This project receives funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 773330 (GAIN)

GAIN SUMMER SCHOOL

Beyond LCA EcoIntensificationSustainabilityIndex EISI

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WHAT IS SUSTAINABILITY?

"the management and conservation of the natural resource base, and the orientation of technological and institutional change in such a manner as to ensure the attainment and continued satisfaction of human needs for present and future generations. Such sustainable development (in the agriculture, forestry, and fisheries sectors) conserves land, water, plant and animal genetic resources, is environmentally non-degrading, technologically appropriate, economically viable and socially acceptable“, FAO

- **Environment**
- **Economy**
- **Social responsibility**
- **Animal welfare**

EcoIntensificationSustainabilityIndex – EISI

- Measure across 4 pillars of sustainability trade-offs of applying GAIN innovations

EISI Objectives

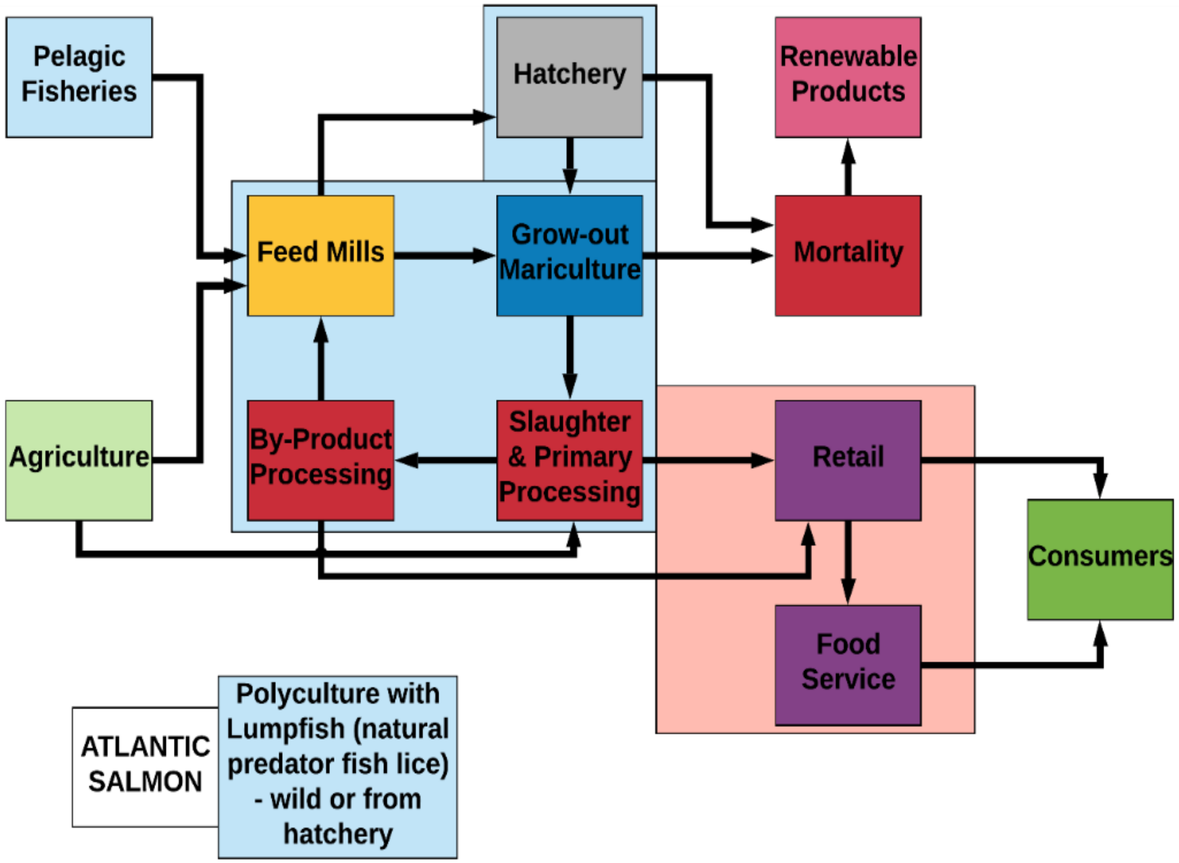
- The EISI is an overall measure of sustainability of GAIN innovations, benchmarked against industry norms
- Not just environmental sustainability but socio-economic and animal welfare evaluation too
- A series of sustainability indicators underpinned by LCA and compiled into a single index
- Stakeholder engagement to evaluate relevance of the index
- Transferable and comparable between systems

Why the EISI?

- Measure the trade-offs between environment, economic or social impacts
- On-farm or through the value chain?
- Local to consumers, regional, or global impacts?
- Retail and consumer organisations want more transparency over responsible sourcing of products
- Value chain actors want more traceability concerning sustainability

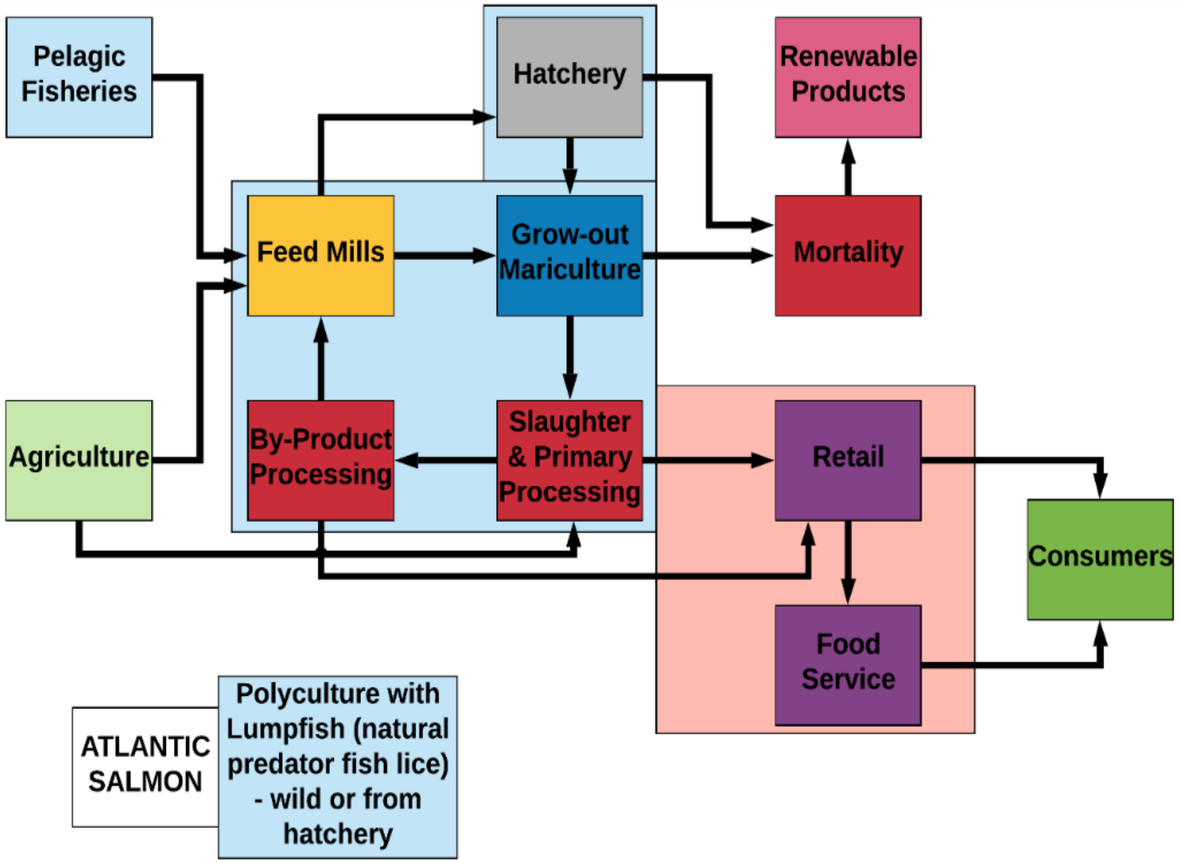
EISI approach - LCA/ VCA

- LCA – measures accumulated environmental impacts throughout a supply chain
- VCA – explores the relationships between different value chain actors and stakeholders and the movement of goods and services
- Related but difficult to integrate



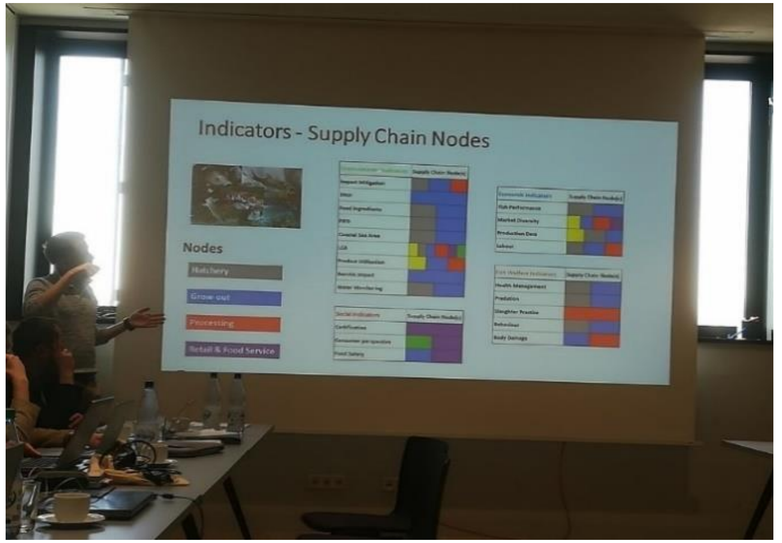
Value Chain Analysis

- Understanding of different parts of the value chain and how they interact
- Where are the bottle necks for growth/ eco-intensification?
- Who are the “lead firms” (Interest)
- Who drives innovation? (Power)
- Where is value added?



Development of the EISI Indicators

- Iterative development between UoS and UNIVE
- List presented at LCA/ VCA workshop, Bremerhaven Feb 2019
- Included GAIN partners from UK, Norway, Poland, Italy, Spain, Portugal
- Everyone provided with background knowledge on LCA and VCA methodology
- Discussed:
  - Structure of aquaculture value chains – define sample frame
  - List of provisional indicators
    - ease of data collection
    - relevance to the industry



Identify stakeholders

- Structured surveys (LCA)
- Semi-structured key informant interviews (VCA)
- Identify most important stakeholders for each

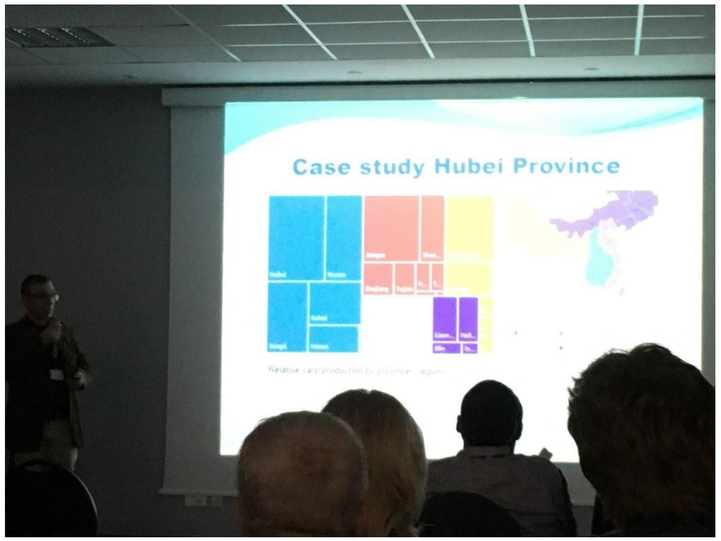
Stakeholder	VCA	LCA
Grow out	✓	✓
Hatcheries	✓	✓
Processors (1° and 2°)	✓	✓
Feed mills	✓	✓
By-product industry	✓	✓
Associations	✓	
R & D facilities	✓	
Distribution	✓	✓
Retail	✓	✓
NGOs	✓	
Academia	✓	

Structured survey vs KI interview

- Structured survey
  - Lists of questions and tables with “quantitative” answers
  - E.g. how much energy, water, raw material do you use?
- Semi structured KI interview
  - Open questions around themes within a conversation, mostly “qualitative” data
  - E.g. describe the legislative barriers to sustainable production What are the sustainability challenges in the industry?
  - Provide context to support quantitative data.

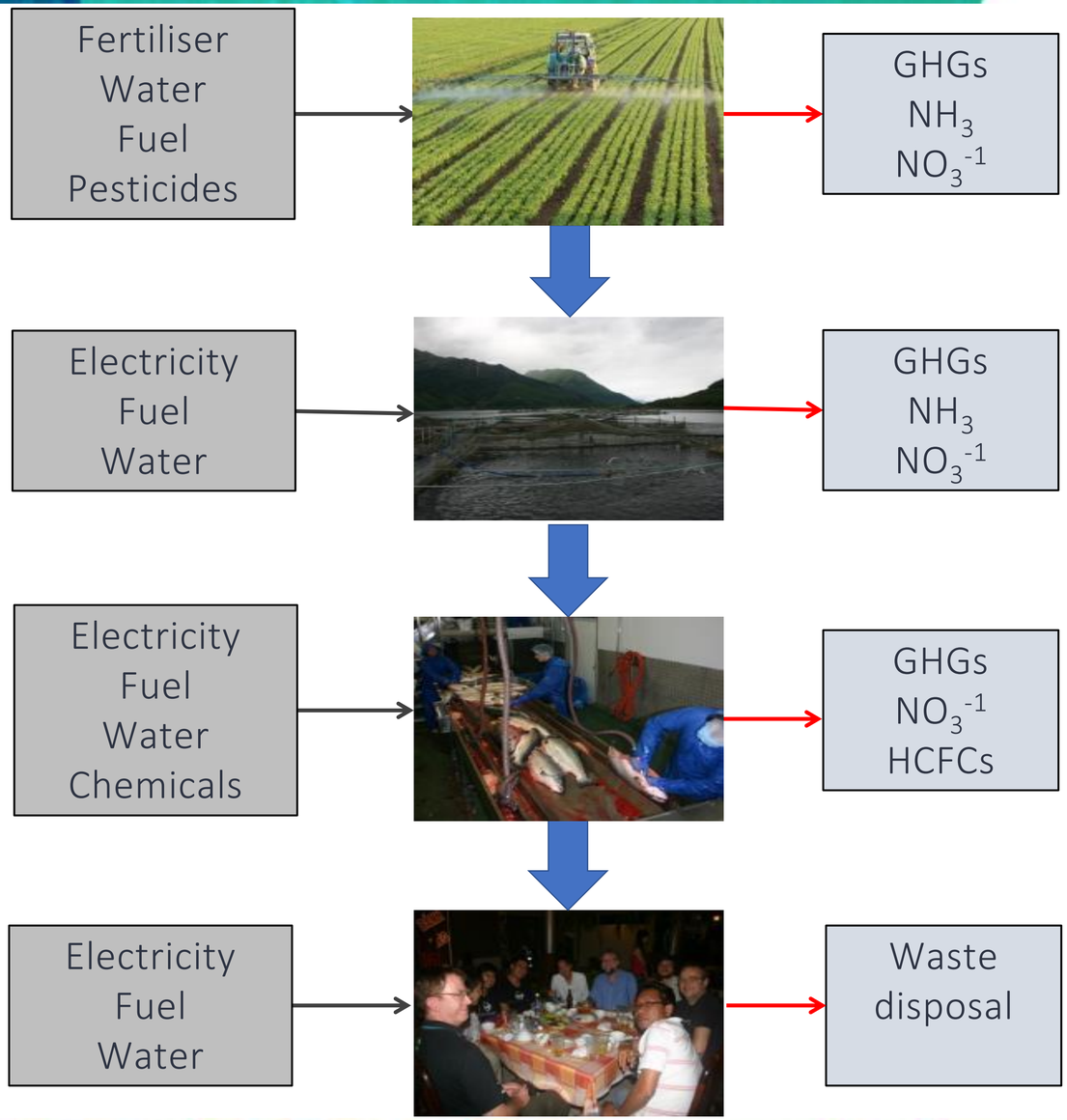
Creating trust

- Work with partners to identify key stakeholders; GIFAS, ZUT, UNIVE, AFBI
- Use their networks to engage with industry and wider stakeholders
- Prepare and pilot surveys
- Broaden surveys through “snowball” networking over extensive field work periods in-country



LCA Recap

- Environmental impacts do not just occur on the production unit
  - Feed ingredients
  - Feed processing
  - On farm production
  - Processing
  - Distribution
  - Consumption
  - Waste disposal
- All require land, water, raw materials and energy, and can lead to harmful emissions



GAIN goal – apply life cycle thinking to all sustainability issues

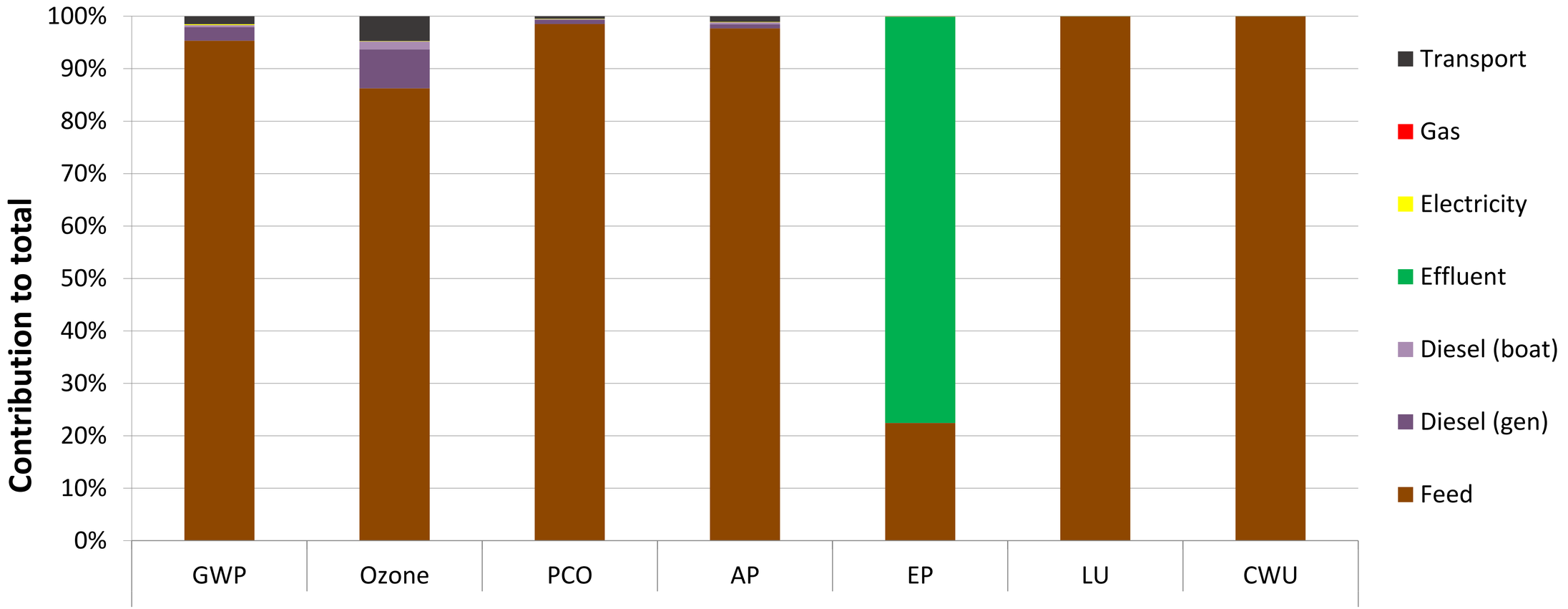
- Identify indicators that can be applied throughout the VC for social, economic and welfare impact
- Also a range of environmental indicators specific to aquaculture
- Reduce waste and encourage circular economy
- Solve challenges with quantification and characterisation
- Challenges of data availability over whole VC
- And relevance to all species

LCA impact categories are linked to the environment

- LCA can assesses the impacts over several environmental criteria
- Typically:
  - Global warming potential
  - Acidification potential
  - Eutrophication potential
  - Photochemical oxidant formation
  - ~~Aquatic/terrestrial/human toxicity potential~~
  - Cumulative energy use
  - Biotic resource use
  - Ozone depletion potential
  - Consumptive water use
  - Land use
  - Novel categories? E.g. Fish In Fish Out ratio

  - Include socio economic indicators bearing in mind characterisation challenges

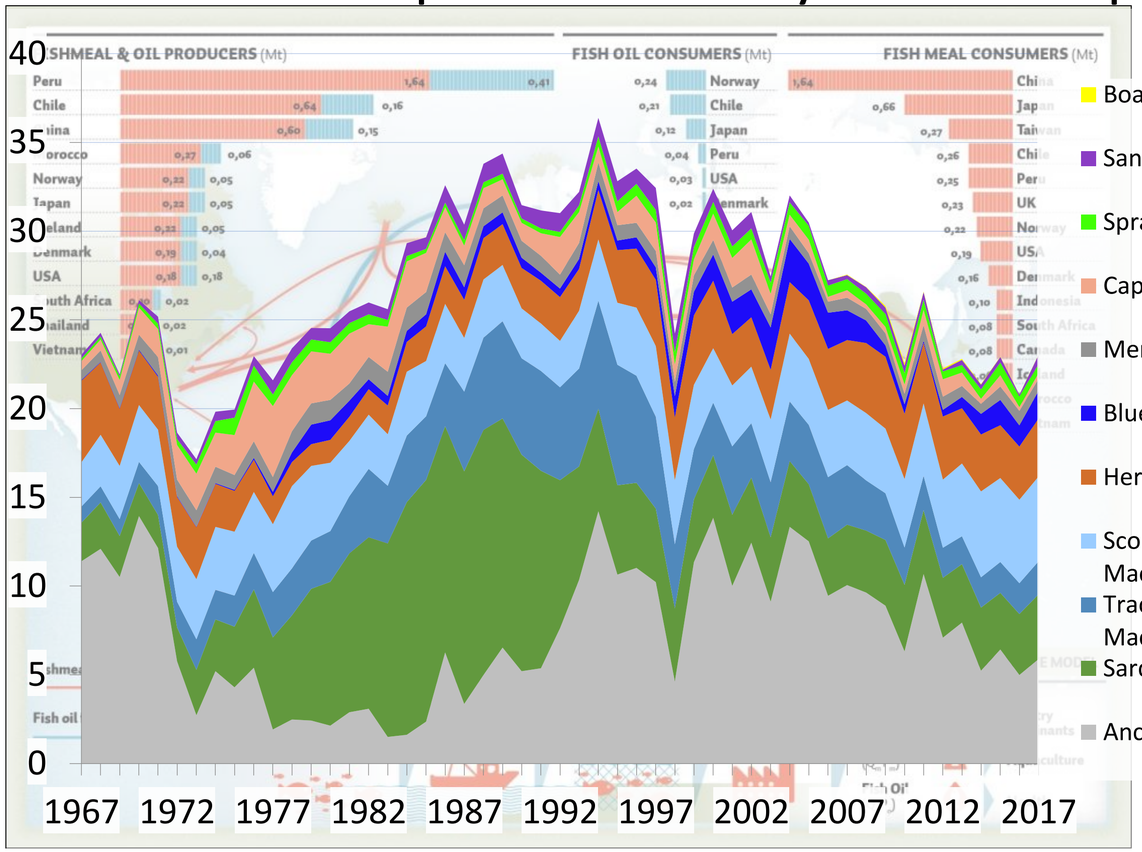
Most of the environmental impacts up to farm-gate are related to feed appropriation

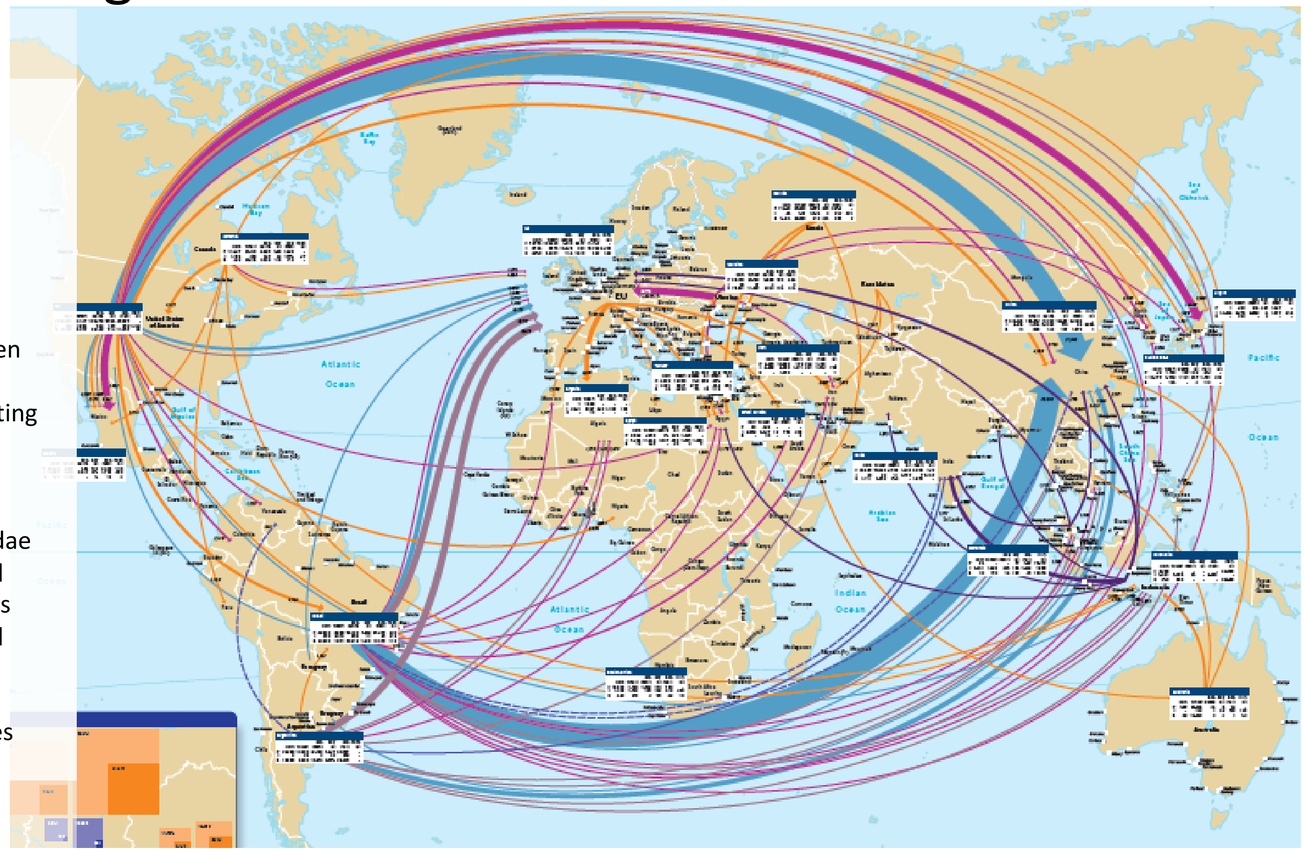


Newton and Little 2018, Mapping the impacts of farmed Scottish salmon from a life cycle perspective

Agri ingredient supply chains are global!

- Aquafeed requirement for marine ingredients
- All livestock dependent on soy and other plant ingredients



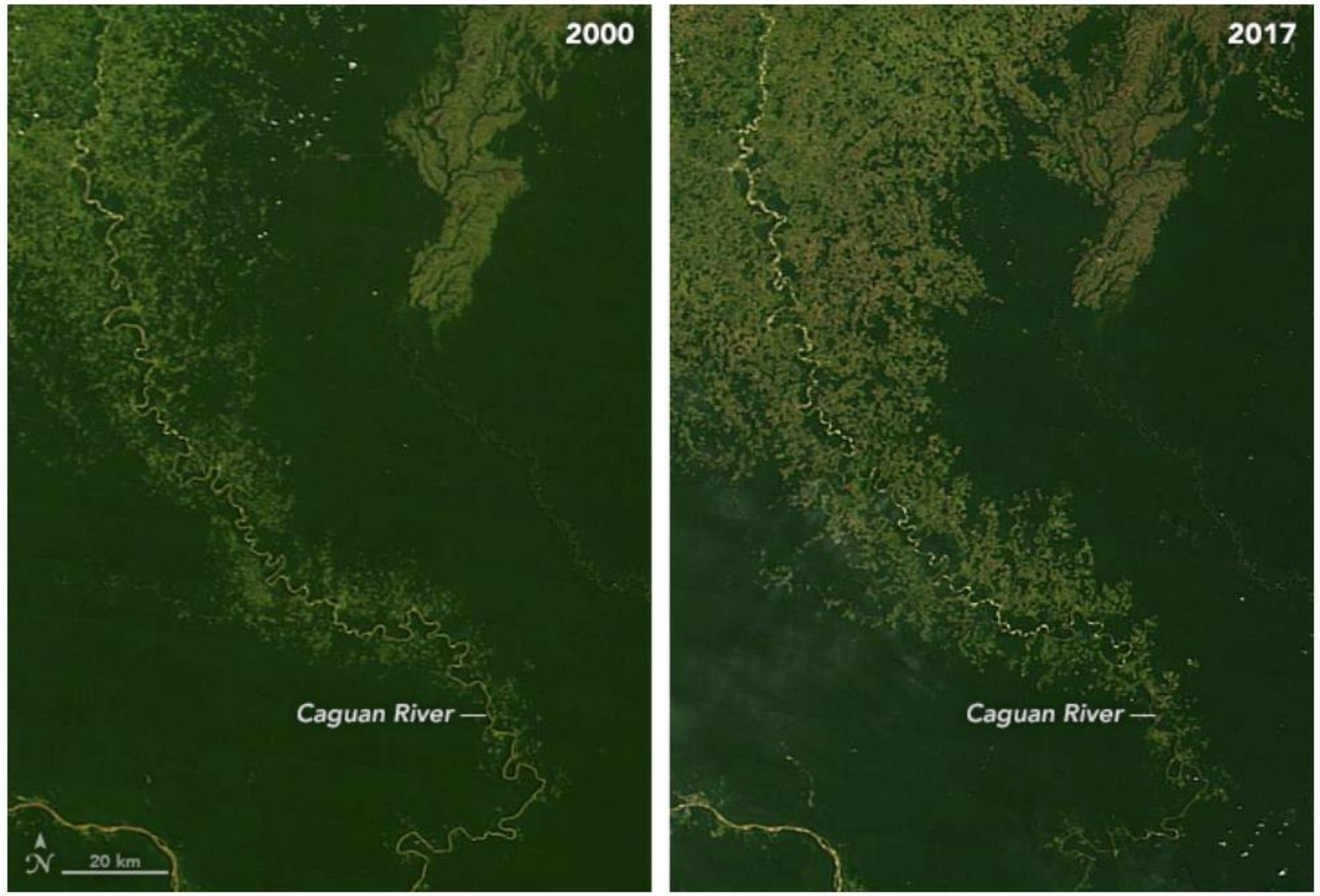


Merino *et al* 2010

https://research.rabobank.com/far/en/sectors/grains-oilseeds/grow-with-the-flow.html

Sustainability of marine ingredient substitutes?

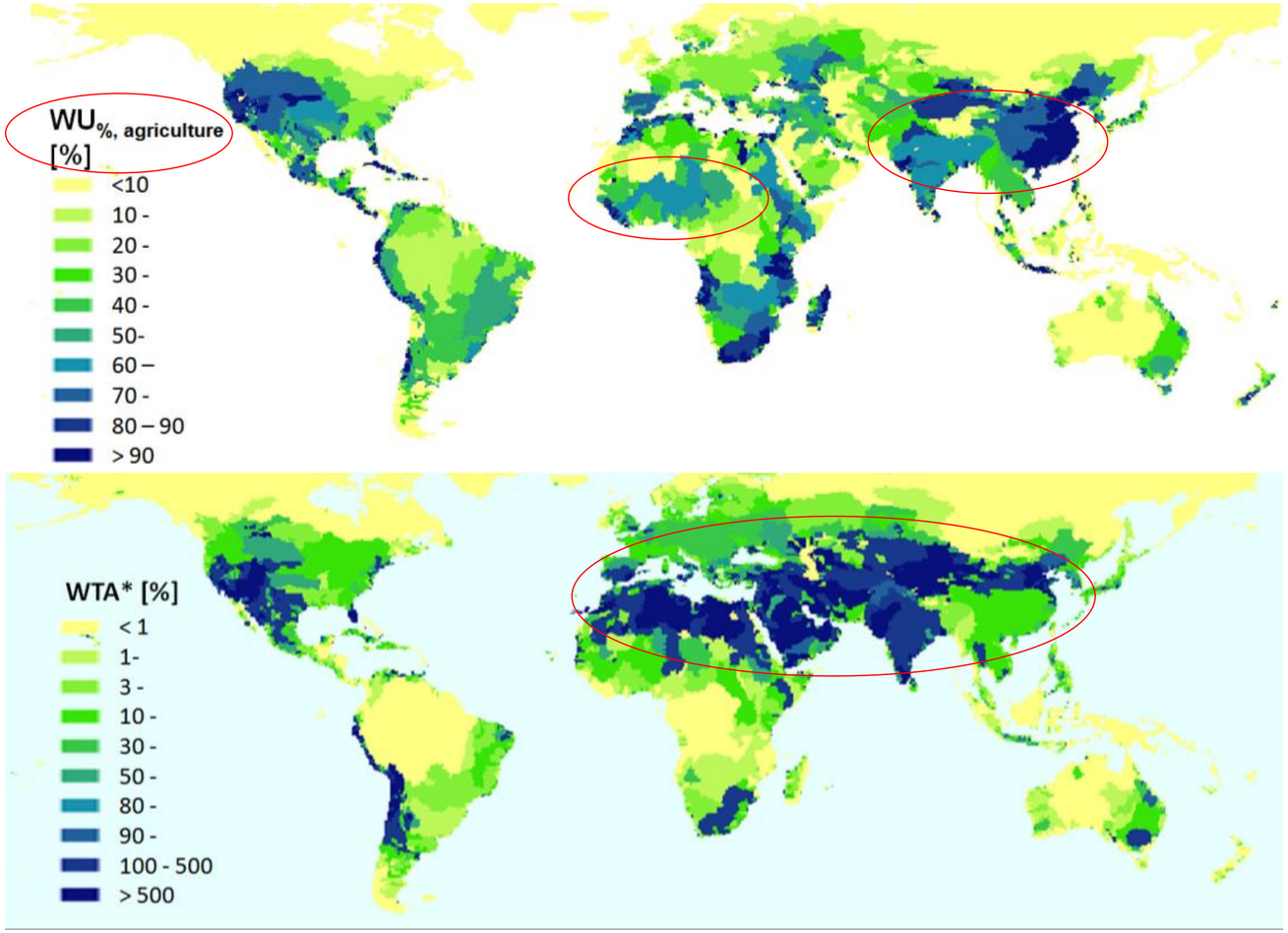
- Much of US soy is GM
- EU and other markets demand non GM
- Soy implicated as major driver of deforestation in sensitive habitats



Land use change in Brazil from 2000 to 2017 linked to soyabean and cattle ranching (source: Nasa accessed 8/5/21)

Freshwater use

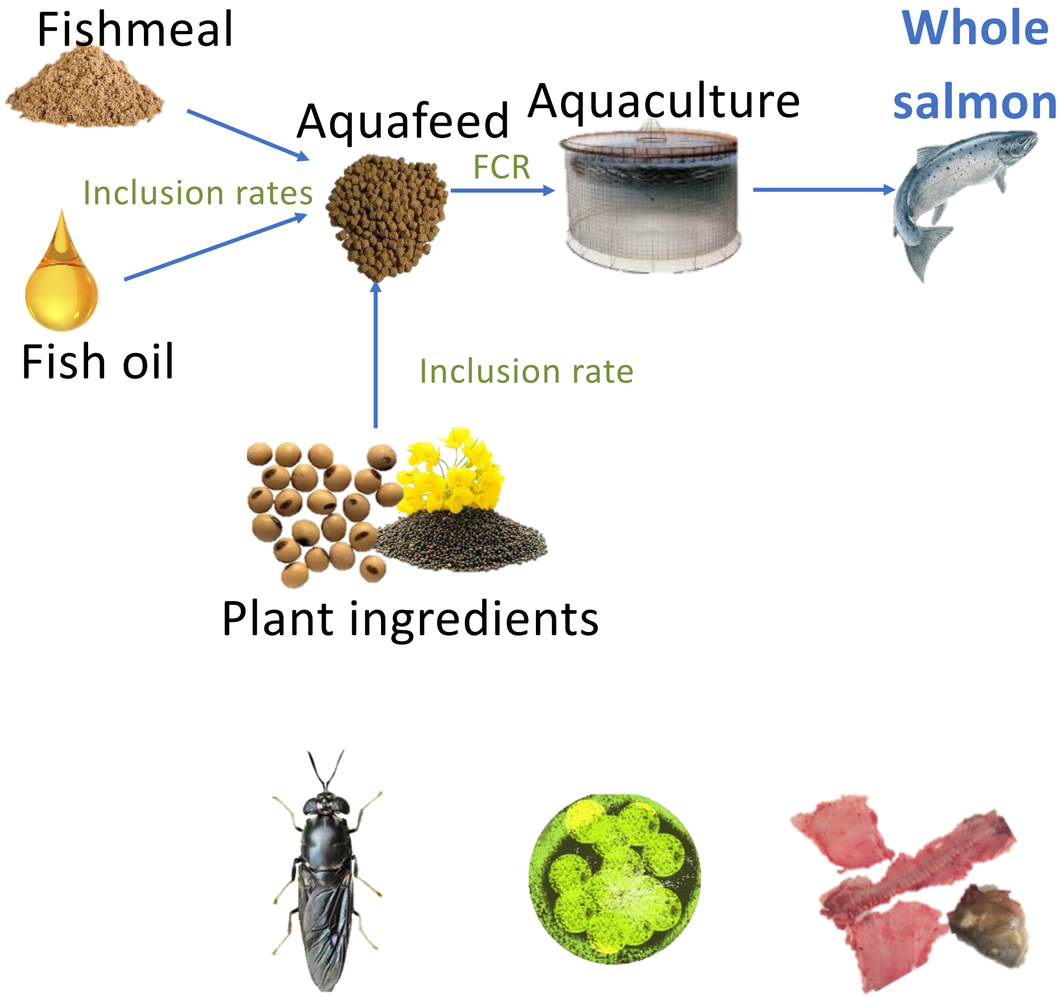
- Many areas extracting more water than is recharged
- Mostly used for agriculture
- Leads to salinisation, sanitation problems, drought, other environmental and public health issues



a) % Water used for agriculture, b) Global water scarcity factor (WTA*); extraction to availability.
Source: Pfister *et al* 2011

Feed often contributes to most environmental impacts

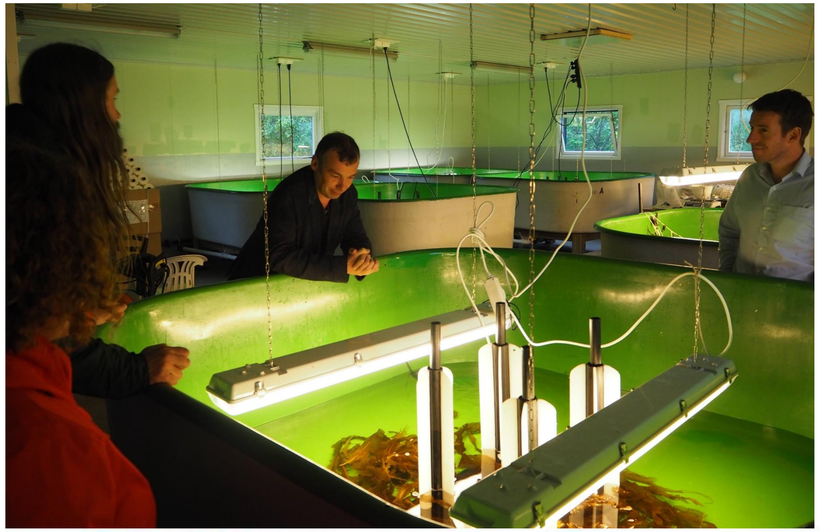
- In most fed aquaculture production systems, feed contributes to >95% of carbon, water and land footprints
- It is imperative to be efficient with the use of feed, i.e. reduce FCRs
  - Reduce mortality/disease, improve delivery, nutrition, management, genetics etc.
- …and to procure feed ingredients from sustainable and responsible sources
- Ever increasing pool of ingredients on the market
- Policies and sustainability credentials are not always clear



What about other sustainability issues?
SOCIAL and ECONOMIC

Consider:

- Sensitivity of data (especially economic)
- Qualitative or quantitative?
- Ability to collect through value chain
- A lot of LCA data is from literature but socio-economic literature data for entire VC?
- Still often limited to aquaculture farm
- Pilot/ trial data not representative
- Transferable between species and systems



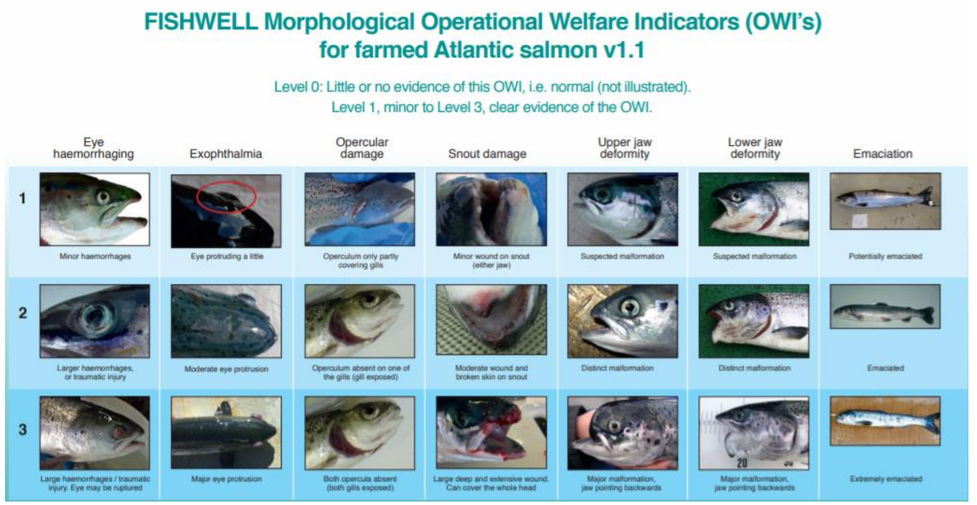
EISI sustainability Indicators – semi-quantitative and qualitative data

- Checklists – weighted % of VC actors meeting requirements – e.g. processing quality assurance, health management
- Amount of value chain that is certified (BAP, ASC, GlobalGAP etc)
- Is there an employee risk assessment? % of industry
- Amount of product going to human food, animal feed, others
- Diversity of products
- Slaughter method

OTHER INDICATORS WELFARE (Dr. Sonia Rey)

Indicator criteria:

- Measurable: in a quantitative way preferably, mainly by SCORING SYSTEM
- Comparable between species and different production systems
- Non-invasive
- Easy to evaluate by farm staff and non disruptive of normal husbandry procedures
- Representatives for the 5 domains (5 freedoms): environment, health, nutrition, behaviour, emotional states



https://www.barfblog.com/2017/09/sea-lice-threatening-salmon-production/

EISI sustainability Indicators

After screening, a final list was established

Economic

Indicators about the economic efficiency of aquaculture (12):

- eFCR
- Fish rejection at processing
- Input Efficiency and Cost Ratio
- Mortality, kg%
- Innovation value addition
- Market diversity
- Etc

Environmental

Indicators from LCA (7):

- Global Warming Pot.
- Acidification Pot.
- Eutrophication Pot.
- Land Use
- Etc

Other Indicators (12):

- Fish-in-fish-out (FIFO)
- Chemicals Use
- Benthic impact
- Etc.

Social

Indicators about the working conditions in aquaculture facilities (7):

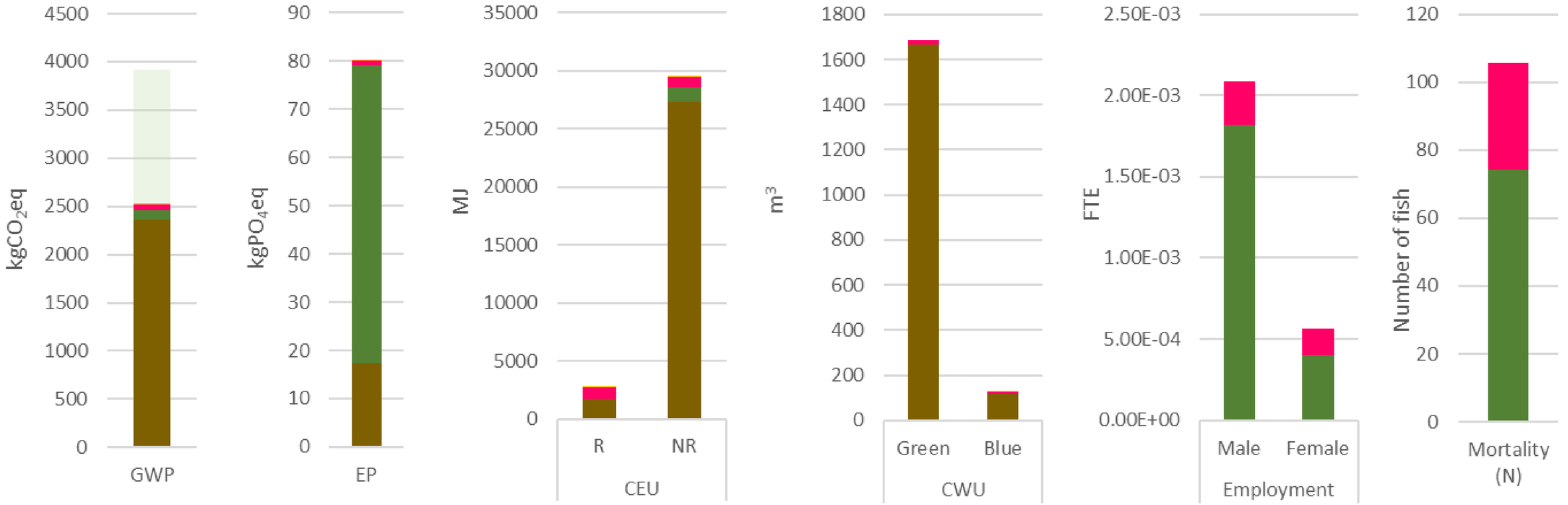
- Labour structure
- Wage structure
- Employment (FTE eq)
- Labour effort/output
- Employee risk and Safety
- Certification
- Etc

Fish Welfare

Indicators about treatment of animals on far and at slughter (12):

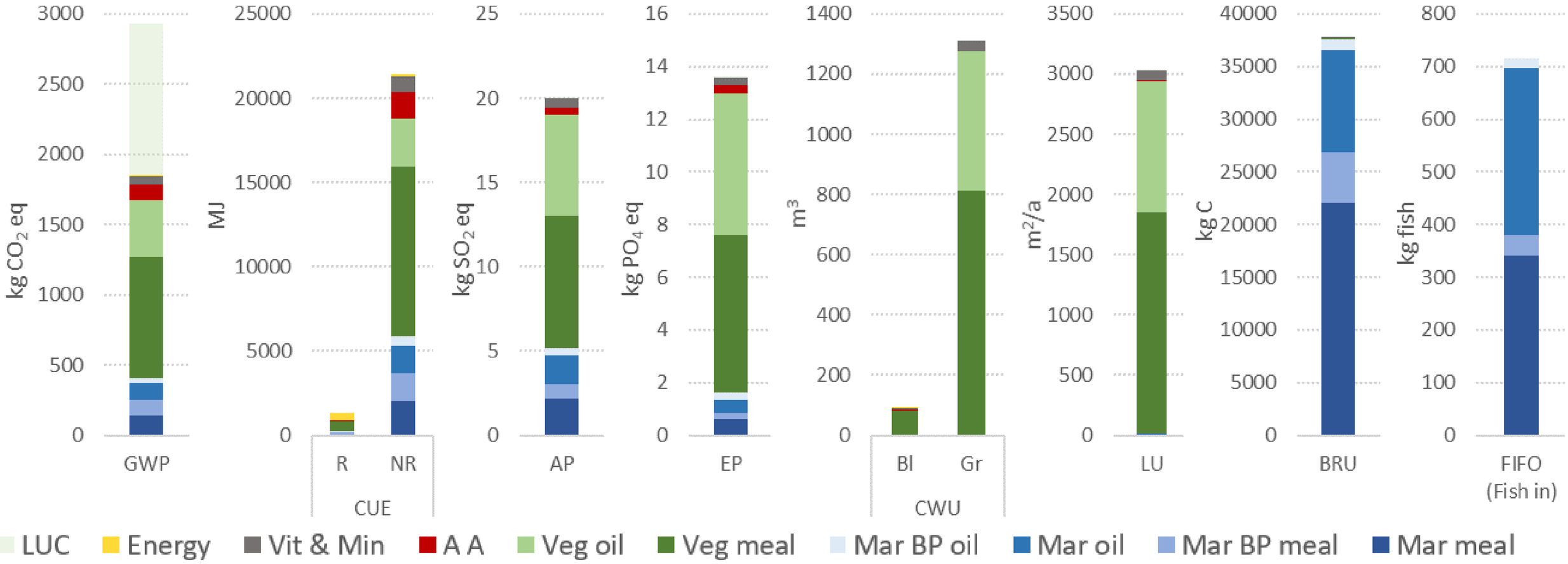
- Active body damage observation
- Mortality, number
- Predation prevention
- Stocking density
- Growth rate
- Slaughter practice score
- Etc

EISI examples – 1 tonne salmon at farm industry benchmark



GWP – Global Warming Potential, EP – Eutrophication Potential, CEU = Cumulative Energy Demand (Renewable and Non-Renewable), CWU – Cumulative Water Use (Green and Blue), LUC – Land Use Change

EISI sustainability Indicators examples – 1 tonne salmon feed



GWP – Global Warming Potential, CEU = Cumulative Energy Demand (Renewable and Non-Renewable), AP - Acidification Potential, EP – Eutrophication Potential, CWU – Cumulative Water Use (Green and Blue), LU – Land Use, BRU – Biotic Resource Use, FIFO – Fish In: Fish Out, LUC – Land Use Change, A A – Amino Acids, Mar – Marine

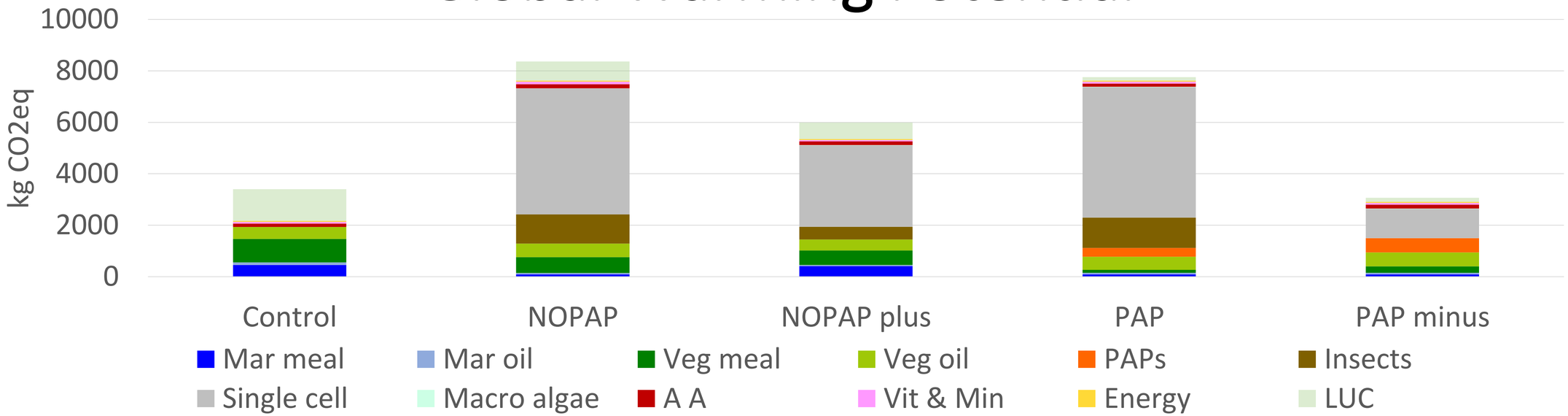
NOVEL INGREDIENT FEED TRIALS

- Nutrition trials for all GAIN species, e.g. salmon

	CTRL	NOPAP	PAP	NOPAP+	PAP-
Mar meals	**17**	**2**	**2**	**17**	**2**
Mar oils	7	3.5	3.5	3.5	3.5
Veg meals	**50.98**	**38.66**	**19.41**	**37.73**	**30.34**
Veg oils	20.5	21.55	20.35	20.05	21.35
PAPs	**0**	**0**	**21.5**	**0**	**34.75**
Insects	**0**	**12.5**	**12.5**	**6.25**	**0**
Single cell	**0**	**14.55**	**14.65**	**9**	**1.75**
Macro algae	0	1.8	1.8	1.8	1.8
AAs	1.5	1.72	1.27	1.85	1.64
Vits and mins	3.03	3.73	3.03	2.83	2.88
Total	100	100	100	100	100
FCR	1.10	1.18	1.03	1.22	1.22

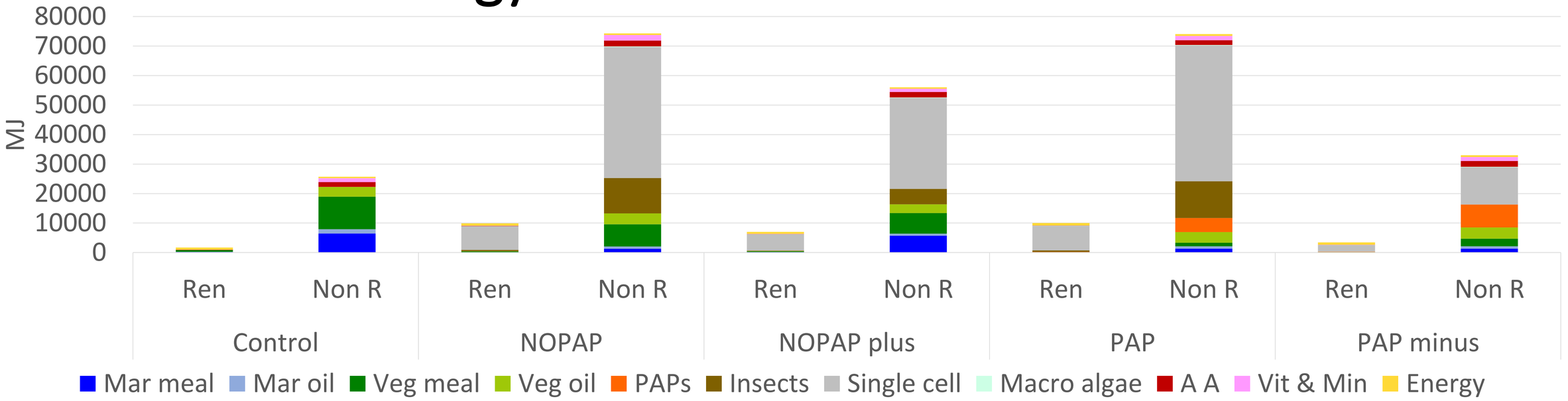
- Assessment relates to fish production and the Feed Conversion Ratio (FCR) for each feed

EISI sustainability Indicators – 1 tonne salmon from trial feeds
Global Warming Potential



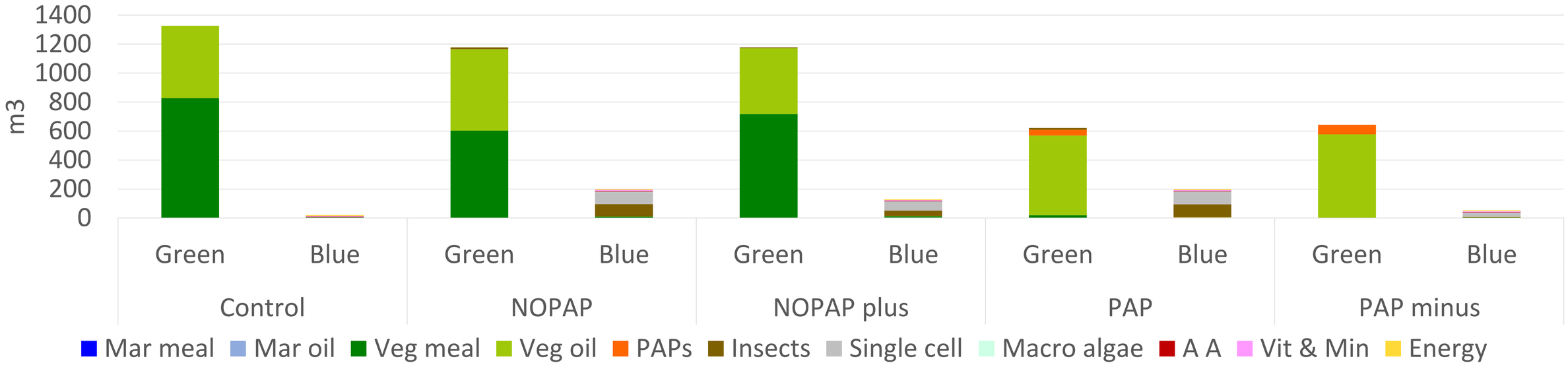
- GWP generally higher than control for trial diets
- Only PAP minus is comparable to control when including LUC
- Single cell (micro algae protein and oil) are large contributors

EISI sustainability Indicators – 1 tonne salmon from trial feeds
Cumulative Energy Use – renewable and non-renewable



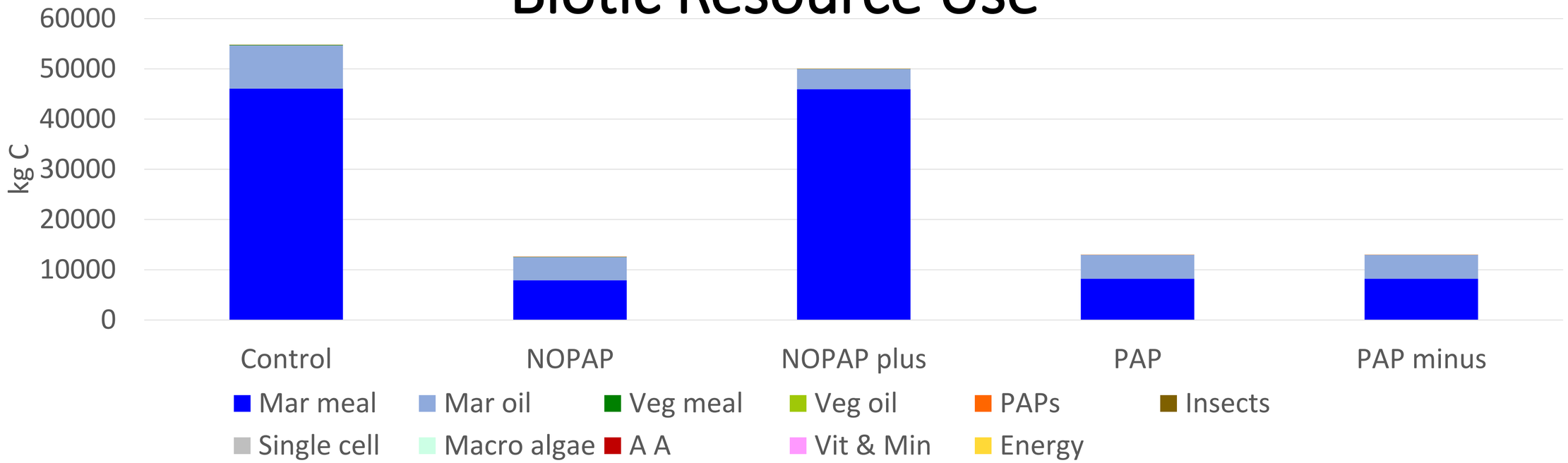
- GWP is related to high CUE for single cell proteins and oils
- Majority of energy is still non-renewable
- Energy requirement for insects is also high

EISI sustainability Indicators – 1 tonne salmon from trial feeds
Consumptive Water Use – “Blue” and “Green”



- Blue water is abstracted, green water is precipitation
- Novel ingredients require more abstracted water than plant ingredients
- Marine ingredients require almost no water

EISI sustainability Indicators – 1 tonne salmon from trial feeds
Biotic Resource Use



- BRU is an approximation of Net Primary Production appropriation through the food chain
- Each trophic level is estimated to be an order of magnitude higher in C content than the one below, e.g. a carnivorous fish, trophic level 4 is 10000 x higher than a primary producer
- Related to marine ingredients, although some BRU impacts result from LUC

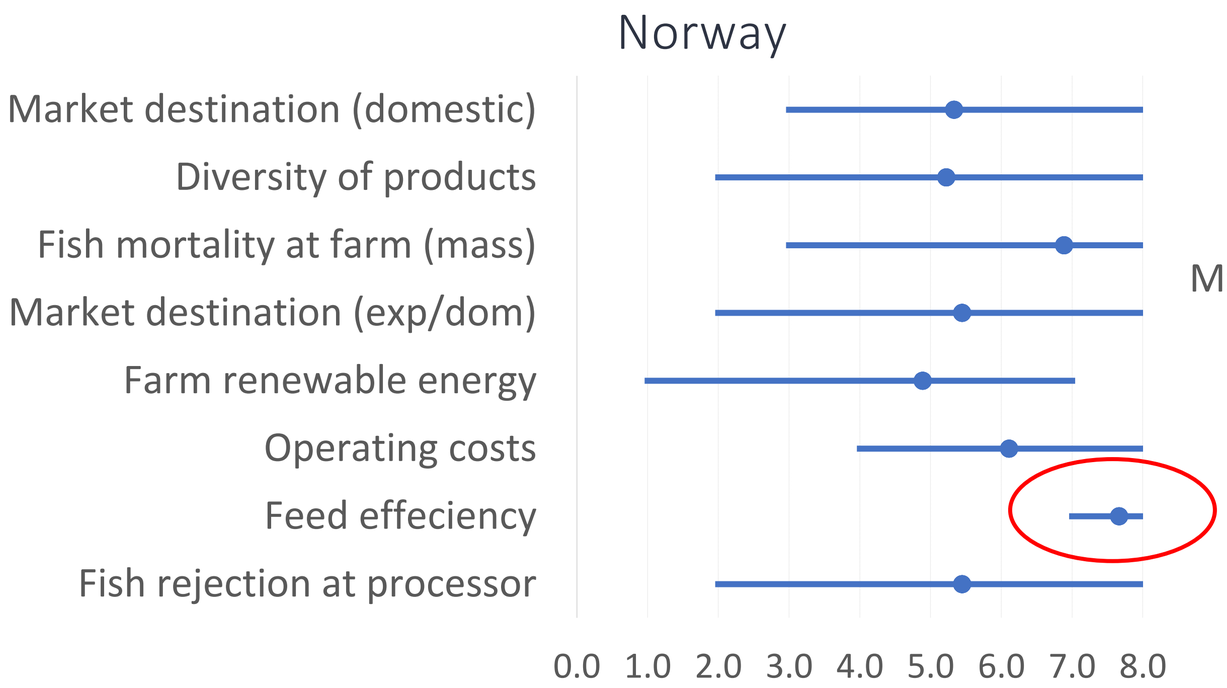
STAKEHOLDER ENGAGEMENT

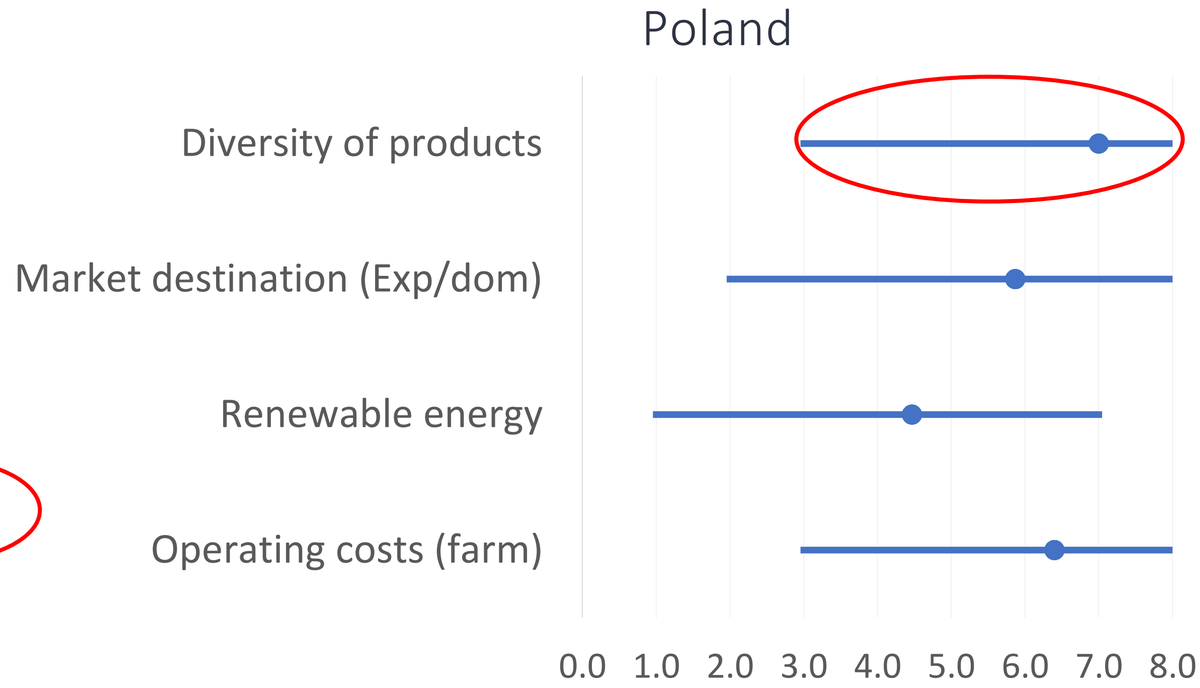
- Part of the Value Chain Analysis
- Used to help weight and group indicators to assemble the index
- What sustainability indicators are most relevant?
- To species, system and different parts of the VC
- Stakeholders asked to score relevance of indicators 1 to 8

- …but are stakeholders informed enough about the whole VC?

STAKEHOLDER ENGAGEMENT

- Economic

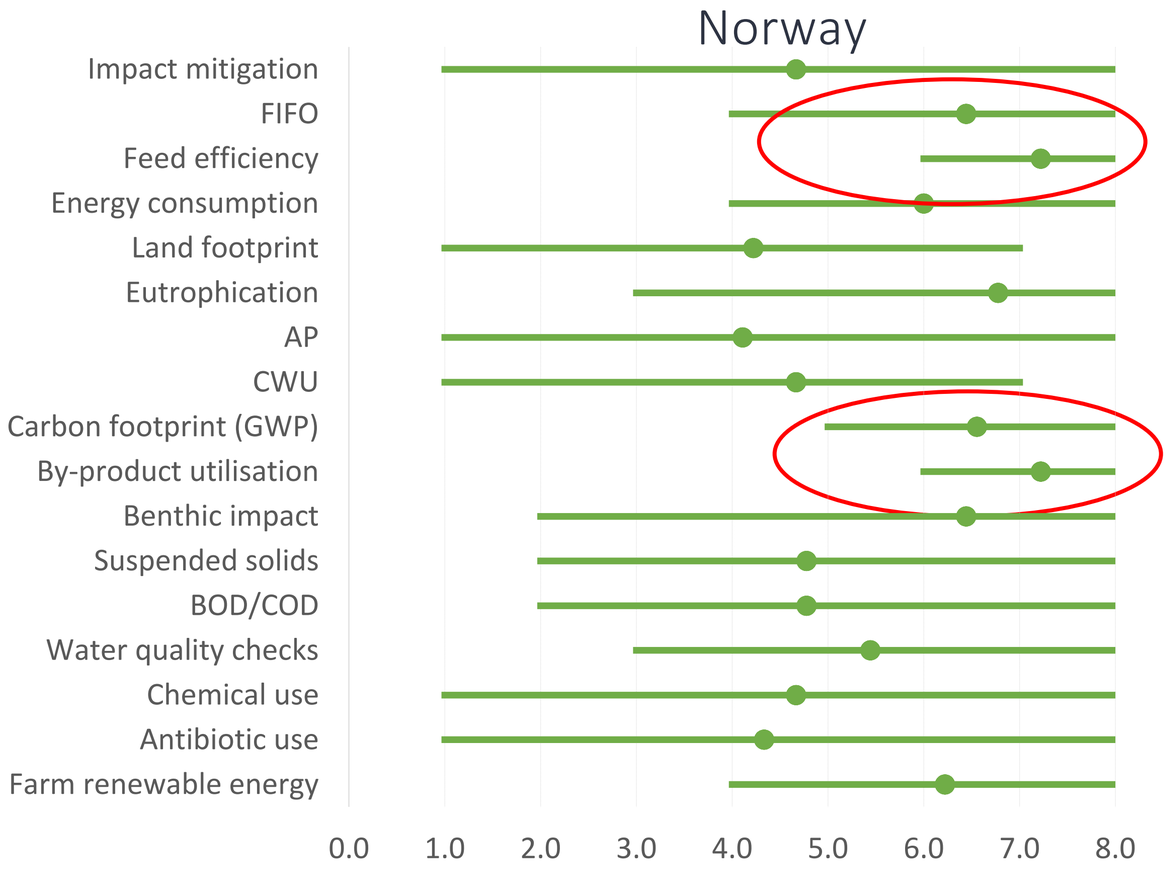


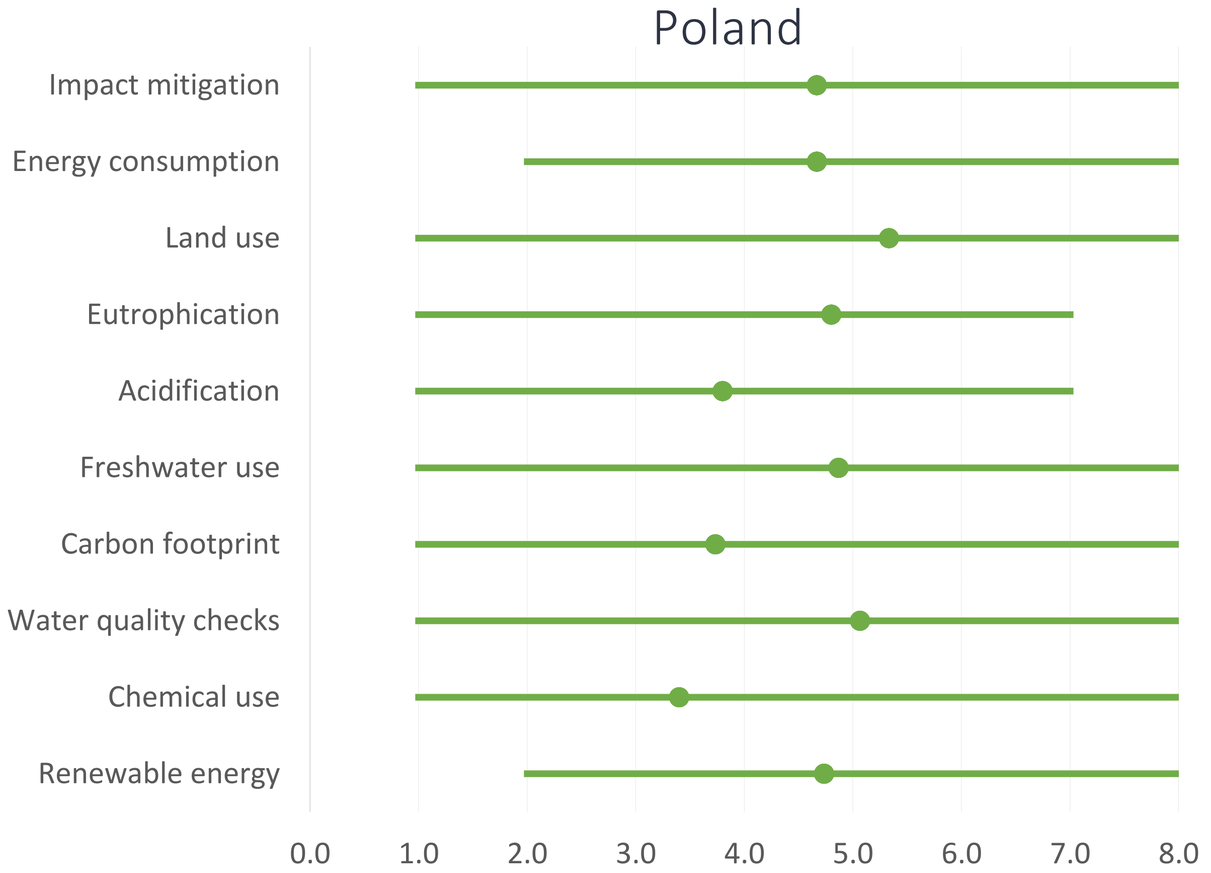


- Fewer data for Poland – relevance/ lack of data

STAKEHOLDER ENGAGEMENT

- Environment





- By-product use, FIFO, Feed, Energy, Benthic impact and Eutrophication in Norway

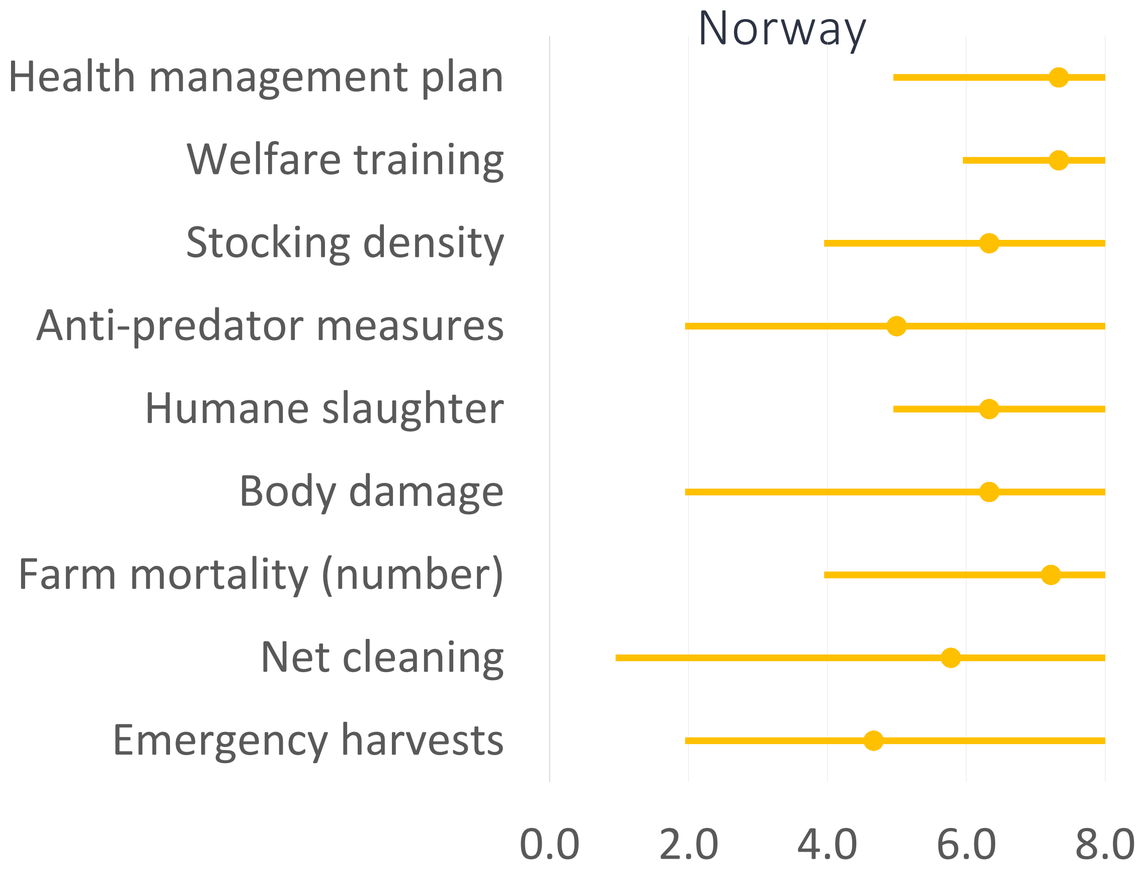
STAKEHOLDER ENGAGEMENT

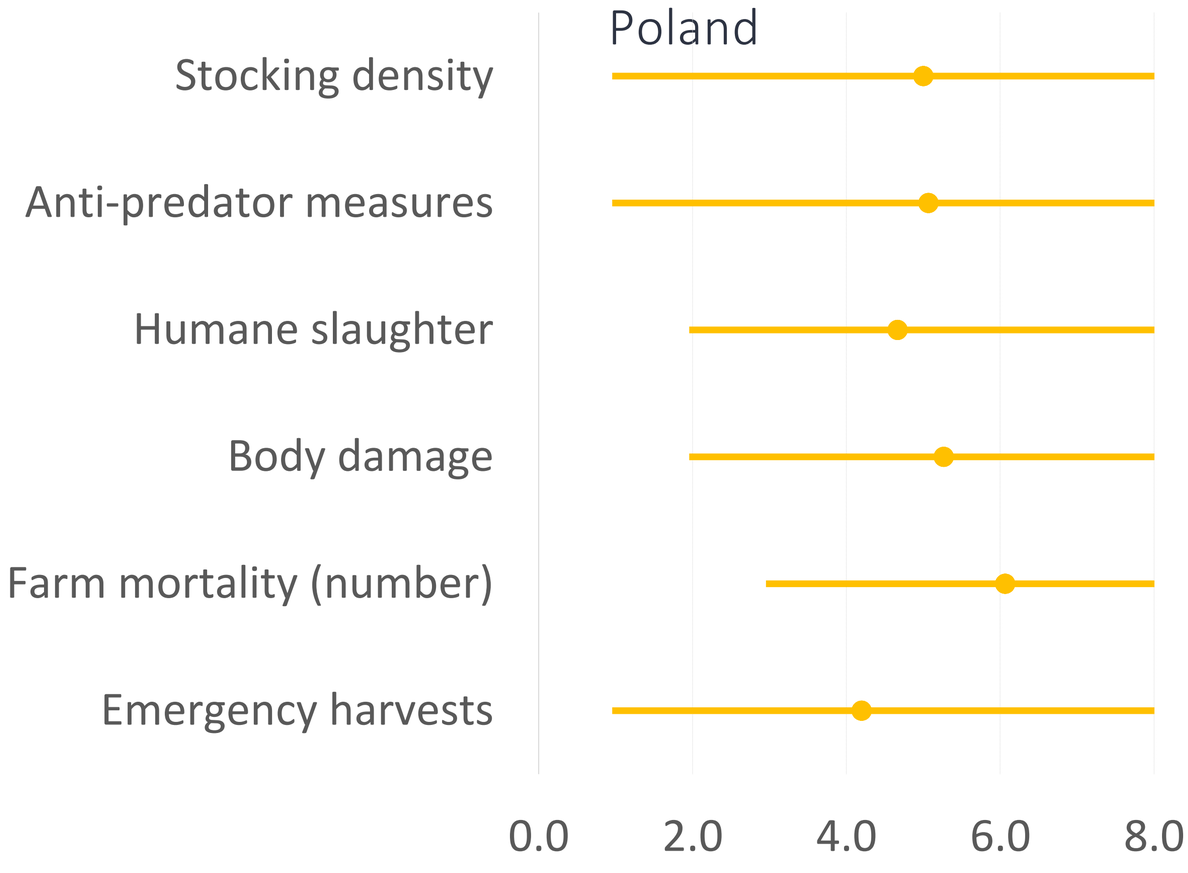
- Social

- Exposure to hazards and appropriate measures in Norway

STAKEHOLDER ENGAGEMENT

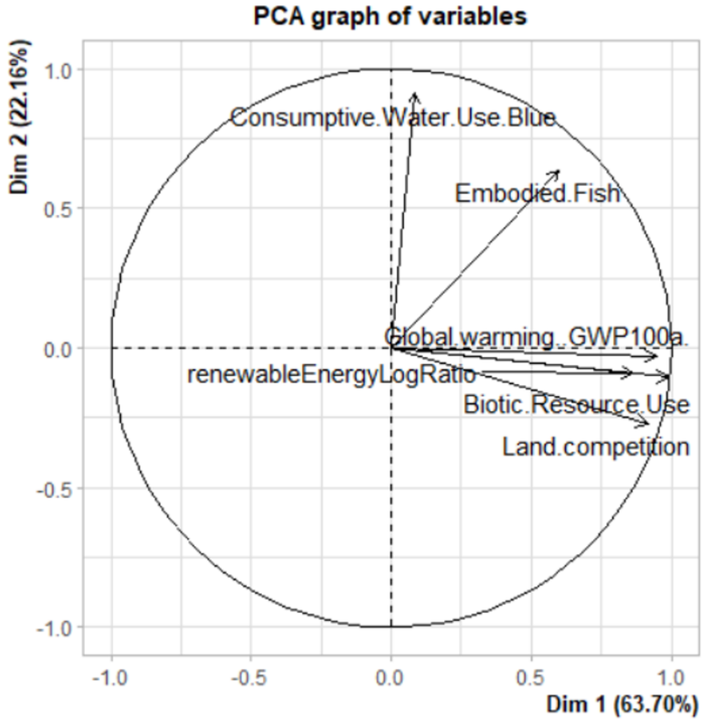
- Welfare

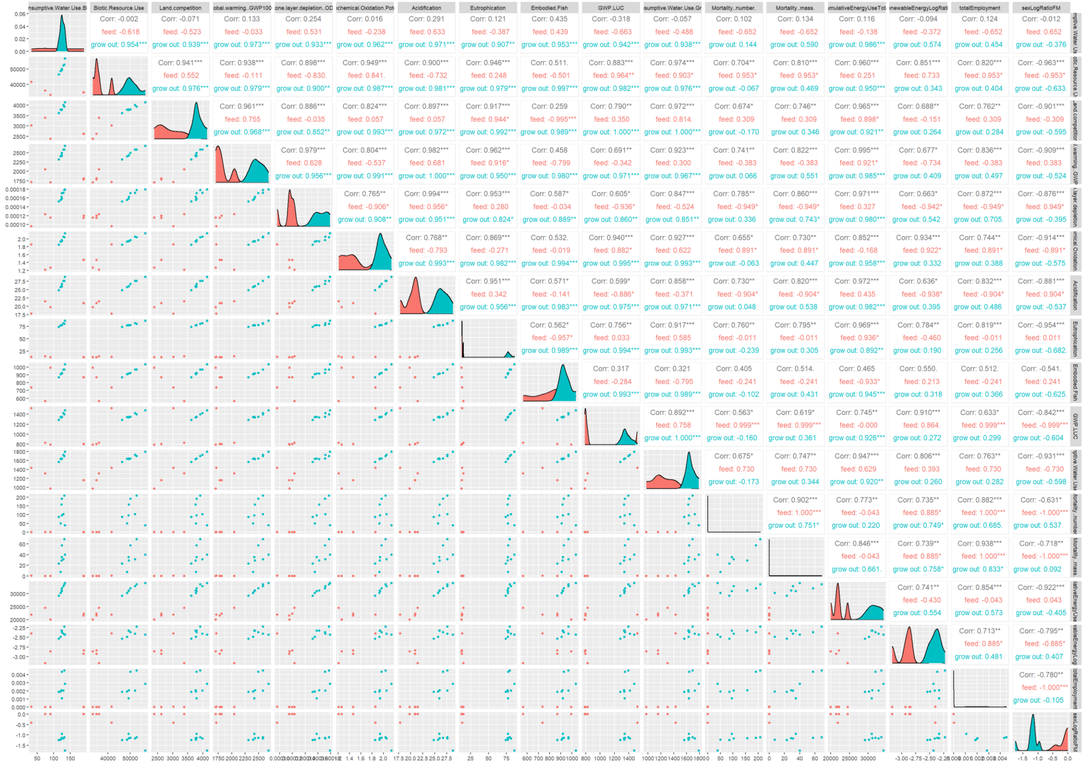




- Welfare issues are considered much more important in Norway

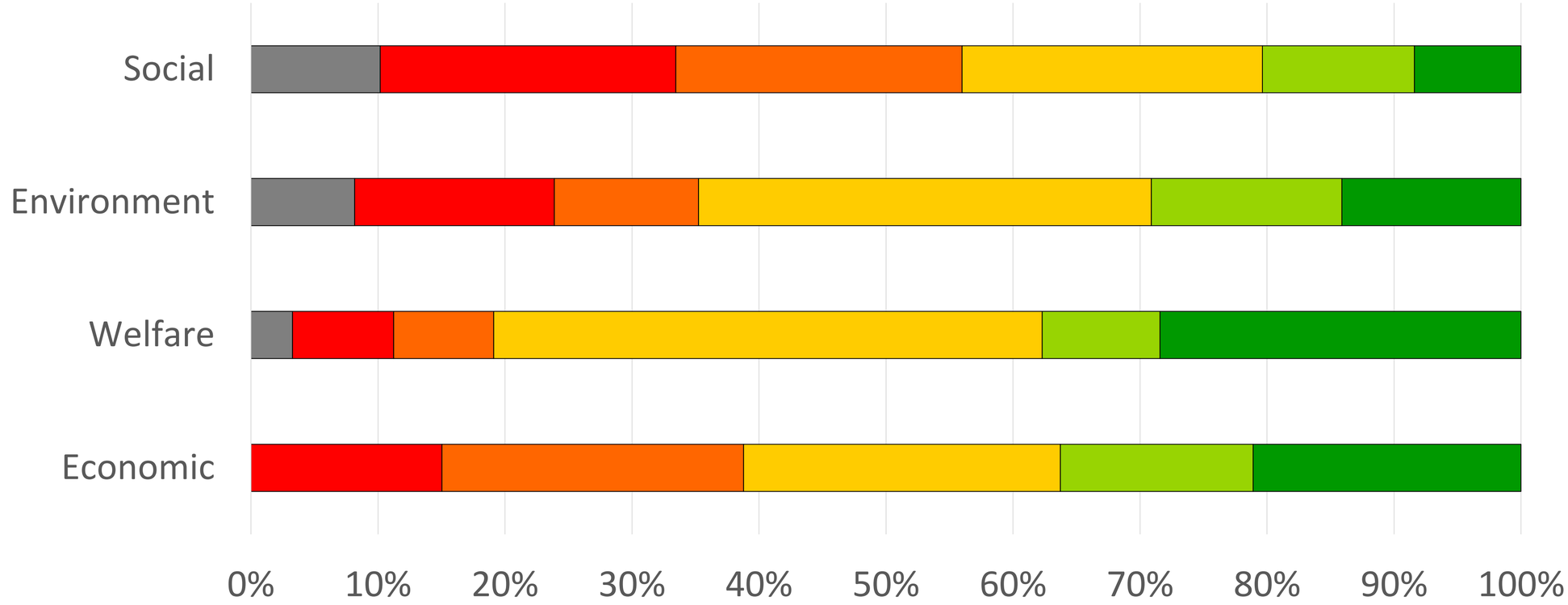
CORRELATION and PCA





- Testing the linkages between indicators using PCA and sensitivity analysis
- Together with stakeholder scores will be used to weight indicators and remove duplication before compilation into the index

How the final index will look



- Series of traffic lights indicators for each species
- Will be able to compare between the different sustainability aspects within and between species

Take home messages

- Sustainability is a lot more than just the environment
- LCA provides a useful framework for developing value chain wide sustainability assessments
- There are many trade-offs between different innovations
- Difficult to obtain data for the whole value chain for some aspects and produce indicators that can be applied consistently
- Aquaculture is extremely diverse – not all indicators are relevant to all systems/ species
- Indices must reflect the differences between systems and species

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