

BARRIERS AND OPPORTUNITIES FOR SAFE TECHNOLOGY ADOPTION

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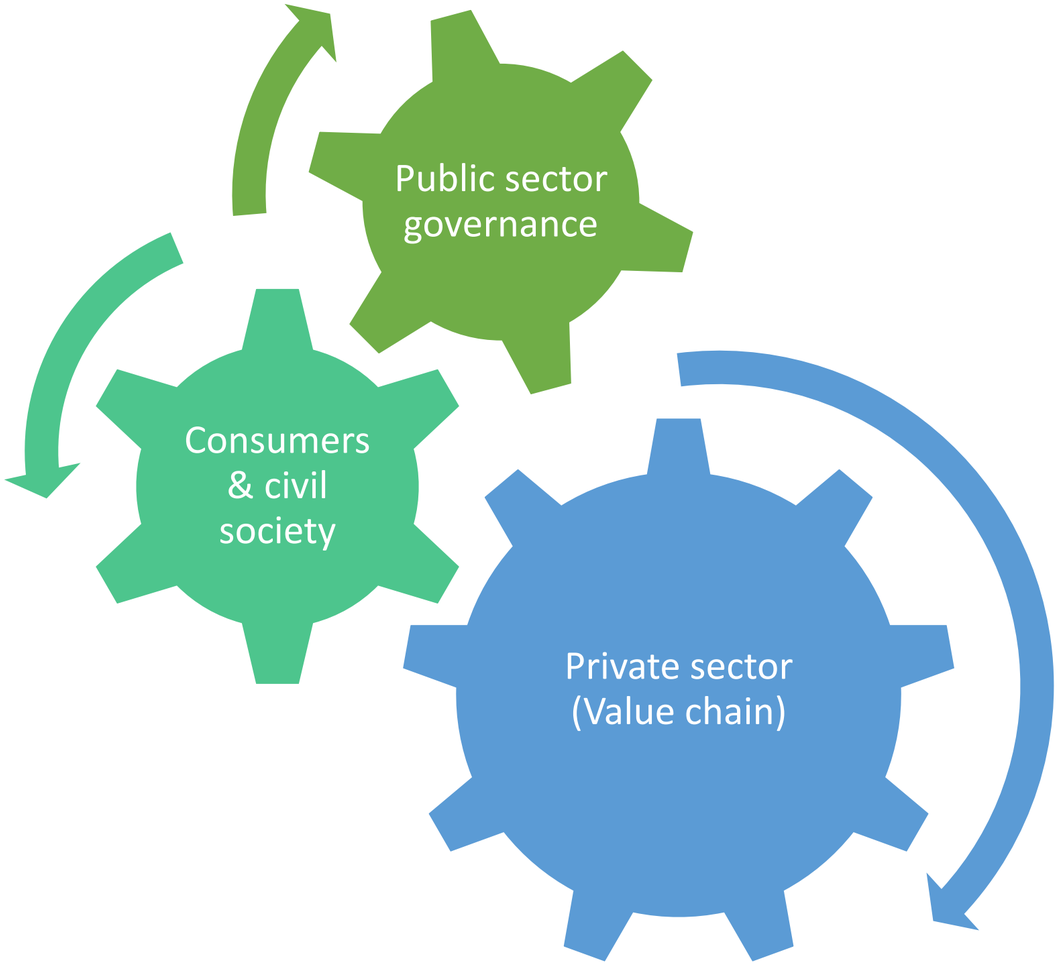
Presentation sources



- D5.1 Report on value chain analysis of European freshwater aquaculture systems
- D5.3 Report on economic models for sustainable aquaculture systems
- D5.5 Report on consumers' perception of freshwater aquaculture system (FWAS) products
- D6.4 SAFE and beyond' strategy with exploitation route map setting out ambitions, and identifying priorities and partners

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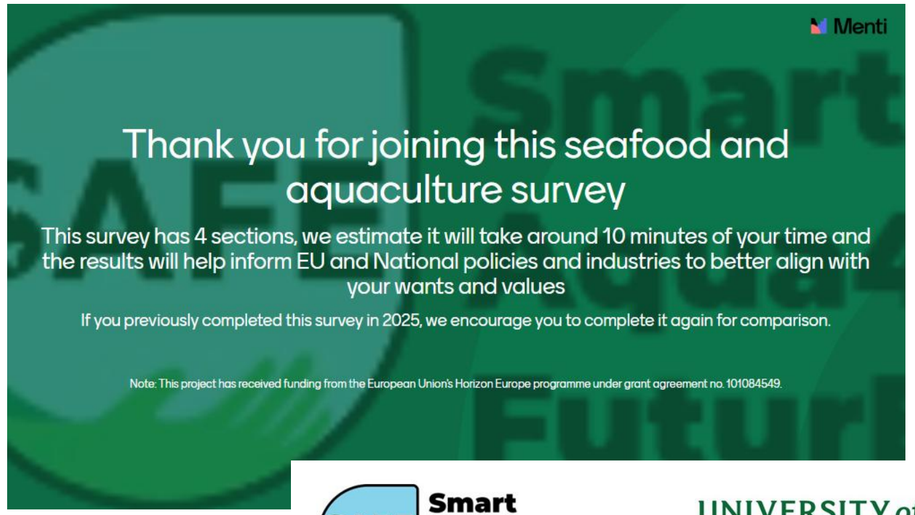
Stakeholder viewpoints

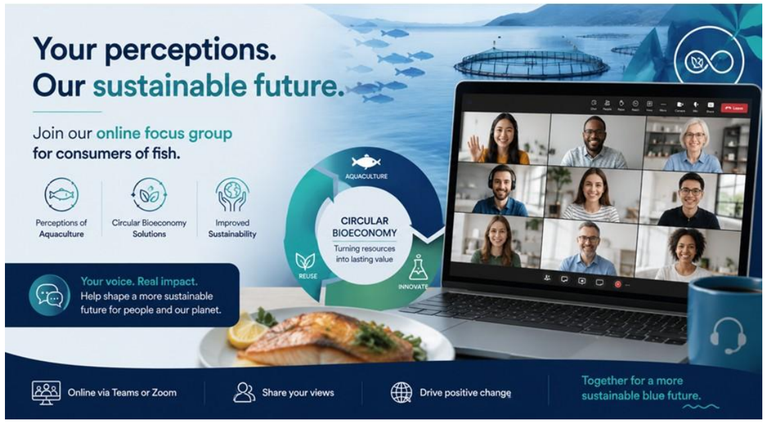


- Aquaculture and other commercial activities are interlocked with the consumer market and all that influences consumer behaviour and with governance bodies that regulate and tax their activities
- Improving sustainability through technical innovations requires an understanding of these linkages and where there may be potential enablers of change

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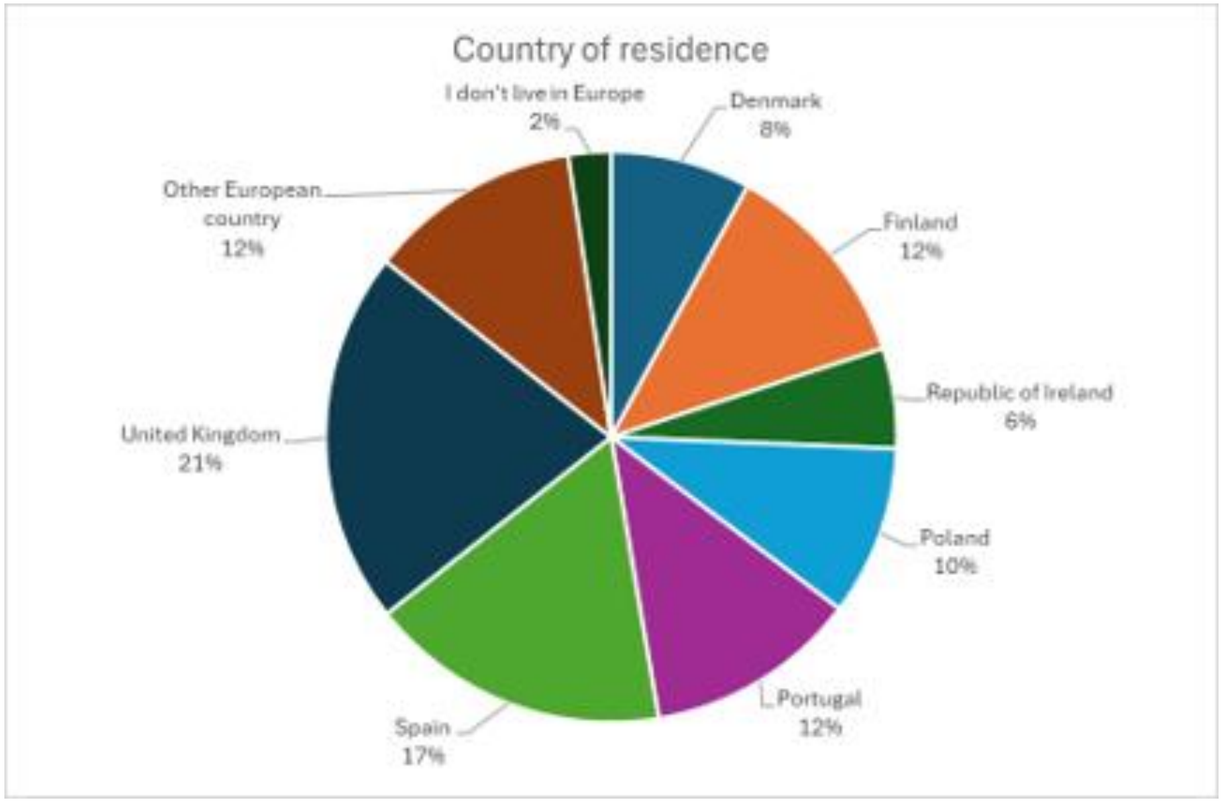
Consumer perspectives

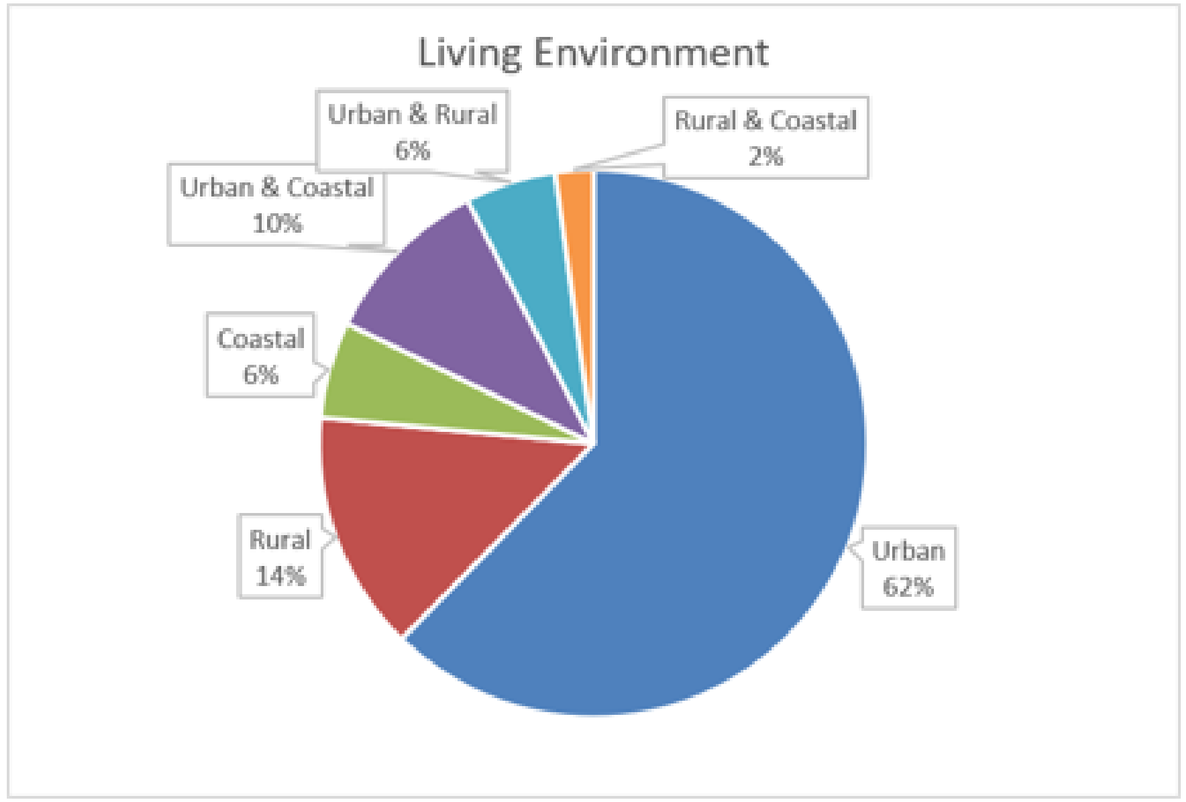




- Online survey in six languages conducted in 2025
  - Exploration of consumption habits and attitudes to aquaculture products and sustainability issues
- Focus groups held more recently in Finland, Ireland, Poland, Portugal and UK
  - Deeper understanding of motivations and influences driving consumer choices

Survey response and demographics – 592 in total





Good spread of nationalities

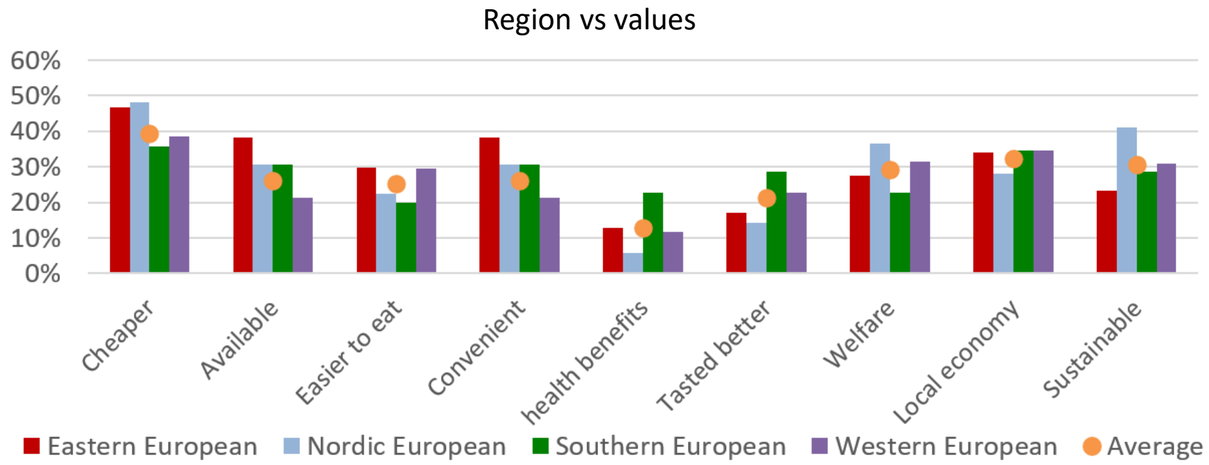
Most respondents were from cities

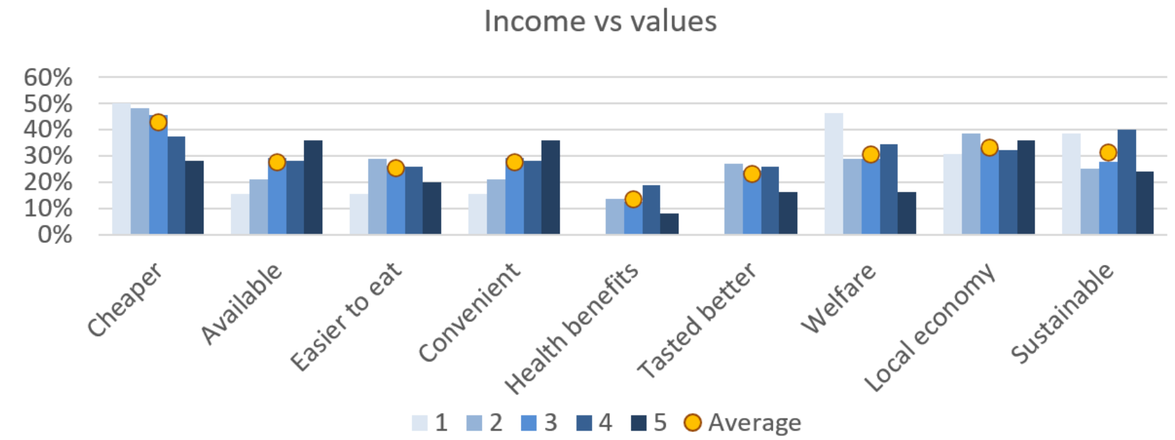
Respondents by language

	English	Finnish	Polish	Portuguese	Spanish	Swedish	Grand Total
Number	290	47	56	73	104	22	592
Percent of total	49%	8%	9%	12%	18%	4%	100%

Consumer values

- Price is key motivating factor
- Welfare, sustainability and support for the local economy all important factors
- Health benefits were not a high motivating factor but focus groups showed food safety was a concern

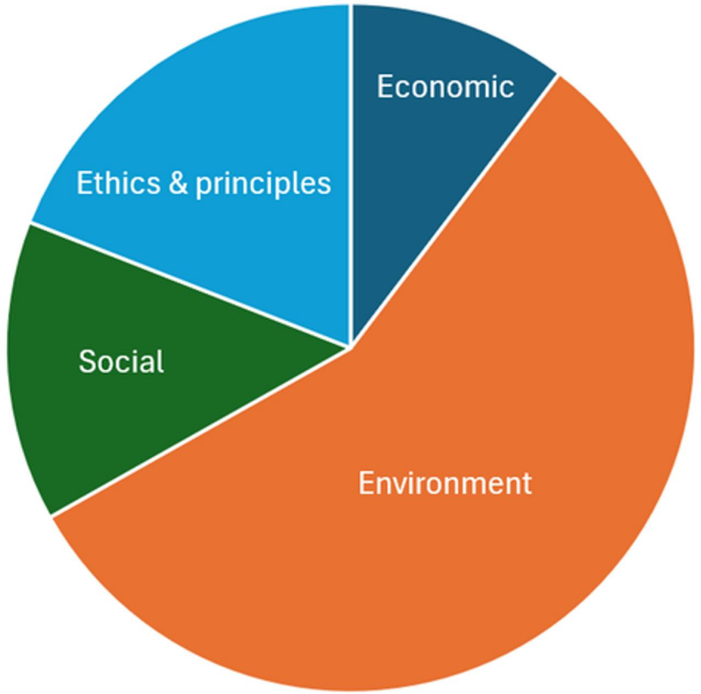




Note: Incomes were self- assessed from 1 (low) to 5 (high)

Consumer understanding of sustainability

- Sustainability did not emerge as a major concern in the focus groups, although more so in Northern European countries
- Environmental issues most mentioned, especially over-fishing, habitat destruction and pollution
- Animal welfare was perceived as a sustainability issue and was the most often mentioned ethical concern
- The issue of trust emerged as a key issue in the focus groups – consumers lacked knowledge and were uncertain about who they could trust

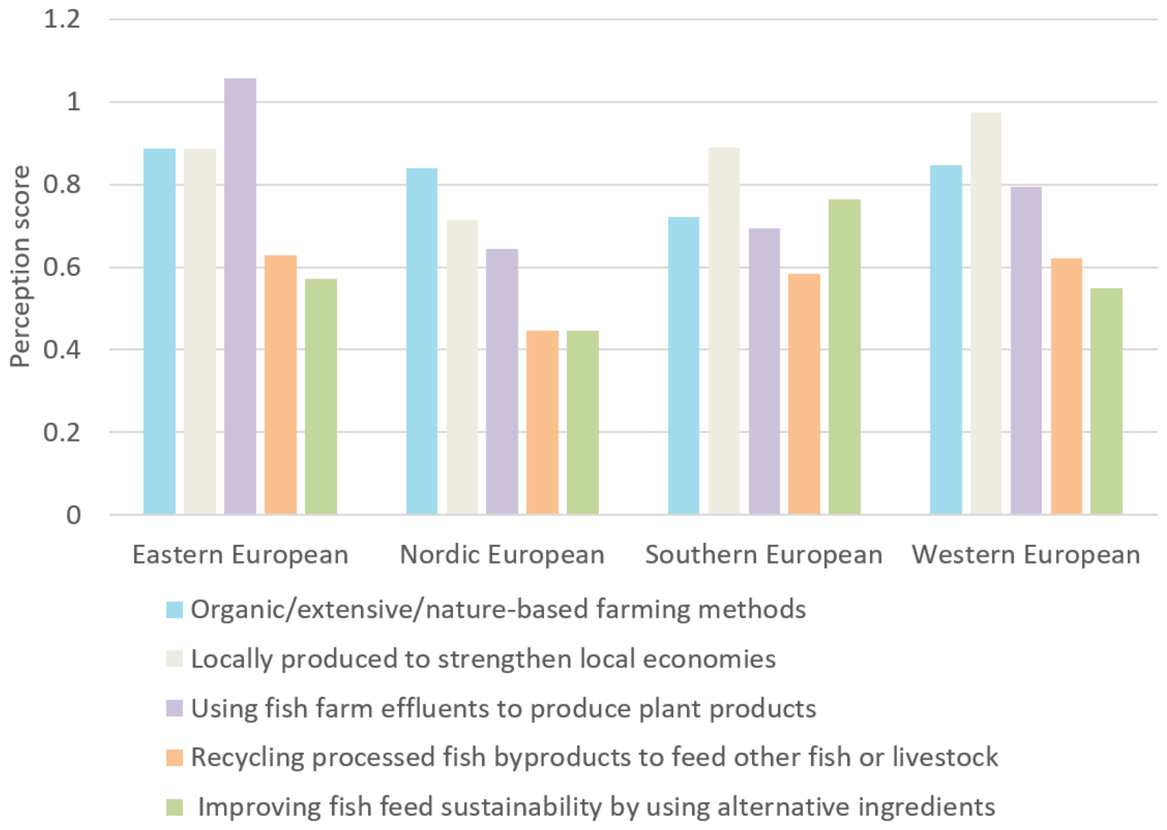


Note: Proportions based on the number of mentions of these themes in free text answers to “what is sustainable seafood to you?”

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Consumer views on sustainability solutions

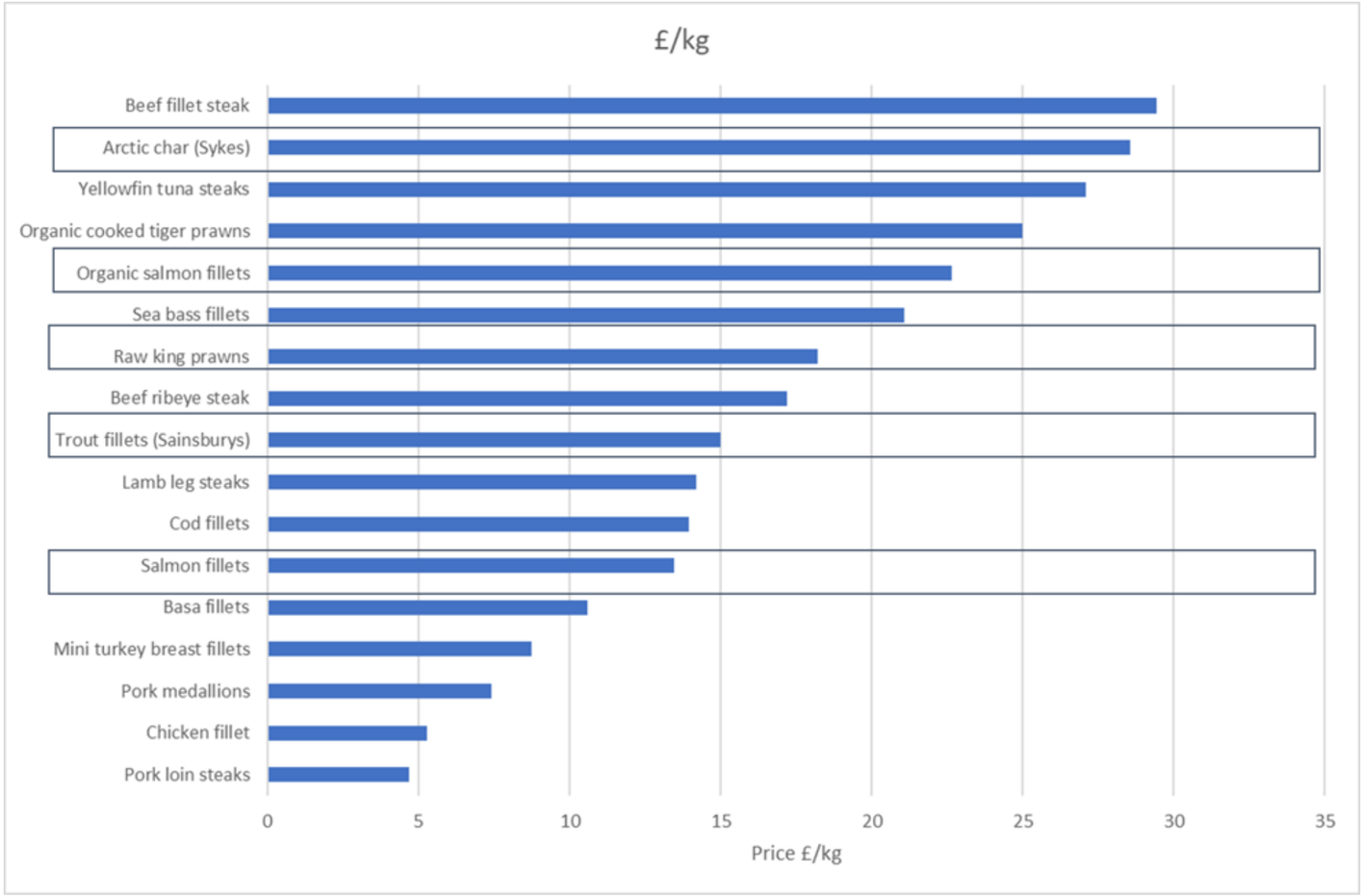
- Survey respondents were asked to rate a selection of sustainability solutions
- All the options were viewed as positive, particularly locally produced, nature-based production methods
- Consumers felt less able to engage with issues around circular feed ingredients



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Consumer take-aways

- Consumers have many choices and are primarily driven by price, taste, convenience and habit
- Knowledge of aquaculture is generally low and complex messages around sustainability practices unlikely to increase willingness to pay for most consumers



Note: These prices are from 2021, but shown to illustrate the price range of meat and fish products

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Business perspectives

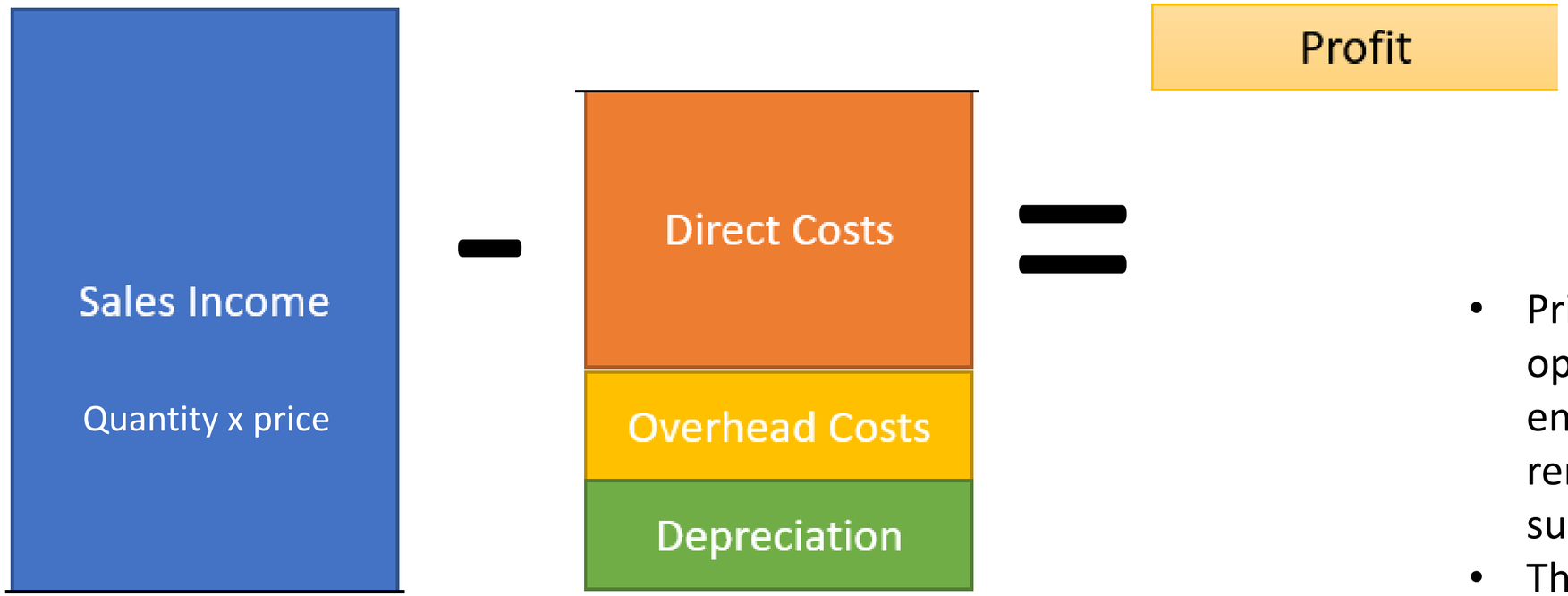


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- Business owners in the aquaculture, insect and mushroom value chains were interviewed as part of the Value Chain Analysis Report
- Financial modelling carried out on SAFE technical innovations

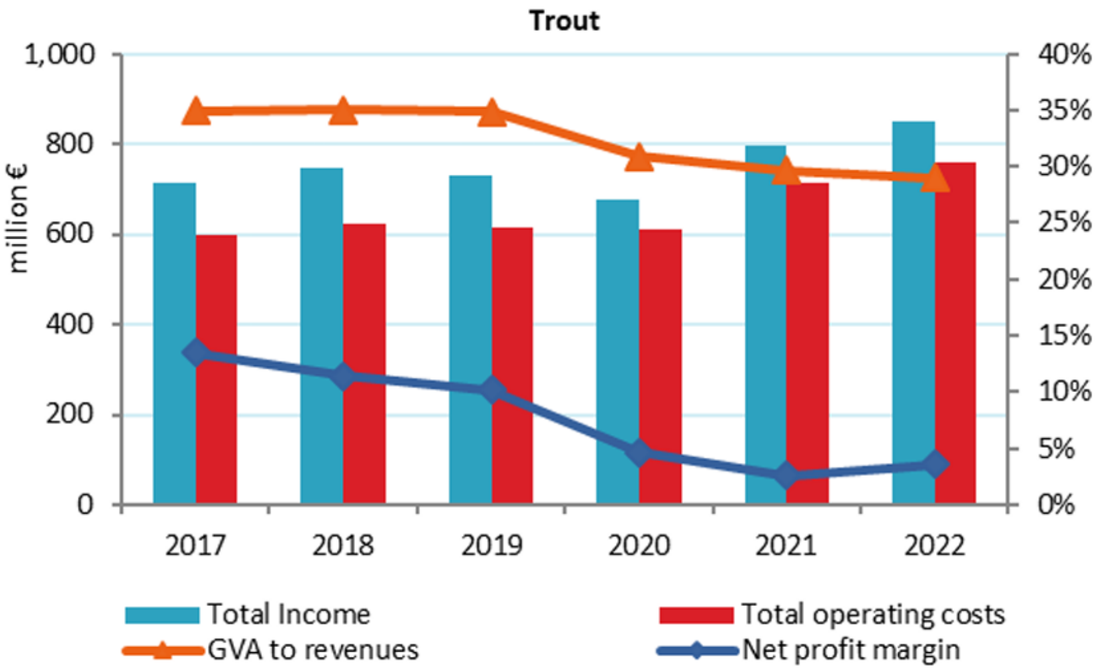
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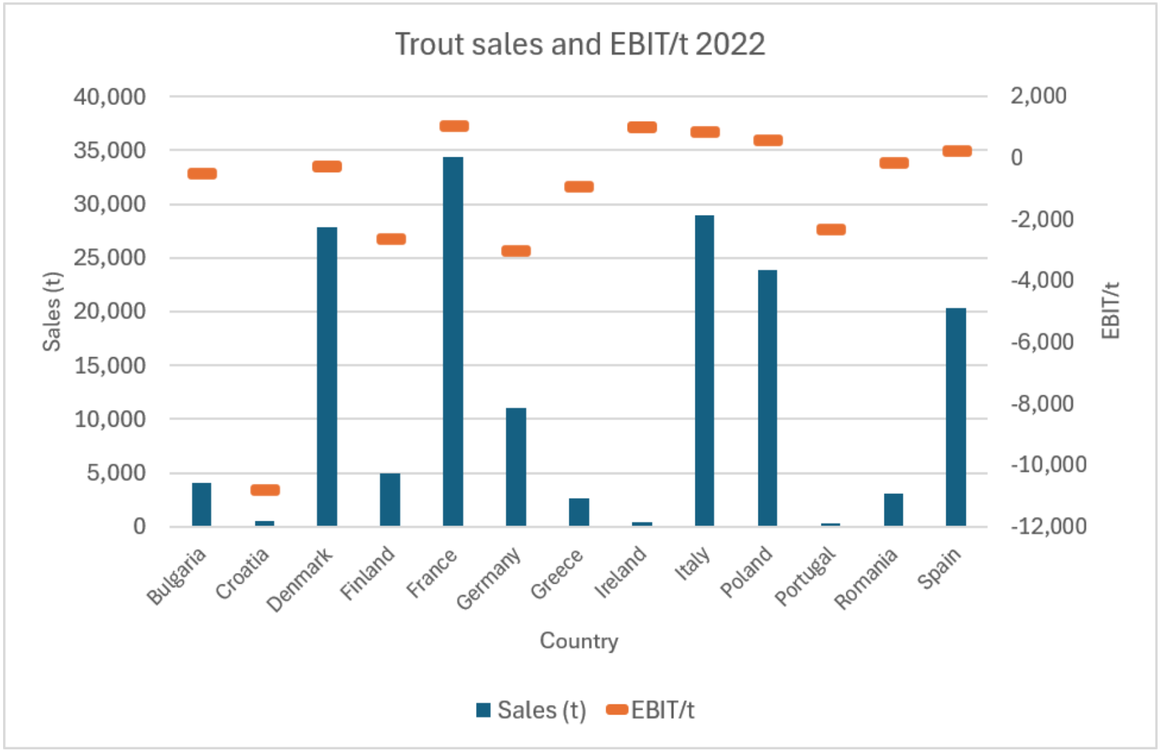
For the private sector, the basic financial equation must balance



- Private sector businesses operate in a competitive environment and need to remain profitable to survive.
- The dynamics of supply and demand predominate for aquaculture producers

EU trout farming profitability

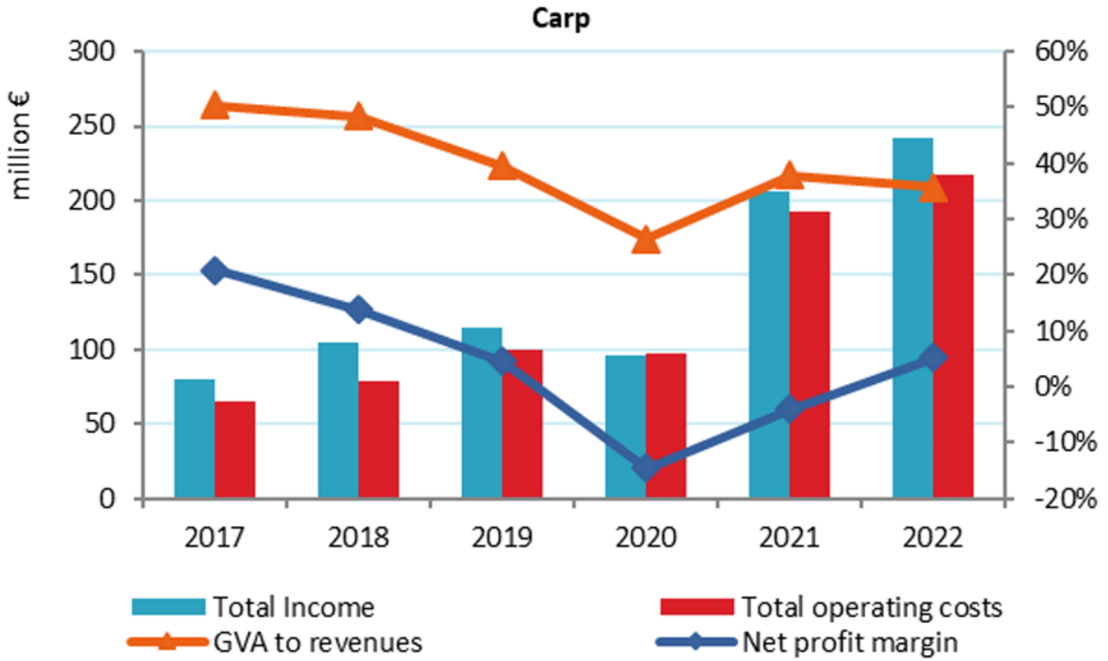


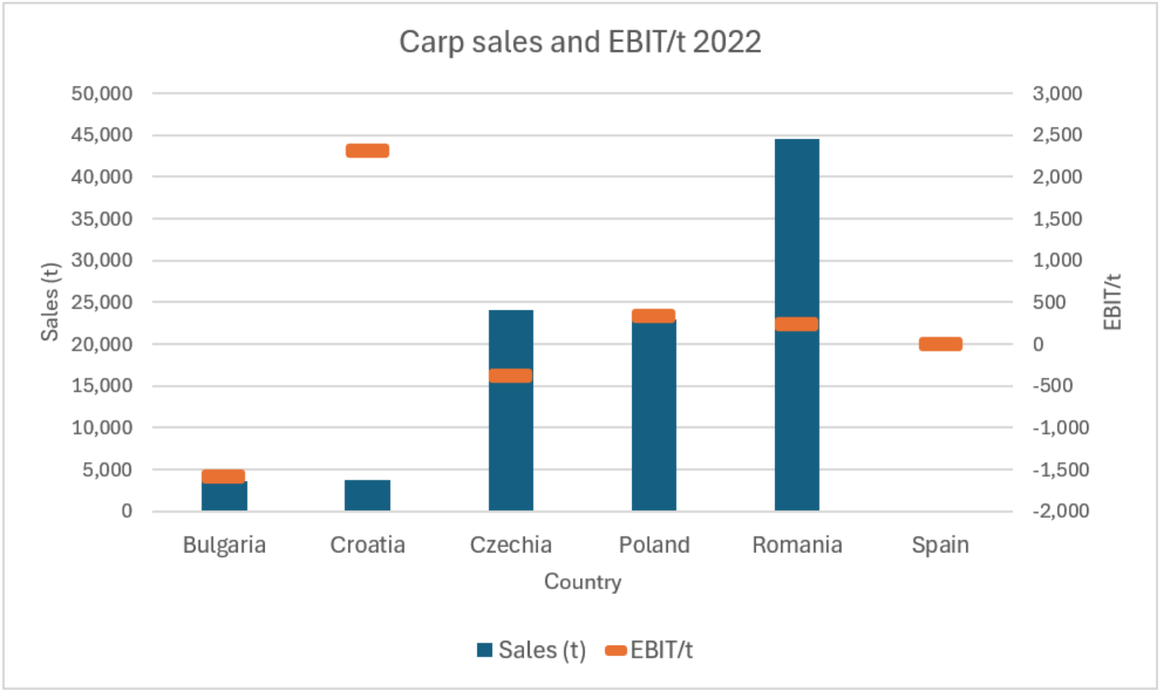


The profitability of trout farming in the EU declined between 2017 and 2021 with a slight improvement in 2022, although in that year only three of the five main producers had positive earnings before interest and tax. (Data from STECF 24-14)

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EU carp farming profitability





The profitability of carp farming in the EU declined between 2017 and 2020 with improvements in 2021 and 2022. In 2022 only three of the six countries for which data is available had positive earnings before interest and tax. (Data from STECF 24-14)

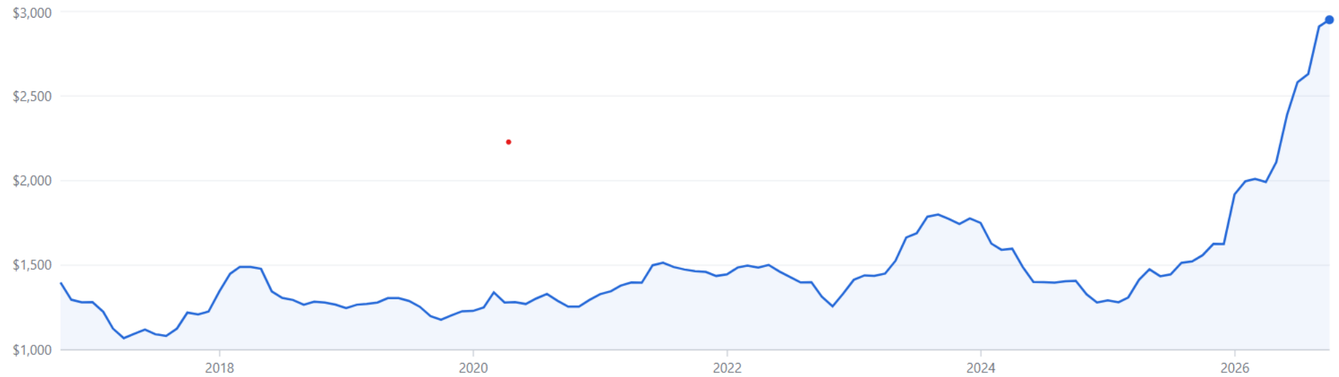
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Feed ingredient commodity prices

Price history

Fishmeal rose 111% over 10 years, from $1,398 in Sep 2016 to $2,951 in Sep 2026.

US dollars | Index | 1Y | 5Y | 10Y | 25Y | All

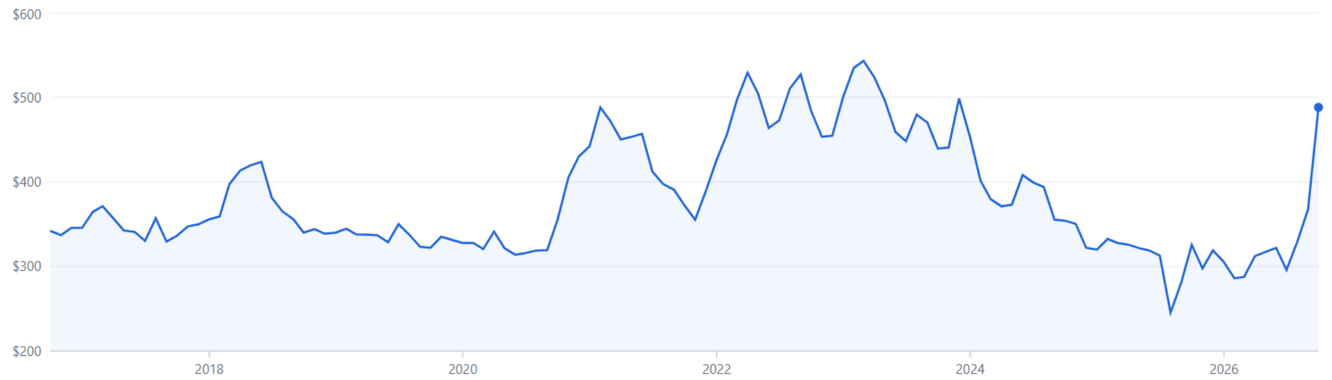


Fishmeal prices have been somewhat volatile, but with an unprecedented increase over 2026

Price history

Soybean meal rose 43% over 10 years, from $342.25 in Sep 2016 to $488.27 in Sep 2026.

US dollars | Index | 1Y | 5Y | 10Y | 25Y | All



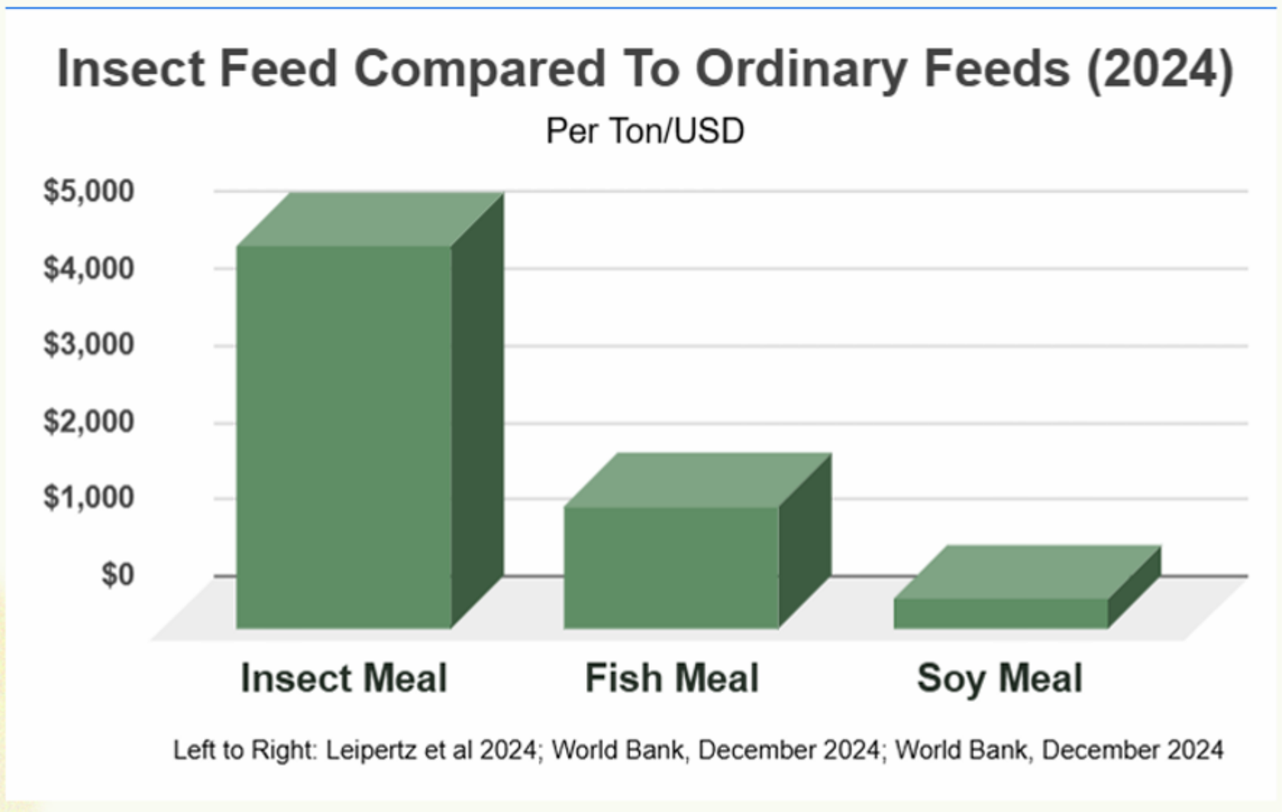
Soybean meal has a lower price per tonne but is still relatively volatile, starting 2026 at a relatively lower price and rising steeply recently.

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Charts from worldpriceindex.org

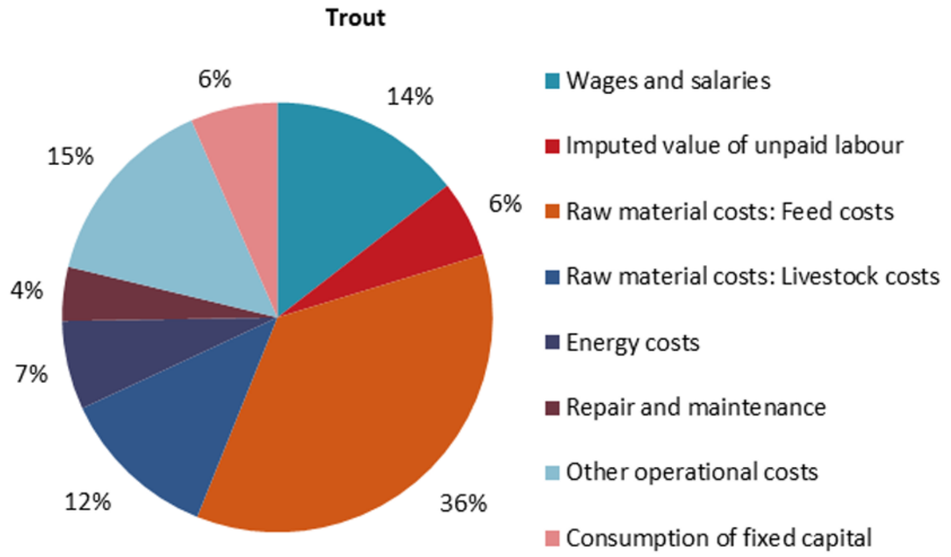
Ingredient cost comparison

- Key challenge is that many alternative (circular) ingredients are more expensive – but the situation is dynamic

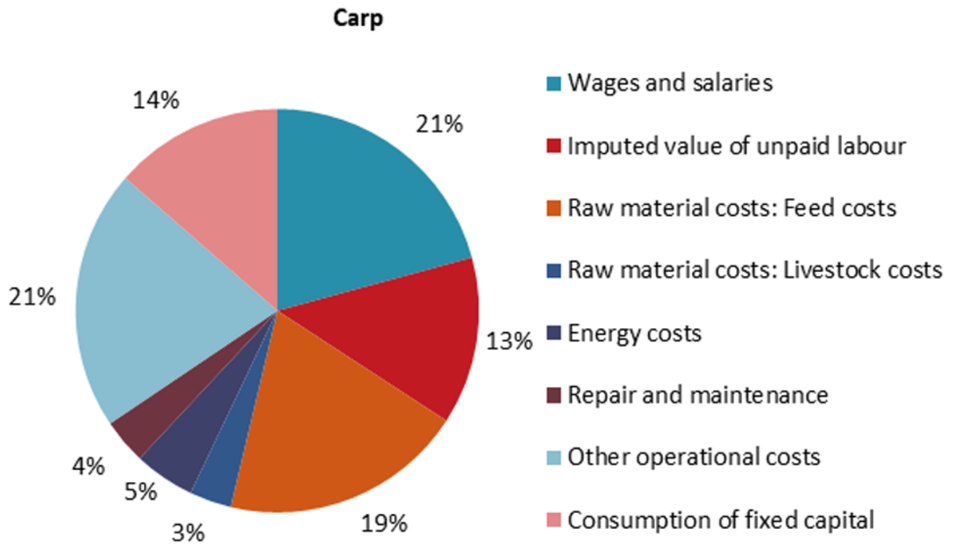


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Cost structures for EU trout and carp in 2022



The cost structure for trout production shows feed as the most significant contributor at 36%



Feed costs are not as significant for carp farming (19% of total in 2022), but still affected by rising commodity prices

Charts from STECF 24-14

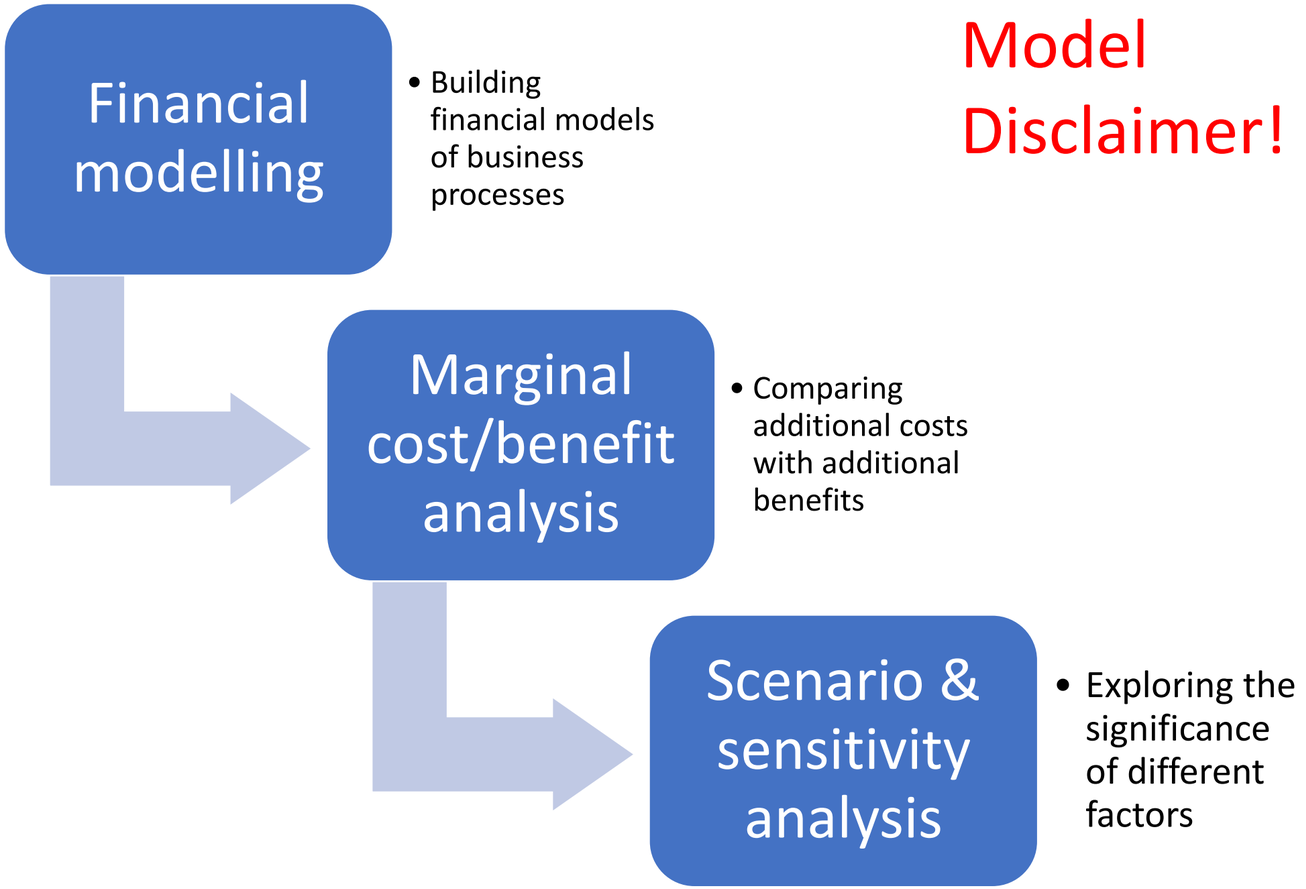
Key criteria for business

Innovations should not add to costs – unless also lead to greater increase in income



Financial viability: Assessment Approach

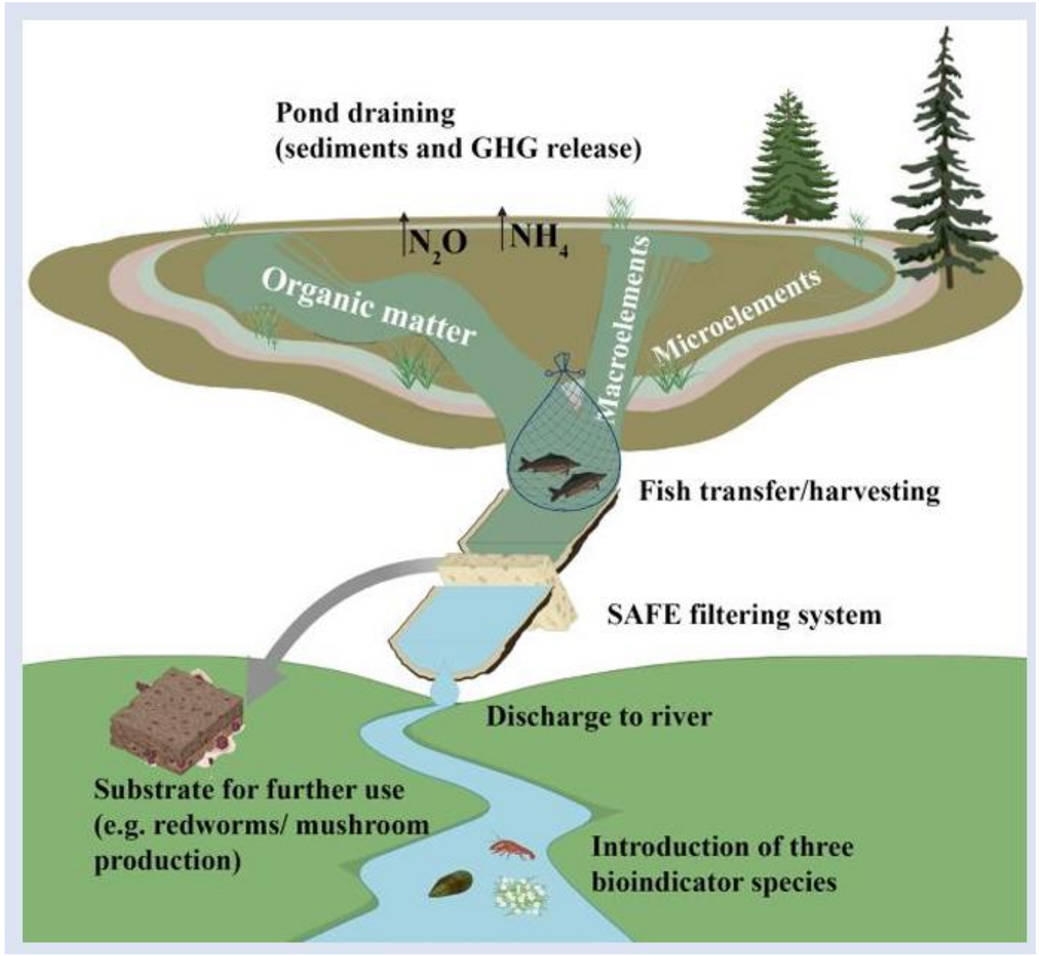
- The main challenge is lack of data – Businesses, especially SMEs are very reluctant to share financial information, and few publish business-to-business prices
- Modelling must be based on some baseline data, but the model itself helps to explore the gaps
- Starting point is identification, quantification and comparison of additional costs and additional benefits of a new activity in financial terms



Model Disclaimer!

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Example: Carp pond sediment for mushroom cultivation





Straw bales in discharge channel collected organic suspended solids during carp pond harvesting



Enriched bales sent to mushroom substrate composter





Carp sediment enriched compost used for oyster mushroom cultivation

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Initial calculations

- System dimensioning – sizes, quantities, rates
- Costings – labour, power, materials etc.
- Cost per enriched bale calculated as €9.80 or €176/tonne

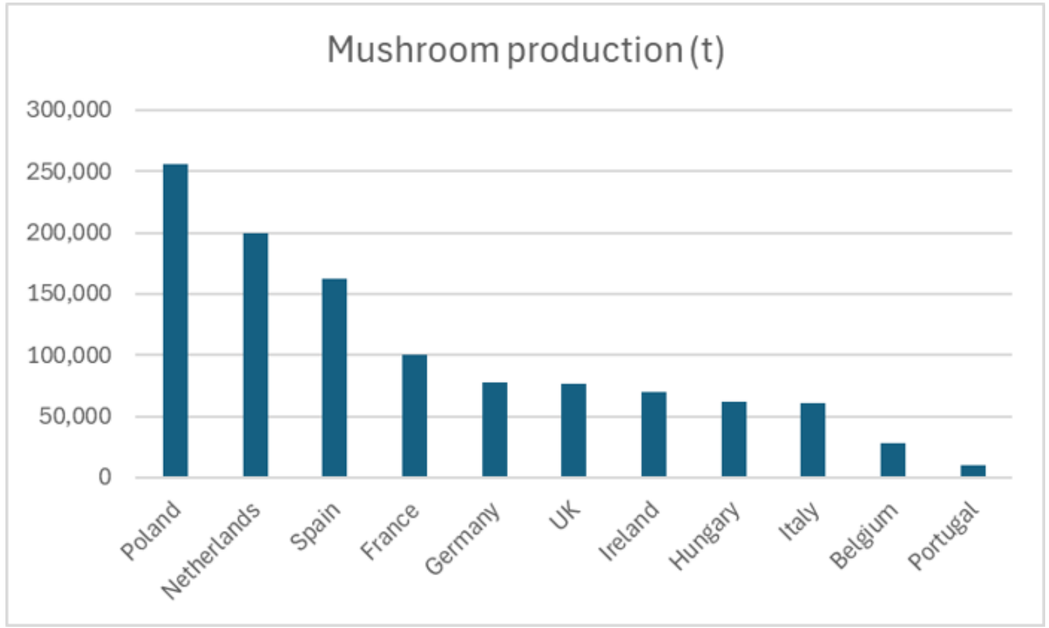
Case study scale & production	
Ha of pond feeding collection channel	80
Annual carp production (t)	25
Collection channel length (m)	224
Collection channel width (m)	
Collection channel depth (m)	
Collection channel area (m^2)	
Collection channel volume (m^3)	
Straw bale volume (m^3)	
Number of straw bales per m^3	
Straw bale initial weight (kg)	
Calculated number of straw bales per tonne	
Straw bale wet weight (kg)	
Straw bale wet weight with sediment (kg)	
Number of wet sediment enriched bales per	
Weight of wet sediment per bale (kg)	
Weight of dried sediment per bale (kg)	
Number of dried sediment enriched bales pe	
Wet to dry sludge multiplier	
Number of straw bales in collection channel	
Weight of sediment removed per year (wet k	
Weight of sediment removed per year (dry w	
Dry weight of sediment removed per tonne o	
Total weight of wet sediment enriched bales	
Total weight of dry sediment enriched bales	

Operating costs	
Person hours labour for bale installation	32
Person hours labour for maintenance (per year)	16
Person hours labour for bale removal	24
Total person hours per year	72
Labour rate (€/person hour)	7.44
Annual labour cost (€)	535.68
Cost of straw bales (€ each)	1
Cost of straw bales (total €)	207
Bale restraints (€/year)	60
Transport	284.33
Service of digger (€/year)	852.99
Cost of clamps to remove bales (€/year)	10
Cost of straps and clips (€/year)	79
Total annual operating cost (€)	2,029
Total cost per m^3 of sediment enriched bales (€)	61.25
Total cost per tonne of wet sediment enriched bales (€)	174.16
Total cost per tonne of dry sediment enriched bales (€)	571.55
Cost per kg sediment (wet weight collected) (€/kg)	**0.67**
Cost per kg sediment (dry weight collected) (€/kg)	**2.04**
Breakeven price per sediment enriched bale (€)	**9.80**

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Market considerations & comparisons

- Oyster mushroom production in Poland estimated at around 80,000 t requiring 400,000 t of substrate
- Implementation of straw bale technology in Polish carp farms could yield around 10,000 t of enriched bales (2.5% of substrate)
- Unincubated compost cost estimated at €120-150/t (cost of straw around €70-80/t) (*compare with €176/tonne for producing enriched bales*)
- Trials indicated little clear improvements in oyster mushroom performance using enriched straw bales



Conclusion: Market volume is there, but the process adds cost to the straw bales without adding value for the customer – A non-starter in commercial terms… unless….?

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Waister 200

Compare with sludge drying from salmonid RAS



- Regulations in Norway require 25% DM sludge to be treated with formic acid prior to licensed disposal at €169/t
- However, if dried to 80-90% DM it can be sold as biofertilizer for €68 per tonne
- For a farm producing around 4,000 t of sludge per annum is it worth investing over €1.5 million in a drier?
- Model based on marginal analysis and calculation of time needed (years) to repay investment.

2 x Waister 200 HP system		
Amount of wet sludge	4,076,800	kg/y
Amount of dried sludge	1,132,444	kg/y
Price for disposal of wet sludge	0.169	€/kg
Value dried sludge	0.068	€/kg
Amount of formic acid	5.00	kg/MT
Price formic acid	0.51	€/kg
Amount of evaporated water	2,944,356	kg/y
Electric power consumption	0.35	kWh/kg
Price of electricity	0.170	€/kWh
Price of service agreement	1,245.00	€/m
Other maintenance costs	10,426	€/y
Price for Waister dryers with heat pump	1,621,275	€
Addition of formic acid to the sludge	10,335	€/y
Disposal of wet sludge [25 % TS]	688,980	€/y
Alternative operating cost (not drying)	**699,315**	€/y
Electric power consumption with HP	175,189	€/y
Service agreement cost	14,940	€/y
Other OPEX	10,426	€/y
Total operating cost with HP	**200,555**	€/y
Value of dried product	77,006	€/y
Reduced OPEX	498,760	€/y
Net profitability before depreciation	**575,766**	€/y
Depreciation (5 years)	324,255	€/y
Net profitability after depreciation	**251,511**	€/y
ROI	**2.82**	y

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Sensitivity analysis and findings

- On baseline assumptions, investment in a drier is worthwhile, with the cost repaid within 3.56 years for the standard model and 2.82 years for the newer technology model
- The new technology model retains much better returns on investment at higher electricity prices, but the standard model is better if electricity prices fall by 50%
- The alternate cost of sludge disposal is critical, especially for the standard drier. If this falls by 50%, the benefit of the drier (avoided cost) fall and the return on investment period is substantially lengthened.

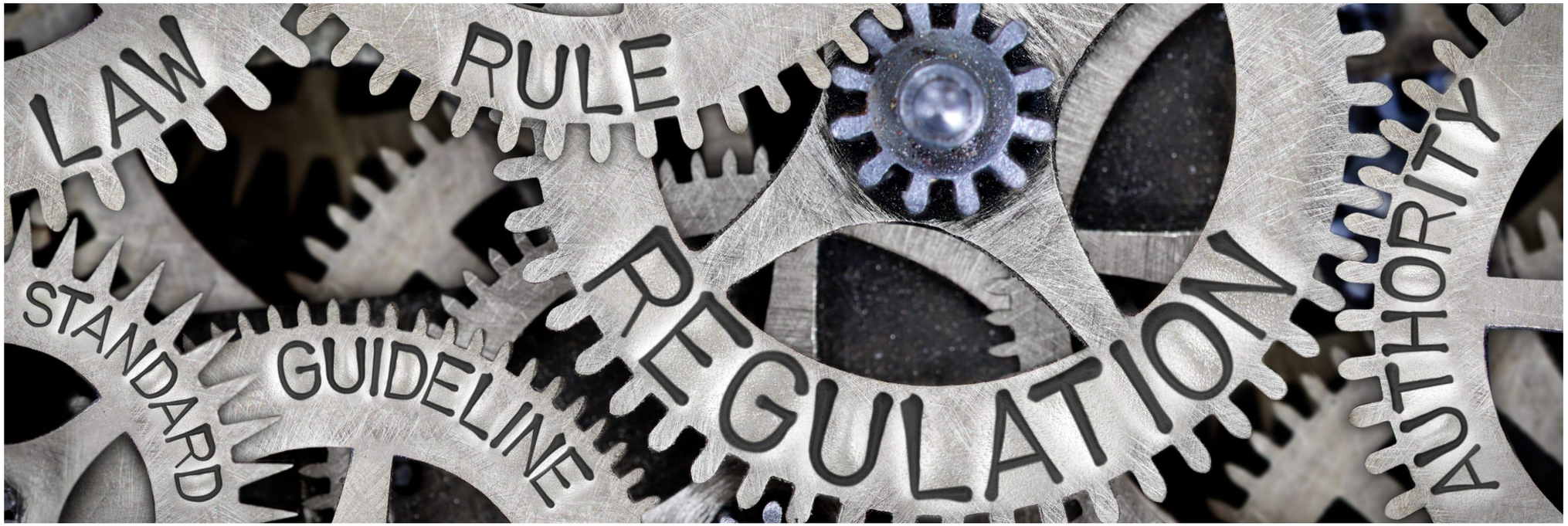
Table 7: Sensitivity analysis on Return on Investment (ROI) years

	Sensitivity analysis (ROI)	-50%	-20%	-10%	Baseline	+10%	+20%	+50%
Standard Heat Pump	Electricity cost	2.15	2.82	3.15	3.56	4.09	4.82	10.27
	Wet sludge disposal cost	60.99	6.7	4.51	3.56	2.94	2.5	1.73
	Dried product price	4.04	3.74	3.65	3.56	3.48	3.4	3.18
CO_2 Heat Pump	Electricity cost	2.44	2.65	2.73	2.82	2.9	3	3.32
	Wet sludge disposal cost	7.01	3.7	3.2	2.82	2.51	2.27	1.76
	Dried product price	3.02	2.89	2.85	2.82	2.78	2.74	2.64

Conclusion: Investment decision heavily dependent on regulatory requirements and government influenced energy prices

Governance perspectives

Policy issues examined from literature and key organisations interviewed as second phase of Value Chain Analysis



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Return to first example….

- Polish farms are allowed to discharge suspended solids without charge if fish production is below 1,500 kg per ha per year. Most farms are below this, but additional production attracts only a small pollution charge
- The cost of sediment collection when including sediment trapped between straw bales was around €81/tonne of fish produced
- Approximately 3.3 t of (wet) sludge was collected per tonne of fish production, which could be sold for farm fertilizer @ €5-10/t (up to €33 per tonne of fish produced)
- If regulators imposed a pollution fee greater than €48 (81-33) per tonne of fish produced, a financial incentive would start to be created for farmers to collect and market organic sediment – reducing environmental impacts and reliance on chemical fertilizers



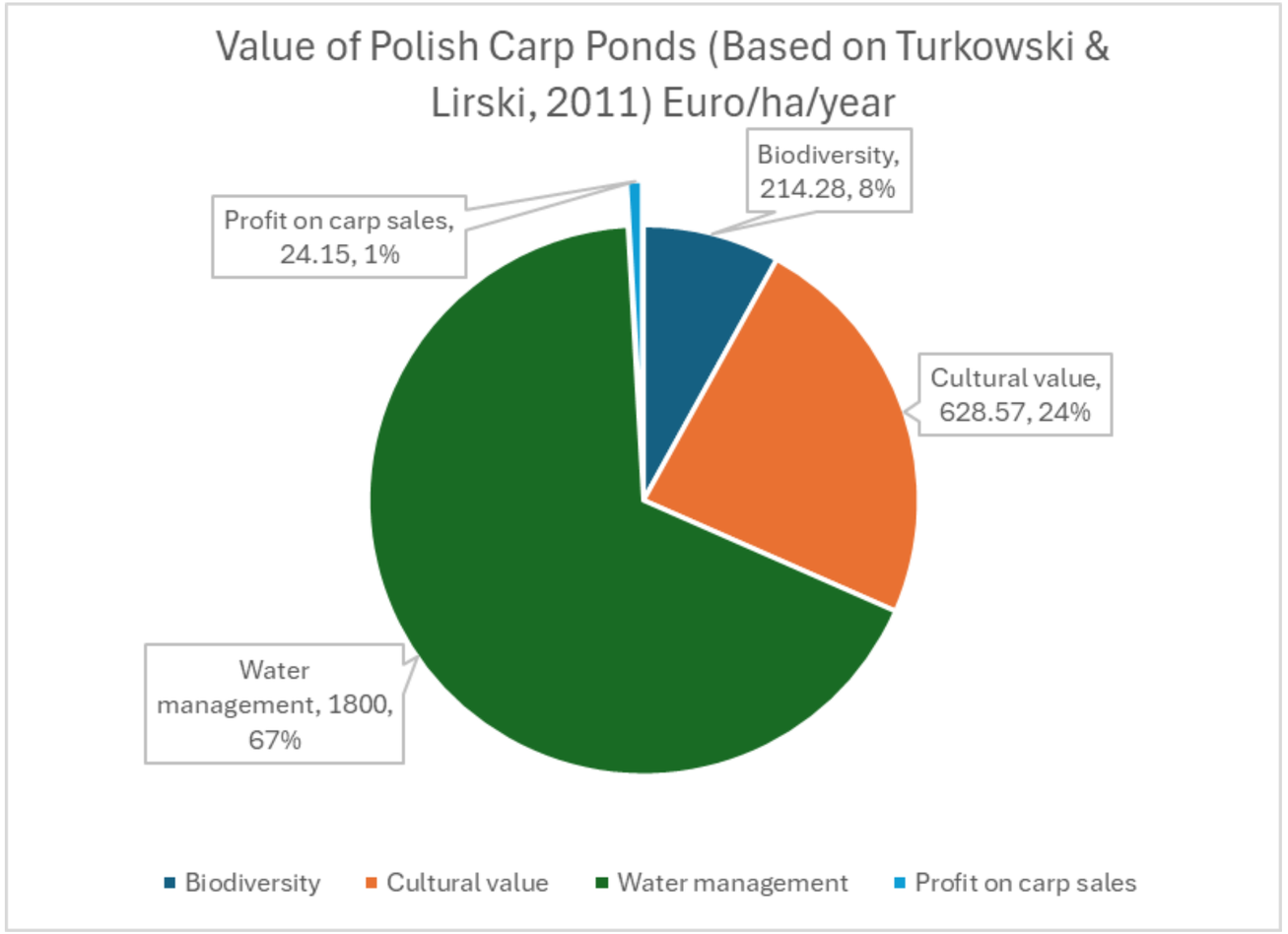


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But the broader environmental economics perspective on Polish carp farming is already complex

Turkowski & Lirski (2011) Estimated the non-productive asset value of Polish carp ponds to be 3.7 billion Euro (€52,875 per ha)



- Profit margins on carp production was -1.93% over 18 farms studied between 2005 and 2007
- The total value of carp farming is likely to substantially exceed the combined financial returns to farmers and the subsidies paid.

Above chart is based on total pond area of 70,000 ha with non-productive value estimated as Euro 2,643 per ha per year

Carp producers in Poland already have access to environmental-related subsidies

- It is recognised that pond carp farms in Poland are generally unprofitable but provide useful services for water management, biodiversity and cultural/recreational values
- Subsidies are paid to enable carp farmers to continue to manage the environment (Approx. EUR 250 ha/year for basic package)

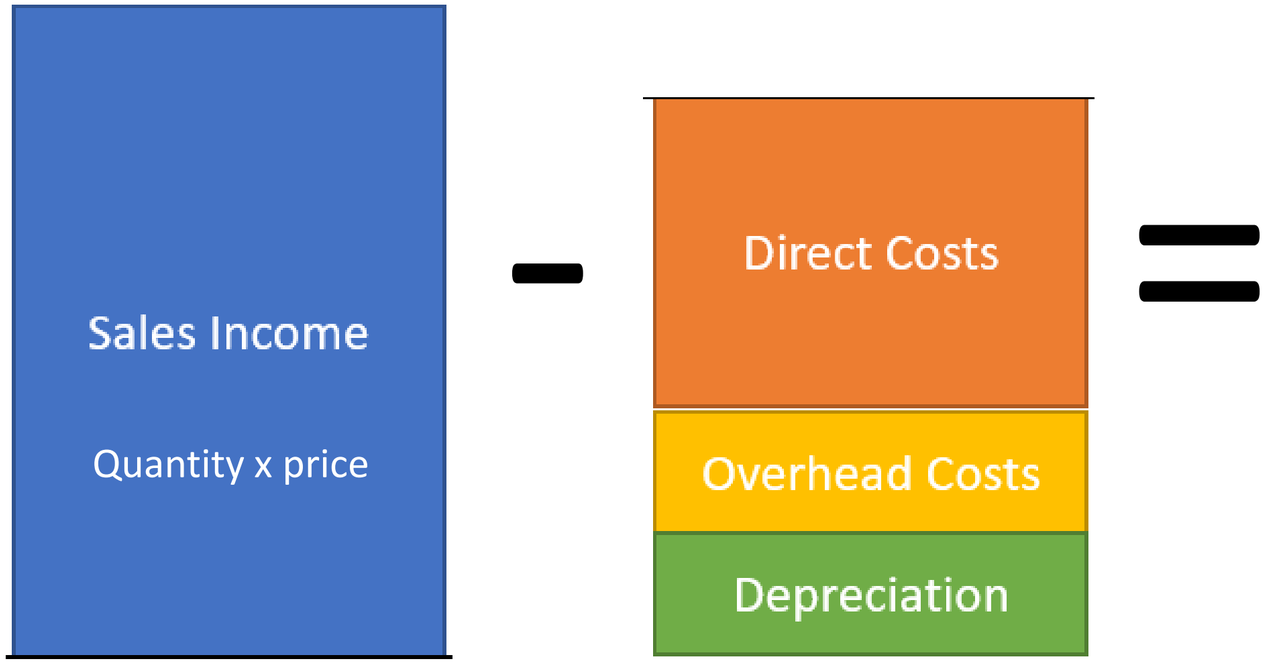
a. PLN 1075.92 per year per hectare of dike area of the fish farming facility on which Package 1 – basic is implemented;
b. PLN 283.43 per year per hectare of dike area of fish ponds – in the case of implementation of Package 2 – extended in the production of additional valuable fish species in the amount of at least 3.75% of the annual weight of carp production in a given fish farming facility;
c. PLN 17,942.12 per year for an educational path and covers only one educational path per applicant during the implementation period of the programme – in the case of the implementation of Package 2 – extended in terms of maintaining and providing access to one educational path not shorter than 2000 running metres in total, on which at least 5 educational stops are located;
d. PLN 183.08 per year per hectare of dike area of fish ponds on which Package 3 – NATURA 2000 is implemented.

Some implications…

- A pollution charge (even if avoided) would increase the cost of fish production and hence fish prices, and potentially reduce consumption
- Reduced fish consumption may harm public health and result in more expenditure on health services. But a better environment could improve health and reduce the cost of health services
- Subsidising the cost of sediment removal would avoid impacts on fish prices, but place a greater burden on public expenditure –possibly counteracted by reduced demand on public health services or an increase in taxes on other less beneficial activities?



Potential intervention points in relation to the basic business equation



Potential adjustments to corporation tax to compensate sustainability investments

Boost with new revenue streams – e.g. through greater valorisation of byproducts or compensation schemes

Sustainability innovations increasing costs

Technical innovations or policy measures to reduce costs

Mechanisms that encourage and enable businesses to implement sustainability innovations will require multiple parallel initiatives to balance additional costs with savings or new revenue streams

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Conclusions

Effective policies need to be more joined-up, and will require clear incentives to businesses through their financial "bottom line" calculations, and support for new market chains to develop around previously discarded or underutilised by-products, and focus on making aquaculture products both more affordable and better trusted by consumers



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Highlighted innovations

Innovation	Technical outcome	Financial assessment	Challenges/opportunities
Fish farm sludge as substrate for mushroom cultivation	Feasible – better suited to some mushroom species	Unfeasible at scale tested as costs exceed price of currently used substrates	Improve collection efficiency; alter fiscal incentives to favour sludge collection and utilisation
Drying of fish farm sludge for fertilizer	Feasible – product can be sold as agricultural fertilizer	Feasible where fiscal environment already penalises waste disposal and energy prices are high	Greater adoption could drive down costs and price, but fiscal and regulatory measures also needed in some countries.
Spent mushroom substrate as substrate for mealworm	Feasible - although variable performance	Potentially competitive with conventional substrates where performance equal or better. Good potential to scale	Further work required on formulations and regulatory aspects supported by improvements in traceability and classification of substrate materials
Mushroom stalk meal for fish feed	Feasible	Only feasible if used as a functional ingredient at low inclusion rates due to high cost of production	Improve efficiency of recovery process to reduce cost
Insect larvae for use in fish feed	Feasible	Unfeasible as a primary protein at current production costs	Changes in feed regulations could enable more economic production
Fish farm sludge and duckweed as vermiculture substrate	Unfeasible without additional substrate, but redworm potential feed ingredient	Likely too expensive as a replacement feed ingredient but production of vermicompost and live worms could be profitable	Fiscal and regulatory incentives could improve uptake, but scale economies also needed.
Production of microalgae in RAS process water	Feasible	Unfeasible at current scale as primary protein source, but some potential as a functional ingredient	Substantial growth in RAS production could lead to commercially viable production but regulation needs development and harmonisation
Smarter grading systems and production planning	Feasible	Cost data not available, but clear potential for beneficial impact for user	Fits with the Vision 2040 for fisheries and aquaculture but competition from multiple technology suppliers







Smart Aqua4 FuturE

Thank you for your attention

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Menti question

Very briefly… What main policy recommendations would you make to encourage the adoption of the presented innovations?

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