

Interreg
Baltic Sea Region



Co-funded by
the European Union

 BLUE ECONOMY
TETRAS



UNIVERSITÀ
DEGLI STUDI
DI MILANO

Environmental performance of semi-commercial RAS in Lithuania and Denmark

Nykøbing Falster | Novembre 6th 2025
Michele Zoli – University of Milan

interreg-baltic.eu/project/tetras



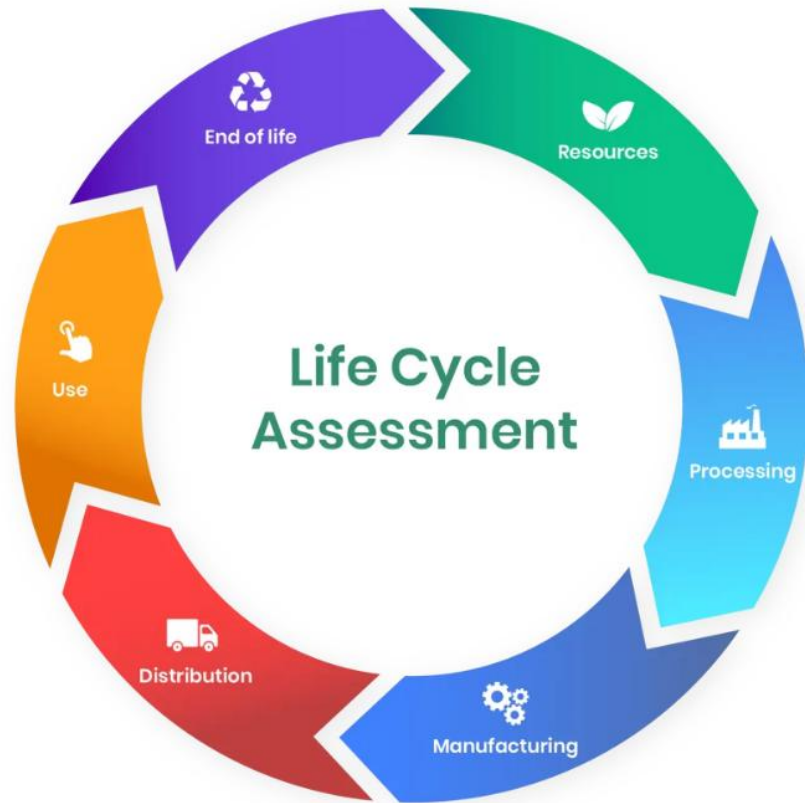
Aim of this study

Environmental impact assessment

- Quantify the environmental impact of the RAS facility for shrimp production in Lithuania (University of Klaipeda);
- Quantify the environmental impact of the RAS facility for *Clarias gariepinus* production in Denmark;
- Identify the main hotspots of these two systems;
- Suggest mitigation strategies and provide guidance for future developments



Life Cycle Assessment approach



LCA consists in the evaluation of mass (production factors, emissions of pollutants into the environment and waste production) and energy flows characterizing the analysed process.

LCA

Life Cycle Assessment is the most used methodology to evaluate environmental performances of products (processes or services). It is a standardized approach (ISO 14040/14044) and it considers the entire life cycle of products, from the extraction of raw materials to the management of waste.



LCA OUTPUTS:

Quantification of different impact categories: carbon footprint, water footprint, etc.

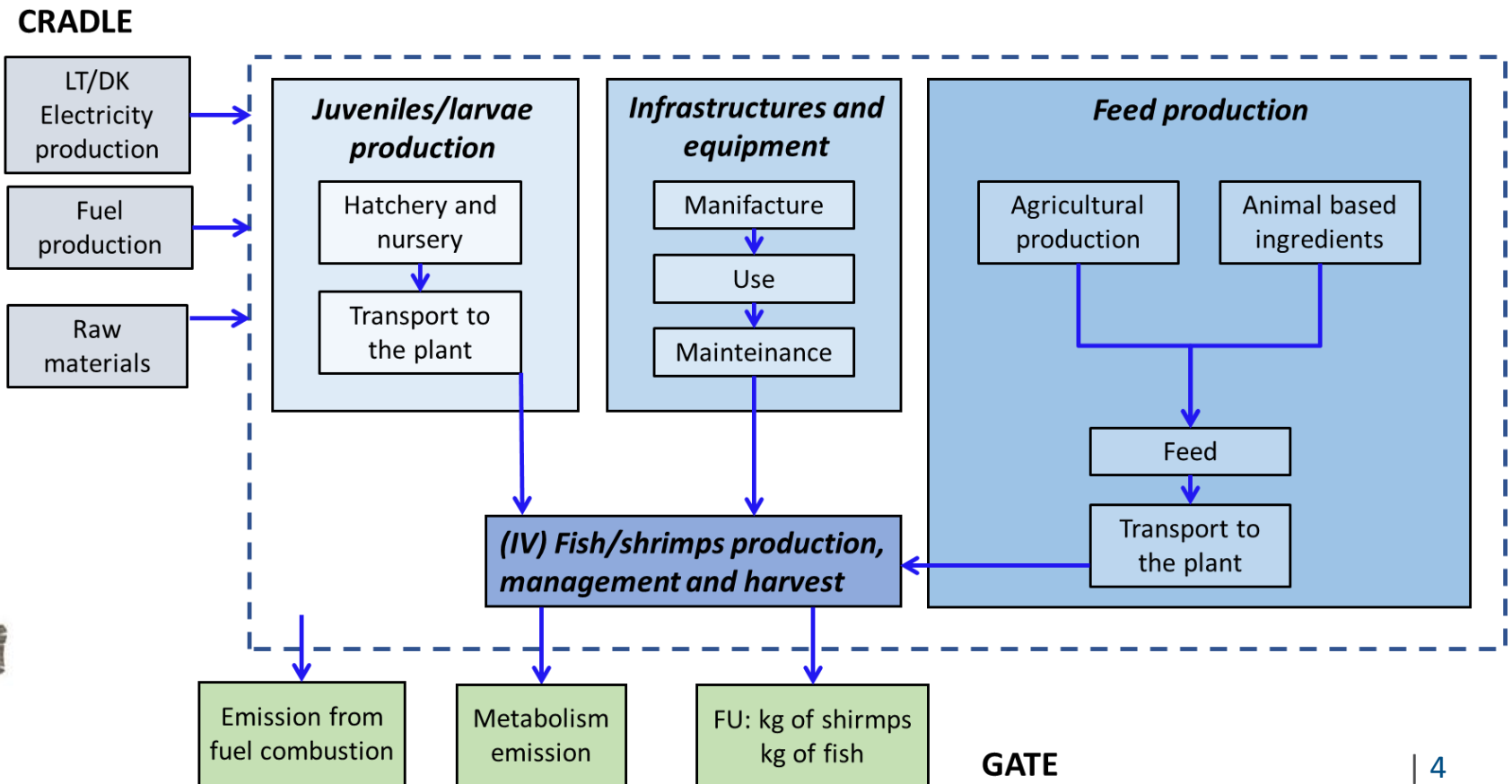


Goal and scope definition

Functional unit: Mass-based FU: ➡ 1 kg of live shrimps
1 kg of live *Clarias*

System boundaries:

From cradle to gate



Analysed system

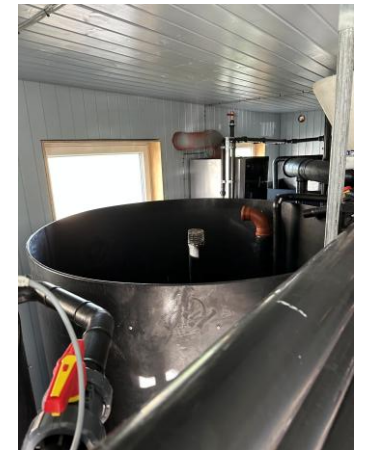
Shrimps rearing

- Experimental facilities in Klaipeda;
- Use of geothermal water;
- Electricity from Lithuanian network;
- Liquid oxygen supply
- From post larvae to commercial size
- 8 different feeds
- 7 tanks



Clarias rearing

- Municipality of Guldborgsund;
- Demostative plant
- Electricity from Denmark network;
- No liquid oxygen – air blower
- From 100g to about 1.5kg;
- One feed
- 2 tanks



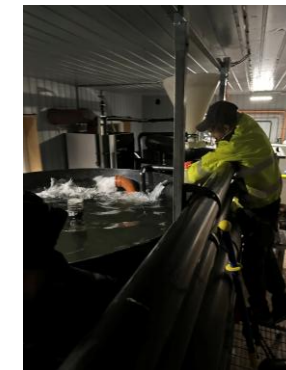
Life Cycle Inventory

Primary data Primary data directly collected and related to the case studies analyzed. Measured data, experimental data. They refer to:

- Final production
- FCR
- Mortality
- Feed provided
- Energy consumption
- Liquid oxygen
- Consumption of other prod. factors
- System set-up

Secondary data Secondary data collected from LCA database, scientific literature, model estimation:

- Feed ingredient inclusions
- Background material
- Energy modelling
- Juveniles modelling
- Metabolism emission (mass balance model)



Life Cycle Inventory

Shrimps rearing



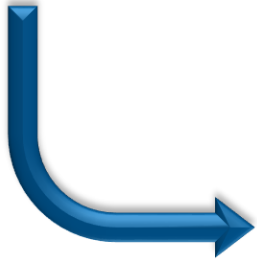
Parameters	unit	1st cycle	2nd cycle
Cycle duration	days	80	92
Juveniles	kg	0.6	0.24
Juveniles transport	km	1,474	1,474
Freshwater	m ³	68	60
Geothermal water	m ³	30	8
Liquid oxygen	kg	45.38	19.95
Electricity	kWh	578.39	252.23
Mortality	%	53	58
FCR	/	1.53	1.54
Emissions			
Ammonia	kg	2.49	1.19
N ureic	kg	1.34	0.64
N solid	kg	2.20	0.83
Phosphate	kg	1.90	1.02
P solid	kg	1.29	0.57
Biomass output			
Shrimps	kg	119.01	51.9

Clarias rearing

Parameters	Unit	Value
Cycle duration	days	201
Juveniles	kg	60
Juveniles single weight	kg	0.1
Total plant volume	m ³	9.5
Water daily recirculation	m ³	9.025
Daily added freshwater	m ³	0.475
Oxygen concentration	mg/l	2.5
Disinfectants (H2O2 footbath)	l	1
Disinfectant - H2O2 hand pump	l	5
Bicarbonate of Soda	kg	107
Sea salt	kg	18
Electricity	kWh	10,275.9
Mortality	%	10
FCR	/	1.05
Emissions		
Ammonia	kg	0.39
N ammonium	kg	17.95
Nitrate	kg	10.89
N solid	kg	8.15
Phosphate	kg	1.62
P solid	kg	3.67
Biomass output		
Fish live weight	kg	842.5
Wastewater	m ³	104.9

➤ In addition all the info related to feed composition and infrastructures

Life Cycle Impact assessment



EF3.1 Method

- Acidification (AC);
- Climate change(CC);
- Freshwater ecotoxicity (ECOTOX);
- Particulate matter formation (PM);
- Eutrophication freshwater, Terrestrial and Marine (FE, TE, ME);
- Human toxicity – carcinogenic effect (HT_c);
- Human toxicity – non carcinogenic effect (HT_nc);
- Ozone layer depletion (OD);
- Photochemical ozone formation (POF);
- Fossil resources use (FRD);
- Mineral and metal resources use (MRD);
- Cumulative energy demand (CED);
- Net Primary Production Use (NNPU).

Results - 1 kg of shrimps

	Unit	1st	2nd
AC	mol H+ eq	0.06	0.08
CC	kg CO ₂ eq	8.91	10.82
FEx	CTUe	176.85	204.93
PM	disease inc.*10 ⁻⁵	0.07	0.09
ME	kg N eq	0.03	0.04
FE	kg P eq	0.02	0.02
TE	mol N eq	0.14	0.16
HT-c	CTUh*10 ⁻⁶	0.01	0.01
HT-nc	CTUh*10 ⁻⁶	0.39	0.26
OD	mg CFC11 eq	0.69	0.75
POF	kg NMVOC eq	0.04	0.04
RU-f	MJ	125.51	159.67
RU-mm	g Sb eq	0.11	0.23
WU	m ³ depriv.	32.58	32.04
CED	MJ eq	165.19	203.23
NPPU	kg C	3,11	3.82



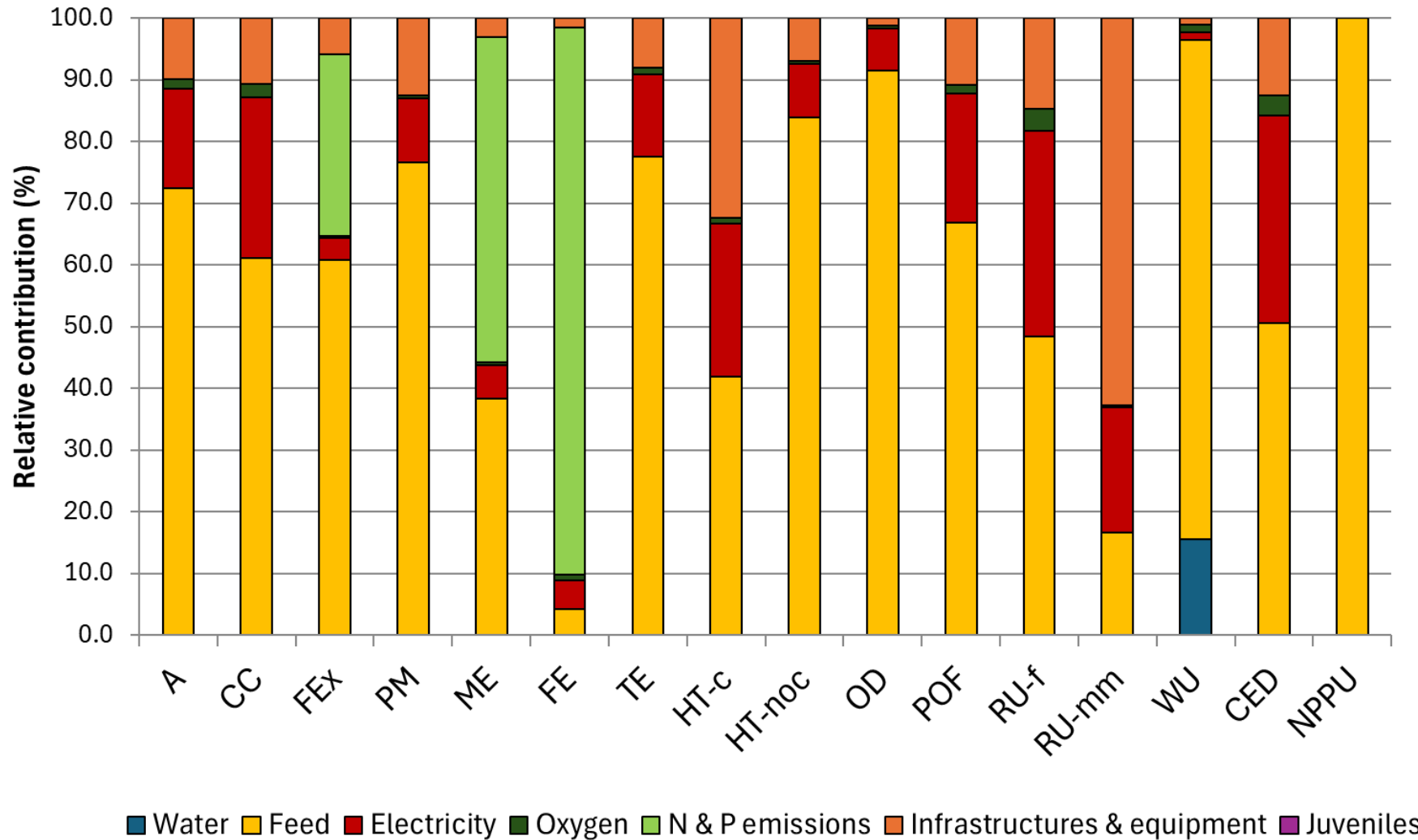
First cycle better than second one

Carbon footprint slightly high compared to literature:

- Cao et al., 2011: 2.7-5.3 kg CO₂ eq;
- Al Eissa et al., 2022: 4 kg CO₂ eq;
- Sun et al., 2023: 4.41-4.97 kg CO₂ eq.

A: Acidification; CC: Climate change; FEx: Freshwater ecotoxicity; PM: Particulate matter formation; ME: Marine eutrophication; FE: Freshwater eutrophication; TE: Terrestrial eutrophication; HT-c: Human toxicity, cancer effects; HT-nc: Human toxicity, non-cancer effects; OD: Ozone depletion; POF: Photochemical ozone formation; RU-f: Resource use, fossils; RU-mm: Resource use, minerals and metals; CED: Cumulative energy demand; NPPU: Net Primary Production Use.

Contribution analysis



Feed is the main hotspot in most categories: 72% A, 62% CC, 76%PM, 50% CED

Electricity impacts for 26% del CC, 33% RU-f, 33.6% CED

Infrastructures are main responsables for RU-mm (63%) and HT-c (33%)

N and P emissions impact on FEx (30%), ME (53%) and FE (87%).

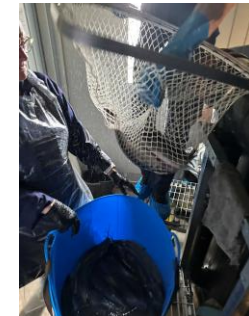
Results – 1 kg of *Clarias*

	Unit	1st
AC	mol H+ eq	0.03
CC	kg CO ₂ eq	4.50
FEx	CTUe	131.85
PM	disease inc.*10 ⁻⁵	0.27
ME	kg N eq	0.03
FE	kg P eq	0.01
TE	mol N eq	0.09
HT-c	CTUh*10 ⁻⁶	0.35
HT-nc	CTUh*10 ⁻⁶	0.12
OD	mg CFC11 eq	0.31
POF	kg NMVOC eq	0.31
RU-f	MJ	0.02
RU-mm	g Sb eq	65.54
WU	m ³ depriv.	9.21
CED	MJ eq	3.36
NPPU	kg C	1.01

Results are in line with previous studies

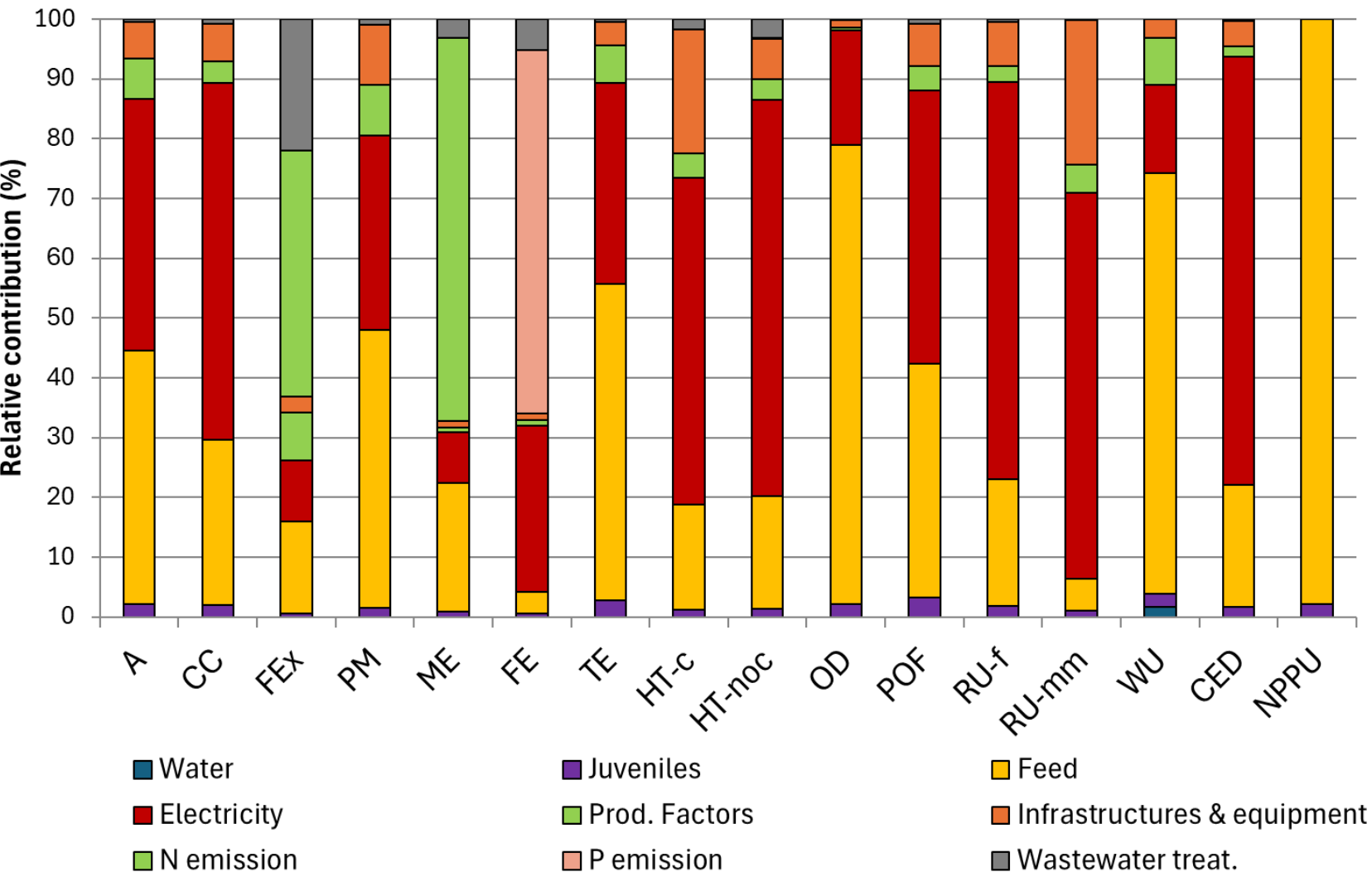
Carbon footprint from literature:

- Cao et al., 2011: 2.7-5.3 kg CO₂ eq;
- Al Eissa et al., 2022: 4 kg CO₂ eq;
- Sun et al., 2023: 4.41-4.97 kg CO₂ eq.



A: Acidification; CC: Climate change; FEx: Freshwater ecotoxicity; PM: Particulate matter formation; ME: Marine eutrophication; FE: Freshwater eutrophication; TE: Terrestrial eutrophication; HT-c: Human toxicity, cancer effects; HT-nc: Human toxicity, non-cancer effects; OD: Ozone depletion; POF: Photochemical ozone formation; RU-f: Resource use, fossils; RU-mm: Resource use, minerals and metals; CED: Cumulative energy demand.

Contribution analysis



Electricity is the main hotspot in most categories: 43% A, 60% CC, 66% RU-f OD, 66% RU-mm, 72% CED.

Feed represents the total of NPPU (98%), the 77% (OD) and «only» 28% of CC.

Infrastructures mainly affect PM (10%), HT-c (20%), RU-mm (24%).

N and **P** emissions impacts on FEX (42%), ME (64%) and FE (61%).

Discussion & conclusions

Shrimps rearing

- There is definitely a production scale effect;
- In any case, the percentage results of the contribution analysis are consistent with the literature;
- Room of improvements → electricity, oxygen, feed.



Clarias rearing

- Overall good environmental performance;
- The analysis can be extended to the fillet and all co-products (although data on their economic value would be required);
- Room of improvements → electricity, system expansion.



THANK YOU FOR YOUR ATTENTION

Michele Zoli

michele.zoli@unimi.it