LCA of novel foods and alternative proteins

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- DIL intro
- Protein problem
- Methodological insights
- Sources alteration and environmental impacts
- Concluding points
- References

Overview
FACTS AND FIGURES

FOUNDED **1983**

MEMBERS **175**

EMPLOYEES **200**

LOCATIONS
- QUAKENBRÜCK (GER)
- BERLIN (GER)
- KARLSRUHE (GER)
- BRUSSELS (BEL)

LEGAL STATUS
REGISTERED ASSOCIATION

DIRECTOR
DR. VOLKER HEINZ

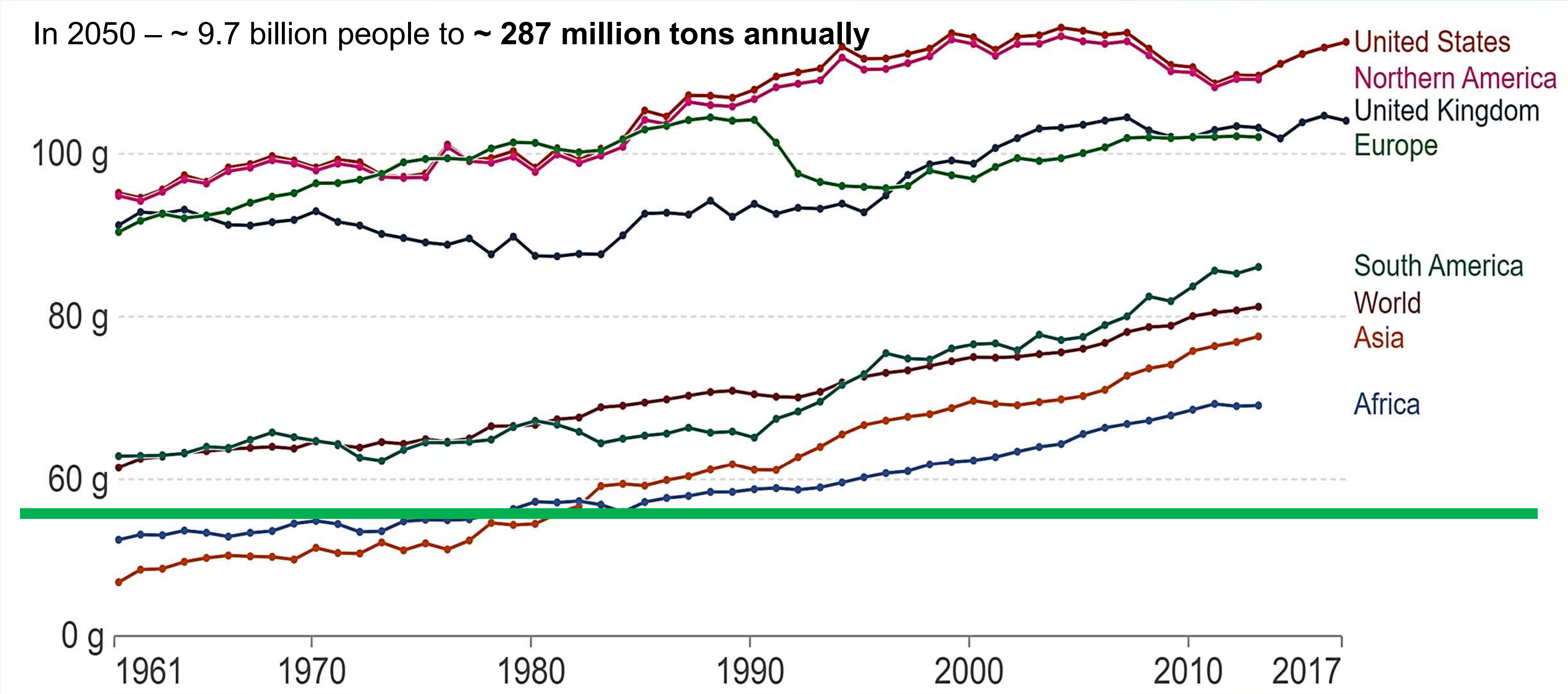
MISSION
KNOWLEDGE FOR SUPERIOR FOODS

Members

Core competences

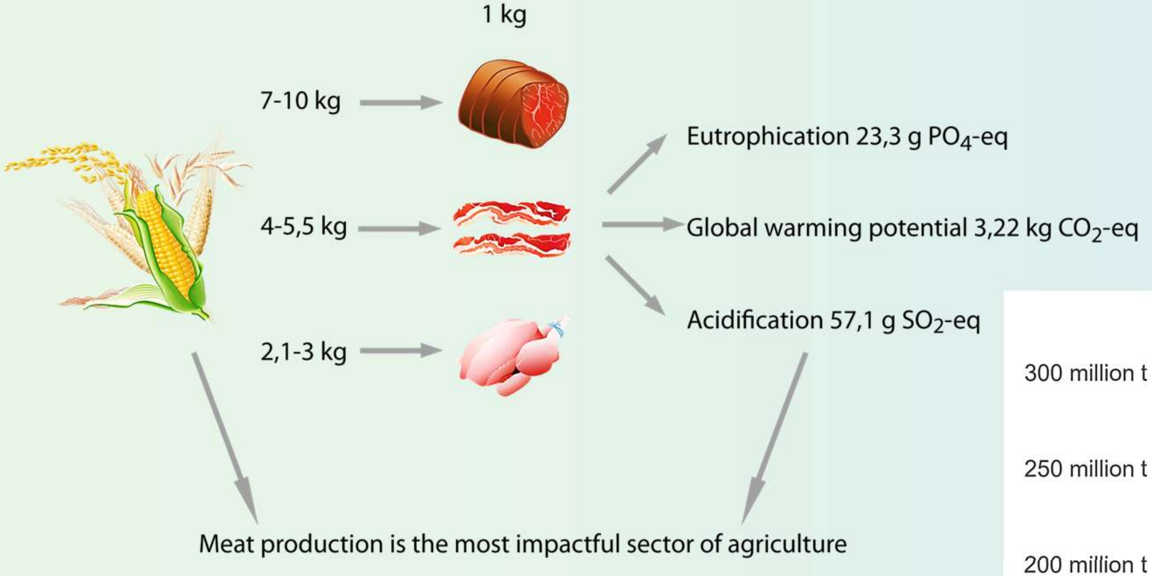
	SAFETY + AUTHENTICITY	STRUCTURE + PROCESSING	SUSTAINABILITY
BIOMASS PRODUCTION	 Food Fraud Checkpoint	 Food Biotechnology	 LCA Analytics
FOOD PROCESSING	 Process Control & Challenge Testing	 Food Physics & Process Engineering	 Automation & Digitalization
HEALTH & WELLBEING	 Food Safety Labs (S3**) (Microbiol./Chemical)	 DNA Sequencing	 Food Data Group

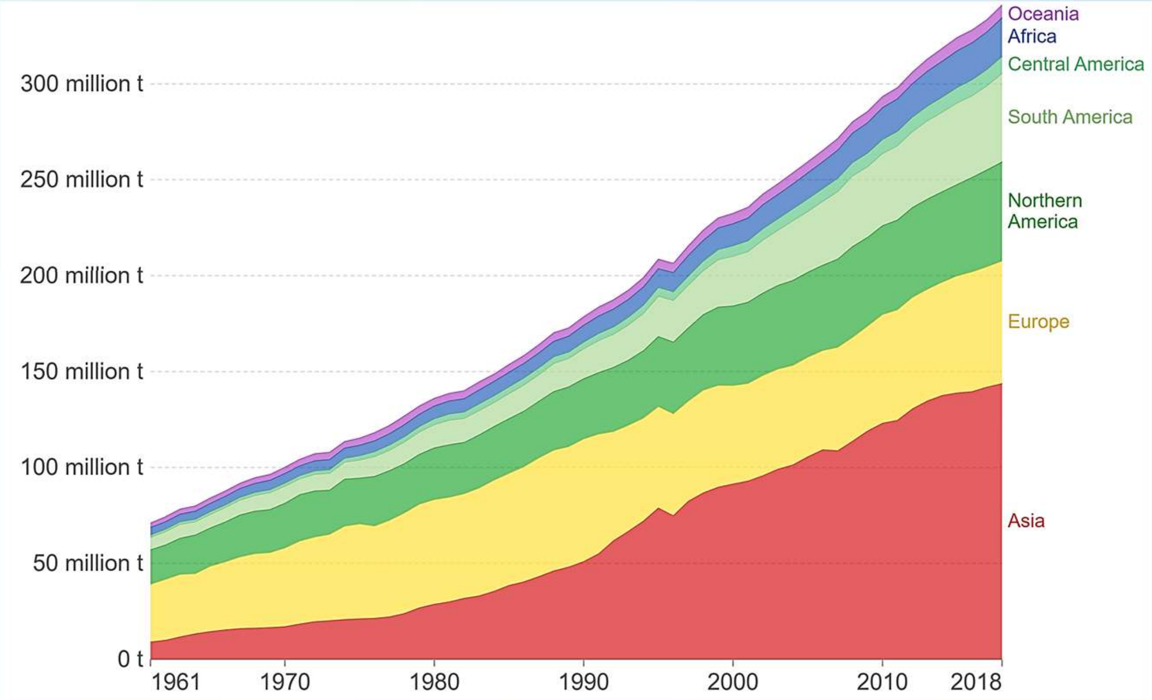
Protein problem



(https://ourworldindata.org/grapher/daily-per-capita-protein-supply)

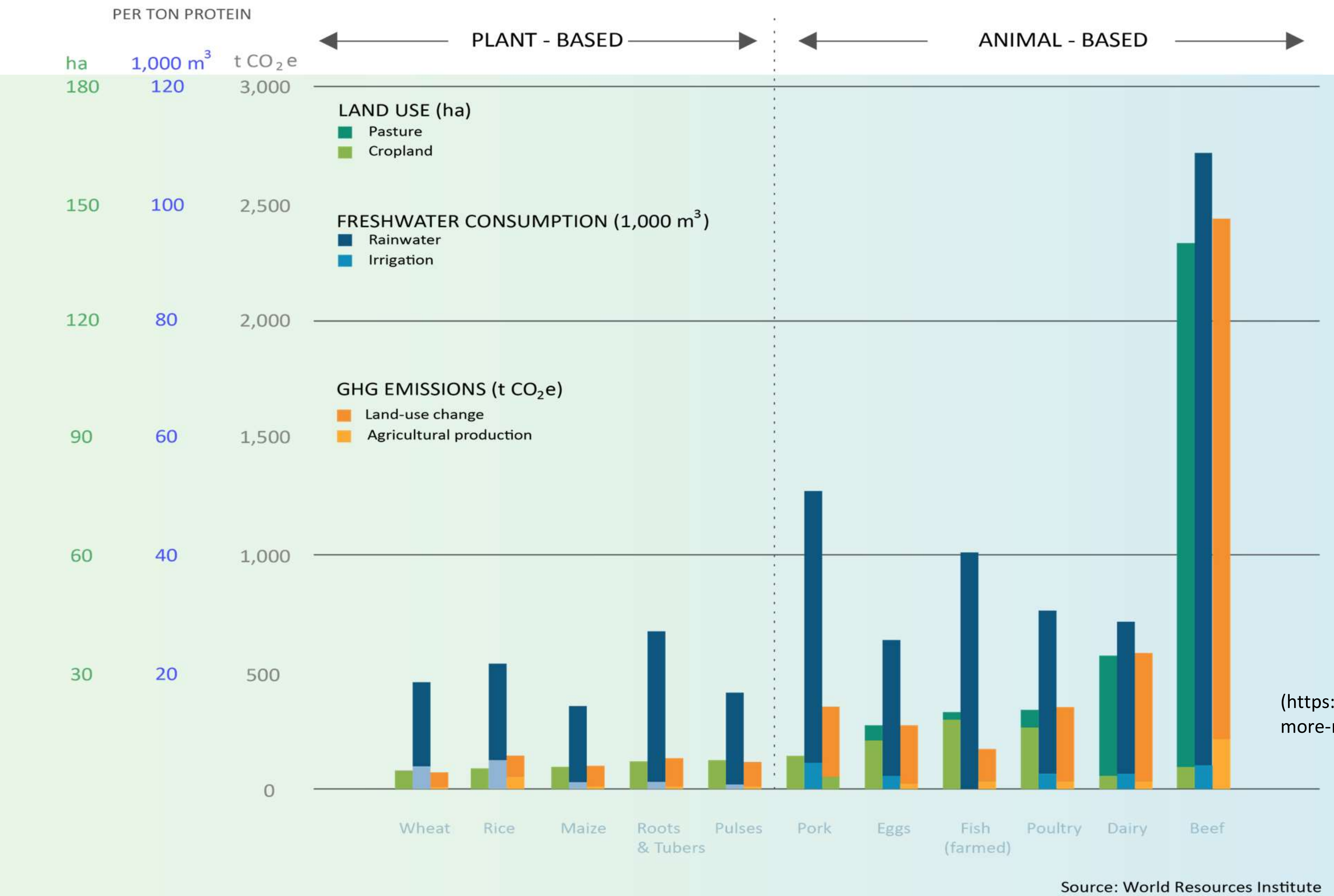
Global meat production trends





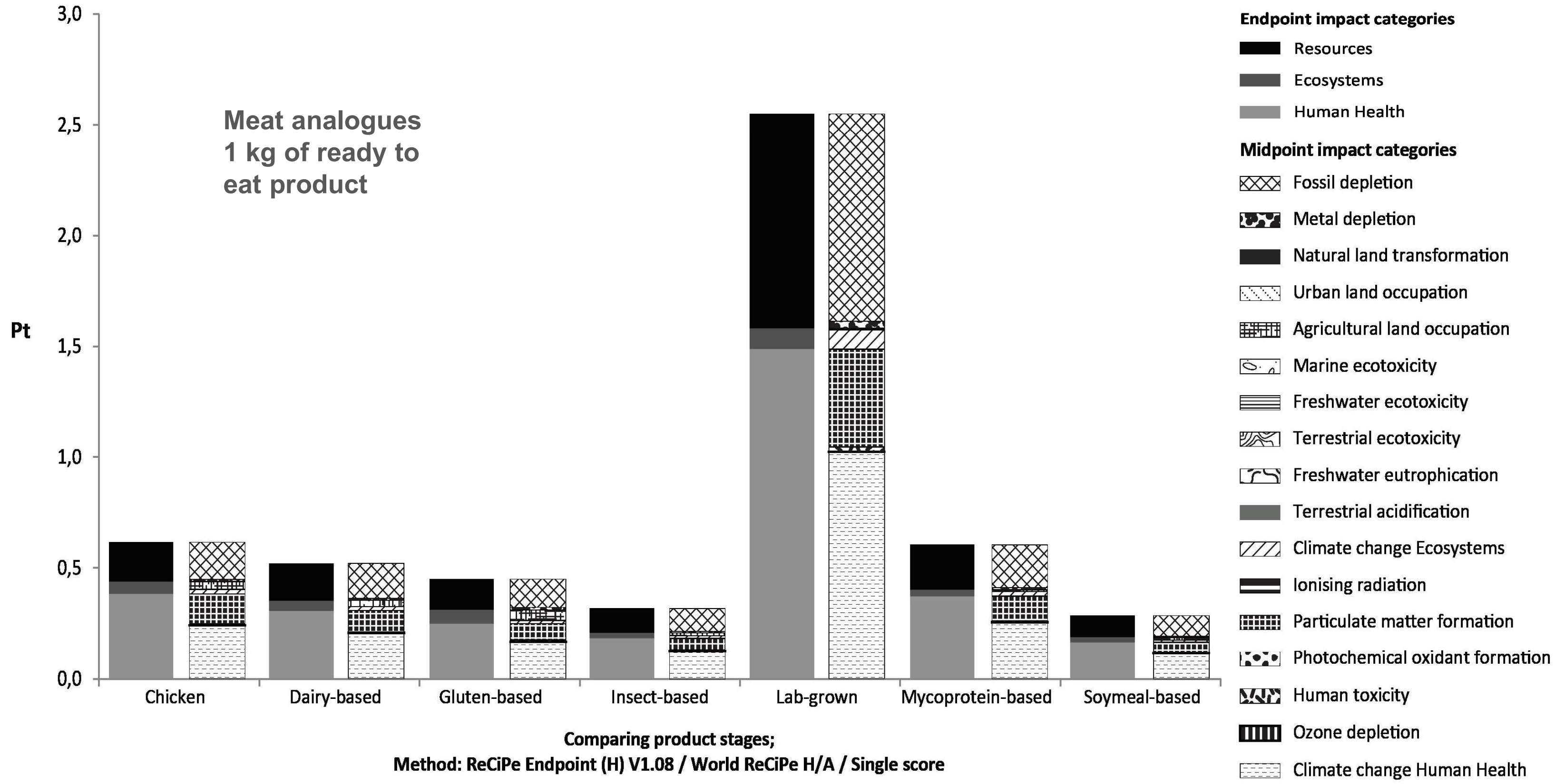
(https://ourworldindata.org/meat-production)

IMPACT OF ANIMAL AND PLANT-BASED FOODS



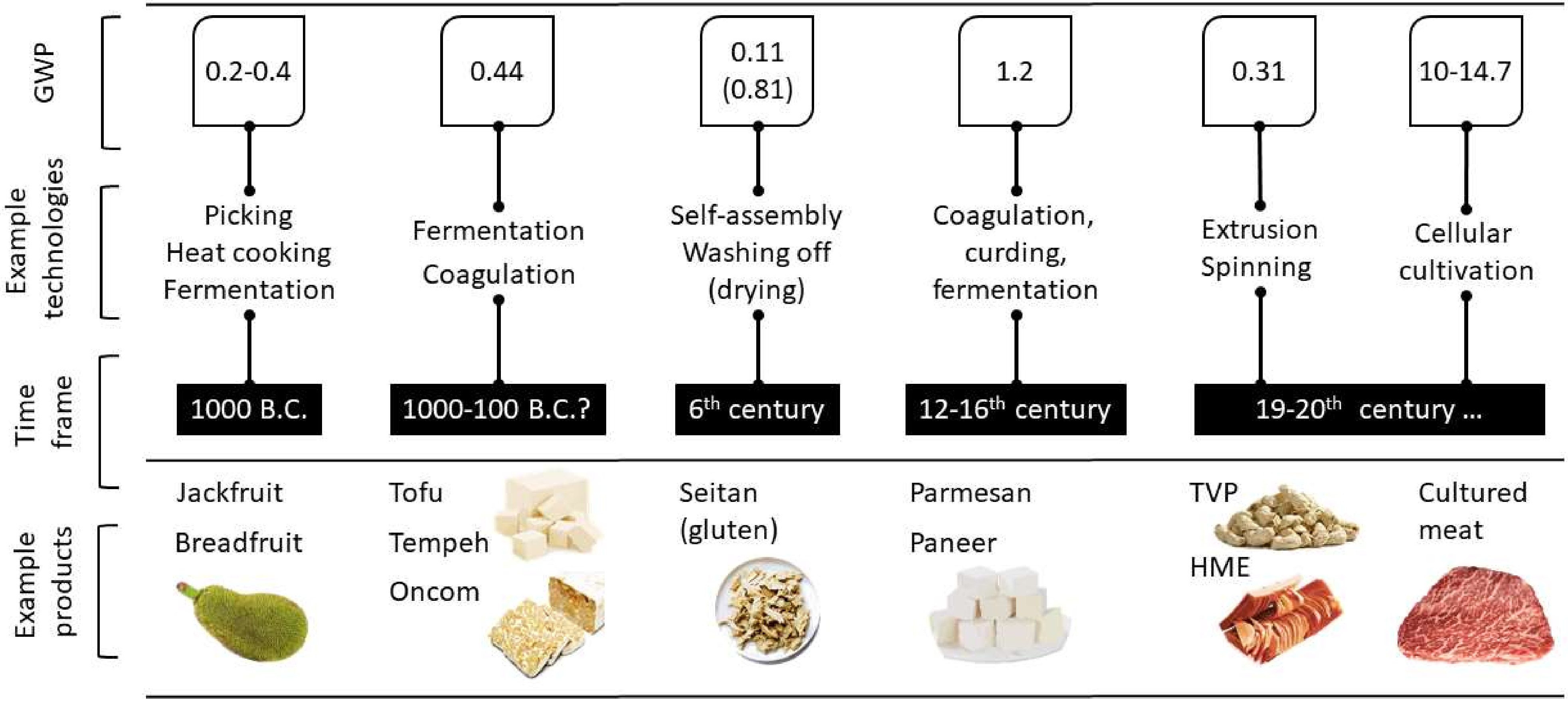
(https://www.wri.org/data/animal-based-foods-are-more-resource-intensive-plant-based-foods)

Environmental impact



Smetana et al., (2015). *IJLCA,* 20(9), 1254–1267.

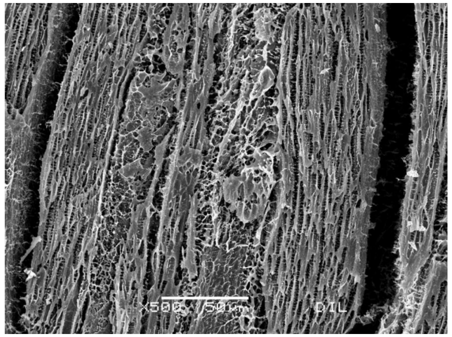
Meat substitution with alternative proteins



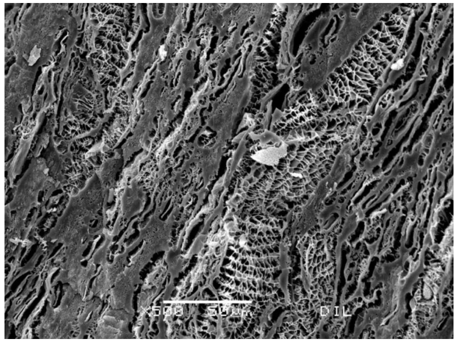
(Smetana et al., under review)

Alternative products

Meat



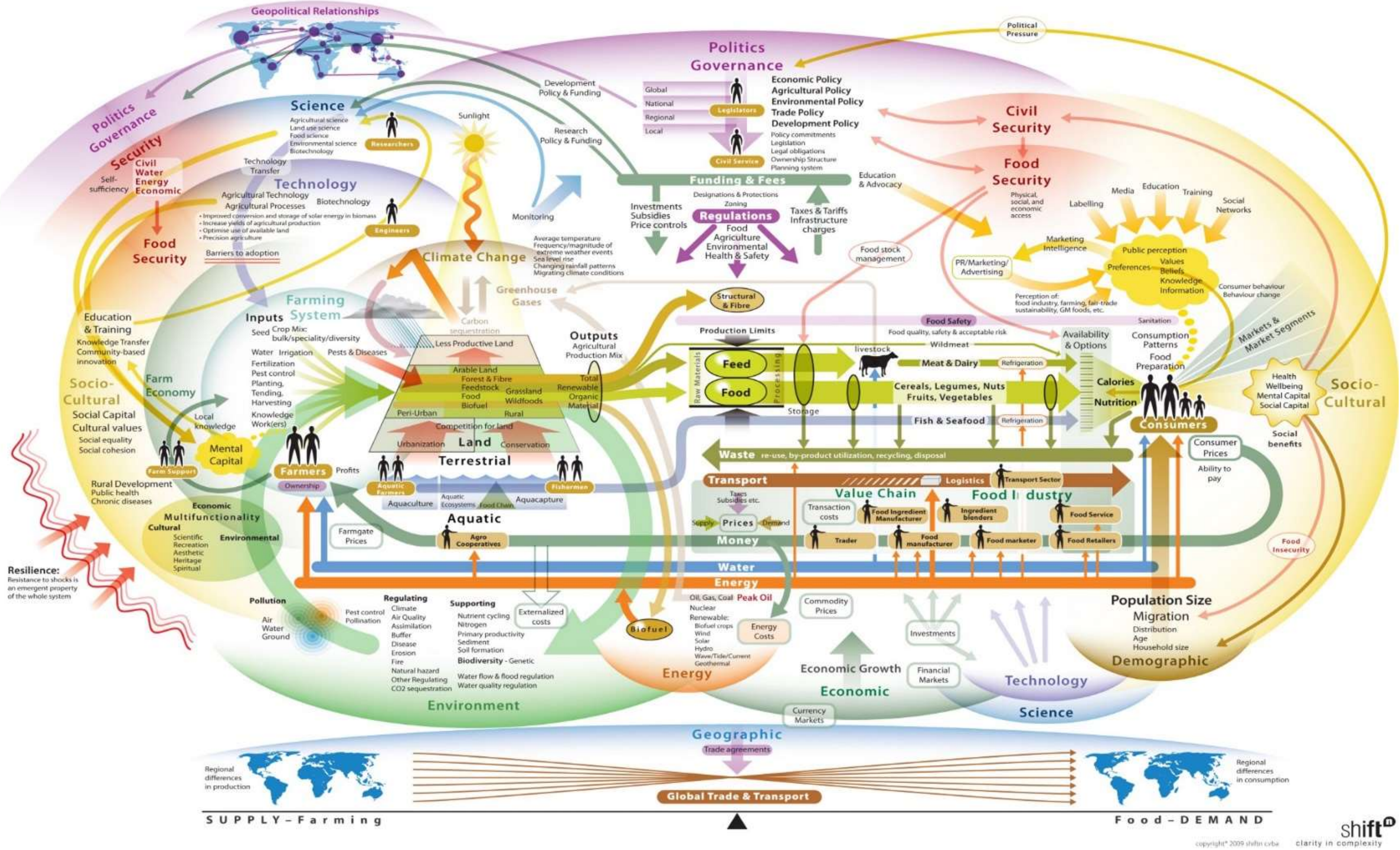
Extruded soy protein



(DIL)

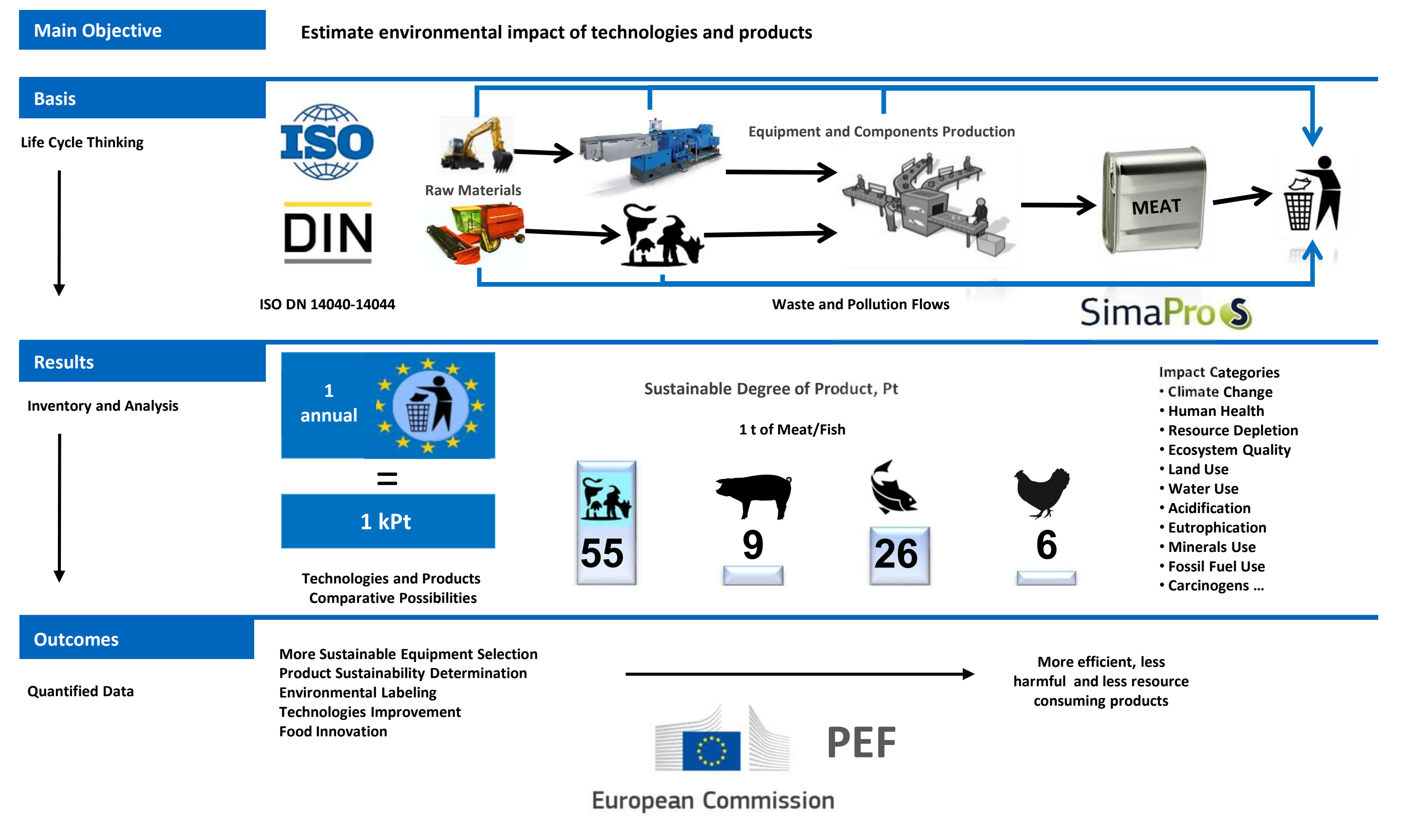
Image after Banksy

Dietary shifts studies for emergency



courtesy of ShiftN

Methodological insights: LCA

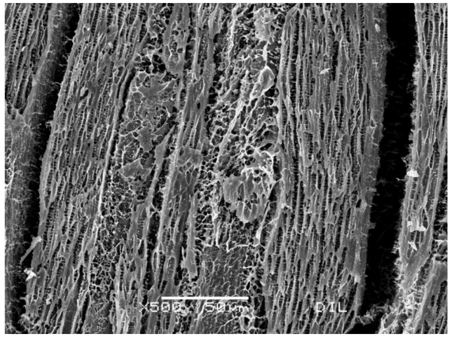


- Hotspots
- Best options
- Cradle-to-grave
- FU
- Comprehensive methods
- Potential impacts

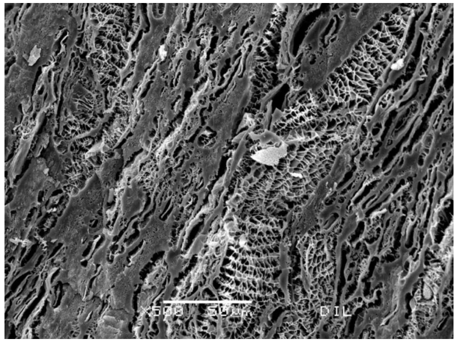
Principles of substitution

Texture and processability

Meat



Extruded soy protein



(DIL)

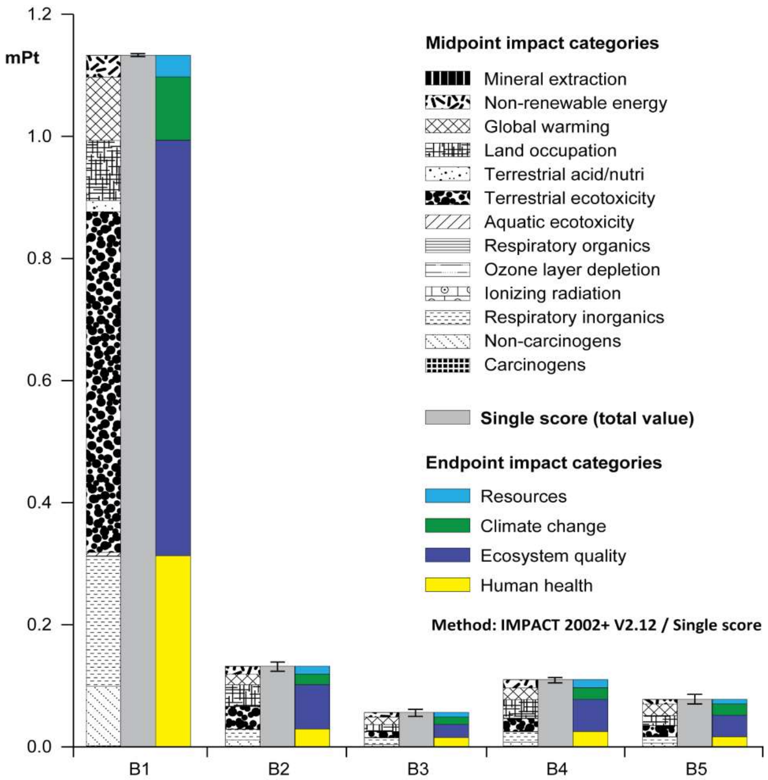
Nutrients

Nutrients and scores	Raw burger patties				
	Beef	Pea	Insect	Fungi (mcm)	Soy
Energy content, kcal in 100 g	235	269	282	255	169
Protein content, %	18	18	21	21	14
Fat, %	20	19	19	14	10
Saturated fat, %	8.4	5	2.1	3	0.7
Sugar, %	0	0	1.4	3.0	1.2
Dietary fibers, %	0.4	1.3	1*	3.1	5.1
Sodium, %	1.0	1.1	1.6	1.2	1.9
Nutri-Score	D	C	D	B	B

(Smetana et al., 2021)

LCA of meat and meat substitutes

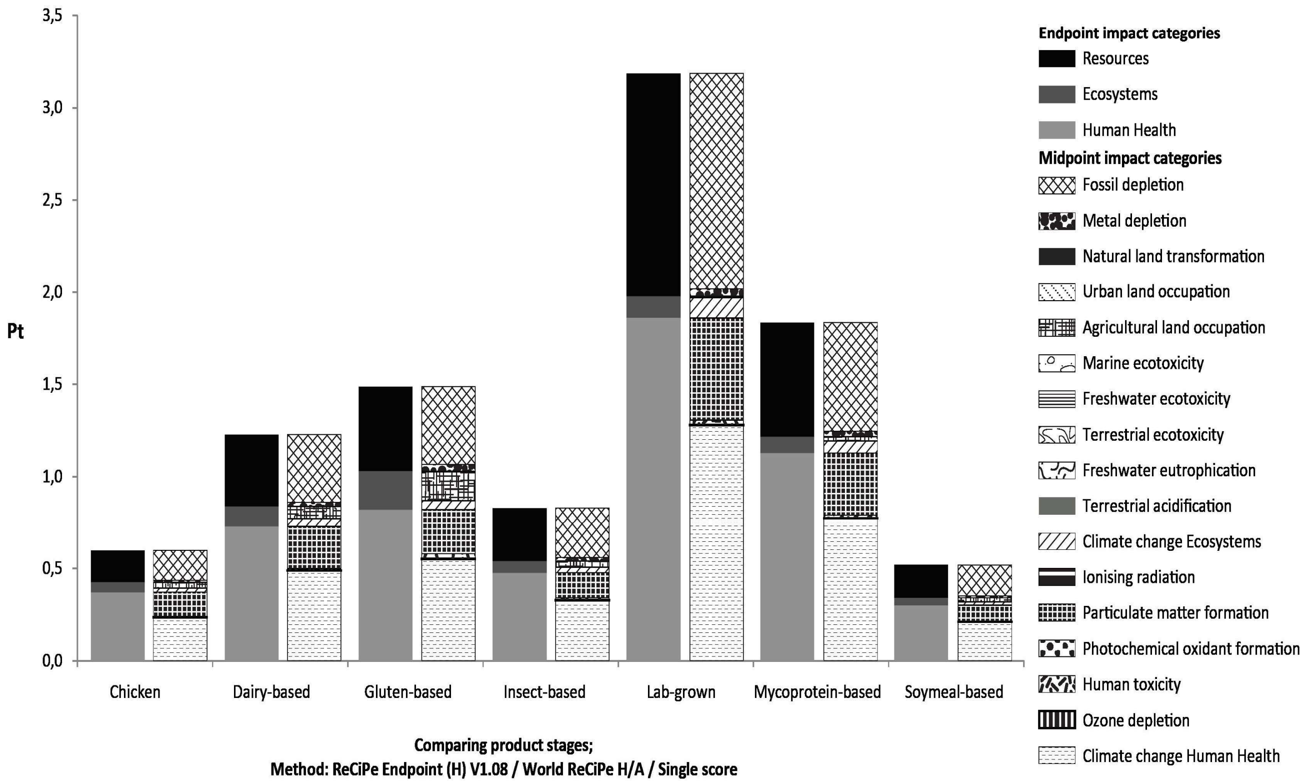
Raw burger patty, 116 g, from cradle to gate



B1 – beef; B2 – pea, B3 – insect; B4 – mycomycelium; B5 - soy

(Smetana et al., 2021)

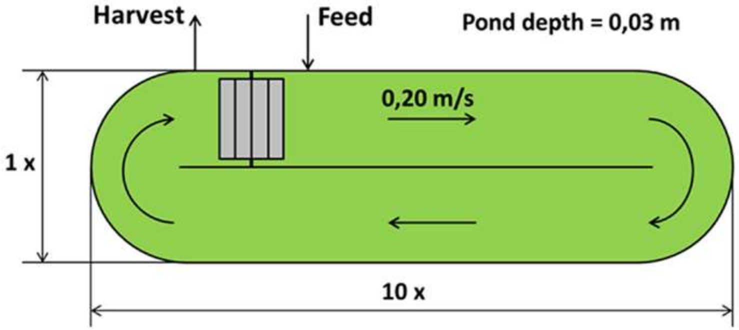
0,3 kg of digested proteins, from cradle to plate



(Smetana et al., 2015)

Microalgae

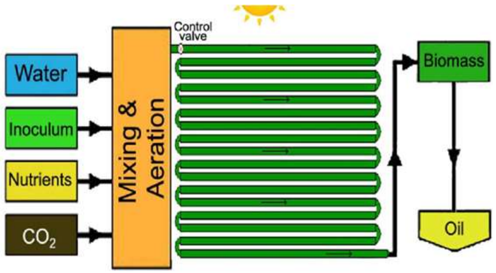
ORP



S = 0,1 ha
H = 0,3 m

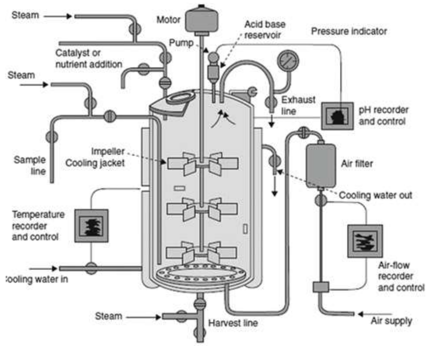
TBR

IGV GmbH



S = 0,05 ha
V = 25 m^3

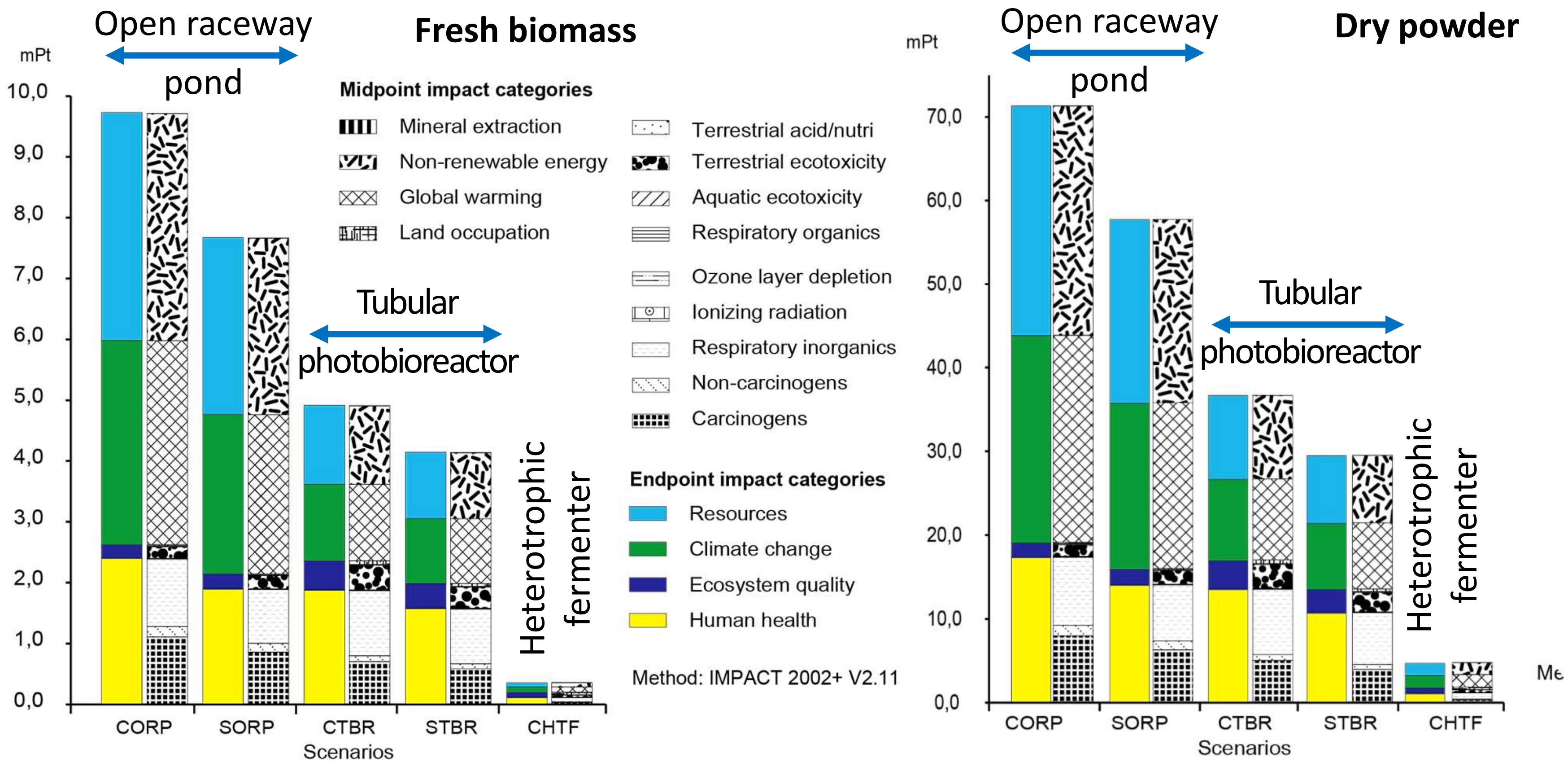
HTF



S = 10 m^2
V = 2,5 m^3

(Smetana et al., 2017)

LCA of Microalgae: large differences between systems

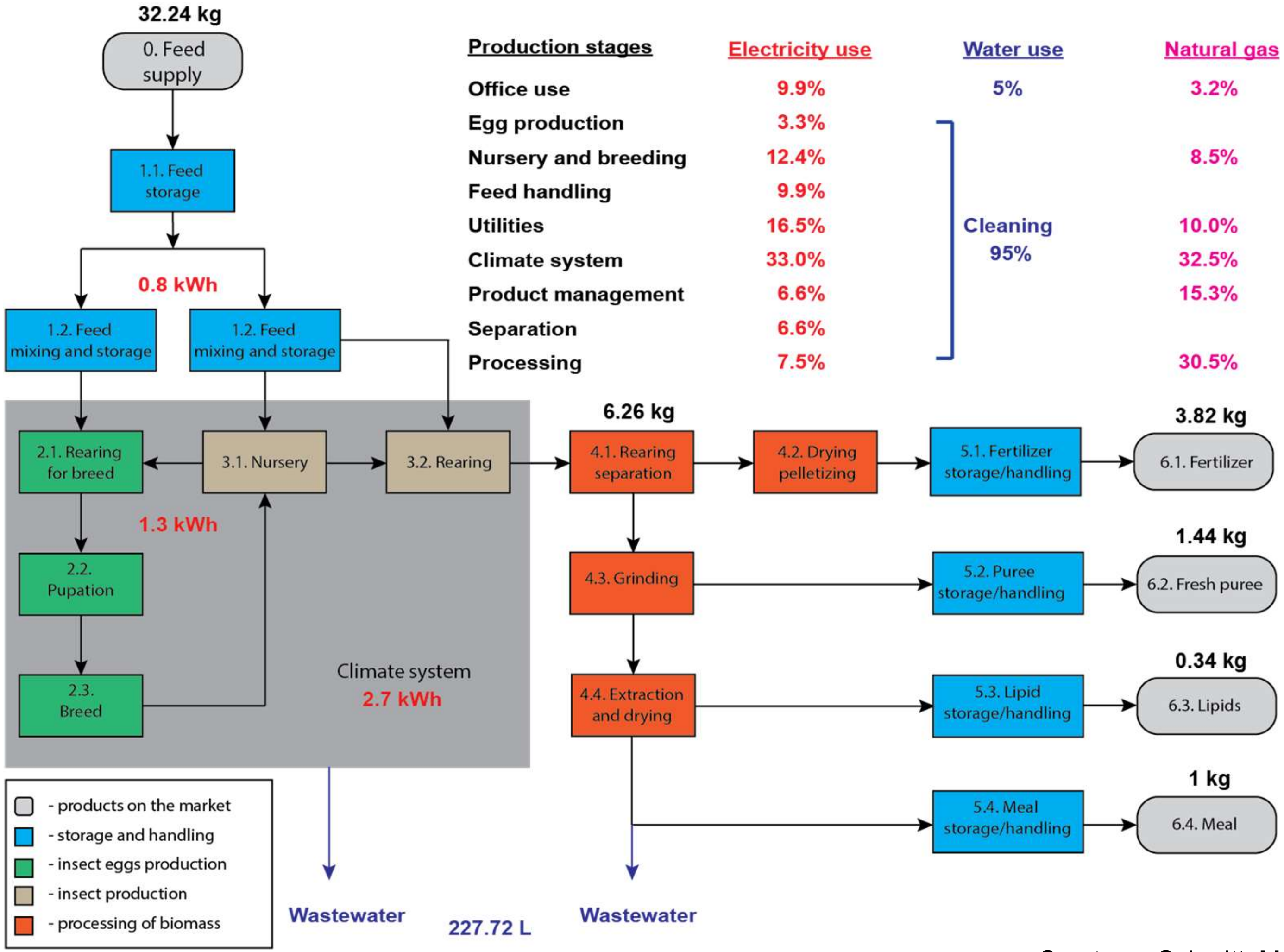


FU1 – 1 kg of product; mPt – millipoints (ecopoints, 1 kPt is equal to the annual impact of one European citizen); CORP – open raceway pond cultivation of *Chlorella vulgaris*; SORP – open raceway pond cultivation of *Arthrospira platensis*; CTBR – tubular photo bioreactor cultivation of *Chlorella vulgaris*; STBR – tubular photo bioreactor cultivation of *Arthrospira platensis*; CHTF – heterotrophic fermenter cultivation of *Chlorella vulgaris*

(Smetana et al., 2017)

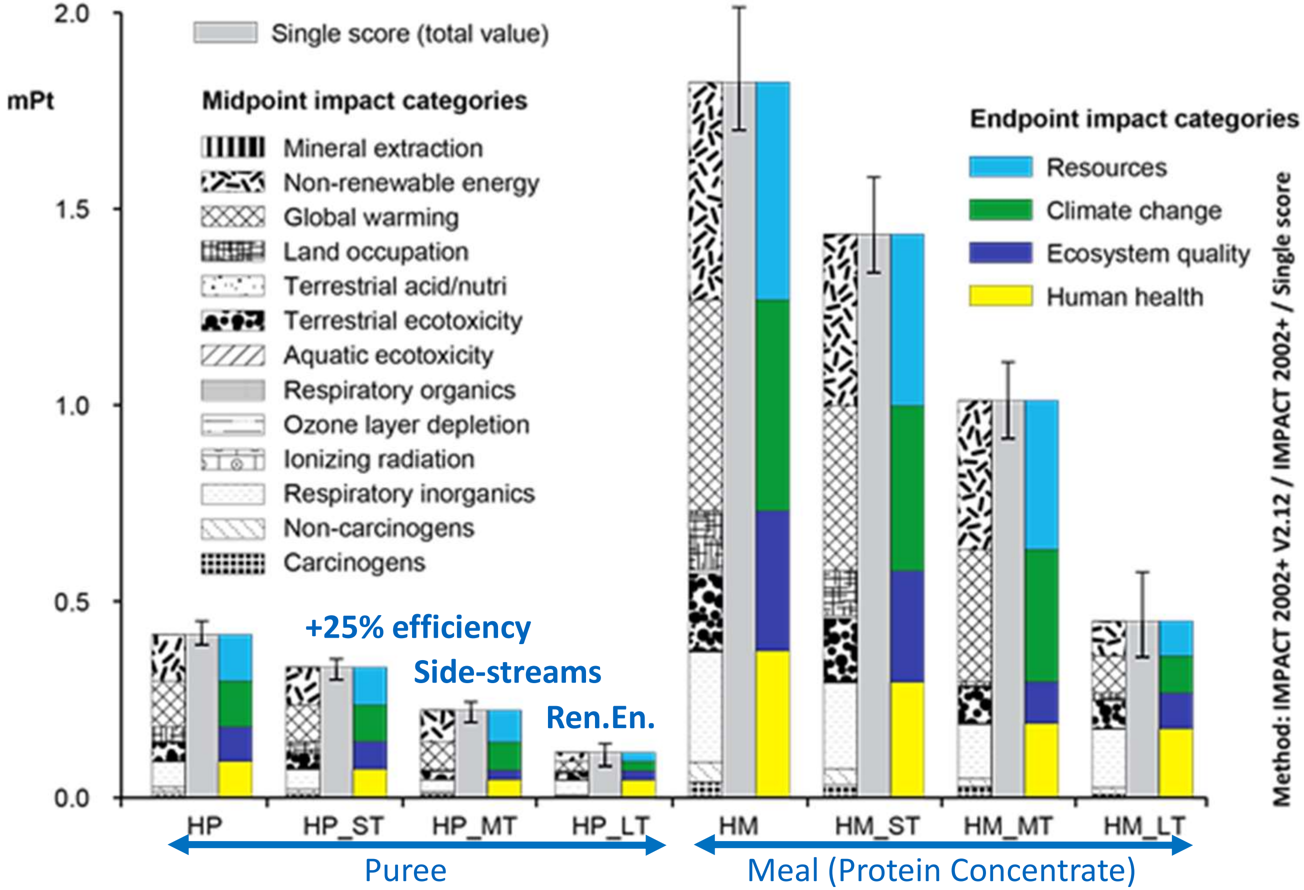
Insects

Production stages	Electricity use	Water use	Natural gas
Office use	9.9%	5%	3.2%
Egg production	3.3%	Cleaning 95%	
Nursery and breeding	12.4%		8.5%
Feed handling	9.9%		
Utilities	16.5%		10.0%
Climate system	33.0%		32.5%
Product management	6.6%		15.3%
Separation	6.6%		
Processing	7.5%		30.5%



Smetana, Schmitt, Mathys, 2019:
https://doi.org/10.1016/j.resconrec.2019.01.042

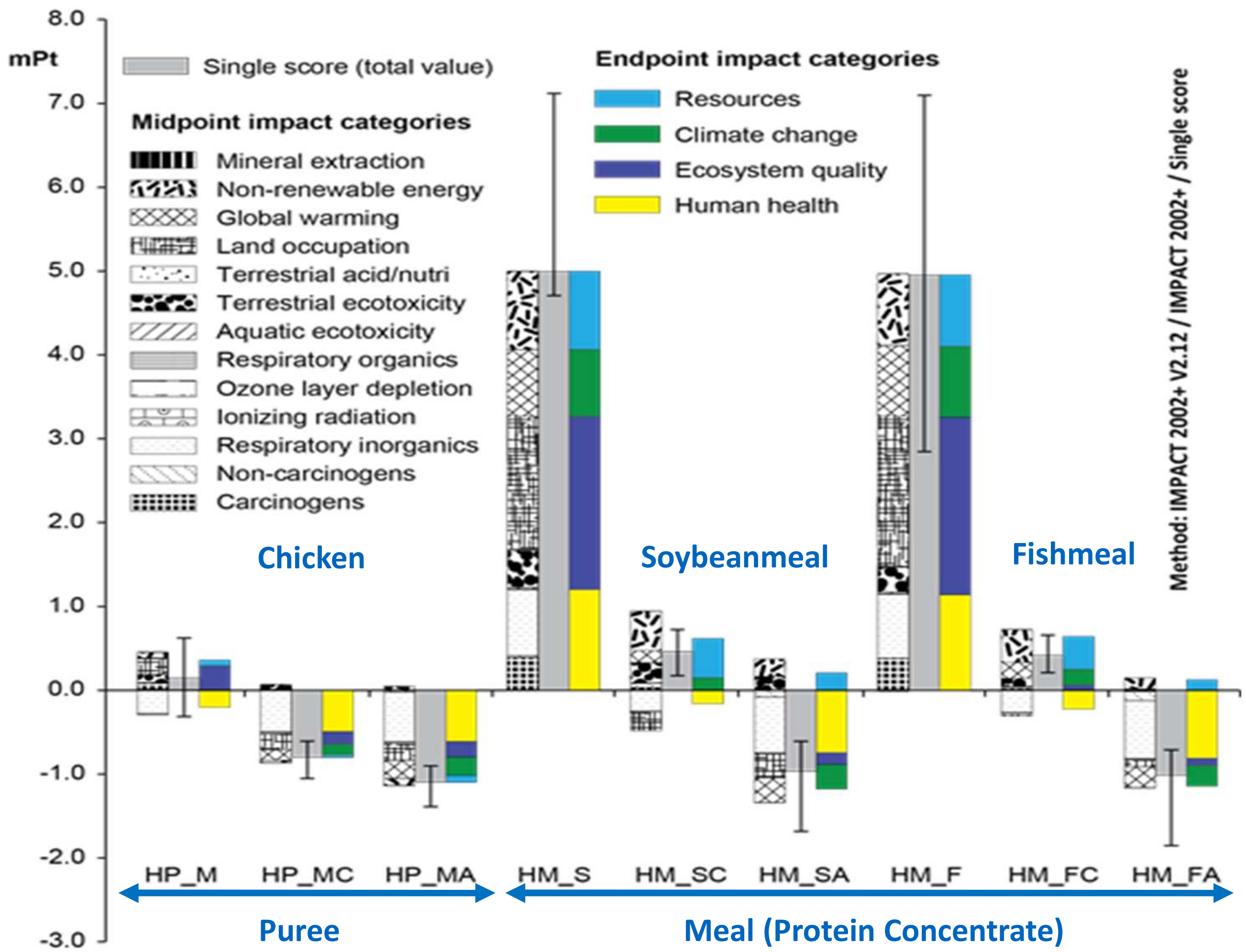
A-LCA of insects



mPt – millipoint, integrated normalized and weighted value of environmental impact

(Smetana, Schmitt & Mathys, 2019)

C-LCA compound effects of insect production



mPt – millipoint, integrated normalized and weighted value of environmental impact

C – composting avoided
A – avoided anaerobic digestion

(Smetana, Schmitt & Mathys, 2019)

SUSINCHAIN beta version online tool

http://susinchain.herokuapp.com/index

SUSINCHAIN LCA and Cost Calculation Tool

Take a Screenshot!

Insect species
Black soldier fly (Hermetia Illucens)

Amount of insect
1

Feed for insects
Milling by-products

Amount of feed/Amount of insect
5

Amount of frass/Amount of insect
1

Utilities for insect cultivation

Natural gas 10

Water 20

Electricity

Wastewater 20

Processing

First step Separation and washing

Second step Blanching

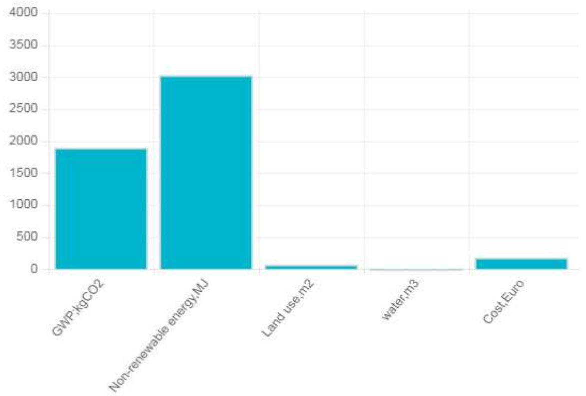
Third step Drying

End product
Extruded dried product

Packaging
Paperboard

Results

Category	Per unit of raw insects (ton)	For the whole production
GWP, kgCO2 eq	1901.52	1901.52
Non-renewable energy, MJ	3034.55	3034.55
Land use, m2	73.77	73.77
Water use, m3	-0.03	-0.03
Cost, Euro	180.93	180.93
Final product weight, ton	0.5	



Recommendations

- Use Polyethylene foil (LPDE) as an packaging option to reduce carbon emission and assure the recycling of LDPE
- If freezing, cooling or drying is used- then we recommend to find solutions to eliminate those process. e.g. Application of fresh biomass with pasteurisation
- Use Kraft paper- packaging paper as an packaging option to reduce cost of packaging
- Use microwave drying process to decrease carbon footprint
- Use Brewer spent grains as feed for insects to reduce impact of production by 87.45 %
- By using electricity instead of natural gas can reduce 91.97 % impact

This study has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement no 861976 project SUSINCHAIN.

Home Feedback

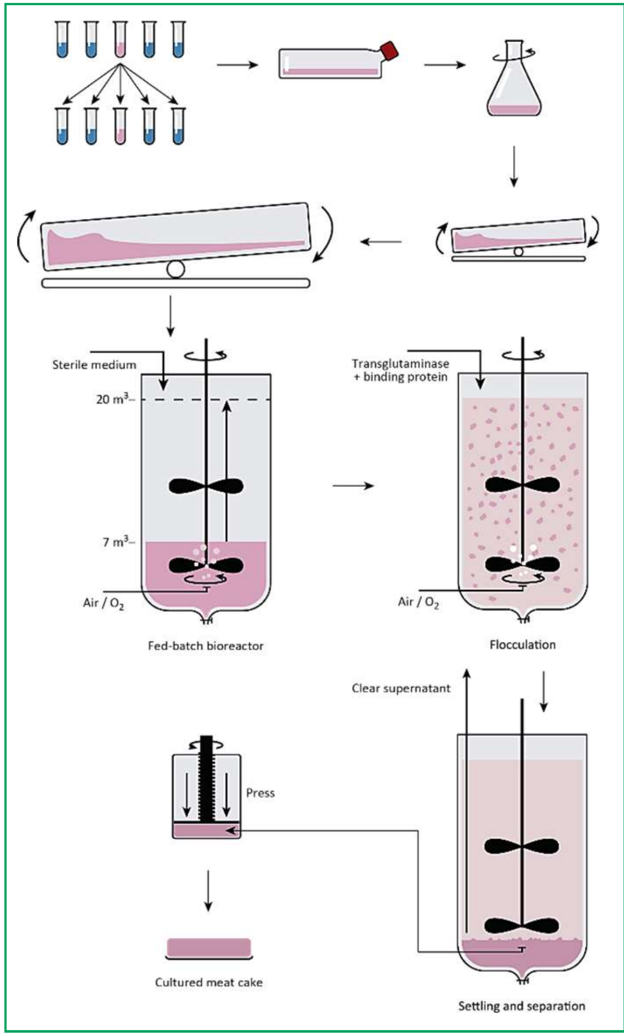
Modelling efficiency of meat culturing

	Self-organizing	Scaffold-based	3D printing (extrusion/droplet)
Production	1 t DM meat	1 t DM meat	1 t DM meat
Reactor scale, duration	20 m³ for 1 month (1.56 t meat)	15 m³ for 44 days (1.38 t meat)	Minimal printing space for 2-3 weeks; 2 m³ for 4 weeks (1.5 t meat)
Technology type	Batch	Batch	Continuous-batch
Initial inoculum	20 m^3 of 5×10^{11} cells per m^3	15 m^3 of 2×10^5 cells mL^{-1}	2 m^3 with $10\text{-}40\times10^6$ cells mL^{-1}
Microcarriers	na	Starch 300 kg	Alginate 50-100 kg*
Water	20-40 tonnes*	118.4 + 180 tonnes	10 tonnes*
Growth medium	(80 tonnes*)	118.4 tonnes	(4-10 tonnes*)
Glucose	included in medium	0.8 tonnes	included in medium
Glutamine	na	69.2 kg	na
NaOH	200 kg*	600 kg	20-40 kg*
Energy	19 840 MJ	22 384 MJ	Printer: 332,6 MJ*; Reactor: 145 MJ*
Sources	Van der Weele et al., 2016; Mattick et al., 2015; own modelling*	Mattick et al., 2015	Murphy & Atala, 2014; Datta et al., 2018; own modelling*

(Carrel, 1912)

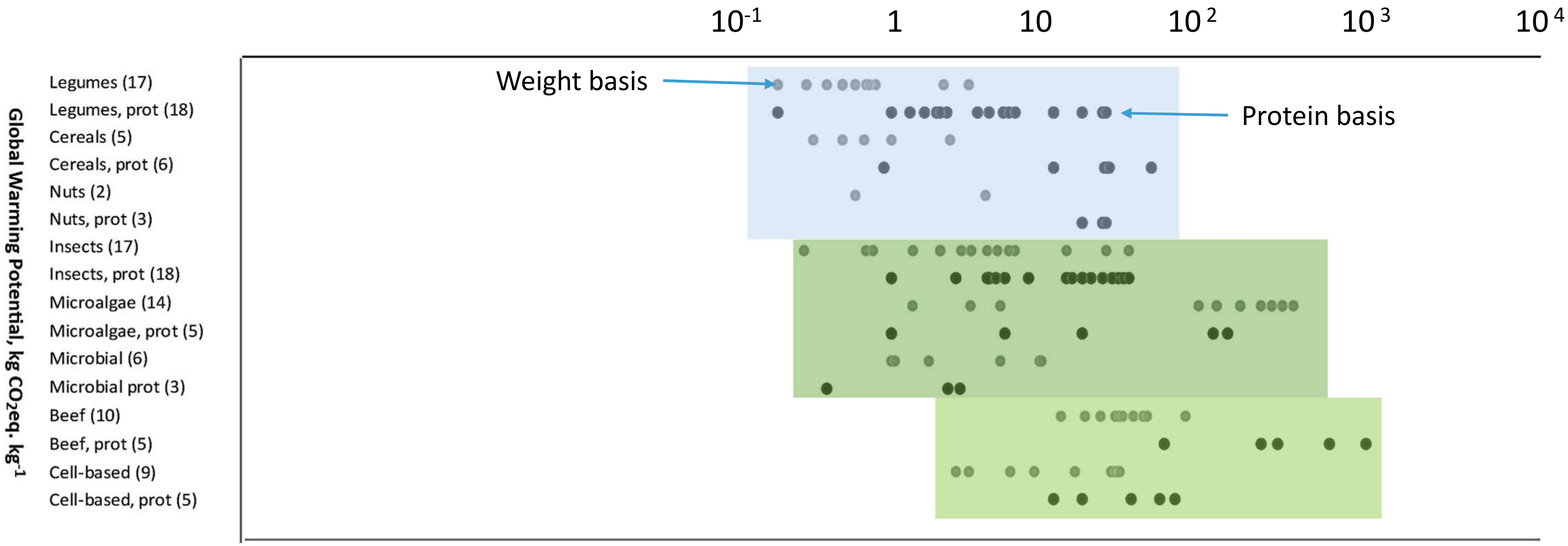
(ENVISIONTEC GmbH)

(DIL e.V.)

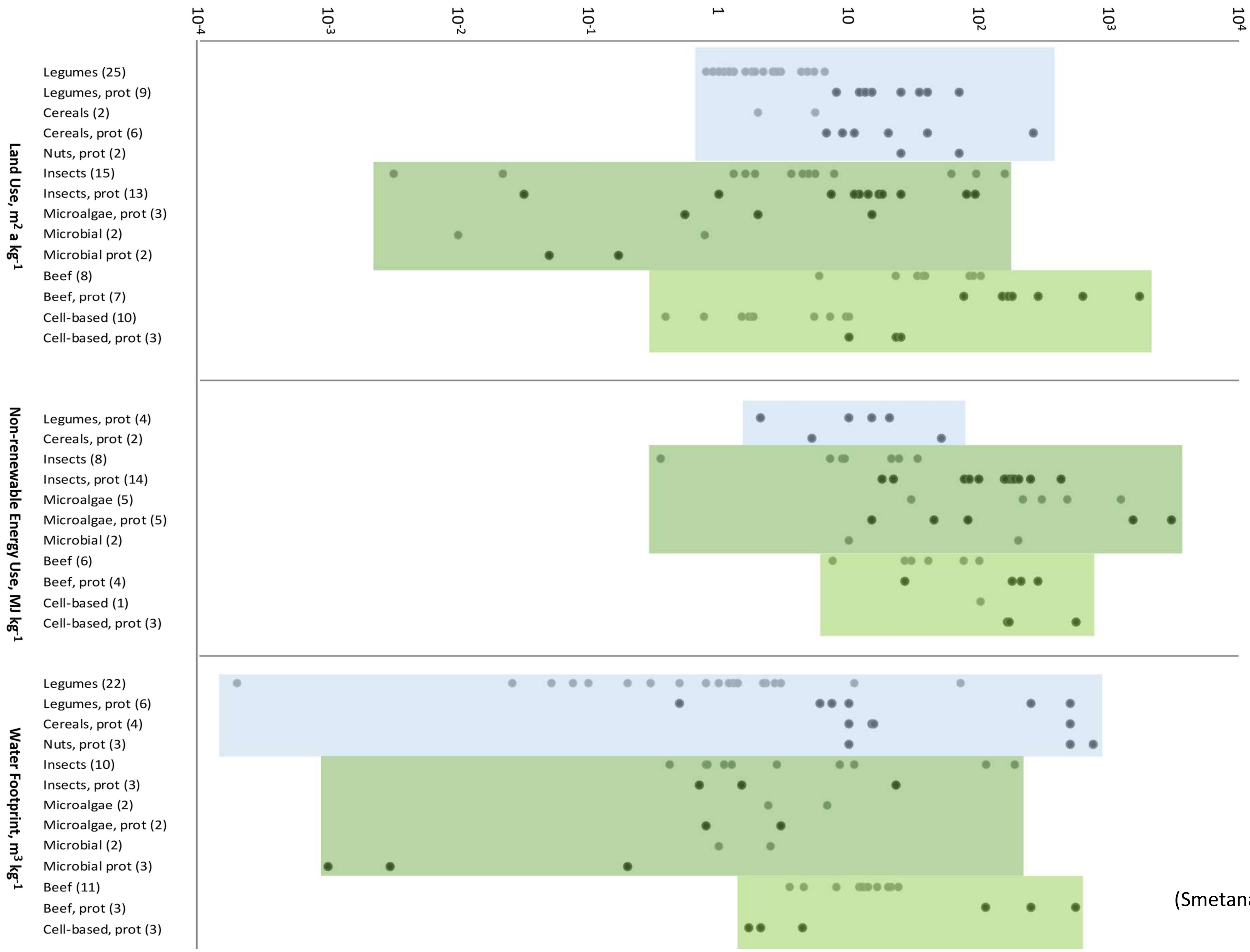


(van der Weele & Tramper, 2014)

Environmental impact overlook

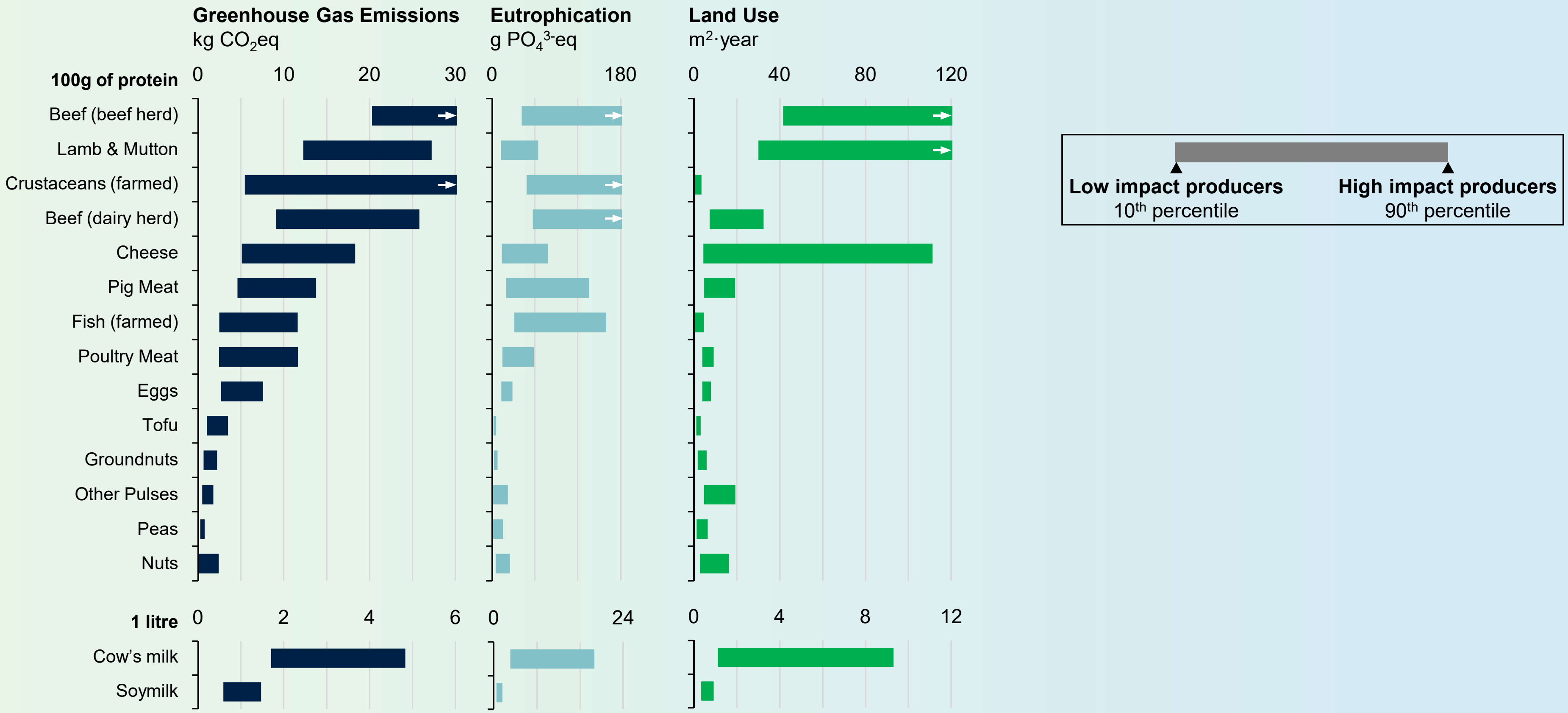


(Smetana et al., under review)



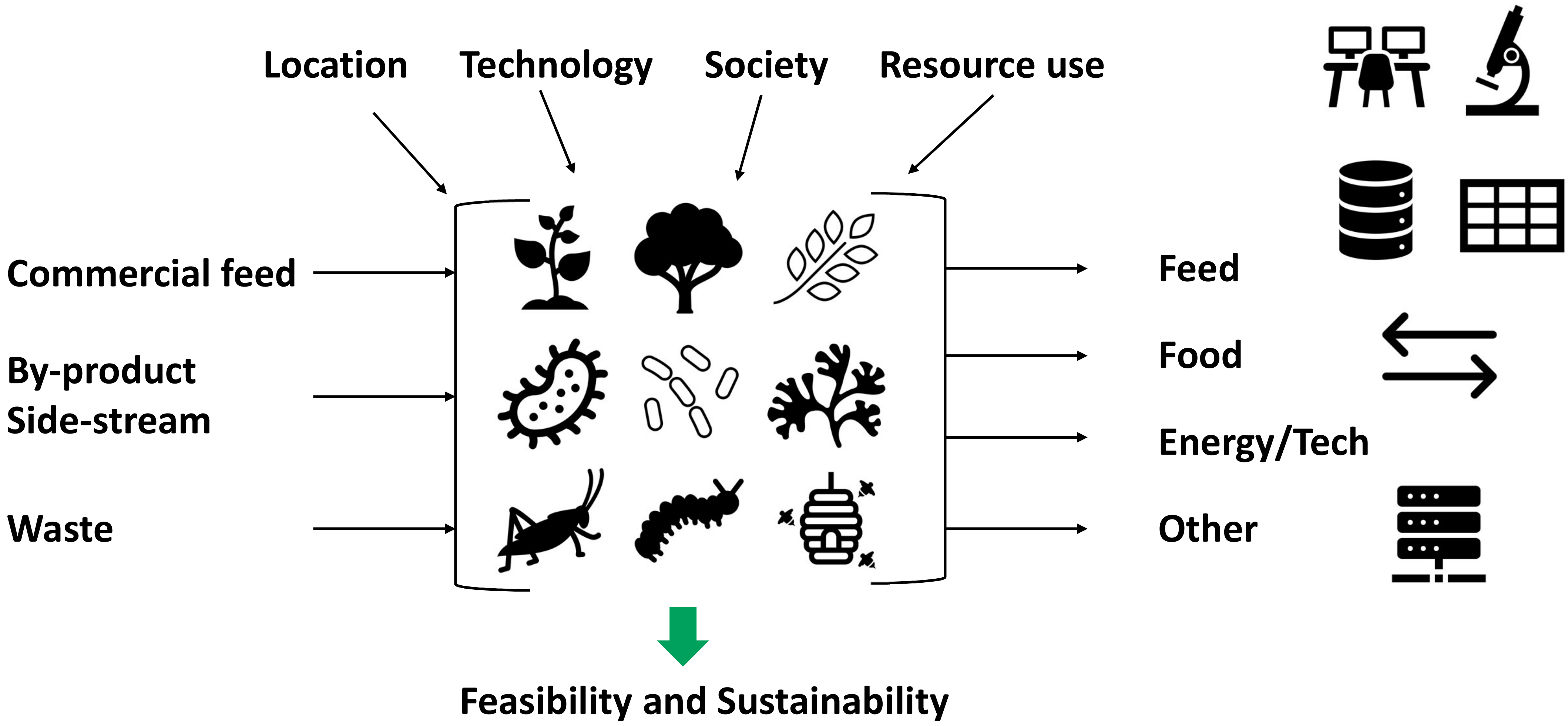
(Smetana et al., under review)

Conventional sources of proteins



(Poore & Nemecek, 2018)

Concluding points



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Thank you for for your attention!

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