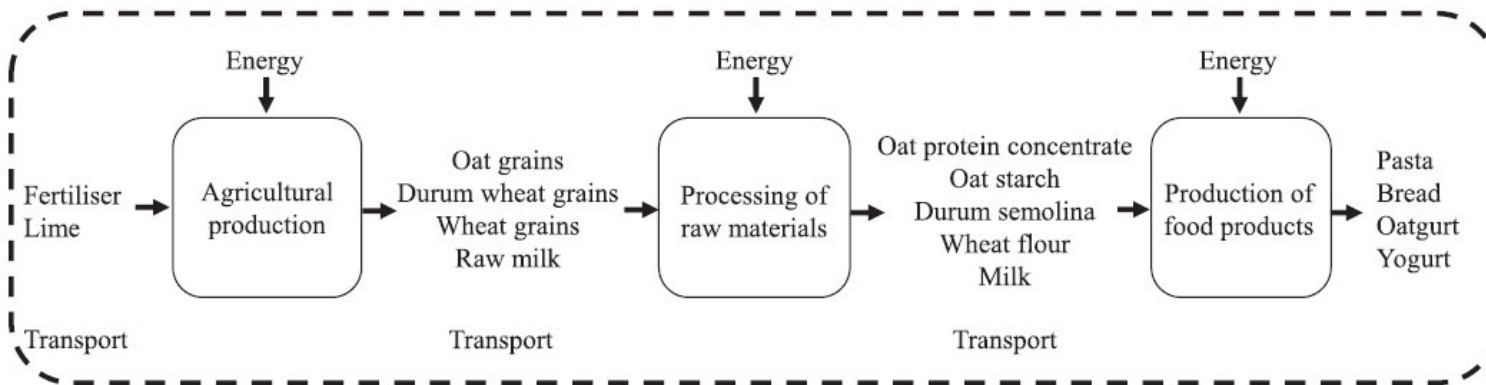
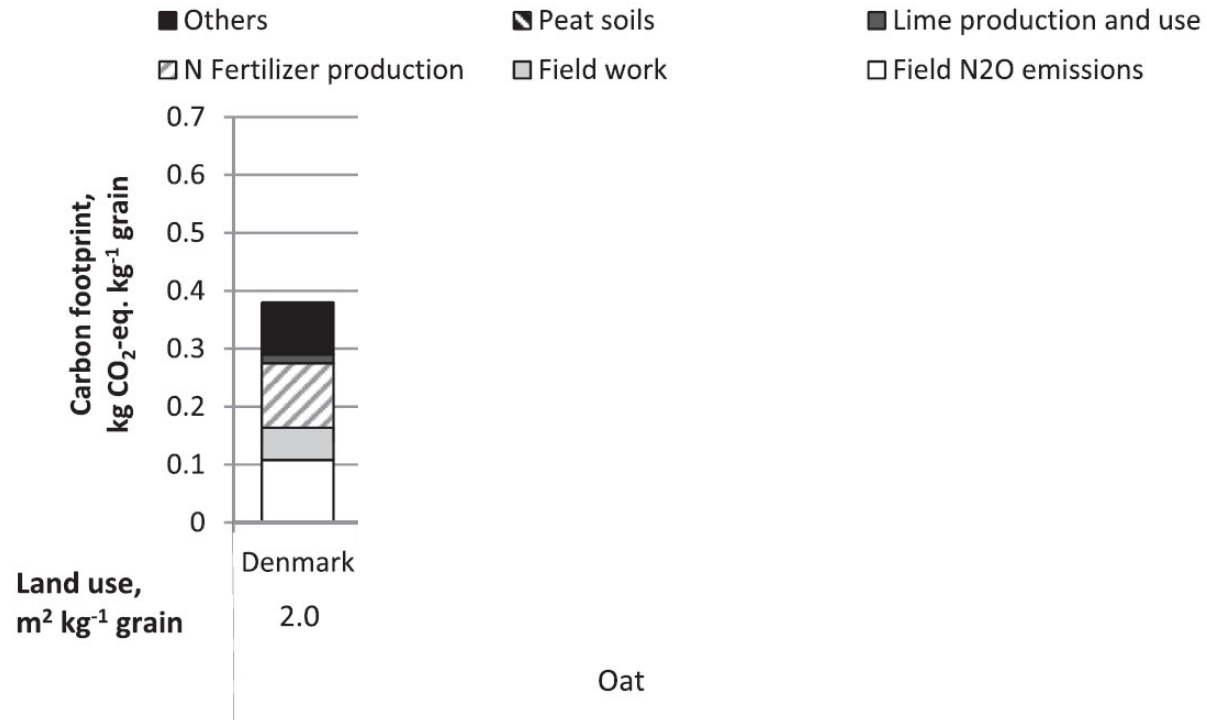


Fig. 1. System boundary of main raw materials and ready-to-eat-food products.

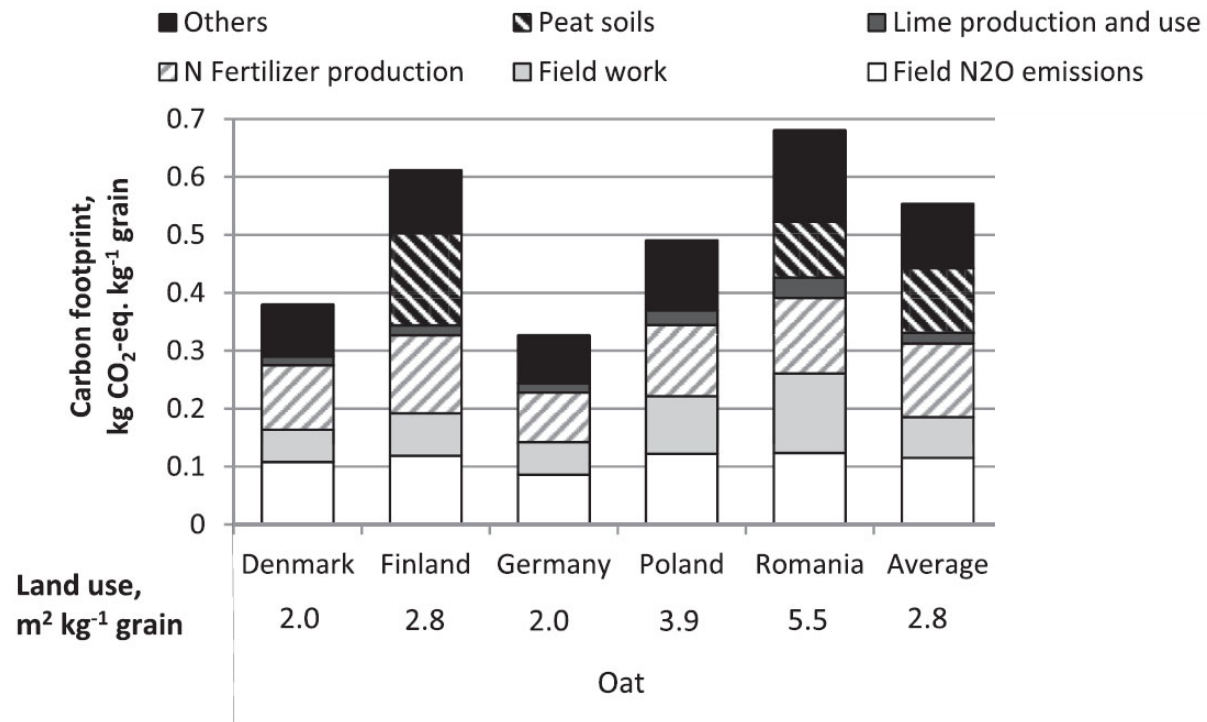


# KLIMAAFTRYK AF HAVRE

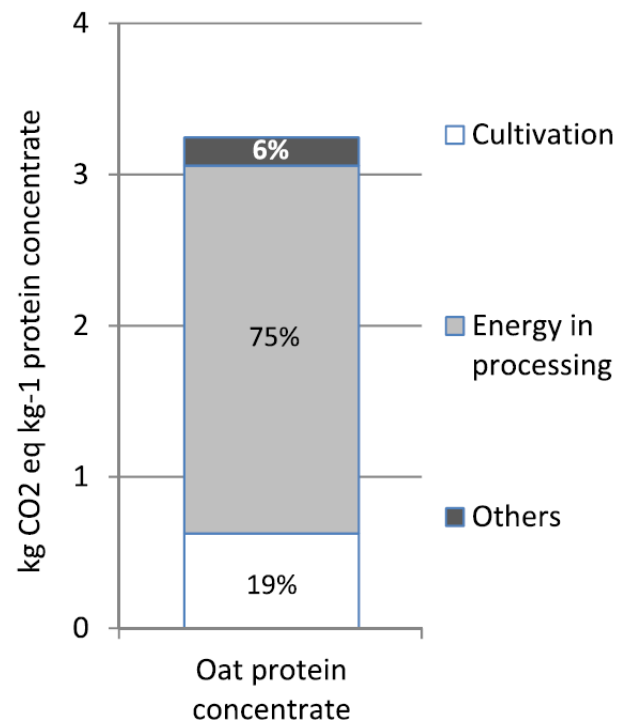




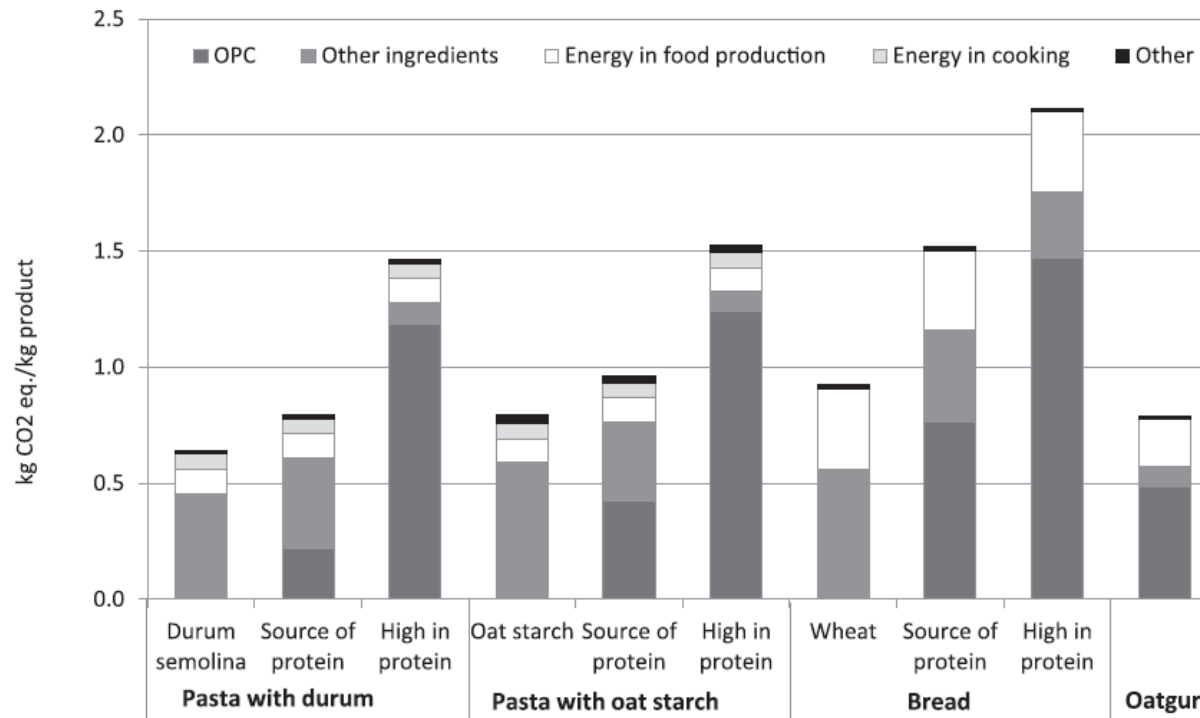
# KLIMAAFTRYK AF HAVRE



# KLIMAAFTRYK AF PROTEINKONCENTRAT



# KLIMAAFTRYK AF PASTA, BRØD OG YOGHURT MED PROTEIN



# KONKLUSION

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- Et klima- og miljøvenligt landbrug kræver samspil mellem de enkelte grene – mark, dyr, bioraffinering og biogas mv. – og hensyn til klima og øvrige bæredygtighedskriterier – hvilket kræver systemanalyse (LCA).
- Vigtigt at have systemperspektivet i udnyttelse af reststrømme i cirkulære fødevarer systemer
  - Reststrømme kan have lavt klimaaftryk, men man skal være opmærksom på energikilden og -forbruget til forarbejdning (f.eks. tørring af våd biomasse)
- Ikke kun klimapåvirkning fra landbrugssystemet – kan være trade-offs med andre påvirkninger som biodiversitet, toxicitet eller dyrevelfærd – kan gå tabt i en optimering med fokus udelukkede på klima.





AARHUS  
UNIVERSITY



Contents lists available at ScienceDirect

# Journal of Cleaner Production

Journal homepage: [www.elsevier.com/locate/jclepro](http://www.elsevier.com/locate/jclepro)



## An approach to include soil carbon changes in life cycle assessments

Bjørn Molt Petersen<sup>a</sup>, Marie Trydeman Knudsen<sup>a,\*</sup>, John Erik Hermansen<sup>a</sup>, Niels Halberg<sup>c</sup>

<sup>a</sup> Department of Agroecology and Environment  
<sup>b</sup> Department of Agriculture and Ecology, FI  
<sup>c</sup> International Centre for Research in Organic

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LCA  
Straw  
Bioenergy  
Organic  
Conventional  
Soybean

## Characterization factors for land use impacts on biodiversity in life cycle assessment based on direct m European farmland in the 'Ter

Marie Trydeman Knudsen<sup>a,\*</sup>, John E. I Philippe Jeanneret<sup>c</sup>, Jean-Pierre Sarthé Sebastian Wolfrum<sup>d</sup>, Peter Dennis<sup>e</sup>

<sup>a</sup> Dept. of Agroecology, Aarhus University, DK-8830 Tjele, Denmark  
<sup>b</sup> Dept. of Energy and Environment, Chalmers University of Technol  
<sup>c</sup> Agronomic Institute for Sustainability Science (IS), Zurich, CH-800  
<sup>d</sup> Institute of Food and Agricultural Resear, Aarhus University, DK-8830 Tjele, Denmark  
<sup>e</sup> Institute of Food and Agricultural Resear, Aarhus University, DK-8830 Tjele, Denmark

### HIGHLIGHTS

- New characterization factors (CF) for land use impacts on biodiversity in LCA
- Provides CFs for different land use types and management (organic or conventional)
- Shows significant differences in CFs between organic and conventional factors
- Compares the new characterization factors with other studies
- Useful for assessing land use impacts on biodiversity in agricultural LCA studies



## Freshwater ecotoxicity assessment of pesticide use in crop production: Testing the influence of modeling choices

Nancy Peña<sup>a,b,\*</sup>, Marie T. Knudsen<sup>d</sup>, Peter Fantke<sup>c</sup>, Assumpció Antón<sup>a</sup>, John E. Hermansen<sup>d</sup>

<sup>a</sup> IRTA, Torre Marimón, Ctra. s-59 Km. 12.1, E-08140, Caldes de Montbui, Barcelona, Spain  
<sup>b</sup> Institute of Environmental Science and Technology (ICTA), Universitat Autònoma de Barcelona (UAB), E-08193, Bellaterra, Barcelona, Spain  
<sup>c</sup> Quantitative Sustainability Assessment Division, Department of Management Engineering, Technical University of Denmark, Øngyngstevns 116, 2800, Kgs. Lyngby, Denmark  
<sup>d</sup> Department of Agroecology, Aarhus University, DK-8830, Tjele, Denmark

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### ABSTRACT

Pesticides help to control weeds, pests, and diseases contributing, therefore, to food availability. However, pesticide fractions not reaching the intended target may have adverse effects on the environment and the field ecosystems. Modeling pesticide emissions and the link with characterizing, associated impacts is currently one of the main challenges in Life Cycle Assessment (LCA) of agricultural systems. To address this challenge, this study takes advantage of the latest recommendations for pesticide emission inventory and impact assessment and frames a suitable interface for those LCA stages and the release of feed crops (maize, grass, winter wheat, spring barley, rapeseed, and peas) in Denmark. The production of feed crops during a 3-year period, testing the effects of inventory modeling and the release of the characterization method (USEtox). Potential freshwater ecotoxicity impacts were calculated in functional units reflecting crop impact profiles per ha and extent of cultivation, and the recent update functional units reflecting crop impact profiles per ha and extent of cultivation, respectively. Ecotoxicity impacts decreased over the period, mainly because of the reduction of insecticides use (e.g., cypermethrin). Three different emissions modeling scenarios were tested; they differ on the underlining assumptions and data requirements. The main aspects influencing impact results are the interface between inventory estimates and impact assessment, and the consideration of intermedia processes, such as crop growth development and pesticide application method. Impact scores for ASI, but the differences in the crop ranking method. Impact scores for ASI were high.



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# Journal of Cleaner Production

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## The importance of including soil carbon changes, ecotoxicity and biodiversity impacts in environmental life cycle assessments of organic and conventional milk in Western Europe

Marie Trydeman Knudsen<sup>a,\*</sup>, Teodora Dorca-Preda<sup>a</sup>, Sylvestre Njakou Djomo<sup>a</sup>, Nancy Peña<sup>b</sup>, Susanne Padel<sup>c</sup>, Laurence G. Smith<sup>c</sup>, Werner Zollitsch<sup>d</sup>, Stefan Hörtenhuber<sup>d</sup>, John E. Hermansen<sup>a</sup>

<sup>a</sup> Dept. of Agroecology, Aarhus University, DK-8830, Tjele, Denmark  
<sup>b</sup> Institute for Food and Agricultural Resear  
<sup>c</sup> The Organic Research Centre, Berkshire,  
<sup>d</sup> Department of Sustainable Agricultural

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LCA  
Soil carbon

nature sustainability

PERSPECTIVE  
<https://doi.org/10.1038/s41893-020-0489-6>

## Towards better representation of organic agriculture in life cycle assessment

Hayo M. G. van der Werf<sup>a,b,c</sup>, Marie Trydeman Knudsen<sup>d</sup> and Christel Cederberg<sup>e</sup>

The environmental effects of agriculture and food are much discussed, with competing claims concerning the impacts of conventional and organic farming. Life cycle assessment (LCA) is the method most widely used to assess environmental impacts of agricultural products. Current LCA methodology and studies tend to favour high-input intensive agricultural systems and misrepresent less intensive agroecological systems such as organic agriculture. LCA assesses agroecological systems inadequately for three reasons: (1) a lack of operational indicators for three key environmental issues; (2) a narrow perspective on functions of agricultural systems; and (3) inconsistent modelling of indirect effects.

Societal interest in sustainable agriculture and food is great and growing<sup>1,2</sup>, leading to a demand for information about the environmental performance of agricultural systems, food products and overall food chains from almost all parts of society and consumers. From this diverse group of stakeholders, different questions arise, such as: 'is product A better or worse for the environment than product B?' 'Does converting to this production system really decrease environmental impacts?' 'Should this innovative management technology be encouraged from an environmental perspective?'

The method most widely used to answer such questions is life cycle assessment (LCA), whose use is now well established for assessing resource depletion issues and environmental and health impacts caused by production of agricultural products. LCA's basic principle<sup>3</sup> is to follow a product through its life cycle, defining a boundary between its 'product system' (the 'technosphere') and the surrounding environment. Energy and material flows (cross-resources) and outputs (for example, emissions to water and air) into impact indicators. LCA thus focuses on negative impacts rather than including positive impacts. The first LCAs were performed in the 1970s by Coca-Cola when it investigated consequences of switching from glass bottles to plastic bottles<sup>4</sup>. In the 1990s, application of LCA to agricultural systems began. From 1992 to 2018, the number of peer-reviewed English-language articles using LCA to

approaches at multiple spatial and temporal scales<sup>5</sup>. Another example of a wider view of agriculture is the concept of agroecology (Fig. 2), recognized by United Nations (UN) institutions as a science and social movement in the transition to sustainable food systems and a pathway to achieving the UN's Sustainable Development Goals (SDGs)<sup>6</sup>. Organic agriculture includes many agroecological practices, its umbrella organization, International Federation of Organic Agriculture Movements (IFOAM) – Organics International, defines it as a "production system that sustains the health of soils, ecosystems and people" and "relies on ecological processes, biodiversity and cycles adapted to local conditions" ultimately basing it on four principles: health, ecology, fairness and care<sup>7</sup>.

Willett et al.<sup>1</sup> highlight the urgency of transforming global food systems to meet the SDGs and the UN's Paris climate agreement, they propose planetary boundaries for six key Earth system processes (climate change, land-system change, freshwater use, nitrogen and phosphorus cycling, and biodiversity losses) which food production and consumption have great impact. There is growing agreement on the need for changes in agricultural systems to make progress towards SDGs. Willett et al.<sup>1</sup> even call for assessment tools and methods that would require appropriate performance of agriculture.

Here, we identify important deficiencies in LCA methodology when assessing agriculture based on agroecological principles, with examples of applying it to organic agriculture. We propose ways to strengthen the ability of LCA to assess agroecological systems.