



# Analytic Hierarchy Process (AHP) for the analysis of the viability of fish side streams valorisation

Optimal utilization of seafood side-streams through the design of new holistic process lines

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# THE OBJECTIVE

● Efficient and sustainable valorization system of seafood side-streams into MARKETABLE PRODUCTS



# SIDE-STREAMS



# VALUABLE END-PRODUCTS



Protein ingredients



Bioactive peptides



Mineral supplements

SMELL

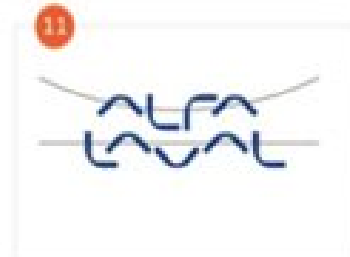
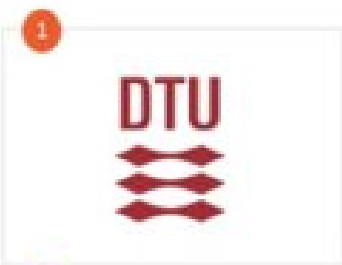


TASTE



Savory compounds

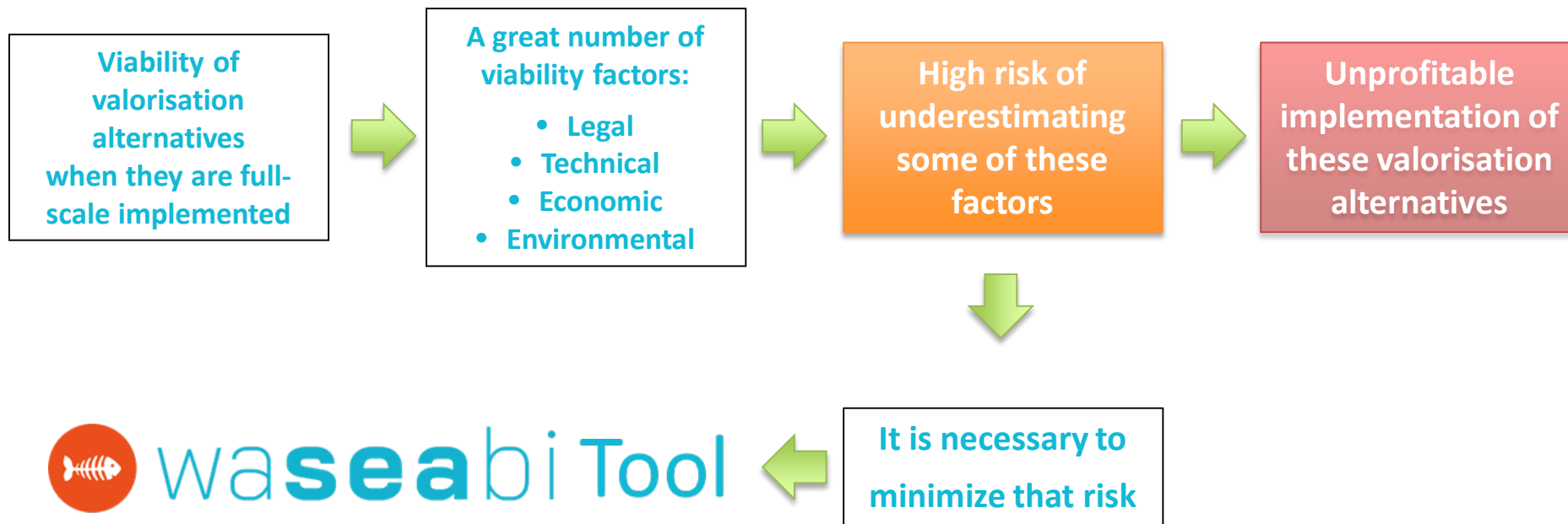




THE WASEABI  
CONSORTIUM



# CHALLENGE



# OBJECTIVE

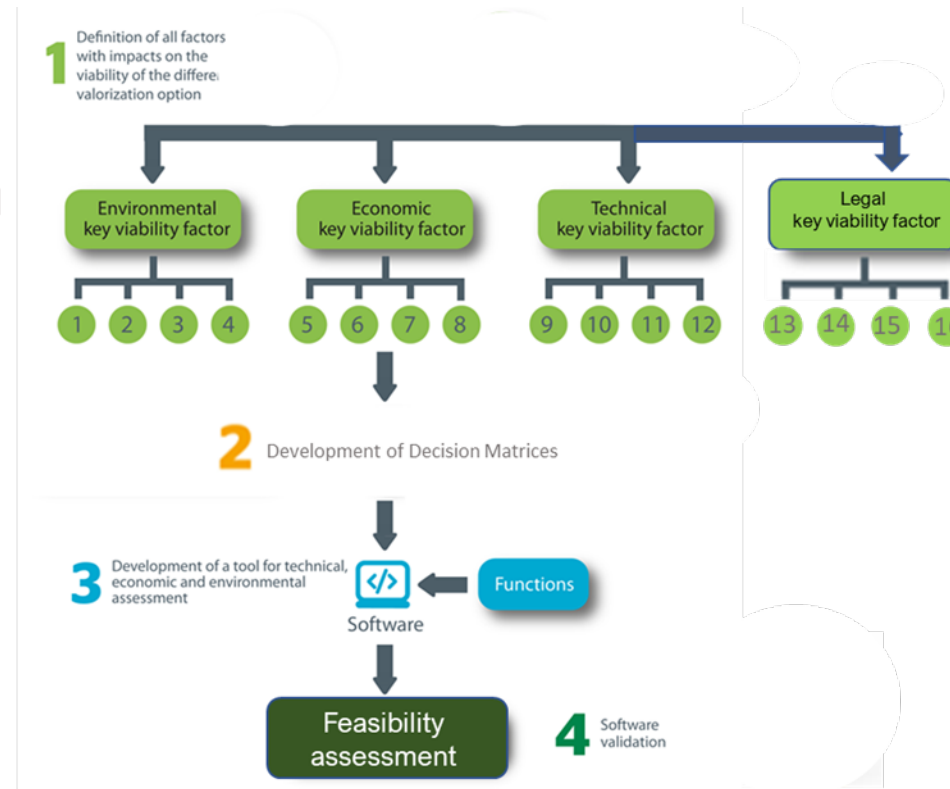
- To help to take the right decision about waste-management strategies.
- To minimize the inherent risk of a full-scale implementation of a new food waste valorisation facility.



# AHP METHOD



AHP method →



# LEGAL VIABILITY

WAHPt: Waseabi AHP tool

Legal\_viability | Tech\_viability | Econom\_viability | Environ\_viability | Weights | Results | Sensitivity

Viability Factor	Units	Value	Sub-problem factor	Kind of factor	Limiting ranges	Conditioning ranges	Relative importance	Check legal viability
1 Listeria monocytogenes	CFU/25g	0.0	Legal aspect/Raw material	Limiting	Absence	Not applicable	Not applicable	<input type="button" value="Add row"/>
2 Total viable cell count	CFU/g	0.0	Legal aspect/final product	Limiting	<=20000	Not applicable	Not applicable	<input type="button" value="Delete row"/>
3 Salmonella spp	CFU/25g	0.0	Legal aspect/final product	Limiting	Absence	Not applicable	Not applicable	
4 Listeria monocytogenes	CFU/g	0.0	Legal aspect/final product	Limiting	Absence	Not applicable	Not applicable	
5 E. Coli	CFU/g	15	Legal aspect/final product	Limiting	<=20	Not applicable	Not applicable	
6 Staphylococcus aureus	CFU/g	0.0	Legal aspect/final product	Limiting	<=200	Not applicable	Not applicable	
7 Pseudomona aeruginosa	CFU/25g	0.0	Legal aspect/final product	Limiting	Absence	Not applicable	Not applicable	
8 Mould/yeast	CFU/g	0.0	Legal aspect/final product	Limiting	<=20	Not applicable	Not applicable	
9 Arsenic (inorganic)	mg/kg	0.0	Legal aspect/final product	Limiting	<=0.22	Not applicable	Not applicable	
10 Arsenic (organic)	mg/kg	0.0	Legal aspect/final product	Limiting	<=0.51	Not applicable	Not applicable	
11 Cadmium	mg/kg	0.0	Legal aspect/final product	Limiting	<=0.09	Not applicable	Not applicable	
12 Lead	mg/kg	0.0	Legal aspect/final product	Limiting	<=0.18	Not applicable	Not applicable	
13 Total Mercury	mg/kg	0.0	Legal aspect/final product	Limiting	<=0.03	Not applicable	Not applicable	

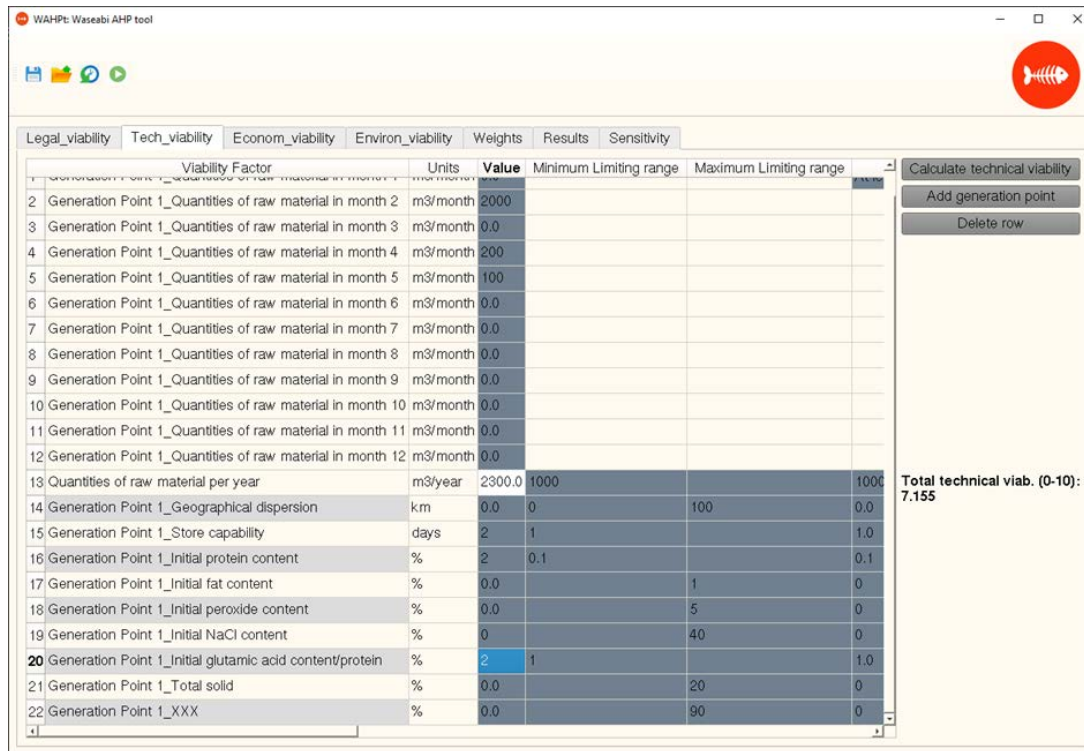
Legal viab.: ok

- It allows to verify the **compliance of the studied side-stream of the legal viability constraints.**
- The output for this analysis is a simple binary result of the type True/False





# TECHNICAL VIABILITY



Viability Factor	Units	Value	Minimum Limiting range	Maximum Limiting range	
1 Generation Point 1_Quantities of raw material in month 1	m3/month	2000			
2 Generation Point 1_Quantities of raw material in month 2	m3/month	0.0			
3 Generation Point 1_Quantities of raw material in month 3	m3/month	200			
4 Generation Point 1_Quantities of raw material in month 4	m3/month	100			
5 Generation Point 1_Quantities of raw material in month 5	m3/month	0.0			
6 Generation Point 1_Quantities of raw material in month 6	m3/month	0.0			
7 Generation Point 1_Quantities of raw material in month 7	m3/month	0.0			
8 Generation Point 1_Quantities of raw material in month 8	m3/month	0.0			
9 Generation Point 1_Quantities of raw material in month 9	m3/month	0.0			
10 Generation Point 1_Quantities of raw material in month 10	m3/month	0.0			
11 Generation Point 1_Quantities of raw material in month 11	m3/month	0.0			
12 Generation Point 1_Quantities of raw material in month 12	m3/month	0.0			
13 Quantities of raw material per year	m3/year	2300.0	1000	1000	
14 Generation Point 1_Geographical dispersion	km	0.0	0	100	0.0
15 Generation Point 1_Store capability	days	2	1	1.0	
16 Generation Point 1_Initial protein content	%	2	0.1	0.1	
17 Generation Point 1_Initial fat content	%	0.0		1	0
18 Generation Point 1_Initial peroxide content	%	0.0		5	0
19 Generation Point 1_Initial NaCl content	%	0		40	0
20 Generation Point 1_Initial glutamic acid content/protein	%	2	1	1.0	
21 Generation Point 1_Total solid	%	0.0		20	0
22 Generation Point 1_XXX	%	0.0		90	0

Total technical viab. (0-10): 7.155

- It consists of several **chemical indicators related to the potential of fish by-products for obtaining high value compounds.**
- The output is a positive number between 0 and 10, representing “0” a low technical viability and “10” a high technical viability.
- If a parameter is out of the limiting range, the score will be “0”, whereas if it is inside the limiting range, the score will be proportional to the conditional range.
- The score of each parameter viability is balanced by applying its relative importance to obtain a weighted score.

# ECONOMICAL VIABILITY

WASP: Waseabi AHP tool

Legal\_viability | Tech\_viability | **Econom\_viability** | Environ\_viability | Weights | Results | Sensitivity

Viability Factor	Units	Year 1	Year 2	Year 3
5 Incomes due to management costs saving	€/year	340400.000	382473.440	429
6 Process yield	0-1	0.02		
7 Quantity of food final product	Tn/year	46.000	48.760	51.6
8 Sale price of the final product	€/Tn	3000	3180.000	337
9 Annual percentage increase	%	6		
10 Incomes due to final product sales	€/year	138000.000	155056.800	174
11 Total Investment	€	92147.436		
12 Depreciation period	Years	10		
13 % of own funds	%	80		
14 € of own funds	€	73717.949		
15 % of public funding (non-refundable)	%	0.0		
16 € of public funding (non-refundable)	€	0.000		
17 % of banks-public loan	%	20		
18 Loan interest	%	5		
19 Years of credit repayment	Years	10		
20 € of banks-public loan	€	19350.962		
21 List of expenses				
22 Quantities of raw material per year	m3/year	2300.0	2438.000	258
23 Logistics costs	€/m3 of raw material	30	31.800	33.7
24 Annual percentage increase	%	6		
25 Operating expenses: Logistics	€/year	69000.000	77528.400	871
26 Number of people	Unit	5	5.0	5.0

Calculate economic viability

Delete year

Generate projection

Investment per unit of material (euros): 250000

Unit of material (m3): 6240

Economic viab.: ok

- The economical parameters selected for the **economic analysis** are:
  - Net Present Value (NPV)
  - Return on investment (ROI)
  - Payback period (PP)
  - Gross Operation Profit (EBITDA).
- The number of years and the CAPEX and OPEX value for the calculation of the scenario can be modified by the user based on their experience.



# ENVIRONMENTAL VIABILITY

WHP: Waseabi AHP tool

Legal\_viability | Tech\_viability | Econom\_viability | Environ\_viability | Weights | Results | Sensitivity

Inputs	Units	Value	Dataset
1 Quantities of raw material per year	m3/year	2300.0	
2 Packaging, plastic, PP	kg/year	0.0	eb6c15a5-abcd-4d1a-ab71-fb1cc3f
3 Packaging, plastic, LDPE	kg/year	0.0	d327f4a5-93a1-4ead-856c-aeb8b2
4 Packaging, plastic, HDPE	kg/year	0.0	a3aefe5b-33c9-4f0c-87ec-d02914
5 Packaging, aluminium	kg/year	0.0	95275ae7-af41-48aa-bef9-8259f1
6 Packaging, glass container	kg/year	0.0	c719be8c-51be-4c23-84c2-e45ea
7 Packaging, liquid packaging board	kg/year	0.0	5ffc5f05-a5d3-42eb-90cb-547e0bf
8 Packaging, corrugated board	kg/year	0.0	574bdb1e-2ed3-46f1-bd14-bb76f7
9 Thermal energy use (choose from list)	MJ/year	0.0	
10 Heat export (MJ)	MJ/year	0.0	
11 Electricity from grid (not certified)	kWh/year	299.000	34960d4d-af62-43a0-aa76-adc5fc
12 Electricity from grid (green certified)	kWh/year	0.0	ce479816-e2dd-44b6-aa54-15350
13 Electricity, own generated (choose from list)	kWh/year	0.0	
14 Electricity export	kWh/year	0.0	34960d4d-af62-43a0-aa76-adc5fc
15 Tap water	m3/year	64.503	212b8494-a769-4c2e-8d82-9a6efe
16 Wastewater to treatment plant	m3/year	2783.000	8126980a-29e9-416c-991d-2aa5fc
17 Plastic waste (choose from list)	kg/year	0.0	
18 Paper and cardboard waste (choose from list)	kg/year	0.0	
19 Municipal solid wastes (choose from list)	kg/year	0.0	
20 Organic wastes (choose from list)	kg/year	690.000	
21 Distance to final destination by (choose from list)	km/year	0.0	
22 Distance to final destination by (choose from list)	km/year	0.0	

Calculate environmental viability

Load single parameter file

Load parameter file for dropdown menus

Save parameters into .xls file

Carbon footprint (kg CO2 eq/kg product): 5.321e+03

Eutrophication (kg NH4 eq./year): 1.620e+01

Water footprint: 2.787e+04

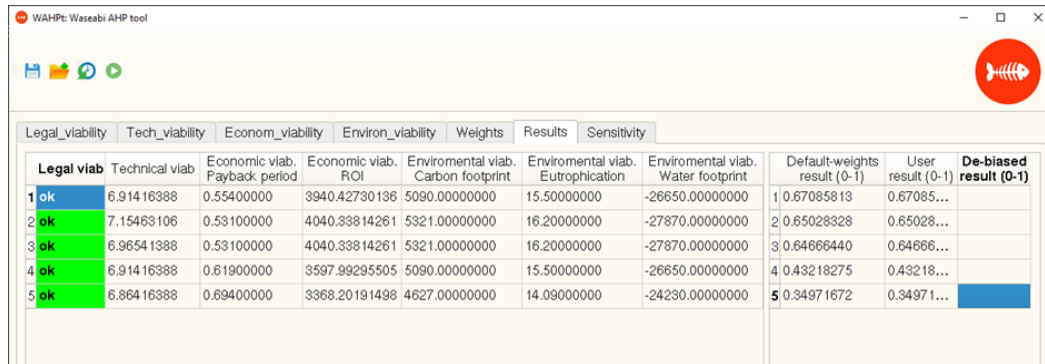
➤ The environmental impacts selected for the environmental assessment are:

- Carbon footprint
- Water footprint
- Eutrophication

➤ Based on a Life Cycle Assessment, the tool asks user data about the most important environmental aspects to calculate the selected impacts.



# VIABILITY SCORE



Legal viab	Technical viab	Economic viab. Payback period	Economic viab. ROI	Environmental viab. Carbon footprint	Environmental viab. Eutrophication	Environmental viab. Water footprint	Default-weights result (0-1)	User result (0-1)	De-biased result (0-1)
1 ok	6.91416388	0.55400000	3940.42730136	5090.00000000	15.50000000	-26650.00000000	1 0.67085813	0.67085...	
2 ok	7.15463106	0.53100000	4040.33814261	5321.00000000	16.20000000	-27870.00000000	2 0.65028328	0.65028...	
3 ok	6.96541388	0.53100000	4040.33814261	5321.00000000	16.20000000	-27870.00000000	3 0.64666440	0.64666...	
4 ok	6.91416388	0.61900000	3597.99295505	5090.00000000	15.50000000	-26650.00000000	4 0.43218275	0.43218...	
5 ok	6.86416388	0.69400000	3368.20191498	4627.00000000	14.09000000	-24230.00000000	5 0.34971672	0.34971...	

- The **single score** is generated based on the relative weight given for each viability.
- If there are **more than one scenario**, one-score projection of the different viability calculations for different scenarios is included based on the Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) technique.

*TOPSIS basic principle assumes that the chosen alternative should simultaneously have the shortest distance from the positive-ideal solution and the farthest distance from the negative-ideal solution.*



## CONCLUSIONS

- AHP method is an appropriate methodology for **helping making decisions about waste management strategies.**
- This tool **assesses different scenarios with a minimum effort and minimize the time** required to evaluate the different scenarios under study.
- It will **help to define fish by-product valorisation strategies** reducing the effort, the environmental impacts and the costs comparing to the traditional procedure.





Thank you for your attention!



Any question?



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