Indicators for DexiAqua

Description of selected indicators and methodological choices for the overall sustainability assessment of SIMTAP systems

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Summary

Introduction

This document describes the indicators selected to evaluate the overall sustainability of Integrated Multi-trophic Aquaculture Systems in the context of the SIMTAP project. In this project, several assessment methods are applied to assess environmental (LCA and Emergy accounting) as well as social (SLCA) and economic (LCC) impacts. A multicriteria methodology called DEXI is then used to bring together the three sustainability dimensions to evaluate the overall sustainability. This document gives a list of the indicators selected for each method and also those that have been added to the overall evaluation when missing following expert's expectations.

In this document, they have been classified into the three sustainability branches. Some concerns several branches so they have been described twice.

Some of these indicators are easily obtainable (direct data) but some are calculated thanks to several input data, more or less easy to obtain and/or assess. In the context of the project, a template has been created to help the data collection as well as the calculation of indicators. It also calculates the associated scales depending on thresholds values defined with experts, to furnish a final and formatted list of indicators, able to be evaluate thanks to Dexi.

All the indicators of this document are then those listed in the "indicator" sheet of the template. Their scales are calculated by filling the rest of the template, following the template guidelines.

Economic sustainability indicators

This section presents the indicators related to economic sustainability. Some of them are calculated to perform Life Cycle Costing. Some have been added following experts expectations.

Indicator	Unit
On farm energy efficiency	Mwh/ton
Total feed conversion rate	kg/kg
Labour productivity	#
Production loss	%
Nutritional quality	g[EPA + DHA]/100g
Average sales prices	€/kg
Paid labour costs	€/kg
Feed costs	€/kg
Juveniles and seedling costs	€/kg
Net Present Value	€
Internal Rate of Return	%
Subsidies weight	€/kg
Emergy Yield Ratio	#
Production diversification	#
Biosecurity and good practices	#
Resistance to environmental constraints	#
Specialization rate	%
Independence towards suppliers	%
Independence towards customers	%
Fish in Fish out Ratio	#

On farm energy efficiency

Short name: OFEE

Type of indicator: Quantitative

Relative dimension and aggregated criteria:

- Environmental sustainability: Productivity of energy used
- Economic sustainability: Resources productivity

Description:
This indicator refers to the productivity of the on-farm energy used per kg of biomass produced. It considers the quantity of energy (in MWh) used by the system during a year.

Unit: MWh / ton

Indicators calculation:

$$\boldsymbol{OFEE = \frac{\sum Quantity\ of\ energy\ used}{Total\ biomass\ produced}}$$

With:
- Quantity of energy used: Quantity in kWh of on farm energy used per year.
- Total biomass produced: Total quantity of biomass produced per year in kg (Final Biomass – Initial Biomass + Variation of stock)

Indicators interpretation:
The lower the indicator is, the more efficient the system is in the use of energy.

Scales definition:

Qualitative scales		Thresholds values	References
Very High	+	Less than 0.5 MWh/T	(IDAQUA 2010)
High		Between 0.5 and 1 MWH/T	
Medium		Between 1 and 1.5 MWh/T	
Low		Between 1.5 and 5 MWh/T	
Very Low	-	More than 5MWh/T	

Effect / overlap / compromise with other indicators:
This indicator is used to assess the productivity of the system in the use of energy resources. A higher on farm energy efficiency can allow higher economic return and an enhancement of the environmental sustainability (by saving non-renewable energy resources). This indicator is merged to assess the productivity of energy used (environmental sustainability) with the percentage of renewable energy as a higher consumption of energy per biomass produced can be balanced by a use of renewable energy on-farm.

References:

(Consensus 2005; Vilain 2008; IDAQUA 2010)

Total feed conversion rate

Short name: TFCR

Type of indicator: Quantitative

Relative dimension and aggregated criteria:

- Economic sustainability: Resources productivity
- Environmental sustainability: Feed efficiency

Description:
This indicator refers to the productivity of the feed use.

Unit: kg / kg

Indicators calculation:

$$\boldsymbol{TFCR = \frac{Quantity\ of\ feed\ used}{Total\ biomass\ produced}}$$

With:

- Quantity of feed used: Quantity in kg of feed (purchased or self-produced) used per year.
- Total biomass produced: Total quantity of biomass produced per year in kg (Final Biomass – Initial Biomass + Variation of stock)

Indicators interpretation:
The lower the indicator is, the more efficient the system is in the use of feed.

Scales definition:

Qualitative scales		Thresholds values	References
Very High	-	More than 2.2	(Fezzardi 2013; IDAQUA 2010)
High		Between 1.8 and 2.2	
Medium		Between 1.6 and 1.8	
Low		Between 1.3 and 1.6	
Very Low	+	Less than 1.3	

Effect / overlap / compromise with other indicators:
A higher on farm feed efficiency can allow higher economic return and an enhancement of the environmental sustainability. Overlaps with the source of feed ingredients and genetics may exist. Moreover, it must be considered that the FCR tends to increase as fish is getting older, so threshold values may be analysed prudently. Moreover, this indicator can be linked with the net primary production use (LCA).

References:

(Consensus 2005; IDAQUA 2010; Fezzardi 2013)

Labour productivity

Short name: LP

Type of indicator: Quantitative

Relative dimension and aggregated criteria:

- Economic sustainability: Resources productivity

Description:
This indicator refers to the productivity of paid labour. It considers “the average output per worker” (Nielsen, Carvalho, et Guillen 2018). It can be calculated as Gross Value Added (GVA) per total costs of labour

Unit: Number

Indicators calculation:

$$LP = \frac{Gross\ Value\ Added}{Total\ costs\ of\ labour}$$

With:

- Gross Value Added: Gross sales + other income (subsidies) - Feed costs – Juveniles and seedlings costs - Energy costs - Repair and maintenance - Other operational costs.
- Total costs of labour: Total costs in € in wages and salaries and the imputed value of unpaid labour (considering owners' wages). NB: If owners' wages is not explicitly defined, add one and a half the basic wages of the country per owner FTE.

Indicators interpretation:

The higher the indicator is, the higher the labour productivity is.

Scales definition:

Qualitative scales		Thresholds values	References
Very High	+	More than 2	(IDAQUA 2010)
High		Between 1.5 and 2	
Medium		Between 1.25 and 1.5	
Low		Between 1 and 1.25	
Very Low	-	Less than 1	

Effect / overlap / compromise with other indicators:
This indicator appreciates the capacity of the system to create wealth from paid labour. A system may be sustainable if the work is efficient and if the wealth created allows to cover cost of labour.

References:

(Nielsen, Carvalho, et Guillen 2018; IDAQUA 2010)

Production loss

Short name: PL

Type of indicator: Quantitative

Relative dimension and aggregated criteria:

- Economic sustainability: Production management
- Social sustainability: Production health management
- Environmental sustainability: Limit organic wastes production

Description:
This indicator refers to the quantity of biomass lost through a year. It considers the percentage of dead or discarded biomass per year.

Unit: %

Indicators calculation:

$$\boldsymbol{PL = \frac{Quantity\ of\ biomass\ lost}{Total\ biomass\ produced} \times 100}$$

With:
- Quantity of biomass lost: Quantity of dead or discarded biomass in kg.
- Total biomass produced: Total quantity of biomass produced per year in kg (Final Biomass – Initial Biomass + Variation of stock)

Indicators interpretation:
The lower the indicator is, the lower production losses are.

Scales definition:

Qualitative scales		Thresholds values	References
Very High	-	More than 40%	(Muniesa et al. 2020)
High		Between 30 and 40%	(Muniesa et al. 2020; IDAQUA 2010)
Medium		Between 20 and 30%	(Muniesa et al. 2020)
Low		Between 10 and 20%	(IDAQUA 2010)
Very Low	+	Less than 10%	(Muniesa et al. 2020; IDAQUA 2010)

Effect / overlap / compromise with other indicators:
This indicator is useful to appreciate the overall sustainability of the system as it increases the economic and environmental performances of the system and the respect of animal welfare. Production loss may depend not only on the system but also on context as it may be influenced by the health status of juveniles and the inflow water quality. However, adoption of good practices and biosecurity measures may lower production loss.

References:

(Consensus 2005; Muniesa et al. 2020; IDAQUA 2010)

Nutritional quality

Short name: LPQ

Type of indicator: Quantitative

Relative dimension and aggregated criteria:

- Economic sustainability: Production management
- Social sustainability: Production of quality-based products

Description:
This indicator is used to appreciate the level of products quality. It appreciates the nutritional quality of the fish products through the percentage of omega 3 (EPA and DHA) of fatty acids contains in fish muscle.

Unit: g/100g

Indicators calculation:

[EPA + DHA] content per 100g of fish

Indicators interpretation:
The higher the indicator is, the higher the nutritional quality is.

Scales definition:

Qualitative scales		Thresholds values (EU)	References
Very High	+	More than 25g/100g	(Valente et al. 2011; Grigorakis 2007; Wassef, Saleh, et El-Abd El-Hady 2009)
High		Between 20 and 25g/100g	
Medium		Between 15 and 20g/100g	
Low		Between 10 and 15g/100g	
Very Low	-	Less than 10 g/100g	

Effect / overlap / compromise with other indicators:
The quality of products is difficult to appreciate as it is linked with subjective appreciation such as hedonic value (referring to the consumer perception of the products) or taste. Nevertheless, the quality of products must be considered from both a social point of view (supply consumers with high quality products) and economic point of view (increasing the value added and the respect of markets expectations). The nutritional quality of products is merged to the indicator fish physical damages to appreciate the level of products quality. EPA and DHA contents of fish products is a commonly used indicator of the nutritional quality.

References:

(Grigorakis 2007; Tacon, Lemos, et Metian 2020; Valente et al. 2011; Wassef, Saleh, et El-Abd El-Hady 2009)

Average sales prices

Short name: ASP

Type of indicator: Quantitative

Relative dimension and aggregated criteria:

- Economic sustainability: Production cost adequacy to sales prices

Description:
This indicator refers to the capacity of the system to valorise efficiently the production. It considers the weighted average of sales price.

Unit: € / kg

Indicators calculation:

$$\boldsymbol{ASP} = \frac{\sum \boldsymbol{Average\ sale\ price\ of\ product\ i} \times (\boldsymbol{quantity\ of\ biomass\ of\ product\ i})}{\boldsymbol{Total\ biomass\ harvested}}$$

or

$$\boldsymbol{ASP} = \frac{\boldsymbol{Total\ gross\ sales}}{\boldsymbol{Total\ biomass\ harvested}}$$

With:

- Average sale price of product i: The average sale price of the product i in €/kg.
- Quantity of biomass of product i: The quantity of biomass harvested of the product i in kg.
- Total biomass harvested: Total quantity of biomass harvested per year in kg
- Total gross sales: Amount in € of the total gross sales without considering subsidies

Indicators interpretation:
The higher the indicator is, the higher the production value is.

Scales definition:

Qualitative scales		Thresholds values (EU)	References
Very High	+	More than 6.5€/kg	(Arikan et Aral 2019; Hadelan et al. 2014; Bjørndal, Guillen, et Rad 2019; Bunting et Shpigel 2009)
High		Between 5.5 and 6.5€/kg	
Medium		Between 4.5 and 5.5€/kg	
Low		Between 4 and 4.5€/kg	
Very Low	-	Less than 4€/kg	

References for seabream and seabass production in Turkey (Bayramoglu 2019)

Effect / overlap / compromise with other indicators:
Sales prices are dependent on the local contexts, markets and type of products sold (fresh, value added …). This indicator measures the capacity of the system to generated turnover. However, it does not consider subsidies or other income that may influenced the overall profitability. Also, this indicator does not consider the effect of the size category on sales price or the geographic context.

References:
(Pelzer et al. 2012; Arikan et Aral 2019; medAID 2017)

Paid labour costs

Short name: PLC

Type of indicator: Quantitative

Relative dimension and aggregated criteria:

- Economic sustainability: Production cost

Description:
This indicator refers to paid labour cost including salary expenses and owners' wages per quantity of biomass produced.

Unit: € / kg

Indicators calculation:

$$PLC = \frac{Total\ costs\ of\ labour}{Total\ biomass\ harvested}$$

With:

- Total costs of labour: Total costs in € in wages and salaries and the imputed value of unpaid labour (considering owners' wages). NB: If owners' wages is not explicitly defined, add one and a half the basic wages of the country per owner FTE.
- Total biomass harvested: Total quantity of biomass harvested per year in kg

Indicators interpretation:
The lower the indicator is, the lower the share of production costs due to paid labour costs is.

Scales definition:

Qualitative scales		Thresholds values	References
Very High	-	More than 1€/kg	(Arikan et Aral 2019; University of stirling 2003) + Expert data
High		Between 0.8 and 1€/kg	
Medium		Between 0.6 and 0.8	
Low		Between 0.4 and 0.6€/kg	
Very Low	+	Less than 0.4€/kg	

Effect / overlap / compromise with other indicators:
This indicator must be carefully interpreted as a low value can be due to low wages. Moreover, the labour remuneration of employees depends on regional minimum wages, the level of qualification needed and the level of automation. Consequently, this indicator should be linked with the labour remuneration indicator and contribution to employment indicator included in the social sustainability dimension.

References:

(IDAQUA 2010; University of stirling 2003; Arikan et Aral 2019)

Feed costs

Short name: FC

Type of indicator: Quantitative

Relative dimension and aggregated criteria:

- Economic sustainability: Production cost

Description:
This indicator refers to feed cost including purchased feed and self-produced feed per quantity of biomass produced.

Unit: € / kg

Indicators calculation:

$$\boldsymbol{PL = \frac{\sum Feed\ costs}{Total\ biomass\ harvested}}$$

With:

- Feed costs: Amount in € of all the feed costs including purchased feed, self-produced feed and fertilizers or other additives.
- Total biomass harvested: Total quantity of biomass harvested per year in kg

Indicators interpretation:
The lower the indicator is, the lower feed costs are.

Scales definition:

Qualitative scales		Thresholds values	References
Very High	-	More than 2€/kg	(Arikan et Aral 2019; University of stirling 2003; Hadelan et al. 2014) + Expert data
High		Between 1.7 and 2€/kg	
Medium		Between 1.5 and 1.7€/kg	
Low		Between 1.3 and 1.5€/kg	
Very Low	+	Less than 1.3€/kg	

Effect / overlap / compromise with other indicators:
This indicator reflects the performance of the system over the feed efficiency and the price of purchased or self-produced feed. Feed costs are mainly affected by the feeding management, world raw materials prices fluctuations and purchased conditions.

References:

(Mathé et al. 2006; Arikan et Aral 2019; University of stirling 2003; Consensus 2005)

Juveniles and seedling costs

Short name: PLC

Type of indicator: Quantitative

Relative dimension and aggregated criteria:

- Economic sustainability: Production cost

Description:
This indicator refers to costs of juveniles and seedling per quantity of biomass produced.

Unit: € / kg

Indicators calculation:

$$\boldsymbol{PLC = \frac{\sum Juveniles\ and\ seedlings\ costs}{Total\ biomass\ harvested}}$$

With:

- Juveniles and seedlings costs: Amount in € of all the juveniles and seedlings costs.
- Total biomass harvested: Total quantity of biomass harvested per year in kg

Indicators interpretation:
The lower the indicator is, the lower juveniles and seedlings costs are.

Scales definition:

Qualitative scales		Thresholds values	References
Very High	-	More than 1.1€/kg	(Arikan et Aral 2019; Nielsen, Carvalho, et Guillen 2018; Llorente et al. 2020; Hadelan et al. 2014) + Expert data
High		Between 0.9 and 1.1€/kg	
Medium		Between 0.7 and 0.9€/kg	
Low		Between 0.5 and 0.7€/kg	
Very Low	+	Less than 0.5€/kg	

Effect / overlap / compromise with other indicators:
This indicator reflects the performance of the system concerning its capacities to have a low mortality rate and to buy juveniles at a low price. However, considering a diversified system producing fish and plants, it seems difficult to well interpreted the value of this indicator.

References:

(Arikan et Aral 2019; Nielsen, Carvalho, et Guillen 2018; Llorente et al. 2020)

Net Present Value

Short name: NPV

Type of indicator: Quantitative

Relative dimension and aggregated criteria:

- Economic sustainability: Profitability

Description:
This indicator refers to the Net Present Value which is the sum of all relevant expected future cash flows discounted at the appropriate discount rate (Campo et Zuniga-Jara 2018).

Unit: €

Indicators calculation (from Valenti et al. 2018 and Trapani et al. 2014) **:**

$$\boldsymbol{NPV} = \sum \frac{\boldsymbol{Ci}}{(\mathbf{1} + \boldsymbol{r})^{\boldsymbol{i}}}$$

With:
- Ci: Net annual cash flows
- R: discount rate (6% (Trapani et al. 2014))
- N: number of years in operation (usually 15 (Trapani et al. 2014) to 20 years (Valenti et al. 2018))

Indicators interpretation:
The higher the indicator is, the higher the NPV is.

Scales definition:

Qualitative scales		Thresholds values	References
High	+	>0 (the project is desirable from the investor's perspective)	(Campo et Zuniga-Jara 2018)
Medium		= 0	
Low	-	<0 (the project is not desirable from the investor's perspective)	

Effect / overlap / compromise with other indicators:
"The NPV is the main criterion for assessing the suitability of any investment program and according to this financial indicator, the greater is its value, the higher will be the convenience of the investment." (Trapani et al. 2014)

References:

(Campo et Zuniga-Jara 2018)

Internal Rate of Return

Short name: IRR

Type of indicator: Quantitative

Relative dimension and aggregated criteria:

- Economic sustainability: Profitability

Description:
This indicator refers to the internal rate of return. It "indicates the percentage rate of return on funds employed" (Lucas et Southgate 2012). "The IRR is the discount rate at which the discounted benefits are equal to the discounted costs, determining a net present value equal to zero" (Trapani et al. 2014).

Unit: %

Indicators calculation (from Valenti et al. 2018 and Trapani et al. 2014) **:**

$$\mathbf{0} = \sum \frac{\boldsymbol{Ci}}{(\mathbf{1} + \boldsymbol{IRR})^{\boldsymbol{i}}}$$

With:

- Ci: Net annual cash flows
- IRR: Internal rate of return
- N: number of years in operation (usually 15 (Trapani et al. 2014) to 20 years (Valenti et al. 2018))

Indicators interpretation:
The higher the indicator is, the higher the IRR is.

Scales definition:

Qualitative scales		Thresholds values	References
High	+	>0	(Lucas et Southgate 2012; Trapani et al. 2014)
Medium		= 0	
Low	-	<0	

Effect / overlap / compromise with other indicators:
"IRR is a useful indicator of the degree of profitability of a project" (Lucas et Southgate 2012). If the IRR of a business exceeds the relevant rate of interest, the business is profitable" (Lucas et Southgate 2012). "According to this indicator, an investment will be convenient if its IRR is higher than a predetermined reference discount rate" (Trapani et al. 2014). IRR "can make small projects appear more attractive than large ones, even though large projects with lower IRRs can be more attractive on an NPV basis" (Trapani et al. 2014)

References:

(Campo et Zuniga-Jara 2018; Lucas et Southgate 2012; Trapani et al. 2014; Valenti et al. 2018)

Subsidies weight

Short name: SW

Type of indicator: Quantitative

Relative dimension and aggregated criteria:

- Economic sustainability: Economic dependency

Description:
This indicator refers to subsides weight. It considers the value of subsidies per kg produced.

Unit: €/kg

Indicators calculation:

$$NS = \frac{Value\ of\ subsidies\ received\ per\ year}{Total\ biomass\ harvested}$$

With:

- Value of subsidies: Value in € of subsidies received
- Total biomass harvested: Total quantity of biomass harvested per year in kg

Indicators interpretation:
The higher the indicator is, the higher subsidies weight is.

Scales definition:

Qualitative scales		Thresholds values	References
High	-	More than 0.42€/kg	(Bjørndal, Guillen, et Rad 2019; Guillen et al. 2019)
Medium		Between 0.22 and 0.42€/kg	
Low	+	Less than 0.22€/kg	

Effect / overlap / compromise with other indicators:
A system dependent on subsidies is less autonomous as it depends on political decisions. Consequently, the viability of the system can be impacted in the long term in case of a decrease of subsidies.

References :

(Bjørndal, Guillen, et Rad 2019; Guillen et al. 2019; Vilain 2008)

Emergy Yield Ratio

Short name: EYR

Type of indicator: Quantitative

Relative dimension and aggregated criteria:

- Environmental sustainability: Use local resources
- Economic sustainability: Economic dependency; resources dependency

Description:
This indicator describes the capacity of the system to use local (i.e. inside system boundaries) resources using the emergy method. It considers the local and imported emergy flows and it shows the efficiency in using purchased inputs (Wilfart et al. 2013).

Unit: Number

Indicators interpretation:
The lower this indicator is, the lower the system uses imported resources and the higher the system uses local resources.

Scales definition:

Qualitative scales		Thresholds values	References
High	+	More than 2	Expert judgement
Medium		Between 1.1 and 2	
Low	-	Less than 1.1	

Effect / overlap / compromise with other indicators:
This indicator is used to appreciate the system capacity to rely on its available local (i.e inside system boundaries) resources. From an economic point of view, a system that is less dependent on imported emergy flows will be more autonomous. From an environmental point of view, the system will use more efficiently local resources.

References:

(Wilfart et al. 2013)

Production diversification

Short name: NS

Type of indicator: Quantitative

Relative dimension and aggregated criteria:

- Environmental sustainability: To foster polyculture and integration of natural cycles

Description:
This indicator considers the number of planned species reared in the system. It does not consider present species but not planned.

Unit: Number

Indicators calculation:

$$NS = \text{ Number of planned species}$$

Indicators interpretation:
The higher the indicator is, the higher the biodiversity of species in the system is.

Scales definition:

Qualitative scales		Thresholds value	References
High	+	More than 5 species	Appreciation
Medium		Between 2 and 5 species	
Low	-	1 specie	

Effect / overlap / compromise with other indicators:
Culturing more than one species permits to enhance the biodiversity within the system. Moreover, this indicator considers that a diversified production system is a way to limit economical risks. On one hand the system is more resilient to pathology risks. Even if one of the reared species is affected by a disease, it cannot affect the entire system as the production of the other can be continued. Moreover, rearing several species together may lower their sensitivity to pathologies and may favour positive interactions. However, it could be more difficult in a diversified system to cure diseases especially in Integrated (or coupled) Recirculated aquaculture system. On the other hand, a diversified system can buffer the impacts of environmental constraints, price variations or regulations modifications.

References :

(Aubin et al. 2014; IDAQUA 2010; Vilain 2008)

Biosecurity and good practices

Short name: BGP

Type of indicator: Quantitative

Relative dimension and aggregated criteria:

- Social sustainability: Respect of animal welfare; Rearing environment
- Economic sustainability: Level of sensitivity to pathology risks
- Environmental sustainability: Protection of local fauna and flora; Disease management

Description:
This indicator refers to the biosecurity measures and good practices developed in the system. It considers a score resulting of the respect of several conditions.

Indicators calculation:

For each condition add 1 point when the condition is respected in the system.

Conditions to respect	Score if respected
Disinfection or restricted access of visitors or vehicles to the production site	+1 otherwise 0
Disinfection or application of a quarantine for juveniles and new plants	+1 otherwise 0
Disinfection or drying up procedures at the end of the production cycle	+1 otherwise 0
Existence of disinfected barriers for employees to access to the production site and to between compartments of the system	+1 otherwise 0
Existence of specific equipment to disinfect inflow water	+1 otherwise 0

Indicators interpretation:
The higher the indicator is, the higher biosecurity and good practices are developed.

Scales definition:

Qualitative scales		Thresholds values	References
High	+	More than 3	
Medium		2 or 3	
Low	-	0 or 1	

Effect / overlap / compromise with other indicators:
This indicator appreciates the capacity to prevent the spread of diseases in the production site and in ecosystems. This indicator is used to assess the sustainability of the system over the economic, social and environmental dimensions as biosecurity and good practices measures reduce the sensitivity to pathology risks, enhance the rearing conditions and the respect of animal welfare and prevent the spread of diseases in ecosystems.

References:

(IDAQUA 2010; medAID 2017)

Resistance to environmental constraints

Short name: SEC

Type of indicator: Quantitative

Relative dimension and aggregated criteria:

- Economic sustainability: Vulnerability

Description:
This indicator refers to the severity of environmental constraints (pollution, natural hazards, abiotic or biotic variations …)

Indicators calculation:

For each category of environmental constraints, appreciate the probability of occurrence (0 never, 1 low, 2 sometimes, 3 often) and the severity (1 low to 3 high). To calculate the score multiplied the two columns.

Category of environmental constraints	Probability of occurrence	Severity	Score
Natural hazards such as drought, flood, storm …	0 to 3	1 to 3	0 to 9
Pollution or contamination of inlet water	0 to 3	1 to 3	0 to 9
Pathogens introduction	0 to 3	1 to 3	0 to 9
Predators	0 to 3	1 to 3	0 to 9
Final score			0 to 36

Nota Bene: If one of the intermediate scores is 9, then final score is 15. Else, it is equal to the sum of intermediate scores.

Indicators interpretation:
The lower the indicator is, the higher the resistance to environmental constraints is.

Scales definition:

Qualitative scales		Thresholds values	References
Very High	+	Less than 5	
High		Between 5 and 8	
Medium		Between 8 and 12	
Low		Between 12 and 15	
Very Low	-	More than 15	

Effect / overlap / compromise with other indicators:
This indicator reflects the capacity of the system to resist to environmental constraints with can interfere with its viability. The indicator calculation allows to consider that a hazardous environmental constraint cannot be risky for the system if it does not occur frequently and vice versa.

References:

(Valenti et al. 2018)

Specialization rate

Short name: SP

Type of indicator: Quantitative

Relative dimension and aggregated criteria:

- Economic sustainability: Resistance to commercial risks

Description:
This indicator refers to the diversification of the system; It considers the ratio of the main product turnover compared to the total turnover.

Unit: %

Indicators calculation:

$$\boldsymbol{SP = \frac{Main\ product\ turnover}{Total\ turnover} \times 100}$$

With:

- Main product turnover: Amount in € of the turnover generated by the main product without considering subsidies.
- Total turnover: Amount in € of the total turnover without considering subsidies

Indicators interpretation:
The higher the indicator is, the lower the system is specialized.

Scales definition:

Qualitative scales		Thresholds values	References
High	-	More than 80%	(Vilain 2008)
Medium		Between 50 and 80%	
Low	+	Less than 50%	

Effect / overlap / compromise with other indicators:
This indicator appreciates the diversification of the system through the specialization rate. A diversified system could be less vulnerable to economic risks (for example price volatility).

References:

(Vilain 2008)

Independence towards suppliers

Short name: ITS

Type of indicator: Quantitative

Relative dimension and aggregated criteria:

- Social sustainability: Quality of the relationship with customers and suppliers

Description:
This indicator refers to the independence towards suppliers. It considers the proportion of inputs (for example feed, seedlings, juveniles, or energy) that are self-produced.

Unit: #

Indicators calculation:

Category of input	Scales	Score	Ponderation
Feed	Less than 20%	**1**	**40%**
	Between 20 and 50%	**2**	
	More than 50%	**3**	
Seedlings	Less than 20%	**1**	**20%**
	Between 20 and 50%	**2**	
	More than 50%	**3**	
Juveniles	Less than 20%	**1**	**30%**
	Between 20 and 50%	**2**	
	More than 50%	**3**	
Energy	Less than 20%	**1**	**10%**
	Between 20 and 50%	**2**	
	More than 50%	**3**	

Indicators interpretation:
The higher the indicator is, the higher the independence towards suppliers is.

Scales definition:

Qualitative scales		Thresholds values	References
High	+	More than 2	
Medium		Between 1 and 2	
Low	-	Less than 1	

Effect / overlap / compromise with other indicators:
This indicator should be considered as a proxy of the autonomy of the system. The goal is to appreciate the capacity of the system of not being dependent on suppliers from a commercial point of view, not to appreciate the self-sufficiency.

References:

(Vilain 2008)

Independence towards customers

Short name: ITC

Type of indicator: Quantitative

Relative dimension and aggregated criteria:

- Social sustainability: Quality of the relationship with customers and suppliers

Description:
This indicator refers to the independence towards customers. It considers the percentage of total income (without subsidies) derived from the biggest customer.

Unit: %

Indicators calculation:

$$ITC = \frac{Income\ derived\ from\ the\ biggest\ customer}{Total\ income}$$

With:

Indicators interpretation:
The lower the indicator is, the higher the independence towards customers is.

Scales definition:

Qualitative scales		Thresholds value	References
High	+	Less than 25%	(Vilain 2008)
Medium		Between 25 % and 50%	
Low	-	More than 50%	

Effect / overlap / compromise with other indicators:
This indicator refers to the dependence of the system to customers. A system which has several customers, is less dependent of customer changing attitudes.

References:

(Vilain 2008; IDAQUA 2010)

Fish in Fish out Ratio

Short name: FIFO

Type of indicator: Quantitative

Relative dimension and aggregated criteria:

- Environmental sustainability: Use sustainable resources for feed
- Economic sustainability: Resistance to commercial risks

Description:
This indicator describes dependence of the system on wild fish resources. It considers the fish in fish out ratio (FIFO), that is generally used as "a measure of the amount of marine resources that are consumed in the production of farmed fish" (Ytrestøyl, Aas, et Åsgård 2015). As the oil content has an influence on the FIFO ratio due to the yield variation of fish oil from wild fish, it was chosen to only consider the level of fish oil in feed to calculate it.

Unit: Number

Indicators calculation:

$$\boldsymbol{FIFO} = \left[\frac{\boldsymbol{Level\ of\ FO\ in\ feed}}{\boldsymbol{Yield\ of\ FO\ from\ wild\ fish}}\right] \times \boldsymbol{FGR}$$

With :

- Level of FO in feed: Quantity in g of fish oil used per kg of feed
- Yield of fish oil from wild fish: Percentage 4.3% (Anchovy from Peru)
- FGR: Food to Gain Ratio FGR: Food to Gain Ratio (considered to be equivalent to the Feed Conversion Rate FCR)

Indicators interpretation:
The lower the indicator is, the higher the use of sustainable resources for feed is.

Scales definition:

Qualitative scales		Thresholds value	References
Very High	-	More than 6	(Kaushik et Troell 2010)
High		Between 4.5 and 6	
Medium		Between 3 and 4.5	
Low		Between 1.5 and 3	
Very Low	+	Less than 1.5	

Effect / overlap / compromise with other indicators:
The dependence of aquaculture on wild fish resources is a major issue in terms of environmental impacts and of market dependency. The Fish In Fish Out (FIFO) ratio is commonly used indicator to appreciate the efficiency of fish farming in the use of wild fishes and the need of the sector for fish resources.

References:

(Kaushik et Troell 2010; Byelashov et Griffin 2014; Ytrestøyl, Aas, et Åsgård 2015)

Social sustainability indicators

This section presents the indicators related to social sustainability. Part of them are calculated to perform Social Life Cycle Assessment. Some have been added following experts expectations.

Indicator	Unit
Interactions with professional institutions	#
Professional involvement	#
Independence towards suppliers	%
Independence towards customers	%
Workload	h/FTE
Health and safety	#lost days/1000h
Job difficulty appreciation	No unit
Labour remuneration	#
Working status	%
Education level	%
Gender equality	%
Production lossFish physical damages	%
Fish physical damages	%
Stocking density	kg/m^3
Biosecurity and good practices	#
Assured supply of products	ton/FTE
Accessibility of products	#
Contribution to employment	#FTE/100000€
Feedstuff locally produced	%
Education contribution	No unit

Interactions with professional institutions

Short name: IWPI

Type of indicator: Quantitative

Relative dimension and aggregated criteria:

- Social sustainability: Quality of the relationship with professional institutions

Description:
This indicator refers to the number of interactions with professional institutions such as farmers 'organizations, other farmers, research and technical institutions and educations centres. Interactions can be considered as on-farm trials, visits, collaborations...

Unit: Number

Indicators calculation:

$$IWPI = Number\ of\ interactions\ with\ professional\ institutions$$

Indicators interpretation:
The higher the indicator is, the higher the interactions with professional institutions are.

Scales definition:

Qualitative scales		Thresholds values	References
High	+	More than one interaction with several actors of the sector per year	
Medium		More than one interaction with one actor of the sector per year	
Low	-	Only one interaction (or less) with one actor of the sector per year	

Effect / overlap / compromise with other indicators:
This indicator appreciates the capacity to develop relationship with professional institutions. A system that has several interactions with other actors contributes to the development of the sector and permit to be less socially isolated.

References:

Professional involvement

Short name: PI

Type of indicator: Quantitative

Relative dimension and aggregated criteria:

- Social sustainability: Quality of the relationship with professional institutions

Description:

This indicator refers to the professional involvement of the farm in the sector organization. It considers the number of participations to seminar or professional meetings per year. This indicator is a proxy of the professional involvement.

Unit: Number

Indicators calculation:

$$\boldsymbol{PI = Number\ of\ participations\ to\ seminar\ or\ professional\ meetings\ per\ year}$$

Indicators interpretation:

The higher the indicator is, the higher the professional involvement is.

Scales definition:

Qualitative scales		Thresholds values	References
High	+	More than 5	(IDAQUA 2010)
Medium		Between 1 to 4	(IDAQUA 2010)
Low	-	0 (no participation)	(IDAQUA 2010)

Effect / overlap / compromise with other indicators:

Exchanges with other actors of the sector through the participation to meetings or seminar improve the development of the sector and permit to be less socially isolated.

References:

(IDAQUA 2010)

Independence towards suppliers

Short name: ITS

Type of indicator: Quantitative

Relative dimension and aggregated criteria:

- Social sustainability: Quality of the relationship with customers and suppliers

Description:
This indicator refers to the independence towards suppliers. It considers the proportion of inputs (for example feed, seedlings, juveniles, or energy) that are self-produced.

Unit: #

Indicators calculation:

Category of input	Scales	Score	Ponderation
Feed	Less than 20%	**1**	**40%**
	Between 20 and 50%	**2**	
	More than 50%	**3**	
Seedlings	Less than 20%	**1**	**20%**
	Between 20 and 50%	**2**	
	More than 50%	**3**	
Juveniles	Less than 20%	**1**	**30%**
	Between 20 and 50%	**2**	
	More than 50%	**3**	
Energy	Less than 20%	**1**	**10%**
	Between 20 and 50%	**2**	
	More than 50%	**3**	

Indicators interpretation:
The higher the indicator is, the higher the independence towards suppliers is.

Scales definition:

Qualitative scales		Thresholds values	References
High	+	More than 2	
Medium		Between 1 and 2	
Low	-	Less than 1	

Effect / overlap / compromise with other indicators:
This indicator should be considered as a proxy of the autonomy of the system. The goal is to appreciate the capacity of the system of not being dependent on suppliers from a commercial point of view, not to appreciate the self-sufficiency.

References:

(Vilain 2008)

Independence towards customers

Short name: ITC

Type of indicator: Quantitative

Relative dimension and aggregated criteria:

- Social sustainability: Quality of the relationship with customers and suppliers

Description:
This indicator refers to the independence towards customers. It considers the percentage of total income (without subsidies) derived from the biggest customer.

Unit: %

Indicators calculation:

$$ITC = \frac{Income\ derived\ from\ the\ biggest\ customer}{Total\ income}$$

With:

Indicators interpretation:
The lower the indicator is, the higher the independence towards customers is.

Scales definition:

Qualitative scales		Thresholds values	References
High	+	More than 50%	(Vilain 2008)
Medium		Between 25 % and 50%	
Low	-	Less than 25%	

Effect / overlap / compromise with other indicators:
This indicator refers to the dependence of the system to customers. A system which has several customers, is less dependent of customer changing attitudes.

References:

(Vilain 2008)

Workload

Short name: WL

Type of indicator: Quantitative

Relative dimension and aggregated criteria:

- Social sustainability: Guarantee of staff protection and fulfilment

Description:
This indicator refers to the workload. It considers the average number of hours worked per year per full time equivalent.

Unit: h / FTE

Indicators calculation:

$$\boldsymbol{WL = \frac{\sum Total\ number\ of\ hours\ worked\ per\ year\ per\ worker}{Number\ of\ full\ time\ equivalent}}$$

With:
- Total number of hours worked per year: Cumulate number of hours worked per year for each employee.
- Number of full time equivalent: Total number of full time equivalent.

Indicators interpretation:
The higher the indicator is, the higher the workload is.

Scales definition:

Qualitative scales		Thresholds values	References
High	-	More than 2200h	
Medium		Between 1600 and 2200h	
Low	+	Less than 1600h	

Effect / overlap / compromise with other indicators:
This indicator reflects the workload through the average number of hours worked per year per full time equivalent. A high number of hours worked per year can disturb the balance between professional and personal life. Nevertheless, as this indicator considers the average number of hours worked, it does not show potential differences between employees.

References:

(Siebert et al. 2018)

Health and safety

Short name: HS

Type of indicator: Quantitative

Relative dimension and aggregated criteria:

- Social sustainability: Guarantee of staff protection and fulfilment

Description:
This indicator refers to the working conditions concerning health and safety. It considers the gravity rate equals to the number of temporary disability lost days caused by work accidents or sick-leave days due to work per year per 1000 working hours. This rate does not take into account fatal accidents.

Unit: number / 1000 hours

Indicators calculation:

$$\boldsymbol{HS = \frac{\sum Total\ number\ of\ temporary\ disability\ lost\ days}{Total\ number\ of\ full\ time\ equivalent}}$$

With:

- Total number of temporary disability lost days: Cumulate number of sick leave days or days of absence from work caused by an accident at work per year
- Total number of hours worked per year: Cumulate number of hours worked per year for each employee.

Indicators interpretation:
The higher the indicator is, the lower the health and safety appreciation is.

Scales definition:

Qualitative scales		Thresholds values	References
High	+	More than 2	(« Taux graden » 2018)
Medium		Between 1 and 2	
Low	-	Less than 1	

Effect / overlap / compromise with other indicators:
Providing a safe and healthy working environment is essential for ensuring workers protection. It is essential for a responsible system to reduce the risks of injuries and accidents by developing preventive measure such as worker training.

References:

(Siebert et al. 2018; Mathé et al. 2006; ASC 2019)

(« Accidents du travail et maladies professionnelles (AT-MP). Statistiques nationales - Démarches de prévention - INRS » s. d.)

(« Taux graden » 2018)

(Eurogip 2016)

Job difficulty appreciation

Short name: JDA

Type of indicator: Qualitative

Relative dimension and aggregated criteria:

- Social sustainability: Guarantee of staff protection and fulfilment

Description:
This indicator refers to the appreciation of the rudeness of the job. It considers a qualitative appreciation of the complexity of the system management, which can be a proxy of the stress.

Unit: No unit

Indicators interpretation:
The higher the indicator is, the higher the job difficulty is.

Scales definition:

Qualitative scales		Thresholds values	References
High	-	The system is complex and requires a constant attention which is stressful.	
Medium		The system is quite complex but does not lead to constant stress situation.	
Low	+	The system is not complex and can be easily manage.	

Effect / overlap / compromise with other indicators:
This indicator relies on a subjective appreciation of the complexity of the system. However, a system that is considered as stressful and requiring a constant attention can impact the fulfilment of workers or their personal life.

References:

Labour remuneration

Short name: LR

Type of indicator: Quantitative

Relative dimension and aggregated criteria:

- Social sustainability: Guarantee of staff protection and fulfilment

Description:
This indicator refers to the labour remuneration of workers including owners. It considers the average salary of workers (including owners) compared to the basic wages of the country.

Unit: Number

Indicators calculation:

$$LR = \frac{Average\ salary\ of\ workers}{Basic\ wages\ of\ the\ country}$$

With:
- Average salary of workers: Sum of all workers' salaries per year (including owners) divided by the number of full time equivalent.
- Basic wages of the country: Value of the basic wages of the country per year.

Indicators interpretation:
The higher the indicator is, the higher the labour remuneration is.

Scales definition:

Qualitative scales		Thresholds values	References
High	+	More than 1.5	(FAO 2016)
Medium		Between 1 and 1.5	
Low	-	Less than 1	

Effect / overlap / compromise with other indicators:
This indicator considers the capacity to remunerate workers. A system that permit to remunerate on average more workers than the basic wages of the country is considered as more socially sustainable. However, as this indicator considers the average salary of workers, it does not permit to observe differences of salary between workers. Furthermore, it cannot permit to know if a worker is less paid than the basic wages of the country.

References:

(Siebert et al. 2018; Mathé et al. 2006; FAO 2016)

Working status

Short name: WS

Type of indicator: Quantitative

Relative dimension and aggregated criteria:

- Social sustainability: Conditions of employment

Description:
This indicator refers to the working status of employees. It considers the percentage of permanent contract employees.

Unit: %

Indicators calculation:

$$\boldsymbol{WS = \frac{Number\ of\ permanent\ contract\ employees\ per\ year}{Total\ number\ of\ employees\ per\ year} \times 100}$$

Indicators interpretation:
The higher the indicator is, the higher the working status is.

Scales definition:

Qualitative scales		Thresholds value	References
High	-	More than 80%	Appreciation
Medium		Between 60 and 80%	
Low	+	Less than 60%	

Effect / overlap / compromise with other indicators:

References:

(Siebert et al. 2018; Success 2018)

Education level

Short name: EL

Type of indicator: Quantitative

Relative dimension and aggregated criteria:

- Social sustainability: Conditions of employment

Description:
This indicator refers to the education level of employees. It considers the percentage of qualified employees (employed more than six months).

Unit: %

Indicators calculation:

$$\boldsymbol{EL = \frac{Number\ of\ qualified\ employees}{Total\ number\ of\ employees} \times 100}$$

With:
- Number of qualified employees: Number of employees with a professional training.

Indicators interpretation:
The higher the indicator is, the higher the education level is.

Scales definition:

Qualitative scales		Thresholds value	References
High	+	More than 30%	(IDAQUA 2010)
Medium		Between 10 and 30%	(IDAQUA 2010)
Low	-	Less than 10%	(IDAQUA 2010)

Effect / overlap / compromise with other indicators:

References:

(Siebert et al. 2018)

(IDAQUA 2010)

(Mathé et al. 2006)

Gender equality

Short name: GE

Type of indicator: Quantitative

Relative dimension and aggregated criteria:

- Social sustainability: Conditions of employment; equal opportunities

Description:
This indicator refers to the gender inclusion and equality. It considers on one hand the percentage of women workers and on the other the existence of a difference of salary between gender.

Unit: %

Indicators calculation:

$$\boldsymbol{GE = \frac{Number\ of\ women\ workers}{Total\ number\ of\ employees}}$$

Indicators interpretation:
The higher the indicator is, the higher the gender equality is.

Scales definition:

Qualitative scales		Thresholds value	References
High	+	The system employs women (at least 30%) and pays them as men	
Medium		The system employs women (at least 30%) less paid than men	
Low	-	The system does not employ enough women (less than 30%)	

Effect / overlap / compromise with other indicators:

References:

(Siebert et al. 2018)

(Kruse et al. 2008)

Production loss

Short name: PL

Type of indicator: Quantitative

Relative dimension and aggregated criteria:

- Economic sustainability: Production management
- Social sustainability: Production health management
- Environmental sustainability: Limit organic wastes production

Description:
This indicator refers to the quantity of biomass lost through a year. It considers the percentage of dead or discarded biomass per year.

Unit: %

Indicators calculation:

$$\boldsymbol{PL = \frac{Quantity\ of\ biomass\ lost}{Total\ biomass\ produced} \times 100}$$

With:
- Quantity of biomass lost: Quantity of dead or discarded biomass in kg.
- Total biomass produced: Total quantity of biomass produced per year in kg (Final Biomass – Initial Biomass + Variation of stock)

Indicators interpretation:
The lower the indicator is, the better the system is managed, as it ensures good health of reared organisms and the higher the system limit organic wastes production.

Scales definition:

Qualitative scales		Thresholds value	References
Very High	+	More than 40%	(Muniesa et al. 2020)
High		Between 30 and 40%	(Muniesa et al. 2020; IDAQUA 2010)
Medium		Between 20 and 30%	(Muniesa et al. 2020)
Low		Between 10 and 20%	(IDAQUA 2010)
Very Low	-	Less than 10%	(Muniesa et al. 2020; IDAQUA 2010)

Effect / overlap / compromise with other indicators:
This indicator is useful to appreciate the overall sustainability of the system as it increases the economic and environmental performances of the system and the respect of animal welfare. Production loss may depend not only on the system but also on context as it may be influenced by the health status of juveniles and the inflow water quality. However, adoption of good practices and biosecurity measures may lower production loss.

References:

(Consensus 2005; Muniesa et al. 2020; IDAQUA 2010)

Fish physical damages

Short name: FPD

Type of indicator: Quantitative

Relative dimension and aggregated criteria:

- Social sustainability: Respect animal welfare; Rearing environment
- Social sustainability: Level of products quality
- Economic sustainability: Level of products quality

Description:
This indicator refers to the fish skin or fin damage. It considers the percentage of fish suffering of skin or fin damage. A sampling of 150 individual fish can be done.

Unit: %

Indicators calculation:

$$SD = \frac{Number\ of\ fish\ with\ skin\ or\ fin\ damages\ or\ deformities}{Total\ number\ of\ fish\ sampled}$$

Indicators interpretation:
The lower the indicator is, the lower reared fish are suffering of physical damages.

Scales definition:

Qualitative scales		Thresholds value	References
High	-	More than 20%	(medAID 2017)
Medium		Between 4% and 20%	
Low	+	Less than 4%	

Effect / overlap / compromise with other indicators:
This indicator is used to appreciate the production health management of the reared fish through the skin and fin damages. Moreover, it is used to appreciate the visual quality of fish for the aggregated indicator level of products quality.

References:

(IDAQUA 2010; medAID 2017)

Stocking density

Short name: SD

Type of indicator: Quantitative

Relative dimension and aggregated criteria:

- Social sustainability: Respect animal welfare; Rearing environment

Description:
This indicator refers to the maximum stocking density of reared animals. It considers the average weight of a defined population in a volume available.

Unit: kg / m³

Indicators calculation (medAID):

$$\boldsymbol{SD = Average\ weight\ of\ a\ population\ (n = 60)\ \times number\ of\ individuals \times volume\ available}$$

Indicators interpretation:
The higher the indicator is, the higher the stocking density is.

Scales definition:

Qualitative scales		Thresholds value	References
High	-	More than 45 kg/m³	(medAID 2017)
Medium		Between 22 and 45 kg/m³	
Low	+	Less than 22kg/m³	

Effect / overlap / compromise with other indicators:
Maximum stocking density is often used as a welfare indicator, as it can have an incidence on fish welfare which is becoming more and more a social expectation. High stocking density can impact fish health and welfare, but also productivity and profitability.

References:

(medAID 2017)

Biosecurity and good practices

Short name: BGP

Type of indicator: Quantitative

Relative dimension and aggregated criteria:

- Social sustainability: Respect of animal welfare; Rearing environment
- Economic sustainability: Level of sensitivity to pathology risks
- Environmental sustainability: Protection of local fauna and flora; Disease management

Description:
This indicator refers to the biosecurity measures and good practices developed in the system. It considers a score resulting of the respect of several conditions.

Indicators calculation:

For each condition add 1 point when the condition is respected in the system.

Conditions to respect	Score if respected
Disinfection or restricted access of visitors or vehicles to the production site	+1 otherwise 0
Disinfection or application of a quarantine for juveniles and new plants	+1 otherwise 0
Disinfection or drying up procedures at the end of the production cycle	+1 otherwise 0
Existence of disinfected barriers for employees to access to the production site and to between compartments of the system	+1 otherwise 0
Existence of specific equipment to disinfect inflow water	+1 otherwise 0

Indicators interpretation:
The higher the indicator is, the higher biosecurity and good practices are developed.

Scales definition:

Qualitative scales		Thresholds value	References
High	+	More than 3	
Medium		2 or 3	
Low	-	Less than 2	

Effect / overlap / compromise with other indicators:
This indicator appreciates the capacity to prevent the spread of diseases in the production site and in ecosystems. This indicator is used to assess the sustainability of the system over the economic, social and environmental dimensions as biosecurity and good practices measures reduce the sensitivity to pathology risks, enhance the rearing conditions and the respect of animal welfare and prevent the spread of diseases in ecosystems.

References:

(IDAQUA 2010; medAID 2017)

Assured supply of products

Short name: AS

Type of indicator: Quantitative

Relative dimension and aggregated criteria:

- Social sustainability: Contribution to food security

Description:
This indicator refers to the capacity of the system to ensure a supply of food products on markets. It considers the quantity of biomass produced in tonnes per full time equivalent.

Unit: tonnes / FTE

Indicators calculation:

$$\boldsymbol{AS = \frac{Dry\ matter\ biomass\ produced}{Number\ of\ Full\ Time\ Equivalent}}$$

With:

- Dry matter biomass produced: Total quantity of dry matter biomass produced per year in tonnes (Final Biomass – Initial Biomass + Variation of stock)
- Number of full time equivalent: Total number of full time equivalent.

Indicators interpretation:
The higher the indicator is, the higher the supply of food products is.

Scales definition:

Qualitative scales		Thresholds value	References
Very High	+	More than 17,5 T/FTE	(Valderrama, Hishamunda, et Zhou, s. d.)
High		Between 12,5 and 17,5 T/FTE	
Medium		Between 7,5 and 12,5 T/FTE	
Low		Between 2,5 and 7,5 T/FTE	
Very Low	-	Less than 2,5 T/FTE	

Effect / overlap / compromise with other indicators:

References:

(Consensus 2005)

(Valderrama, Hishamunda, et Zhou, s. d.)

Accessibility of products

Short name: ACP

Type of indicator: Quantitative

Relative dimension and aggregated criteria:

- Social sustainability: Contribution to food security

Description:
This indicator refers to the accessibility of products for customers. It considers the average sales price compared to the basic wages of the country.

Unit: Number

Indicators calculation:

$$ACP = \frac{\mathit{Average\ sales\ price}}{\frac{\mathit{Monthly\ basic\ wages\ of\ the\ country}}{1000}}$$

With:
- Averages sales price: Please refer to "average sales price" indicator calculation
- Basic wages of the country: Value of the basic wages of the country per year.

Indicators interpretation:
The lower the indicator is, the higher the accessibility of products is.

Scales definition:

Qualitative scales		Thresholds values (EU)	References
Very High	+	Less than 4	(Arikan et Aral 2019; Hadelan et al. 2014; Bjørndal, Guillen, et Rad 2019; Bunting et Shpigel 2009)
High		Between 4 and 4.5	
Medium		Between 4.5 and 5.5	
Low		Between 5.5 and 6.5	
Very Low	-	More than 6.5	

Effect / overlap / compromise with other indicators:

References:

(Gholifar et al. 2017)

Contribution to employment

Short name: ILE

Type of indicator: Quantitative

Relative dimension and aggregated criteria:

- Social sustainability: Contribution to the local development

Description:
This indicator refers to the contribution to employment. It considers the number of FTE generated per 100 000€ of total revenue (i.e turnover).

Unit: FTE / 100000€

Indicators calculation:

$$\boldsymbol{EL = \frac{Number\ of\ Full\ Time\ Equivalent}{Turnover/100000}}$$

With:

- Turnover: Turnover in 100 000€
- Number of full time equivalent: Total number of full time equivalent.

Indicators interpretation:
The lower the indicator is, the higher the contribution to employment is.

Scales definition:

Qualitative scales		Thresholds value	References
Very High	+	More than 1.2	(STECF 2018) (Guillen 2019) (FRAMIAN BV 2009) (Llorente et al. 2020) (STECF 2016)
High		Between 0.9 and 1.2	
Medium		Between 0.7 and 0.9	
Low		Between 0.4 and 0.7	
Very Low	-	Less than 0.4	

Effect / overlap / compromise with other indicators:
This indicator can be influenced by a better valorisation of products on markets or a higher productivity.

References:

(Bostock et al. 2016)

Feedstuff locally produced

Short name: FSLP

Type of indicator: Quantitative

Relative dimension and aggregated criteria:

- Environmental sustainability: Use local resources
- Social sustainability: Use local resources

Description:
This indicator refers to the share of feedstuff locally produced. It considers the percentage of feedstuff not imported at a national level.

Unit: %

Indicators calculation:

$$\boldsymbol{FSLP = \frac{Quantity\ of\ feedstuff\ not\ imported}{Total\ quantity\ of\ feed\ stuff\ used} \times 100}$$

With:

Indicators interpretation:
The lower the indicator is, the higher the feedstuff are locally produced.

Scales definition:

Qualitative scales		Thresholds value	References
High	+	More than 60%	Appreciation
Medium		Between 40 and 60%	
Low	-	Less than 40%	

Effect / overlap / compromise with other indicators:
The use of local resources is an issue both in terms of social and environmental sustainability, as it enhances the socio-economic dynamism of the country and it reduce the impact caused by transports of feedstuff. However, this indicator must be analysed carefully as a feedstuff can be produced only a small distance away but in another country.

References :

Education contribution

Short name: EC

Type of indicator: Quantitative

Relative dimension and aggregated criteria:

- Social sustainability: Contribution to the local development

Description:
This indicator refers the contribution to education. It considers the number of trainee hired per year and/or the number of educational tour and/or pedagogical presentation.

Unit: no unit

Indicators interpretation:
The higher the indicator is, the higher the education contribution is.

Scales definition:

Qualitative scales		Thresholds value	References
High	+	At least one trainee hired and [at least one educational tour or at least one presentation to students]	
Medium		At least one trainee hired or at least one educational tour or at least one presentation to students	
Low	-	No trainee hired and no educational tour nor presentation to students	

Effect / overlap / compromise with other indicators:
Contribution to education affects the multifunctionality of the system by not being only a production system but also by ensuring the training of students or even other farmers.

References :

(Vilain 2008)

Environmental sustainability indicators

This section presents the indicators related to environmental sustainability. Part of them are calculated to perform Life Cycle Assessment. Some have been added following experts expectations.

Indicator	Unit
Health costs	€/kg
Total Nitrogen emissions	kg/ton
Suspended solid emissions	kg/ton
On farm ground surface used	m^2/ton
Global warming potential	kg CO_2 eq
Acidification potential	kg SO_2 eq
Eutrophication potential	kg PO_4^{3-} eq
Fish in Fish out Ratio	#
Percentage of renewability	%
Percentage of wild juveniles and plants used	%
Water demand	m^3/kg
Net primary production use	kg C eq
Global land competition	m^2
Total cumulative energy demand	GJ
Percentage of nitrogen derived from co-products	%
Percentage of phosphorus recovered	%
Production loss	%
Percentage of renewable energy used	%
On farm energy efficiency	MWh/ton
Total feed conversion rate	kg/kg
Nitrogen use efficiency	%
Feedstuff locally produced	%
Emergy Yield Ratio	#
Predator control	No unit
Biosecurity and good practices	#
Production diversification	#
Multi-trophic integration	#
Escapees management	%

Health costs

Short name: HC

Type of indicator: Quantitative

Relative dimension and aggregated criteria:

- Environmental sustainability: Negative local impact on ecosystems; chemicals and contaminants emissions

Description:
This indicator refers to the quantity of chemicals (pesticides, therapeutants, disinfectants) used per quantity of biomass produced. As the measure of chemicals and contaminants emissions is difficult, health costs used per kg of biomass was introduced as a proxy.

Unit: €/kg

Indicators calculation:

$$\boldsymbol{CCE = \frac{Cost\ of\ chemicals\ used}{Total\ biomass\ produced}}$$

With:

- Cost of chemicals used: Total cost in € of chemicals (pesticides, therapeutants, disinfectants) used.
- Total biomass produced: Total quantity of biomass produced per year in kg (Final Biomass – Initial Biomass + Variation of stock)

Indicators interpretation:
The lower the indicator is, the lower the system emits chemicals and contaminants in local ecosystems.

Scales definition:

Qualitative scales		Thresholds value	References
High	-	More than 0.06€/kg	(Hadelan et al. 2014; Bregnballe, Eurofish, et FAO 2015) + Expert data
		Between 0.04 and 0.06€/kg	
Low	+	Less than 0.04€/kg	

Effect / overlap / compromise with other indicators:
A responsible use of chemicals is needed to ensure the welfare of animals reared while limiting the environmental impacts.

References:

Total Nitrogen emissions

Short name: TNE

Type of indicator: Quantitative

Relative dimension and aggregated criteria:

- Environmental sustainability: Contribution to local eutrophication

Description:
This indicator refers to quantity of total nitrogen (ammonia, ammonium, nitrite and nitrate) released by the system per **ton** of biomass produced.

Unit: kg / Tonne

Indicators calculation:

$$\boldsymbol{TNE = \frac{Quantity\ of\ total\ nitrogen\ released}{Total\ biomass\ produced}}$$

With:
- Quantity of total nitrogen emissions: Quantity in kg of total nitrogen emissions
- Total biomass produced: Total quantity of biomass produced per year in **tonnes** (Final Biomass – Initial Biomass + Variation of stock)

Indicators interpretation:
The higher the indicator is, the higher the system contribute to the local eutrophication of ecosystems

Scales definition:

Qualitative scales		Thresholds value	References
High	-	More than 94kg/T	(Aubin, Tocqueville 2010)
Medium		Between 40 and 94 kg/T	(Aubin, Tocqueville 2010)
Low	+	Less than 40 kg/T	(Aubin, Tocqueville 2010)

Effect / overlap / compromise with other indicators:
This indicator can be linked with the feed efficiency as an improvement of the feed conversion rate can lower the total nitrogen emissions. Moreover, it can be linked with the waste recycling as an improvement of the waste recycling can lower the total nitrogen emissions.

References:

(IDAQUA 2010)

(Aubin, Tocqueville 2010)

Suspended solid emissions

Short name: SSE

Type of indicator: Quantitative

Relative dimension and aggregated criteria:

- Environmental sustainability: Contribution to local eutrophication

Description:
This indicator refers to quantity of suspended solid emissions per quantity of biomass in tons.

Unit: kg / Tonne

Indicators calculation:

$$SSE = \frac{Quantity\ of\ suspended\ solid\ emissions}{Total\ biomass\ produced}$$

With:
- Quantity of total nitrogen emissions: Quantity in kg of suspended solid emissions
- Total biomass produced: Total quantity of biomass produced per year in **tonnes** (Final Biomass – Initial Biomass + Variation of stock)

Indicators interpretation:
The higher the indicator is, the higher the system contribute to the local eutrophication of ecosystems.

Scales definition:

Qualitative scales		Thresholds value	References
High	-	More than 405kg/T	(Aubin, Tocqueville 2010)
Medium		Between 57 and 405 kg/T	
Low	+	Less than 57 kg/T	

Effect / overlap / compromise with other indicators:
This indicator can be linked with the feed efficiency as an improvement of the feed conversion rate can lower the suspended solid emissions. Moreover, it can be linked with the waste recycling as an improvement of the waste recycling can lower the suspended solid emissions.

References:

(IDAQUA 2010)

(Aubin, Tocqueville 2010)

On farm ground surface used

Short name: OFGS

Type of indicator: Quantitative

Relative dimension and aggregated criteria:

- Environmental sustainability: Negative local impact on ecosystems

Description:
This indicator refers to on-farm land used efficiency. It considers the surface in m² of local land used by the system per quantity of biomass produced in **tonnes**.

Unit: m²/**Ton**

Indicators calculation:

$$\boldsymbol{OFGS = \frac{On\ farm\ ground\ surface\ used}{Total\ biomass\ produced}}$$

With:
- On farm ground surface used: Surface in m² used by the system to produce
- Total biomass produced: Total quantity of biomass produced per year in **tonnes** (Final Biomass – Initial Biomass + Variation of stock)

Indicators interpretation:
The lower the indicator is, the lower the system require local land to produce

Scales definition:

Qualitative scales		Thresholds value	References
High	-	More than 4 m²/T	(Chen et al. 2015)
Medium		Between 0.2 and 4 m²/T	
Low	+	Less than 0.2m²/T	

Effect / overlap / compromise with other indicators:
This indicator evaluates the land footprint of the system. It is considered that more the system produces per land surface the more it potentially saves ecosystems.

References:

(Rey-Valette et al. 2008)

(Bregnballe, Eurofish, et FAO 2015)

Global warming potential

Short name: CCC

Type of indicator: Quantitative

Relative dimension and aggregated criteria:

- Environmental sustainability: Negative global impact on ecosystems

Description:
This indicator refers to a midpoint life cycle assessment impact category: global warming potential (GWP). It quantifies the amount of greenhouse gases (GHG) emitted by the system. It is given in kg CO_2 eq per Functional Unit (i.e. quantitative amount that represents the function delivered by the system, as for example the production of 1kg of fish). All greenhouse gases (GHG) are expressed in a single unit thanks to characterization factors. CML-IA characterization method is used.

Indicator calculation:

$$GWP = \sum e_i * CF_i$$

$$with\ e_i\ the\ emission\ of\ GHG\ i\ and\ CF_i\ the\ associate\ characterisation\ factor$$

Unit: kg CO_2 eq

Indicators interpretation:
The lower the indicator is, the lower the system contribute to the climate change

Scales definition:

Qualitative scales		Thresholds value	References
Very High	-	More than 8 T/T	(Bohnes et al. 2019; Cao, Diana, et Keoleian 2013; Poore et Nemecek 2018)
High		Between 6 and 8 T/T	
Medium		Between 4.5 and 6 T/T	
Low		Between 2 and 4.5 T/T	
Very Low	+	Less than 2 T/T	

Effect / overlap / compromise with other indicators:

References:

(Bohnes et al. 2019)

Acidification potential

Short name: AP

Type of indicator: Quantitative

Relative dimension and aggregated criteria:

- Environmental sustainability: Negative global impact on ecosystems

Description:
This indicator refers to a midpoint life cycle assessment impact category: acidification potential (AP). It aims to evaluate the contribution of the system to acidification of surrounding environment. It is given in kg SO_2 eq per Functional Unit (i.e. quantitative amount that represents the function delivered by the system, as for example the production of 1kg of fish). CML-IA characterization method is used.

Indicator calculation:

$$AP = \sum e_i * CF_i$$

$$with\ e_i\ the\ emission\ of\ substance\ i\ and\ CF_i\ the\ associate\ characterisation\ factor$$

Unit: kg SO_2 eq.

Indicators interpretation:
The lower the indicator is, the lower the system has a potential of acidification

Scales definition:

Qualitative scales		Thresholds value	References
High	-	More than 35kg/T	(Bohnes et al. 2019; Cao, Diana, et Keoleian 2013)
Medium		Between 15 and 35kg/T	
Low	+	Less than 15kg/T	

Effect / overlap / compromise with other indicators:

References:

(Bohnes et al. 2019)

Eutrophication potential

Short name: EP

Type of indicator: Quantitative

Relative dimension and aggregated criteria:

- Environmental sustainability: Negative global impact on ecosystems

Description:
This indicator refers to a midpoint life cycle assessment impact category: eutrophication potential (EP). It aims to evaluate the contribution of the system to marine and freshwater eutrophication. It is given in kg PO_4^{3-} éq per Functional Unit (i.e. quantitative amount that represents the function delivered by the system, as for example the production of 1kg of fish). CML-IA characterization method is used.

Indicator calculation:

$$EP = \sum e_i * CF_i$$

$$with\ e_i\ the\ emission\ of\ substance\ i\ and\ CF_i\ the\ associate\ characterisation\ factor$$

Unit: kg PO_4^{3-} éq.

Indicators interpretation:
The lower the indicator is, the lower the system has a potential of eutrophication

Scales definition:

Qualitative scales		Thresholds value	References
High	-	More than 70kg/T	(Bohnes et al. 2019; Cao, Diana, et Keoleian 2013)
Medium		Between 35 and 70kg/T	
Low	+	Less than 35kg/T	

Effect / overlap / compromise with other indicators:

References:

(Bohnes et al. 2019)

Fish in Fish out Ratio

Short name: FIFO

Type of indicator: Quantitative

Relative dimension and aggregated criteria:

- Environmental sustainability: Use sustainable resources for feed
- Economic sustainability: Resistance to commercial risks

Description:
This indicator describes dependence of the system on wild fish resources. It considers the fish in fish out ratio (FIFO), that is generally used as "a measure of the amount of marine resources that are consumed in the production of farmed fish" (Ytrestøyl, Aas, et Åsgård 2015). As the oil content has an influence on the FIFO ratio due to the yield variation of fish oil from wild fish, it was chosen to only consider the level of fish oil in feed to calculate it.

Unit: Number

Indicators calculation:

$$\boldsymbol{FIFO} = \left[\frac{\boldsymbol{Level\ of\ FO\ in\ feed}}{\boldsymbol{Yield\ of\ FO\ from\ wild\ fish}}\right] \times \boldsymbol{FGR}$$

With :

- Level of FO in feed: Quantity in g of fish oil used per kg of feed
- Yield of fish oil from wild fish: Percentage 4.3% (Anchovy from Peru)
- FGR: Food to Gain Ratio FGR: Food to Gain Ratio (considered to be equivalent to the Feed Conversion Rate FCR)

Indicators interpretation:
The lower the indicator is, the higher the use of sustainable resources for feed is.

Scales definition:

Qualitative scales		Thresholds value	References
Very High	-	More than 6	(Kaushik et Troell 2010)
High		Between 4.5 and 6	
Medium		Between 3 and 4.5	
Low		Between 1.5 and 3	
Very Low	+	Less than 1.5	

Effect / overlap / compromise with other indicators:
The dependence of aquaculture on wild fish resources is a major issue in terms of environmental impacts and of market dependency. The Fish In Fish Out (FIFO) ratio is commonly used indicator to appreciate the efficiency of fish farming in the use of wild fishes and the need of the sector for fish resources.

References:

(Kaushik et Troell 2010; Byelashov et Griffin 2014; Ytrestøyl, Aas, et Åsgård 2015)

Percentage of renewability

Short name: PR

Type of indicator: Quantitative

Relative dimension and aggregated criteria:

- Environmental sustainability: Use sustainable natural resources

Description:

This indicator describes the capacity of the system to use sustainable resources using the emergy method. It considers the percentage of renewability (% R) which is the percentage of renewable emergy used by the system (Wilfart et al. 2013).

Unit: %

Indicators interpretation:

The higher this indicator is, the higher the system use sustainable resources.

Scales definition:

Qualitative scales		Thresholds value	References
High	+	More than 40%	
Medium		Between 20 and 40%	
Low	-	Less than 20%	

Effect / overlap / compromise with other indicators:

References:

(Wilfart et al. 2013)

Percentage of wild juveniles and plants used

Short name: SSJ

Type of indicator: Quantitative

Relative dimension and aggregated criteria:

- Environmental sustainability: Negative local impact on ecosystems

Description:
This indicator refers to the use of wild juveniles and seedlings.

Unit: %

Indicators calculation:

$$\boldsymbol{USRJ = \frac{Quantity\ of\ wild\ juveniles\ and\ seedlings}{Total\ quantity\ of\ juveniles\ and\ seedlings} \times 100}$$

With:

- Quantity of wild juveniles and seedlings: Quantity in kg of juveniles and seedlings recruited from wild populations
- Total quantity of juveniles and seedlings: Total quantity of juveniles and seedlings used in kg.

Indicators interpretation:
The lower the indicator is, the lower the system uses wild juveniles and seedlings

Scales definition:

Qualitative scales		Thresholds value	References
High	-	More than 50%	Expert appreciation
Medium		Between 10 and 50%	
Low	+	Less than 10%	

Effect / overlap / compromise with other indicators:
Juveniles supply is one of the main factor in fish production, “if aquaculture is to be sustainable, juvenile supply and recruits must also be” (Consensus 2005). As integrated and diversified also produces plants, seedlings must not be recruited from wild populations.

References:

ASC

(Consensus 2005)

(Mathé et al. 2006)

Water demand

Short name: WD

Type of indicator: Quantitative

Relative dimension and aggregated criteria:

- Environmental sustainability: To limit the use of resources

Description:

This indicator refers to a midpoint life cycle assessment impact category: water demand (WD). It aims at evaluating the pressure that the system involves to the water resources. It is given in m^3 per Functional Unit (i.e. quantitative amount that represents the function delivered by the system, as for example the production of 1kg of fish). CML-IA characterization method is used.

Indicator calculation:

$$WD = \sum c_i * CF_i$$

$$with\ c_i\ the\ consumption\ of\ water\ i\ and\ CF_i\ the\ associate\ characterisation\ factor$$

Unit: m^3/kg

Indicators interpretation:

The lower the indicator is, the lower the system uses water.

Scales definition:

Qualitative scales		Thresholds value	References
High	-	More than 125m³/kg	(Bohnes et al. 2019)
Medium		Between 10 and 125 m³/kg	
Low		Between 1 and 10 m³/kg	
Very Low	+	Less than 1m³/kg	

Effect / overlap / compromise with other indicators:

References:

(Bohnes et al. 2019)

(Martins et al. 2010)

Net primary production use

Short name: NPPU

Type of indicator: Quantitative

Relative dimension and aggregated criteria:

- Environmental sustainability: To limit the use of resources

Description:
This indicator refers to a midpoint life cycle assessment impact category: Net primary production use (NPPU). It aims at quantifying human pressure on biotic resources by accounting carbon stocked by the organisms (Papatryphon et al. 2003, Papatryphon et al. 2004). It is given in kg C eq per Functional Unit (i.e. quantitative amount that represents the function delivered by the system, as for example the production of 1kg of fish).

Indicator calculation:

$$NPPU = \sum m_i * CF_i$$

$$with\ m_i\ the\ mass\ of\ element\ i\ involved\ in\ the\ system\ and\ CF_i\ the\ associate\ characterisation\ factor$$

Unit: kg C éq/kg of live weight seafood

Indicators interpretation:
The lower the indicator is, the lower the system uses primary production.

Scales definition:

Qualitative scales		Thresholds value	References
High	-	More than 85kg/kg	(Bohnes et al. 2019)
Medium		Between 15 and 85 kg/kg	
Low	+	Less than 15kg/kg	

Effect / overlap / compromise with other indicators:

References:

(Bohnes et al. 2019)

(Martins et al. 2010)

Global land competition

Short name: GLC

Type of indicator: Quantitative

Relative dimension and aggregated criteria:

- Environmental sustainability: To limit the use of resources

Description:
This indicator refers to a midpoint life cycle assessment impact category: Land competition (LC). It aims to evaluate the pressure involved by the system on the land occupation and its competition with other uses/activities. It is given in m² per Functional Unit (i.e. quantitative amount that represents the function delivered by the system, as for example the production of 1kg of fish).

Unit: m²

Indicators interpretation:
The lower the indicator is, the lower the system uses directly and indirectly land.

Scales definition:

Qualitative scales		Thresholds value	References
Very High	-	More than 5500m²/T	Expert data + (Cao, Diana, et Keoleian 2013; Poore et Nemecek 2018)
High		Between 2500 and 5500m²/T	
Medium		Between 1500 and 2500 m²/T	
Low		Between 800 and 1500 m²/T	
Very Low	+	Less than 800 m²/T	

Effect / overlap / compromise with other indicators:
This indicator can be compared to the local land competition as a system can have a small footprint at a local scale but needing indirectly land out of the burdens of the system.

References:

Total cumulative energy demand

Short name: TCED

Type of indicator: Quantitative

Relative dimension and aggregated criteria:

- Environmental sustainability: To limit the use of resources; Energy demand

Description:

This indicator refers to a midpoint life cycle assessment impact category: Total Cumulative Energy Demand (TCED). It is given in GJ per Functional Unit (i.e. quantitative amount that represents the function delivered by the system, as for example the production of 1kg of fish).

Unit: GJ

Indicators interpretation:

The lower the indicator is, the lower the direct and indirect use of energy is.

Scales definition:

Qualitative scales		Thresholds value	References
Very high	-	More than 110GJ/T	(Aubin, Tocqueville 2010) (Bohnes et al. 2019) (Cao, Diana, et Keoleian 2013)
High		Between 70 and 110 GJ/T	
Medium		Between 45 and 70 GJ/T	
Low		Between 30 and 45 GJ/T	
Very Low	+	Less than 30GJ/T	

Effect / overlap / compromise with other indicators:

This indicator can be compared with the indicator productivity of energy used, in order to analyse the on-farm energy consumption and the indirect energy consumption linked to feed processing for example.

References:

(Bohnes et al. 2019; Cao, Diana, et Keoleian 2013)

Percentage of nitrogen derived from co-products

Short name: PNCB

Type of indicator: Quantitative

Relative dimension and aggregated criteria:

- Environmental sustainability: Limit production wastes and increase recycling; Use of co-products and by-products as inputs

Description:
This indicator refers to the use of co-products or by-products as input for feed and fertilizer. It considers the quantity of nitrogen introduced in the system and generated from co-products or by-products.

Unit: %

Indicators calculation:

$$PNCB = \frac{Quantity\ of\ nitrogen\ coming\ from\ co\ products\ \ in\ inputs}{Total\ nitrogen\ used\ in\ inputs}$$

With:
- Quantity of nitrogen coming from by or co products in kg
- Total nitrogen used in inputs in kg

Indicators interpretation:
The higher the indicator is, the higher the system use co-products and by-products

Scales definition:

Qualitative scales		Thresholds value	References
High	+	More than 50%	
Medium		Between 20 and 50%	
Low	-	Less than 20%	

Effect / overlap / compromise with other indicators:
This indicator approximates the use of co-products and by-products as inputs in the system. It refers to the concept of circular economy as it integrates the reuse of a potential waste as resource. The fact that nitrogen is one of the major nutrients to provide to the species reared in the system, justifies it use for the calculation of this indicator.

References:

Percentage of phosphorus recovered

Short name: PPR

Type of indicator: Quantitative

Relative dimension and aggregated criteria:

- Environmental sustainability: Limit production of wastes and increase recycling; Waste recycling

Description:
This indicator refers to the share of phosphorus recycled in the system. It considers the quantity of phosphorus recycled by organism reared in the system or reused in other system (as a fertilizer for example).

Unit: %

Indicators calculation:

$$PPR = \frac{Quantity\ of\ phosphorus\ recycled\ or\ reused}{Quantity\ of\ phosphorus\ used\ in\ inputs} \times 100$$

With:
- Quantity of phosphorus recycled: quantity of phosphorus recycled inside the system or reused in another system in kg.
- Quantity of phosphorus used in inputs in kg.

Indicators interpretation:
The higher the indicator is, the higher the percentage of phosphorus recycled is.

Scales definition:

Qualitative scales		Thresholds value	References
High	+	More than 30%	
Medium		Between 15 and 30%	
Low	-	Less than 10%	

Effect / overlap / compromise with other indicators:
Theis indicator appreciates the capacity of the system to recover the nutrient used in inputs by recycling its inside the system or by extracting and reusing it in another system (for example by spreading sludges into fields). The fact that phosphorus is becoming a precious resource justifies its use to calculate this indicator.

References:

Production loss

Short name: PL

Type of indicator: Quantitative

Relative dimension and aggregated criteria:

- Economic sustainability: Production management
- Social sustainability: Production health management
- Environmental sustainability: Limit organic wastes production

Description:
This indicator refers to the quantity of biomass lost through a year. It considers the percentage of dead or discarded biomass per year.

Unit: %

Indicators calculation:

$$PL = \frac{Quantity\ of\ biomass\ lost}{Total\ biomass\ produced}$$

With:
- Quantity of biomass lost: Quantity of dead or discarded biomass in kg.
- Total biomass produced: Total quantity of biomass produced per year in kg

Indicators interpretation:
The lower the indicator is, the better the system is managed, as it ensures good health of reared organisms and the higher the system limit organic wastes production.

Scales definition:

Qualitative scales		Thresholds value	References
Very High	+	More than 40%	(Muniesa et al. 2020)
High		Between 30 and 40%	(Muniesa et al. 2020; IDAQUA 2010)
Medium		Between 20 and 30%	(Muniesa et al. 2020)
Low		Between 10 and 20%	(IDAQUA 2010)
Very Low	-	Less than 10%	(Muniesa et al. 2020; IDAQUA 2010)

Effect / overlap / compromise with other indicators:
This indicator is useful to appreciate the overall sustainability of the system as it increases the economic and environmental performances of the system and the respect of animal welfare. Production loss may depend not only on the system but also on context as it may be influenced by the health status of juveniles and the inflow water quality. However, adoption of good practices and biosecurity measures may lower production loss.

References:

(Consensus 2005; Muniesa et al. 2020; IDAQUA 2010)

(Muniesa et al. 2020)

Percentage of renewable energy used

Short name: PRE

Type of indicator: Quantitative

Relative dimension and aggregated criteria:

- Environmental sustainability: To limit the use of resources; Energy demand

Description:
This indicator refers to the share of on farm renewable energy used by the system. It considers the percentage of on farm energy used that is renewable. Renewable energy is defined as on-farm produced renewable energy (with solar panel for example).

Unit: %

Indicators calculation:

$$\boldsymbol{PRE = \frac{Quantity\ of\ on\ farm\ renewable\ energy\ used}{Quantity\ of\ on\ farm\ energy\ used} \times 100}$$

With:

Indicators interpretation:
The higher the indicator is, the higher the rate of renewable energy used is.

Scales definition:

Qualitative scales		Thresholds value	References
High	+	More than 50%	
Medium		20% to 50%	
Low	-	Less than 20%	EU objectives

Effect / overlap / compromise with other indicators:
The percentage of renewable energy used is merged with the indicator on farm energy efficiency in order to appreciate the productivity of energy used. Consequently, a system less efficient in terms of energy use can be consider as more sustainable if it is use renewable energy.

References:

On farm energy efficiency

Short name: OFEE

Type of indicator: Quantitative

Relative dimension and aggregated criteria:

- Environmental sustainability: Productivity of energy used
- Economic sustainability: Resources productivity

Description:
This indicator refers to the productivity of the on-farm energy used per kg of biomass produced. It considers the quantity of energy (in MWh) used by the system during a year.

Unit: MWh / ton

Indicators calculation:

$$\boldsymbol{OFEE = \frac{\sum Quantity\ of\ energy\ used}{Total\ biomass\ produced}}$$

With:
- Quantity of energy used: Quantity in kWh of on farm energy used per year.
- Total biomass produced: Total quantity of biomass produced per year in kg (Final Biomass – Initial Biomass + Variation of stock)

Indicators interpretation:
The lower the indicator is, the more efficient the system is in the use of energy.

Scales definition:

Qualitative scales		Thresholds values	References
Very High	+	Less than 0.5 MWh/T	(IDAQUA 2010)
High		Between 0.5 and 1 MWH/T	
Medium		Between 1 and 1.5 MWh/T	
Low		Between 1.5 and 5 MWh/T	
Very Low	-	More than 5MWh/T	

Effect / overlap / compromise with other indicators:
This indicator is used to assess the productivity of the system in the use of energy resources. A higher on farm energy efficiency can allow higher economic return and an enhancement of the environmental sustainability (by saving non-renewable energy resources and limiting the greenhouse gas effect). This indicator is merged to assess the productivity of energy used (environmental sustainability) with the percentage of renewable energy as a higher consumption of energy per biomass produced can be balanced by a use of renewable energy on-farm.

References:

(Consensus 2005; Vilain 2008; IDAQUA 2010)

Total feed conversion rate

Short name: TFCR

Type of indicator: Quantitative

Relative dimension and aggregated criteria:

- Economic sustainability: Resources productivity
- Environmental sustainability: Feed efficiency

Description:
This indicator refers to the productivity of the feed use.

Unit: kg / kg

Indicators calculation:

$$\boldsymbol{TFCR} = \frac{\boldsymbol{Quantity\ of\ feed\ used}}{\boldsymbol{Total\ biomass\ produced}}$$

With:

- Quantity of feed used: Quantity in kg of feed (purchased or self-produced) used per year.
- Total biomass produced: Total quantity of biomass produced per year in kg (Final Biomass – Initial Biomass + Variation of stock)

Indicators interpretation:
The lower the indicator is, the more efficient the system is in the use of feed.

Scales definition:

Qualitative scales		Thresholds values	References
Very High	-	More than 2.2	(Fezzardi 2013; IDAQUA 2010)
High		Between 1.8 and 2.2	
Medium		Between 1.6 and 1.8	
Low		Between 1.3 and 1.6	
Very Low	+	Less than 1.3	

Effect / overlap / compromise with other indicators:
A higher on farm feed efficiency can allow higher economic return and an enhancement of the environmental sustainability. Overlaps with the source of feed ingredients and genetics may exist. Moreover, it must be considered that the FCR tends to increase as fish is getting older, so threshold values may be analysed prudently. Moreover, this indicator can be linked with the net primary production use (LCA).

References:

(Consensus 2005; IDAQUA 2010; Fezzardi 2013)

Nitrogen use efficiency

Short name: NUE

Type of indicator: Quantitative

Relative dimension and aggregated criteria:

- Environmental sustainability: Feed efficiency

Description:
This indicator considers the percentage of total Nitrogen inputs (mainly provided by fish feed and biomass stocked) recovered in biomass. Nitrogen contains in the inlet water can be ignored for the calculation.

Unit: %

Indicators calculation:

$$NUE = \frac{Quantity\ of\ nitrogen\ used\ in\ input}{Quantity\ of\ nitrogen\ produced\ in\ output}$$

With:

- Quantity of nitrogen in input: Quantity of nitrogen brought to the system in the input (mainly provided by fish feed and biomass stocked)
- Quantity of nitrogen in output: Quantity of nitrogen contained in the output biomass

Indicators interpretation:
The higher the indicator is, the higher the nitrogen use efficiency is.

Scales definition:

Qualitative scales		Thresholds value	References
High	+	More than 30%	
Medium		Between 15 and 30%	
Low	-	Less than 15%	

Effect / overlap / compromise with other indicators:
This indicator is complementary with the TFCR to assess the feed efficiency. It analyses the share of nitrogen in inputs that is recovered in the output biomass. Moreover, the Nitrogen Use Efficiency permits to understand of the potential NH3 emissions, thus, it can be linked with the Total Nitrogen Emissions indicator.

References :

(Boyd et al. 2007; Jaeger et al. 2019; Duarte et al. 2009)

Feedstuff locally produced

Short name: FSLP

Type of indicator: Quantitative

Relative dimension and aggregated criteria:

- Environmental sustainability: Use local resources
- Social sustainability: Use local resources

Description:
This indicator refers to the share of feedstuff locally produced. It considers the percentage of feedstuff not imported at a national level.

Unit: %

Indicators calculation:

$$FSLP = \frac{Quantity\ of\ feedstuff\ not\ imported}{Total\ quantity\ of\ feed\ stuff\ used} \times 100$$

With:

Indicators interpretation:
The lower the indicator is, the higher the feedstuff are locally produced.

Scales definition:

Qualitative scales		Thresholds value	References
High	+	More than 60%	Appreciation
Medium		Between 40 and 60%	
Low	-	Less than 40%	

Effect / overlap / compromise with other indicators:
The use of local resources is an issue both in terms of social and environmental sustainability, as it enhances the socio-economic dynamism of the country and it reduce the impact caused by transports of feedstuff. However, this indicator must be analysed carefully as a feedstuff can be produced only a small distance away but in another country.

References :

Emergy Yield Ratio

Short name: EYR

Type of indicator: Quantitative

Relative dimension and aggregated criteria:

- Environmental sustainability: Use local resources
- Economic sustainability: Economic dependency; resources dependency

Description:
This indicator describes the capacity of the system to use local (i.e. inside system boundaries) resources using the emergy method. It considers the local and imported emergy flows and it shows the efficiency in using purchased inputs (Wilfart et al. 2013).

Unit: Number

Indicators interpretation:
The lower this indicator is, the lower the system uses imported resources and the higher the system uses local resources.

Scales definition:

Qualitative scales		Thresholds values	References
High	+	More than 2	Expert judgement
Medium		Between 1.1 and 2	Expert judgement
Low	-	Less than 1.1	Expert judgement

Effect / overlap / compromise with other indicators:
This indicator is used to appreciate the system capacity to rely on its available local (i.e inside system boundaries) resources. From an economic point of view, a system that is less dependent on imported emergy flows will be more autonomous. From an environmental point of view, the system will use more efficiently local resources.

References:

(Wilfart et al. 2013)

Predator control

Short name: PC

Type of indicator: Qualitative

Relative dimension and aggregated criteria:

- Environmental sustainability: Protection of local fauna and flora species

Description:
This indicator considers the non-use of lethal predator control.

Unit: No Unit

Indicators interpretation:
The non-use of lethal predator control is required

Scales definition:

Qualitative scales		Thresholds values	References
Not acceptable	-	Use of lethal predator control	
Acceptable	+	Non-use of lethal predator control	

Effect / overlap / compromise with other indicators:

References:

ASC

Biosecurity and good practices

Short name: BGP

Type of indicator: Quantitative

Relative dimension and aggregated criteria:

- Social sustainability: Respect of animal welfare; Rearing environment
- Economic sustainability: Level of sensitivity to pathology risks
- Environmental sustainability: Protection of local fauna and flora; Disease management

Description:
This indicator refers to the biosecurity measures and good practices developed in the system. It considers a score resulting of the respect of several conditions.

Indicators calculation:

For each condition add 1 point when the condition is respected in the system.

Conditions to respect	Score if respected
Disinfection or restricted access of visitors or vehicles to the production site	+1 otherwise 0
Disinfection or application of a quarantine for juveniles and new plants	+1 otherwise 0
Disinfection or drying up procedures at the end of the production cycle	+1 otherwise 0
Existence of disinfected barriers for employees to access to the production site and to between compartments of the system	+1 otherwise 0
Existence of specific equipment to disinfect inflow water	+1 otherwise 0

Indicators interpretation:
The higher the indicator is, the higher biosecurity and good practices are developed.

Scales definition:

Qualitative scales		Thresholds values	References
High	+	More than 3	
Medium		2 or 3	
Low	-	0 or 1	

Effect / overlap / compromise with other indicators:
This indicator appreciates the capacity to prevent the spread of diseases in the production site and in ecosystems. This indicator is used to assess the sustainability of the system over the economic, social and environmental dimensions as biosecurity and good practices measures reduce the sensitivity to pathology risks, enhance the rearing conditions and the respect of animal welfare and prevent the spread of diseases in ecosystems. “One of the best ways to mitigate the risk of disease transfer to wild stocks is to reduce or eliminate the disease from happening initially.” (ASC 2019)

References:

(IDAQUA 2010)

Production diversification

Short name: NS

Type of indicator: Quantitative

Relative dimension and aggregated criteria:

- Environmental sustainability: To foster polyculture and integration of natural cycles

Description:
This indicator considers the number of planned species reared in the system. It does not consider present species but not planned.

Unit: Number

Indicators calculation:

$$NS = \ Number\ of\ planned\ species$$

Indicators interpretation:
The higher the indicator is, the higher the biodiversity of species in the system is.

Scales definition:

Qualitative scales		Thresholds value	References
High	+	More than 5 species	Appreciation
Medium		Between 2 and 5 species	
Low	-	1 specie	

Effect / overlap / compromise with other indicators:
Culturing more than one species permits to enhance the biodiversity within the system. Moreover, this indicator considers that a diversified production system is a way to limit economical risks. On one hand the system is more resilient to pathology risks. Even if one of the reared species is affected by a disease, it cannot affect the entire system as the production of the other can be continued. Moreover, rearing several species together may lower their sensitivity to pathologies and may favour positive interactions. However, it could be more difficult in a diversified system to cure diseases especially in Integrated (or coupled) Recirculated aquaculture system. On the other hand, a diversified system can buffer the impacts of environmental constraints, price variations or regulations modifications.

References :

(Aubin et al. 2014; IDAQUA 2010; Vilain 2008)

Multi-trophic integration

Short name: MTL

Type of indicator: Quantitative

Relative dimension and aggregated criteria:

- Environmental sustainability: To foster polyculture and integration of natural cycles

Description:
This indicator considers the number of planned trophic levels in the system.

Unit: Number

Indicators calculation:

$$\boldsymbol{MTL = Number\ of\ planned\ trophic\ levels}$$

Indicators interpretation:
The higher the indicator is, the higher the integration of natural cycles in the system is.

Scales definition:

Qualitative scales		Thresholds value	References
High	+	3 trophic levels or more	
Medium		2 trophic levels	
Low	-	1 trophic level	

Effect / overlap / compromise with other indicators:
Integration of natural cycles within the enhancement of the multitrophic diversity of the system allows to use the complementarity between trophic level to enhance the efficiency and the sustainability of the system.

References:

(Aubin et al. 2014)

Escapees management

Short name: EM

Type of indicator: Quantitative

Relative dimension and aggregated criteria:

- Environmental sustainability: Maintenance of genetic diversity

Description:
This indicator considers the percentage of escapees per year.

Unit: %

Indicators calculation:

$$EM = \%\ \boldsymbol{of\ escapees\ per\ year}$$

Indicators interpretation:
The lower the indicator is, the higher the capacity of the system to manage escapees is.

Scales definition:

Qualitative scales		Thresholds value	References
High	-	More than 4%	ASC
Medium		Between 0.5% and 4%	ASC; Friends of the sea
Low	+	Less than 0.5%	Friends of the sea

Effect / overlap / compromise with other indicators:
Genetic differences may exist between farmed fish and wild populations of the same species. It raises concerns about the potential impact of interbreeding.

References :

(ASC 2019)

Friends of the sea

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