SUSTAINABILITY IN ORGANIC AGRICULTURE AND FOOD

BY MARIE TRYDEMAN KNUDSEN

MARIE TRYDEMAN KNUDSEN

- Senior Researcher at Department of Agroecology at Aarhus University and member of the Danish Climate Council
- Agronomist and PhD in life cycle assessment (LCA) of agricultural products
- Scientific focus on climate and environmental impact and sustainability of food and agricultural systems – where I primarily use life cycle assessment as a tool. Teaching a course on 'Agriculture in a global context'.

OUR WORK IN THE LCA TEAM

SYSTEM ANALYSIS and LIFE CYCLE ASSESSMENT (LCA) of:

- **Agroforestry and integrated agricultural systems** (MIXED, **OUTFIT**)
- Livestock production systems (PATHWAYS, Pork 4.0)
- **Organic vegetable production (ClimateVeg)**
- **Alternative organic fertilizers (ClimOptic)**
- Biorefinery and **green protein** (GreenEggs, GreenVALLeys, GrassTools)
- Peat soils and alternative growth substrates (CANAPE, Peatwise, BioSubstrate)
- Alternative packaging (SinProPack)
- **Sustainable and healthy diets (SustainOrganic)**
- Circular agriculture and GHG accounting at farm level (CIRKULÆR)
- Methodological development with regard to e.g. soil carbon and biodiversity






OUR WORK IN THE LCA

SYSTEM ANALYSIS and LIFE CYCLE ASSESSME

- **Agroforestry and integrated agricultural sy**
- Livestock production systems (PATHWAYS, Pork 4
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- Alternative packaging (SinProPack)
- **Sustainable and healthy diets (Su inC nic)**
- Circular agriculture and GHG accounting at farm
- Methodological development with regard to e.g. s

What is the climate and envionmental impact?

Mitigation options and potentials of alternative systems?

How is it estimated?

What are the methodological challenges?

ORGANIC SYSTEMS FROM SOIL, PLANTS, LIVESTOCK TO DIETS

THE FOOD SYSTEM FROM HELICOPTER VIEW

ENVIRONMENTAL IMPACT FROM AGRICULTURE

Climate

Eutrophication

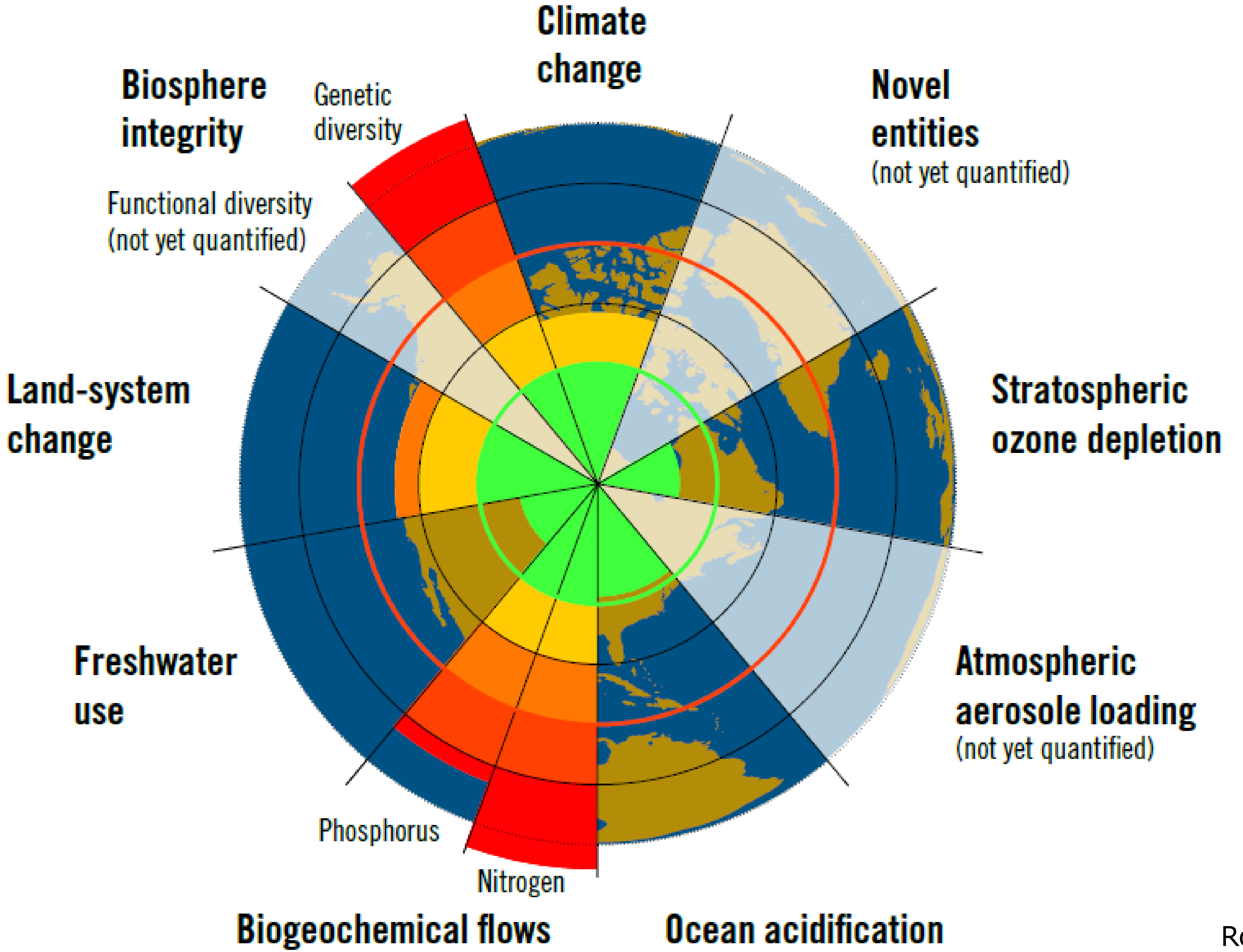
Soil quality and carbon seq.

Ecotocixity

Biodiversity

AARHUS
UNIVERSITY
DEPARTMENT OF AGROECOLOGY

MARIE TRYDEMAN KNUDSEN
SENIOR RESEARCHER



Rockström et al. (2015)

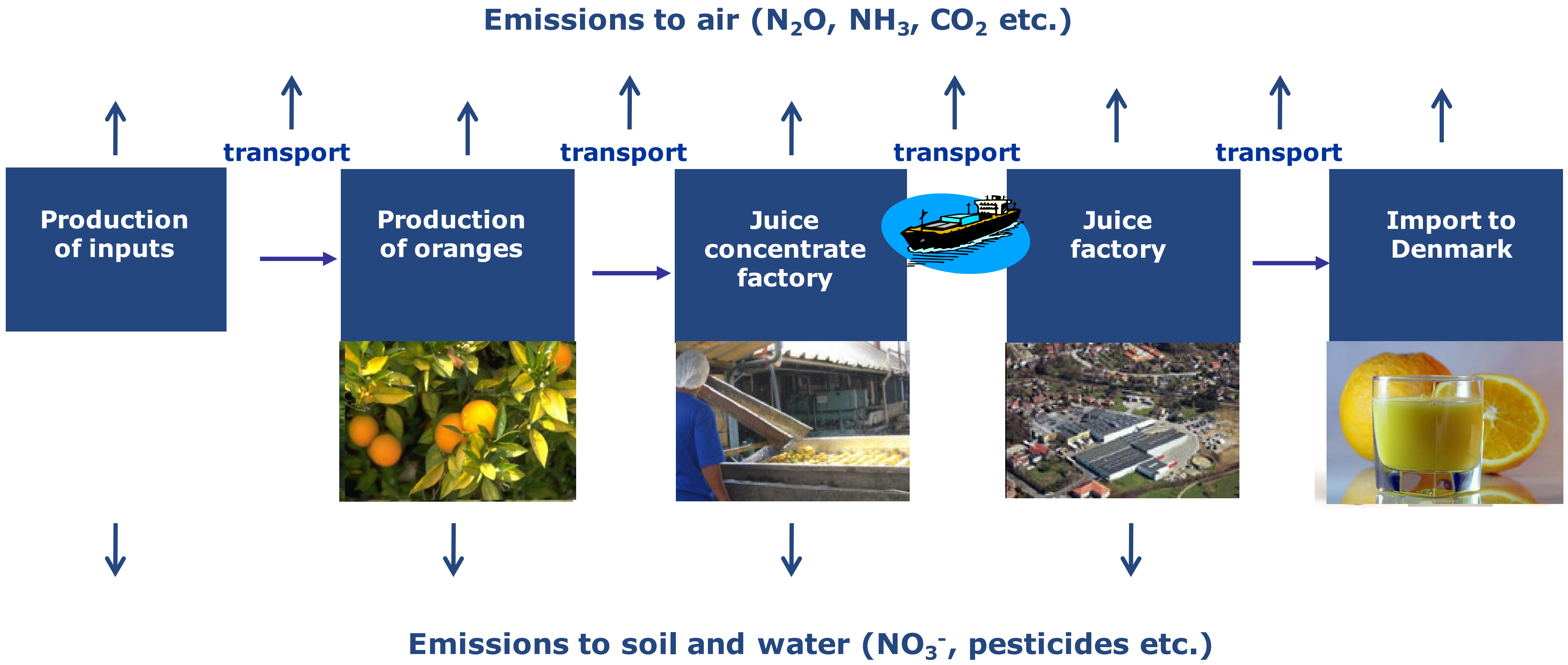

SUSTAINABLE DEVELOPMENT KNOWLEDGE PLATFORM
HOME
HIGH-LEVEL POLITICAL FORUM
STATES
SIDS
SDGS
TOPICS
UN SYSTEM
STAKEHOLDER ENGAGEMENT
PARTNERSHIPS
RESOURCES
ABOUT
SUSTAINABLE DEVELOPMENT GOALS
1 NO POVERTY
2 ZERO HUNGER
3 GOOD HEALTH AND WELL-BEING
4 QUALITY EDUCATION
5 GENDER EQUALITY
6 CLEAN WATER AND SANITATION
7 AFFORDABLE AND CLEAN ENERGY
8 DECENT WORK AND ECONOMIC GROWTH
9 INDUSTRY, INNOVATION AND INFRASTRUCTURE
10 REDUCED INEQUALITIES
11 SUSTAINABLE CITIES AND COMMUNITIES
12 RESPONSIBLE CONSUMPTION AND PRODUCTION
13 CLIMATE ACTION
14 LIFE BELOW WATER
15 LIFE ON LAND
16 PEACE, JUSTICE AND STRONG INSTITUTIONS
17 PARTNERSHIPS FOR THE GOALS

CARBON FOOTPRINT OF FOOD?

Climate

20-30% of our total carbon footprint

CALCULATED USING LIFE CYCLE ASSESSMENT



THE IDEA BEHIND THE LCA APPROACH

- Look at the whole system – so you can reduce the climate and environmental impact in the food or agricultural system without creating new environmental problems in other parts of the system

- Documentation of the possibilities to create a more environmentally and climate friendly food and agricultural system

- Identification of hotspots – the size of emissions and carbon sequestration in relation to each other – and in relation to the rest of the system

- Comparison of different systems and products

PRODUCT ENVIRONMENTAL FOOTPRINT (PEF)

European Commission

ENVIRONMENT

The development of the PEF and OEF methods

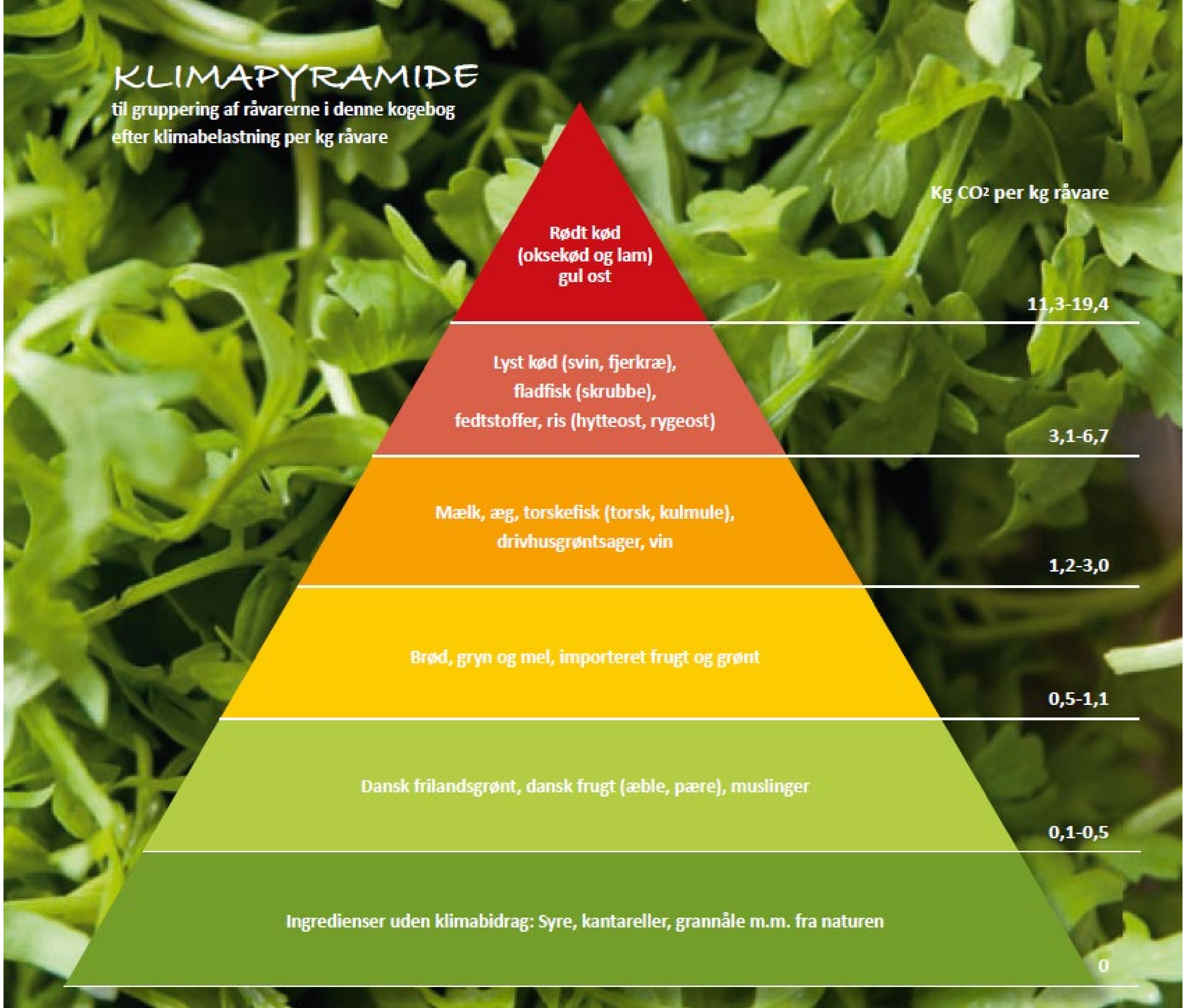
DG Environment has worked together with the European Commission's Joint Research Centre (JRC IES) and other European Commission services towards the development of a **harmonised methodology for the calculation of the environmental footprint of products and organisations** (including carbon).

Existing methods and initiatives were taken into account

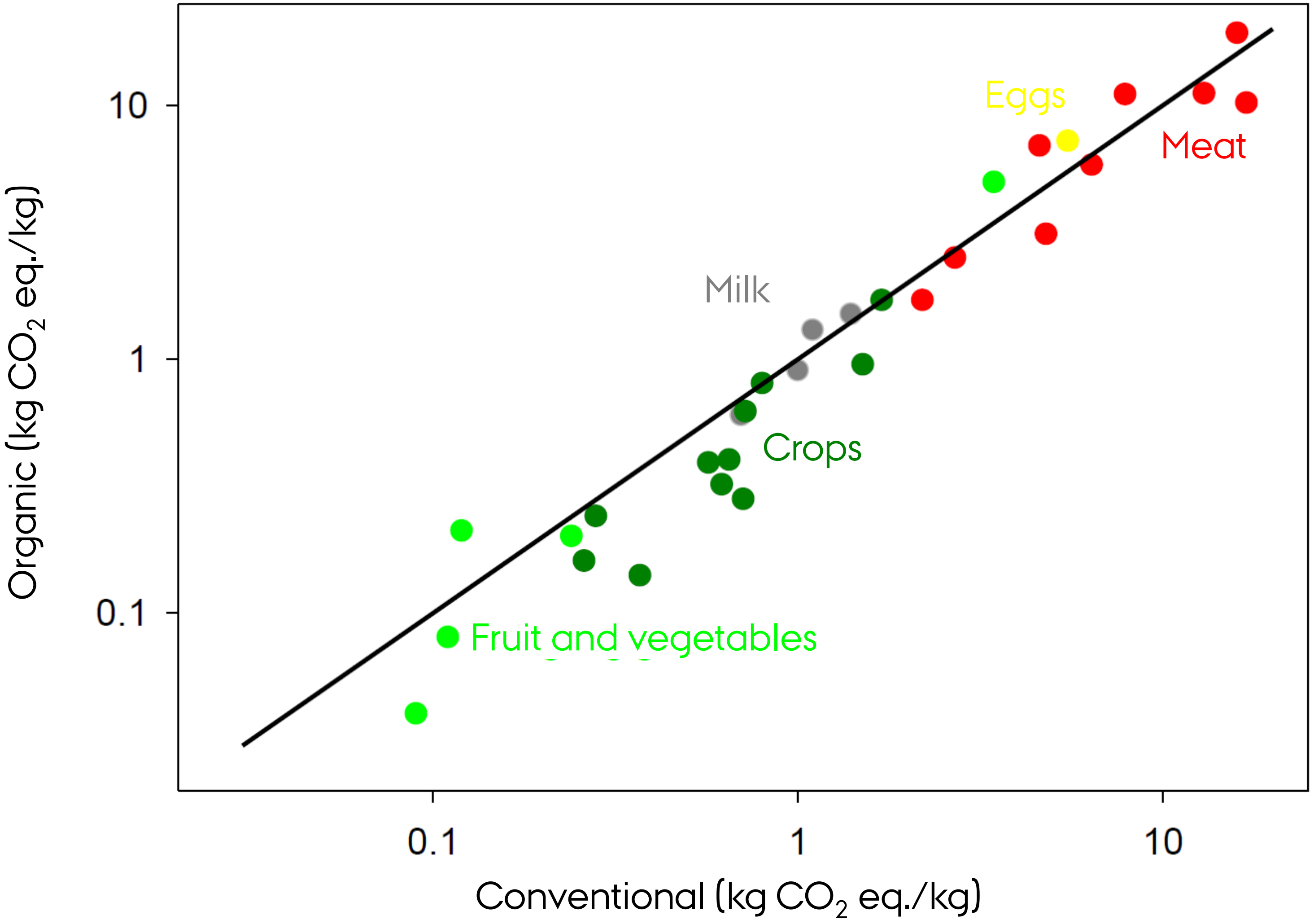
- For the product angle, the International Reference Life Cycle Data System (ILCD) Handbook as well as other existing methodological standards and guidance documents (ISO 14040-44, PAS 2050, BP X30, WRI/WBCSD GHG protocol, Sustainability Consortium, ISO 14025, Ecological Footprint, etc).
- For the organisation angle, the Reference Life Cycle Data System Handbook (ILCD Handbook), as well as other existing methodological standards and guidance documents (Global Reporting Initiative, WRI GHG Protocol, CDP Water Footprint, ISO 140064, DEFRA guidance on GHG reporting, ADEME Bilan Carbone, etc).

The final methods, called Product Environmental Footprint (PEF) and Organisation Environmental Footprint (OEF), were published as an Annex to the Commission Recommendation on the use of common methods to measure and communicate the life cycle environmental performance of products and organisations. The two methods are tightly interlinked and will have many elements in common.

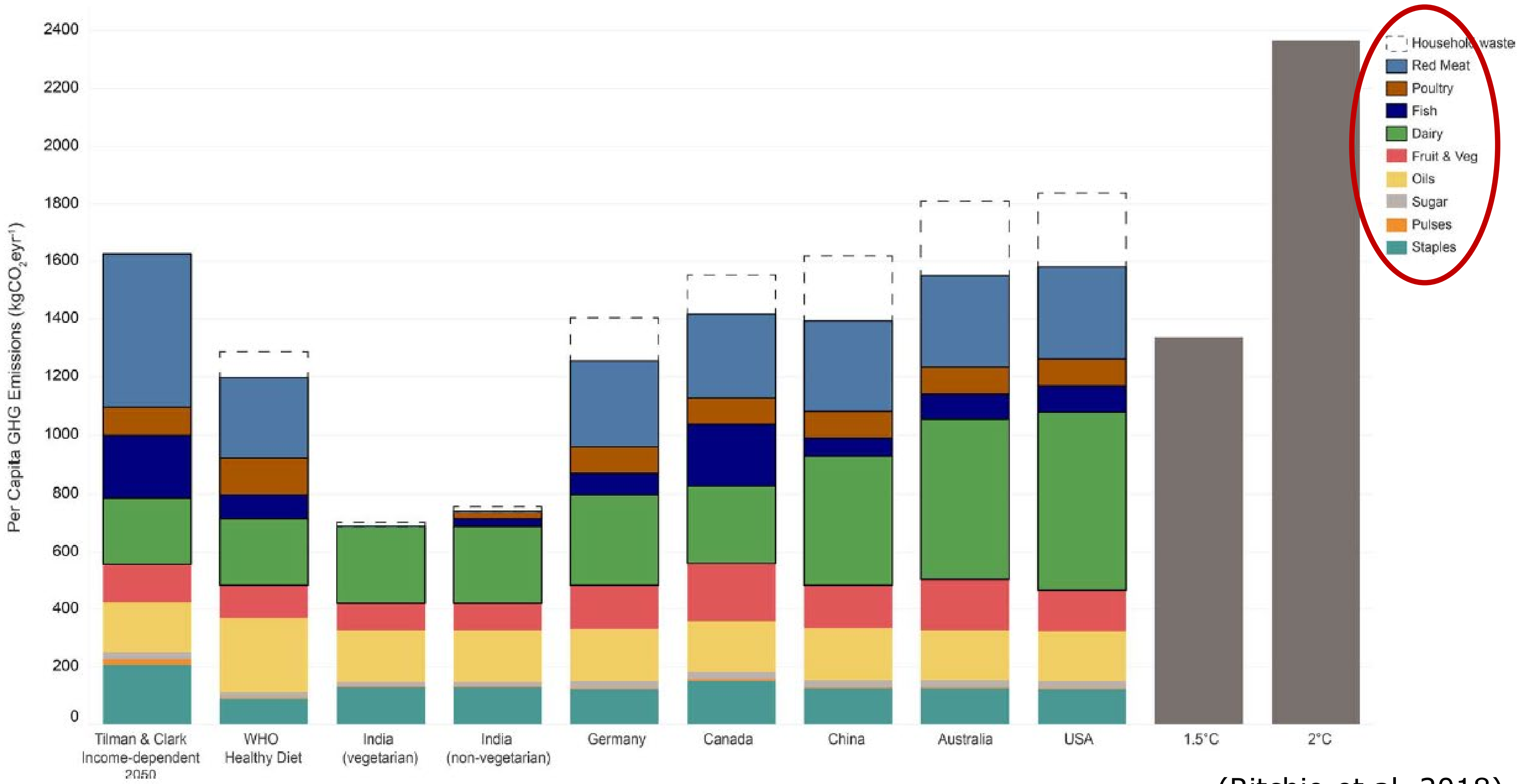
This version was developed taking into account the results of 2011 road test, the results of the invited expert consultation and of a consultation between Commission services.


KLIMAPYRAMIDE
til gruppering af råvarerne i denne kogebog
efter klimabelastning per kg råvare
Kg CO^{2} per kg råvare
Rødt kød
(oksekød og lam)
gul ost
11,3-19,4
Lyst kød (svin, fjerkræ),
fladfisk (skrubbe),
fedtstoffer, ris (hytteost, rygeost)
3,1-6,7
Mælk, æg, torskefisk (torsk, kulmule),
drivhusgrøntsager, vin
1,2-3,0
Brød, gryn og mel, importeret frugt og grønt
0,5-1,1
Dansk frilandsgrønt, dansk frugt (æble, pære), muslinger
0,1-0,5
Ingredienser uden klimabidrag: Syre, kantareller, grannåle m.m. fra naturen
0

CARBON FOOTPRINT OF ORGANIC AND CONVENTIONAL FOOD



CARBON FOOTPRINT FROM DIETS



(Ritchie et al. 2018)

> „Without a transformation of the global food system, the world risks failing to meet the UN Sustainable Development Goals (SDGs) and the Paris Agreement and the data are both sufficient and strong enough to warrant immediate action „

\- EAT-LANCET REPORT, 2019

ENVIRONMENTAL IMPACT FROM AGRICULTURE

Climate

Eutrophication

Soil quality and carbon seq.

Ecotocixity

Biodiversity

ENVIRONMENTAL IMPACT FROM AGRICULTURE

Climate

Eutrophication

Soil quality and carbon seq.

Ecotocixity

Biodiversity

ENVIRONMENTAL IMPACT OF ORGANIC AGRICULTURE

Climate

Eutrophication

Less pesticide residues i urine

(Hyland et al. 2019)

Ecotocixity

Soil quality and carbon seq.

Biodiversity

Higher microbial activity in organic fields (Lori et al. 2017)

Better possibilities for natural behavior for livestock and a lower use of antibiotics (Sørensen et al. 2015)

30% higher biodiversity on organic fields (Tuck et al. 2014)


Some agricultural systems contribute more to biodiversity than others…

Science of the Total Environment 580 (2017) 358–366

Contents lists available at ScienceDirect

Science of the Total Environment

journal homepage: www.elsevier.com/locate/scitotenv

Characterization factors for land use impacts on biodiversity in life cycle assessment based on direct measures of plant species richness in European farmland in the 'Temperate Broadleaf and Mixed Forest' biome

Marie Trydeman Knudsen [a,*], John E. Hermansen [a], Christel Cederberg [b], Felix Herzog [c], Jim Vale [j], Philippe Jeanneret [c], Jean-Pierre Sarthou [d,e], Jürgen K. Friedel [f], Katalin Balázs [g], Wendy Fjellstad [h], Max Kainz [i], Sebastian Wolfrum [i], Peter Dennis [j]

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[c] Agroscope, Institute for Sustainability Sciences ISS, Zurich CH-8046, Switzerland
[d] Toulouse University, ENSAT, UMR 1248 AGIR, Castanet-Tolosan F-31326, France
[e] INRA, UMR 1248 AGIR, Chemin de Borde-Rouge, Castanet-Tolosan F-31326, France
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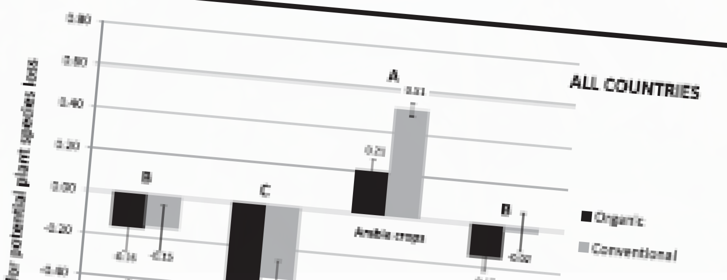
[g] Institute of Environmental and Landscape Management, MKK, Szent István University, Páter K. u.1, Gödöllő H-2100, Hungary
[h] Norwegian Forest and Landscape Institute (NFLI), N-1431 Ås, Norway
[i] Munich Technical University, Freising D-85350, Germany
[j] Institute of Biological, Environmental and Rural Sciences, Penglais Campus, Aberystwyth University, UK-SY23 3DD, UK

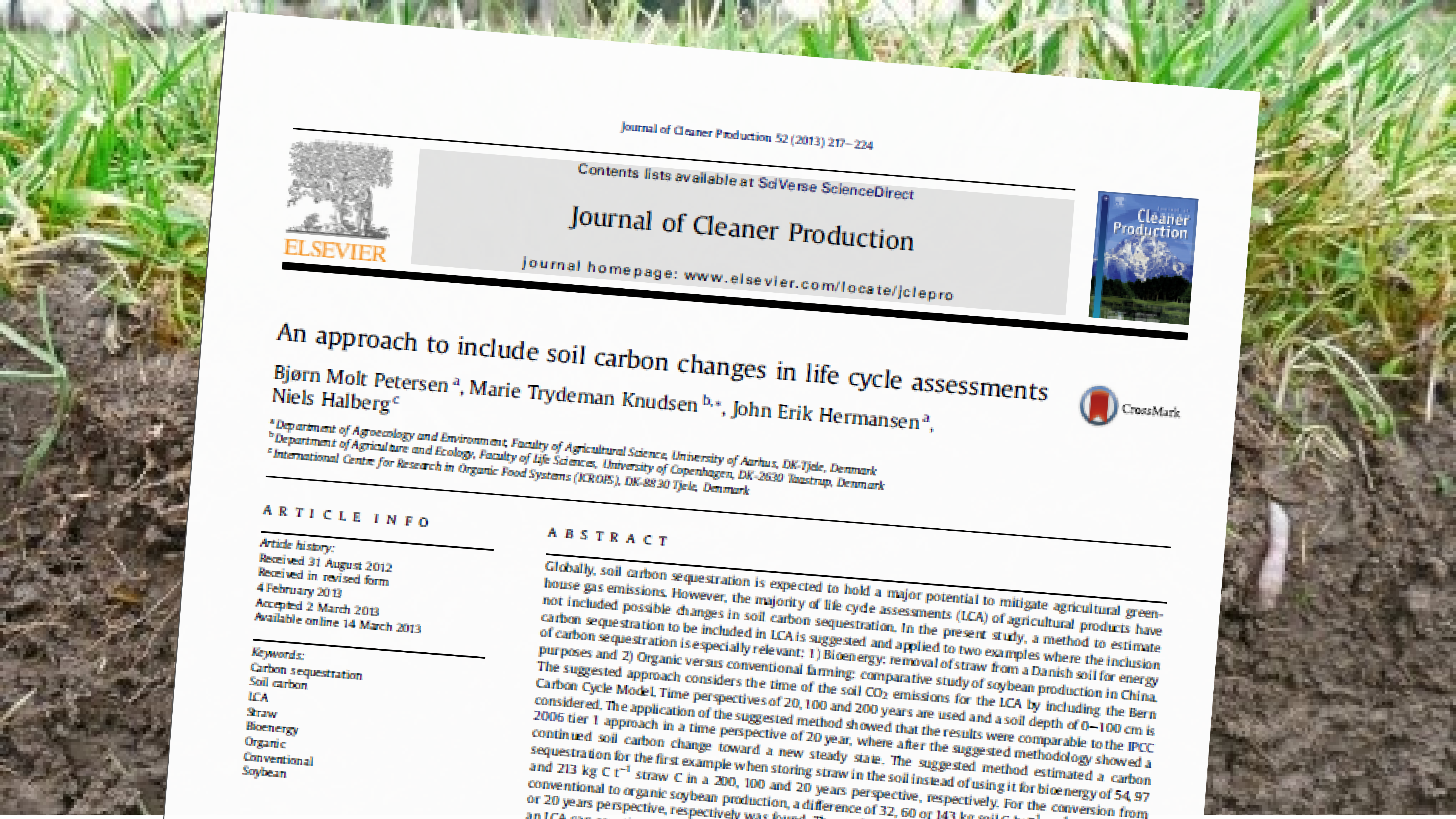
HIGHLIGHTS

- 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 fields
- Compares the new characterization factors with other studies
- Useful for assessing land use impacts on biodiversity in agricultural LCA studies

GRAPHICAL ABSTRACT




Some agricultural systems contribute more to soil carbon sequestration than others…



Journal of Cleaner Production 52 (2013) 217–224

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Journal of Cleaner Production

journal homepage: www.elsevier.com/locate/jclepro

ELSEVIER

An approach to include soil carbon changes in life cycle assessments

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Organic
Conventional
Soybean

ABSTRACT

Globally, soil carbon sequestration is expected to hold a major potential to mitigate agricultural greenhouse gas emissions. However, the majority of life cycle assessments (LCA) of agricultural products have not included possible changes in soil carbon sequestration. In the present study, a method to estimate carbon sequestration to be included in LCA is suggested and applied to two examples where the inclusion of carbon sequestration is especially relevant: 1) Bioenergy: removal of straw from a Danish soil for energy purposes and 2) Organic versus conventional farming: comparative study of soybean production in China. The suggested approach considers the time of the soil CO_2 emissions for the LCA by including the Bern Carbon Cycle Model. Time perspectives of 20, 100 and 200 years are used and a soil depth of 0–100 cm is considered. The application of the suggested method showed that the results were comparable to the IPCC 2006 tier 1 approach in a time perspective of 20 year, where after the suggested methodology showed a continued soil carbon change toward a new steady state. The suggested method estimated a carbon sequestration for the first example when storing straw in the soil instead of using it for bioenergy of 54, 97 and 213 kg C t^{-1} straw C in a 200, 100 and 20 years perspective, respectively. For the conversion from conventional to organic soybean production, a difference of 32, 60 or 143 kg soil C ha^{-1} … or 20 years perspective, respectively was found. …

Journal of Cleaner Production 209 (2019) 1332–1341

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ELSEVIER

Journal of Cleaner Production

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

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Pesticide emission factors
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Ecotoxicity characterization
Life cycle impact assessment (LCIA)
Feed crops
Agriculture

A B S T R A C T

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 related mass distribution of pesticide avoiding a temporal overlapping. Here, freshwater ecotoxicity impacts of the production of feed crops (maize, grass, winter wheat, spring barley, rapeseed, and peas) in Denmark were evaluated during a 3-year period, testing the effects of inventory modeling and the recent updates of the characterization method (USEtox). Potential freshwater ecotoxicity impacts were calculated in two 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 emission modeling scenarios were tested; they differ ... sumptions and data requirements. The main ...

Journal of Cleaner Production 215 (2019) 433–443

Contents lists available at ScienceDirect

Journal of Cleaner Production

journal homepage: www.elsevier.com/locate/jclepro

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 [a, *], Teodora Dorca-Preda [a], Sylvestre Njakou Djomo [a], Nancy Peña [b], Susanne Padel [c], Laurence G. Smith [c], Werner Zollitsch [d], Stefan Hörtenhuber [d], John E. Hermansen [a]

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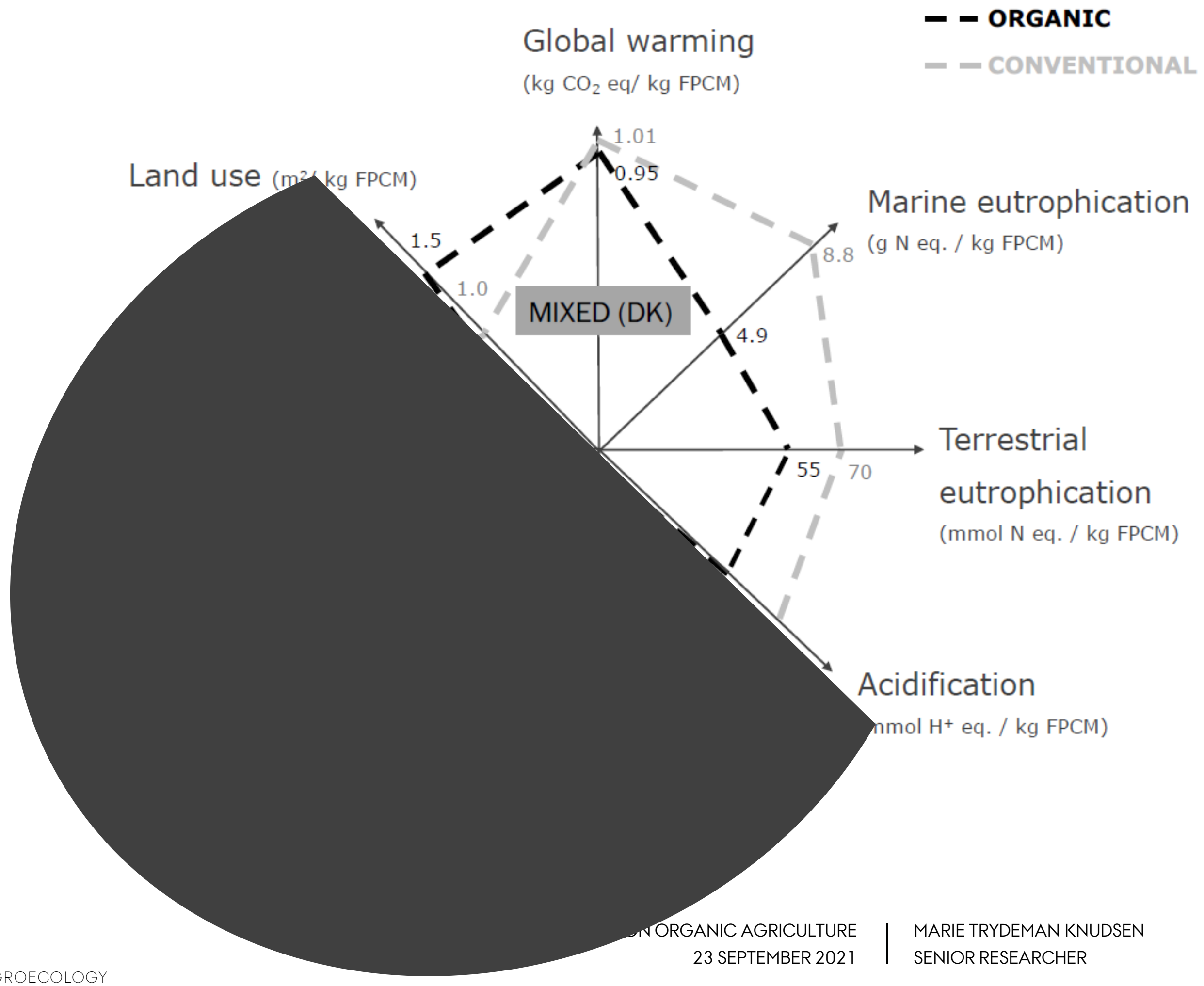
Organic
Biodiversity
Dairy
Ecotoxicity
LCA
Soil carbon

A B S T R A C T

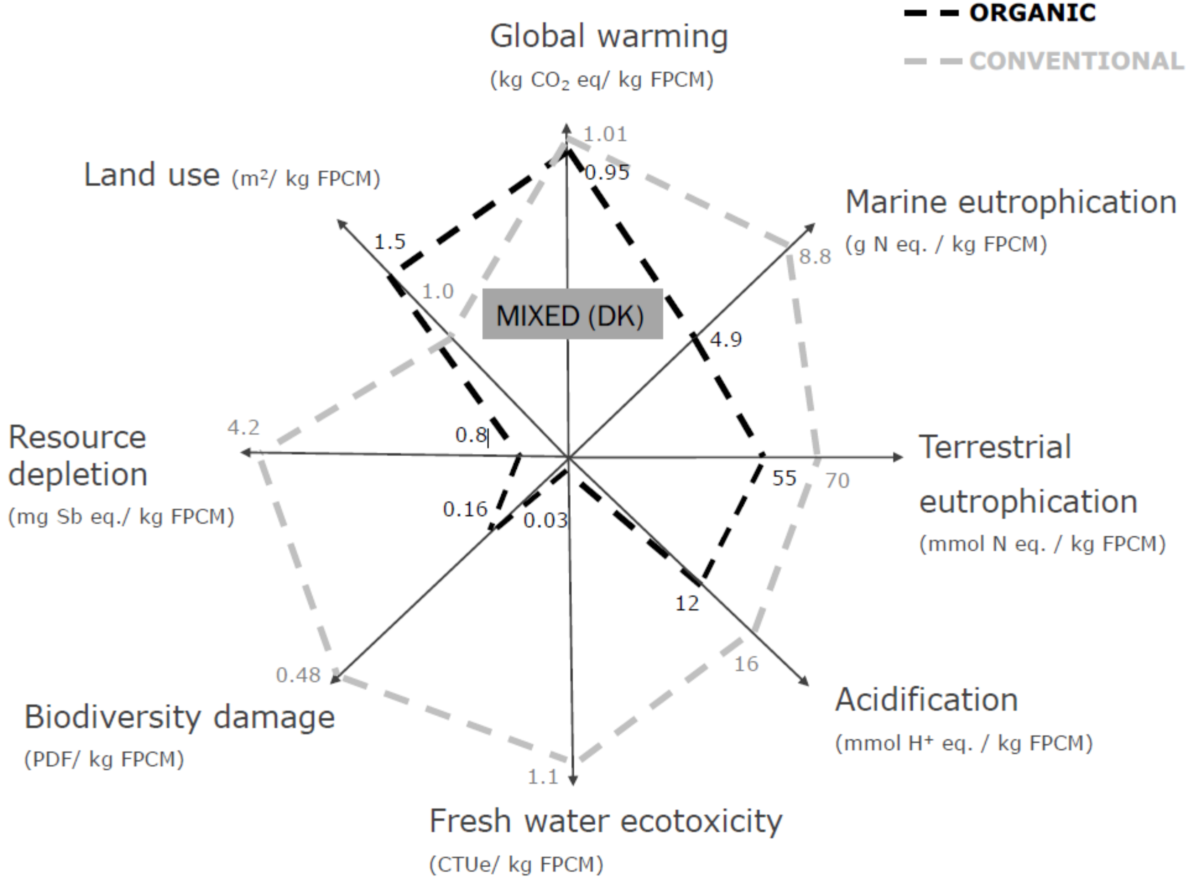
Estimates of soil carbon changes, biodiversity and ecotoxicity have often been missing from life cycle assessment based studies of organic dairy products, despite evidence that the impacts of organic and conventional management may differ greatly within these areas. The aim of the present work was therefore to investigate the magnitude of including these impact categories within a comprehensive environmental impact assessment of organic and conventional dairy systems differing in basic production conditions. Three basic systems representative of a range of European approaches to dairy production were selected for the analysis, i.e. (i) low-land mixed crop-livestock systems, (ii) lowland grassland-based systems, (iii) and mountainous systems. As in previous publications, this study showed that when assessing climate change, eutrophication and acidification impact organic milk has a slightly lower impact than conventional, although land-use is higher ... Including soil carbon changes reduced the ...

MÆLKS MILJØPÅVIRKNING



Source: Knudsen et al. 2019

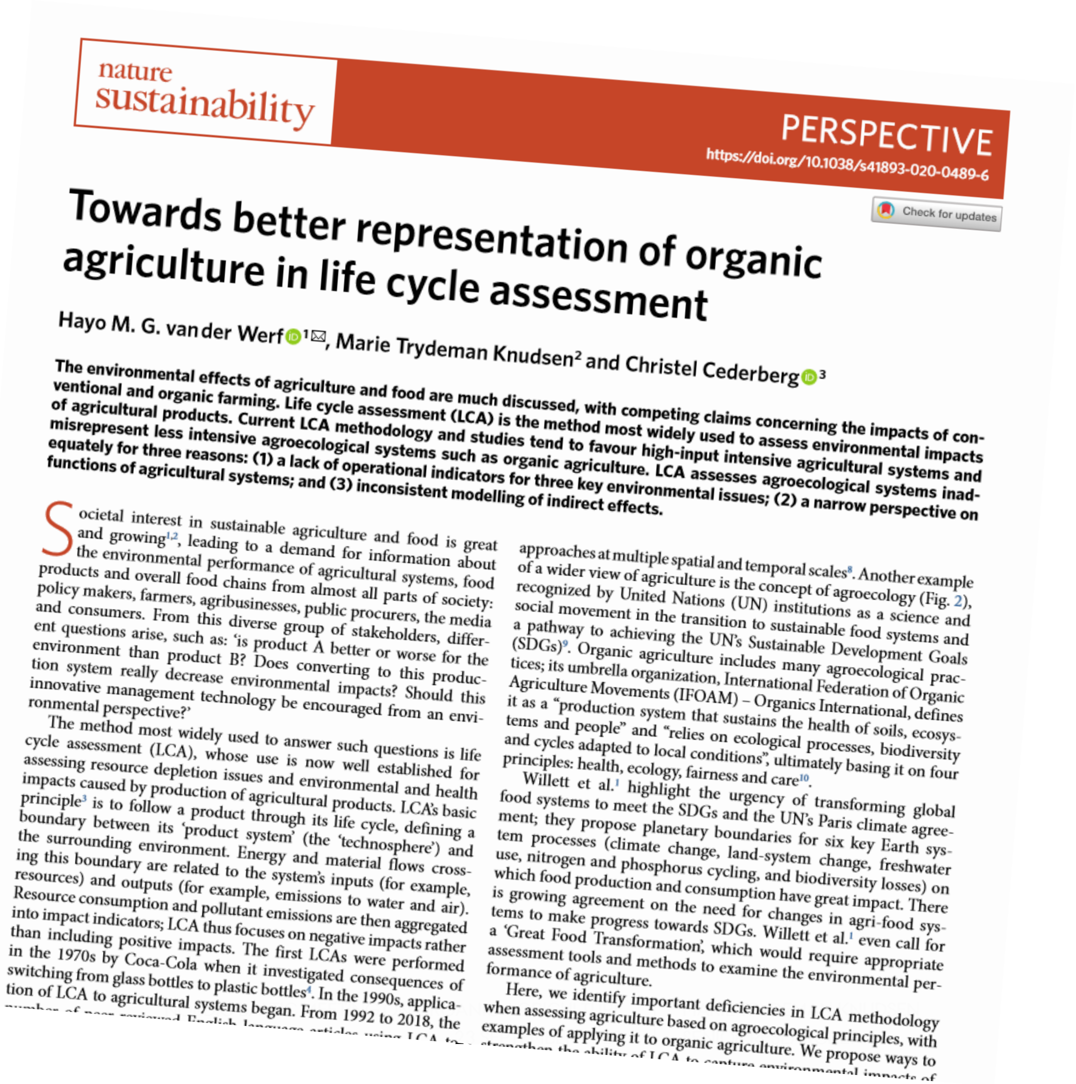
MÆLKS MILJØPÅVIRKNING



Source: Knudsen et al. 2019

ARTIKEL I "NATURE SUSTAINABILITY"

(Van der Werf, Knudsen & Cederberg)



nature sustainability

PERSPECTIVE

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

Check for updates

Towards better representation of organic agriculture in life cycle assessment

Hayo M. G. van der Werf[1], Marie Trydeman Knudsen[2] and Christel Cederberg[3]

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[1,2], 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: policy makers, farmers, agribusinesses, public procurers, the media 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[3] 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 crossing this boundary are related to the system's inputs (for example, resources) and outputs (for example, emissions to water and air). Resource consumption and pollutant emissions are then aggregated 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[4]. In the 1990s, application of LCA to agricultural systems began. From 1992 to 2018, the

approaches at multiple spatial and temporal scales[8]. 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)[9]. 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[10].

Willett et al.[1] 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) on which food production and consumption have great impact. There is growing agreement on the need for changes in agri-food systems to make progress towards SDGs. Willett et al.[1] even call for a 'Great Food Transformation', which would require appropriate assessment tools and methods to examine the environmental 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

ARTIKEL I "NATURE SUSTAINABILITY"

(Van der Werf, Knudsen & Cederberg)

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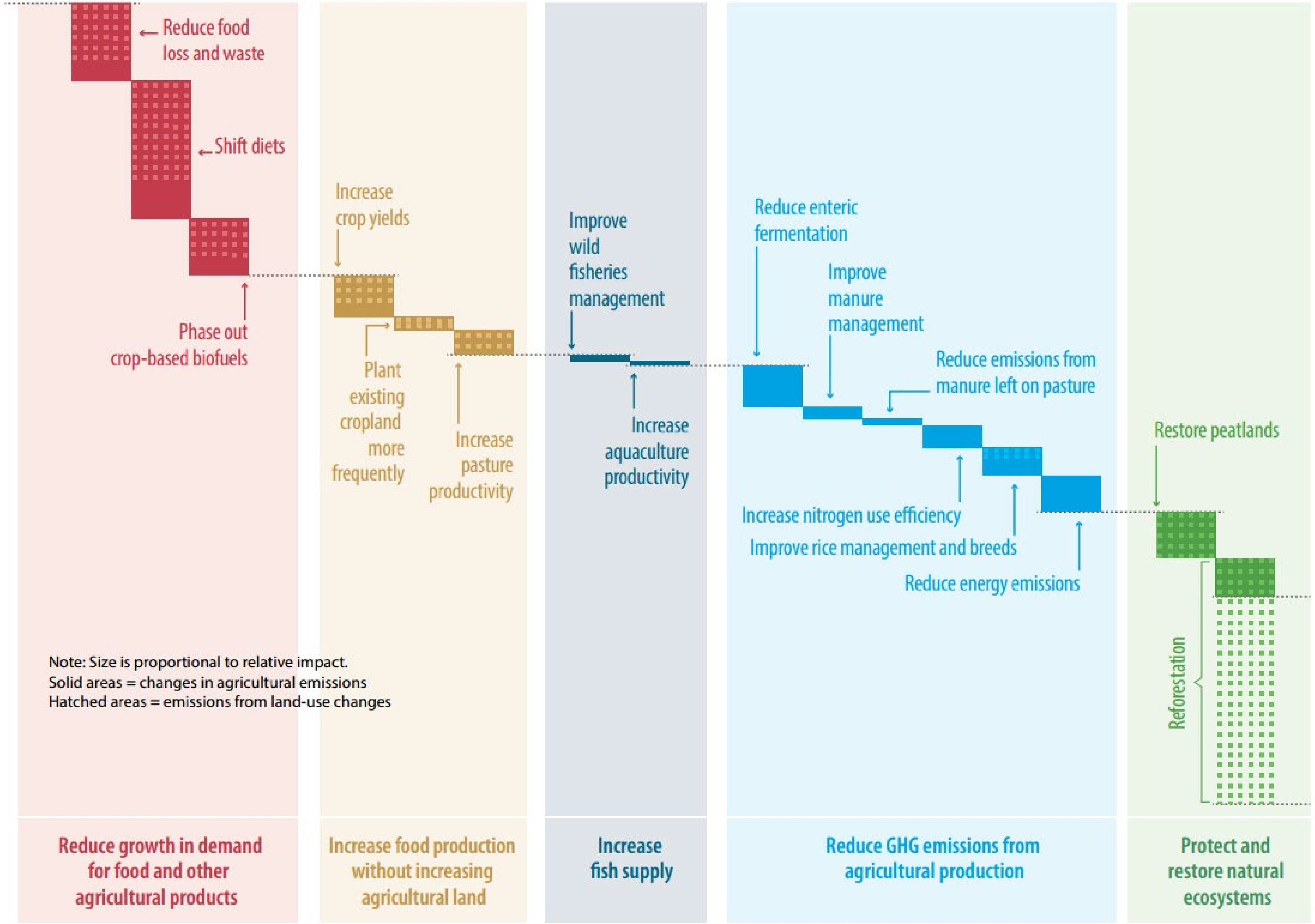
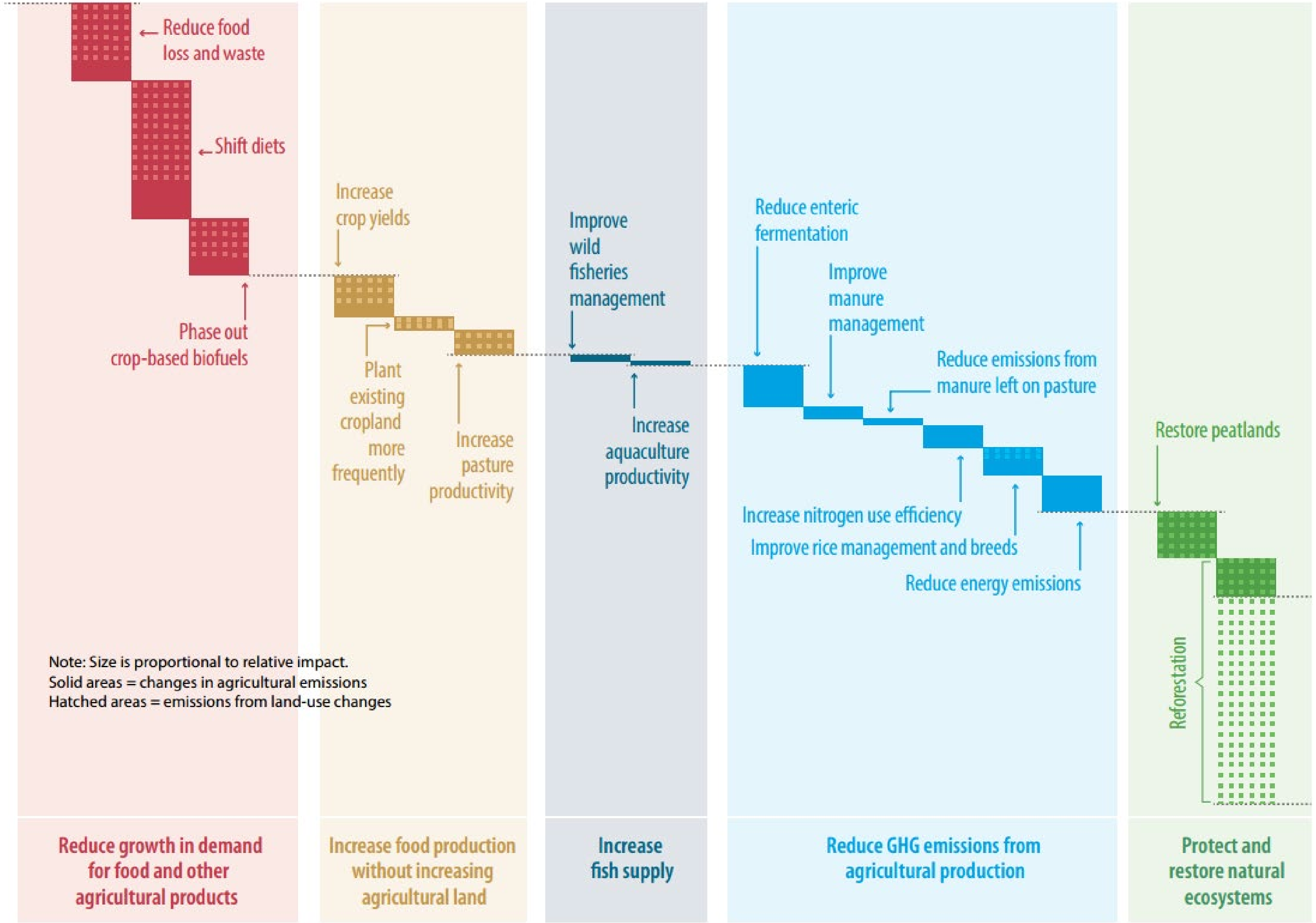
IMPROVEMENT OPTIONS IN FOOD SYSTEMS



UN (2019)

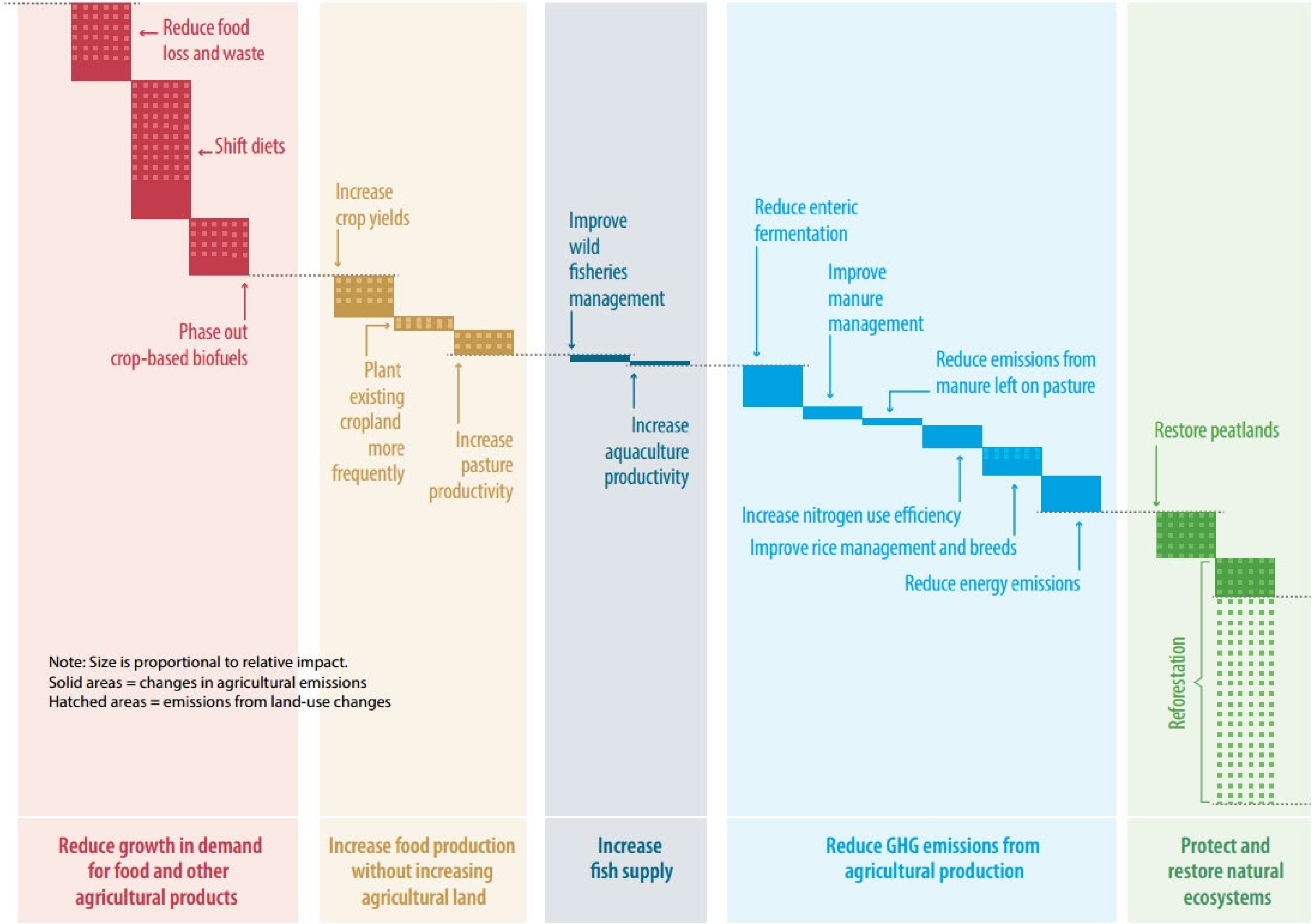
IMPROVEMENT OPTIONS IN THE FOOD CONSUMPTION



- Reduce consumption of livestock products
- Reduce food waste

UN (2019)

IMPROVEMENT OPTIONS IN AGRICULTURE



- Increase the N use and reduce losses and emissions – higher yields
- Reduce energy consumption and produce energy (biogas)
- Capture CO_2 via trees and soils – and avoid emissions from organic soils

UN (2019)

IMPROVEMENT OPTIONS IN AGRICULTURE

- Increase the N use and reduce losses and emissions – higher yields
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CONCLUSION

Action in relation to our agricultural and food systems is necessary

When optimizing/changing our agricultural and food systems it is important to:

- Improve both at production and consumption of food
- Assess impacts both per area unit and at product level
- Assess impacts not only on climate, but also on biodiversity, eutrophication, ecotoxicity and animal welfare

Identify and assess trade-offs – so we make decisions with open eyes

AARHUS UNIVERSITY

En fødevarevision fra Sverige
(Karlsson et al. 2018)

	Normative decisions
Food consumption oriented	Future diets should be based on the type of food currently consumed and seek to fulfil Nordic nutrient recommendations.
	Food waste should be reduced compared to current levels.
	Future diets should facilitate equitable consumption based on local resources.
Production oriented	Food should be produced locally, but food not possible* to produce locally should be imported.
	The food should be produced in an organic farming system acknowledging agroecological principles.
	More durable breeds of grazing animals should be used to be able to graze in rough terrain.
	Some land currently used for annual cropping is unsuited for this and should be left for nature conservation.
	Semi-natural pastures should be grazed by livestock to promote biodiversity and preserve the cultural landscape.
Resource use oriented	Arable land should primarily be used to grow food for humans, not livestock feed or bioenergy crops.
	By-products from food production should be used to feed livestock.
	Agriculture should be self-sufficient in renewable energy, but should not provide energy for other parts of society.

Madspild skal reduceres

Kosten skal baseres primært på lokale resourcer

Kosten skal produceres økologisk

Mindre produktive arealer skal gå til natur

Græs- og naturarealer skal afgræsses for naturpleje

Dyrkningsarealet skal primært bruges til plantebaserede fødevarer, ikke foder eller bioenergi

Biprodukter fra fødevareproduktionen bruges som foder

Landbruget skal være selvforsynende med fornybar energi, men ikke forsyne andre dele af samfundet med energi

En fødevarevision fra Sverige
(Karlsson et al. 2018)

- Stor reduktion i kødforbruget
- Klimaaftryk der lever op til kravene fra Parisaftalen

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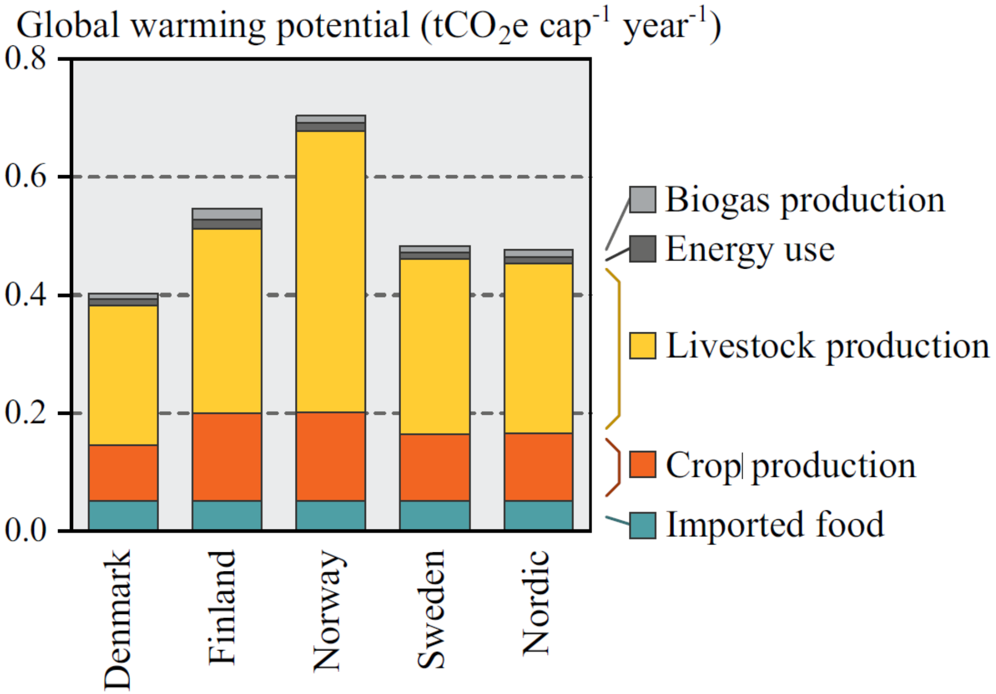

NORDI