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Sustainability criteria for the blue economy

Guidelines

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The *Sustainability Criteria for a Blue Economy* study proposes a framework for assessing sustainable outcomes across the blue economy sectors. The Blue Economy Sustainability Framework (BESF) is intended to help inform public policy and investment decisions. It consists of indicators to measure sustainability criteria which are both 'common' (can be applied to any of the blue economy sectors) and '(sub)sector-specific'. These have been designed for application at different scales (e.g. project, company and sector) and levels (e.g. local and national) as well as in different geographic zones.

These Guidelines are provided as an accompanying document to the main report, to provide details on how to use the indicators as well as with definitions of key concepts. While these Guidelines offer suggestions on the application of the indicators, the flexibility of the framework requires the end-user to clearly identify the scale at which the data on the activity is to be collected, and at which level a sustainability assessment is most appropriate. Examples of the applications of the BESF can be found in the case studies[1]. Lessons learned from the application of the BESF in case studies, as well as further recommendations on the use of the BESF, can be found in the main report.

Disclaimer

[1] See the separate deliverable *Blue economy development framework – Case studies applying the sustainability criteria for the Blue Economy.*

Contents

Guidelines on the application of the sustainability criteria and indicators for Blue Economy

Structure and scope of Blue Economy Sustainability Framework

The structure of the Blue Economy Sustainability Framework (BESF) follows the dimensions-criteria-indicators hierarchical nesting approach, linking indicators to the four dimensions of sustainability (economic, environmental, social and governance). For each dimension, a number of indicators are defined. One or more indicators are associated with a criterion[2] and measure related variables, features or characteristics. For the purpose of this study, the definition proposed by Valenti et al. (2018) has been used:

> *"indicators are relevant variables to be measured that reflect each criterion and can be determined qualitatively or quantitatively. A unit is associated to each indicator"*[3].

The indicators are at the core of the framework, providing a powerful tool to analyse the complexity and characteristics of sectors in a structured and coherent way.

The Blue Economy Sustainability Framework consists of 3 sets of indicators:

- **Common indicators** – applicable to multiple sectors. In total the BESF contains 44 common indicators covering the four sustainability dimensions: environmental, economic, social and governance.
- **Key indicators** – a sub-set of 20 common indicators that are considered as the required minimum set of indicators for conducting a sustainability review[4]
- **Subsector-specific indicators** – indicators specific to the sub-sectors outlined in the table below:

[2] Multiple indicators can be associated with a single criterion. For example, the indicators '*Total revenues generated by local enterprises'* and '*Local public revenue generated through time (taxes, fees, etc.)*' are both economic indicators for the criterion "Economic benefits".

[3] Valenti, W. C., Kimpara, J. M., Preto, B. D. L., & Moraes-Valenti, P. (2018). Indicators of sustainability to assess aquaculture systems. Ecological indicators, 88, 402-413.

[4] 20 of the common indicators have been selected as 'key indicators', establishing an essential and required minimum set of criteria and indicators for conducting a review of the sustainability of a given activity, project, company or sector.

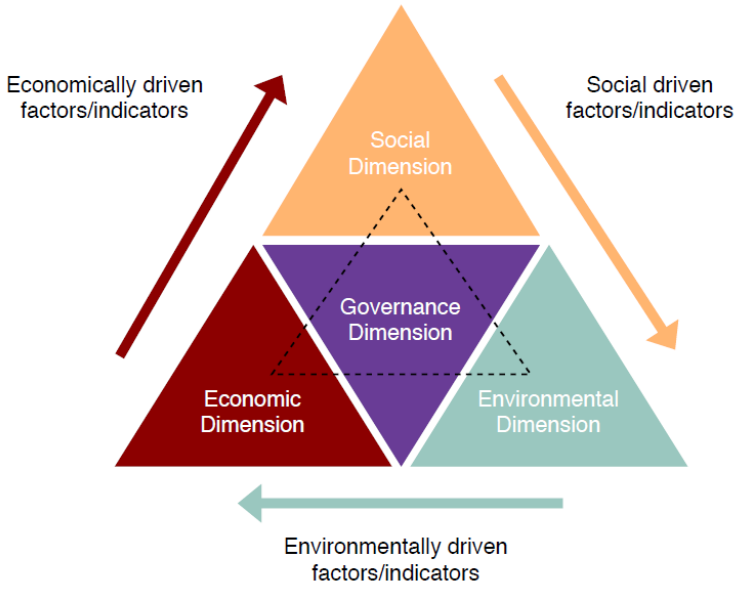
Table 1: Overview of the number of sector-specific indicators

Sectors	Sub-sectors	Number of sector-specific indicators per dimension				Total
		Environmental	Economic	Social	Governance	
Non-Living Resources	Extraction of minerals	2	2			**4**
	Extraction of oil and gas	5	3			**8**
	Extraction of water – Desalination	4	4		2	**10**
Living Resources	Fish and shellfish harvesting	3	2		4	**9**
	Fish and shellfish processing	3	5	1	1	**10**
	Marine plant and algae harvesting	3	2		4	**9**
	Aquaculture	8	5			**13**
Renewable Energy	Renewable energy generation	2	5			**7**
Maritime Transport	Transport infrastructure	4	2		2	**8**
	Transport shipping	8	2			**10**
Coastal Tourism and Leisure	Tourism and leisure infrastructure/activities	2	1	3	3	**9**
Public sector	Coastal defence and flood protection	3	4			**7**

In total, the BESF contains 148 indicators (44 common and 104 sector-specific) organised in an indicator database. The main challenge in the BESF was to keep the number of indicators manageable and succinct, while covering the most important aspects for each dimension to the extent possible. To this end, for some sub-sectors the sector-specific indicators do not cover all four dimensions, although all dimensions are covered when supplemented with the common/key indicators. Also, the sector-specific indicators remain broad and do not capture the specificities between different technologies (e.g. desalination), farmed species (e.g. aquaculture) etc. If a detailed assessment that includes sector specificities is expected, then the proposed indicator set of the BESF can be further refined and supplemented by indicators available from additional sector-specific frameworks. This framework provides a harmonized and systematic assessment tool that can be applied to multiple blue economy sectors, as opposed to the more detailed and in-depth sector-specific frameworks.

Dynamic balance between the dimensions of sustainability

Figure 1: Balance in sustainability dimensions for the blue economy sectors



The strength of the framework lies in its ability to consider and combine different dimensions of sustainability. While developing the BESF, it became apparent that many of the existing frameworks contained a gap in the governance dimension. Sustainability management, however, presents a complex and multidimensional concept that strives to create a dynamic balance between economic, social, environmental and institutional/governance dimensions (Figure 1). It is therefore crucial to consider the balance between the four dimensions when drawing conclusions.

The application of the framework ensures that the evolution of the same system or case study can be monitored over time and the opportunities and constraints identified. It reveals limitations and elements that need to be improved to move towards a more sustainable system. Therefore, the framework can be used as a tool for setting goals, determining actions, and assessing the effectiveness of actions and efficacy of interventions to follow the progress towards sustainability. The balance between the four dimensions ensures a holistic perspective of sustainability while also bringing together the measurement of variables of very different natures. This framework is specifically useful for those public and private investors with a focus on a holistic approach and multiple blue economy sectors. The outcomes of the framework facilitate these public and private investors in informed decision making, including on where exactly to act to enhance a sustainable blue economy.

The current framework is not intended to be used for certification or sustainability labelling or for EIA purposes. Neither is it intended for a comparative assessment of the sustainability performance between different activities. Finally, it is up to the end-user of the framework to make a judgement on the sustainability performance of an activity – most indicators provide nominal values that need to be normalized by a common reference unit (e.g. production, area etc.) to enable direct comparisons between different systems/case studies. The BESF provides the necessary data collection framework to enable the end-user to make an informed decision on the sustainability of an activity across the four dimensions, namely economic, social, environmental and governance.

If a comparative assessment is desired, there are various ways the framework can be adapted to allow for this:

- The indicators can be converted to a performance scale, using science- or policy-based standard values and reference points. Indicators are transformed to dimensionless variables by assigning zero to the worst score and 100 to the best one (Valenti et al. 2011)
- Consolidating indicators in radial graphs

- Aggregate indicators in sustainability sub-indices for each dimension or a single overall index/score
- Attributing weighting according to the importance of each indicator
- Identifying a threshold/benchmark (this may be difficult, given the different scale of interventions)

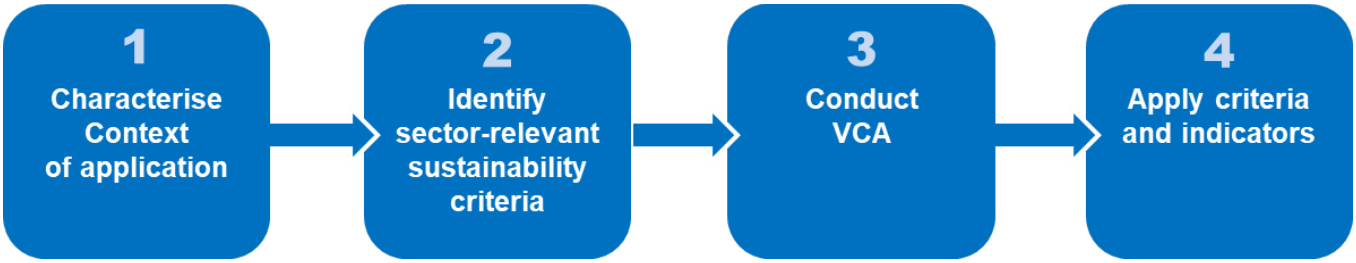
Objectives and approach of the guidelines

The objective of these guidelines is to provide guidance on the use of the framework, in different sectors and geographical regions including the application of the value-added chain (VCA), sustainability criteria and indicators developed for the BESF.

Steps for applying the Blue Economy Sustainability Framework

The guidelines are structured following 4 main steps:

Figure 2: Steps for the application of the Blue Economy Sustainability Framework



Step 1: Characterise the context of the blue economy activity to be reviewed

As a first step, the activity that is being reviewed based on the BESF needs to be characterised. Here, we suggest the use of the table below. The more precise one is in their definition of the different aspects to consider in the activity, the more the use of the BESF is facilitated.

Table 2: Template to characterise the context of application

Sub-sector	
Location	As specific as possible, including a map where possible
Blue Economy Sector / sub-sector	A comprehensive list of blue economy sectors/sub-sectors can be found in Table 1. It is advised to align with the terminology used in this table.
Main Stakeholders	Governmental organisations, private sector, NGOs, research, etc.
Sustainability Dimensions Covered	Which generic opportunities/constraints for a sustainable blue economy exist for the following dimensions? Economic: Environmental: Social: Governance:
Geographic area / spatial scale	Determine the spatial scale, e.g. local, company-level, national, regional etc. as the unit of analysis
Time period covered	Determine the years to be considered, especially relevant for the data collection when applying the indicators

Step 2: Identify sustainability criteria relevant to sub-sector

Table 4 and Table 5 provide an overview of the sustainability criteria grouped per dimension (environmental, economic, social and governance) for each sub-sector. The tables present the criteria to which the indicators of the BESF have been attributed to. The distinction is made between criteria associated with common indicators (■ **pink**) and sector-specific indicators (▲ **grey**). Some of the common indicators have been specified as key indicators[5]; criteria which are associated with at least one key indicator are *shaded* in ⭘ **blue**. As a first step in the application of the BESF, the user can view the criteria relevant for the sub-sector prior to applying the corresponding indicators.

Table 3: Matrix overview of the sustainability criteria grouped for the environmental dimension for each sub-sector

Sectors	Sub-sectors	Environmental dimension																				
⭘ Key indicator ■ Common indicator ▲ Sector-specific indicator		Chemical use	Emissions to air	Emissions to water	Energy efficiency	Farm management	Fishery management	Flood safety	Harvesting Management	Impact on environment	Impact on ecosystems	Infrastructure capacity	Introduction of invasive species	Level of energy consumption	Level of water consumption	Mitigation	Oil spill response	Status of stock	Supply chain	Level of fuel consumption	Use of shore power	Waste/wastewater management	Water quality
Non-living Resources	Extraction of minerals		⭘		■					▲	⭘	▲		⭘		⭘						⭘	
	Extraction of oil and gas		⭘	▲	■					▲	⭘			⭘		⭘	▲					⭘	
	Extraction of water - Desalination	▲	⭘		■						⭘	▲		⭘		⭘						⭘	▲

[5] 20 of the common indicators have been selected as 'key indicators' (some of which share the same criteria), establishing an essential and required minimum set of criteria and indicators for conducting a review of the sustainability of a given activity, project, company or sector. The selection for key indicators was based on the RACER methodology (evaluating the Relevance, Acceptance, Credibility, Easiness and Robustness of indicators). All common indicators were scored by five independently working experts whose expertise covered all four dimensions of sustainability.

Sectors	Sub-sectors	Environmental dimension																				
⭘ Key indicator ■ Common indicator ▲Sector-specific indicator		Chemical use	Emissions to air	Emissions to water	Energy efficiency	Farm management	Fishery management	Flood safety	Harvesting Management	Impact on environment	Impact on ecosystems	Infrastructure capacity	Introduction of invasive species	Level of energy consumption	Level of water consumption	Mitigation	Oil spill response	Status of stock	Supply chain	Level of fuel consumption	Use of shore power	Waste/wastewater management	Water quality
Living Resources	Fish and shellfish harvesting		⭘		■		▲				⭘			⭘		⭘		▲				⭘	
	Fish and shellfish processing		⭘		■						⭘			⭘		⭘						⭘	
	Marine plant and algae harvesting		⭘		■				▲		⭘			⭘		⭘		▲				⭘	
	Aquaculture	▲	⭘		■	▲					⭘			⭘		⭘			▲			⭘	▲
Renewable Energy	Renewable energy generation		⭘		■						⭘			⭘		⭘						⭘	
Maritime Transport	Transport infrastructure		⭘		■						⭘		▲	⭘		⭘	▲				▲	⭘	▲
	Transport shipping	▲	⭘		■						⭘		▲	⭘[6]		⭘				▲	▲	⭘	

[6] This also includes a sector-specific indicator on level of fuel consumption

Sectors	Sub-sectors	Environmental dimension																				
⭘ Key indicator ■ Common indicator ▲Sector-specific indicator		Chemical use	Emissions to air	Emissions to water	Energy efficiency	Farm management	Fishery management	Flood safety	Harvesting Management	Impact on environment	Impact on ecosystems	Infrastructure capacity	Introduction of invasive species	Level of energy consumption	Level of water consumption	Mitigation	Oil spill response	Status of stock	Supply chain	Level of fuel consumption	Use of shore power	Waste/wastewater management	Water quality
Coastal Tourism and Leisure	Tourism and leisure infrastructure /activities		⭘		■						⭘			⭘	▲	⭘						⭘	
Public sector	Coastal defence and flood protection		⭘		■			▲			⭘			⭘		⭘						⭘	

Table 4: Matrix overview of the sustainability criteria grouped for the economic dimension for each sub-sector

Sectors	Sub-sectors	Economic criteria											
⭘ Key indicator ■ Common indicator ▲Sector-specific indicator		Concentration of businesses	Costs	Durability of structure	Economic benefits	Economic viability	Employment	Feed management	Financial viability	Flood safety	Funding	Infrastructure capacity	Processing conditions
Non-Living Resources	Extraction of minerals	■	■		■	⭘	⭘		⭘		■		
	Extraction of oil and gas	■	■		■	⭘	⭘		⭘		■		
	Extraction of water - Desalination	■	■		■	⭘	⭘		⭘		■	▲	
Living Resources	Fish and shellfish harvesting	■	■		■	⭘	⭘		⭘		■		
	Fish and shellfish processing	■	■		■	⭘	⭘		⭘		■		▲
	Marine plant and algae harvesting	■	■		■	⭘	⭘		⭘		■		
	Aquaculture	■	■		■	⭘	⭘	▲	⭘		■		
Renewable Energy	Renewable energy generation	■	■		■	⭘	⭘		⭘		■	▲	
Maritime Transport	Transport infrastructure	■	■		■	⭘	⭘		⭘		■		
	Transport shipping	■	■		■	⭘	⭘		⭘		■		
Coastal Tourism and Leisure	Tourism and leisure infrastructure/activities	■	■		■	⭘	⭘		⭘		■		
Public sector	Coastal defence and flood protection	■	■	▲	■	⭘	⭘		⭘	▲	■		

Table 5: Matrix overview of the sustainability criteria grouped for the social and governance dimensions for each sub-sector

Sectors	Sub-sectors	Social criteria						Governance criteria																
● Key indicator ■ Common indicator ▲ Sector-specific indicator		Employment conditions	Health and safety management	Inclusiveness	Level of acceptance by stakeholders	Social balance	Fairness in renumeration	Certification and labeling	Climate change	Development control	Education on sustainability	Fishery management	Harvesting management	Impact assessment	Innovation	Level of stakeholder engagement	Nature-Based Solutions	Permits	Risk management	Strategy and vision	Supply chain	Sustainable infrastructure	Hazardous waste management
Non-Living Resources	Extraction of minerals	●	■	●	●		●	●	■		■			●	■	●	■	■	■	■	■		
	Extraction of oil and gas	●	■	●	●		●	●	■		■			●	■	●	■	■	■	■	■		
	Extraction of water - Desalination	●	■	●	●		●	●	■		■			●	■	●	■	■	■	■	■		
Living Resources	Fish and shellfish harvesting	●	■	●	●		●	●	■		■	▲		●	■	●	■	■	■	■	■		
	Fish and shellfish processing	●	■	●	●	▲	●	●	■		■			●	■	●	■	■	■	■	■		
	Marine plant and algae harvesting	●	■	●	●		●	●	■		■		▲	●	■	●	■	■	■	■	■		

Sectors	Sub-sectors	Social criteria						Governance criteria															
● Key indicator ■ Common indicator ▲Sector-specific indicator		Employment conditions	Health and safety management	Inclusiveness	Level of acceptance by stakeholders	Social balance	Fairness in renumeration	Certification and labeling	Climate change	Development control	Education on sustainability	Fishery management	Harvesting management	Impact assessment	Innovation	Level of stakeholder engagement	Nature-Based Solutions	Permits	Risk management	Strategy and vision	Supply chain	Sustainable infrastructure	Hazardous waste management
	Aquaculture	●	■	●	●		●	●	■		■			●	■	●	■	■	■	■	■		
Renewable Energy	Renewable energy generation	●	■	●	●		●	●	■		■			●	■	●	■	■	■	■	■		
Maritime Transport	Transport infrastructure	●	■	●	●		●	●	■		■			●	■	●	■	■	■	■	■	▲	▲
	Transport shipping	●	■	●	●		●	●	■		■			●	■	●	■	■	■	■	■		
Coastal Tourism and Leisure	Tourism and leisure infrastructure /activities	●	■	●	●	▲	●	●	■	▲	■			●	■	●	■	■	■	■	■		
Public sector	Coastal defence and flood protection	●	■	●	●		●	●	■		■			●	■	●	■	■	■	■	■		

Step 3: Conduct a VCA

The objective of the value chain analysis approach (VCA) is to introduce and characterise a blue economy sector. The theoretical background originates from Porter (1985): a value chain is defined as "a set of activities that a business carries out to create value for its customers". It is useful to examine the business activities; see how they are interconnected and understand which of them add value (and so identify sources of competitive advantage)[7]. Porter's VCA enables the analysis of sectors distinguishing the different segments in the production cycle including a) inbound logistics, b) operations, c) outbound logistics, d) marketing and sales and e) service. The identification of different phases in the production cycle is important as segments do not have the same degree of (un)sustainability.

The 'quick scan' VCA enables the end-user to identify the generic opportunities and constraints regarding environmental, economic, social and governance sustainability for each segment. The end-user may use a variety of methods, such as a literature study, key interviews, focus groups and/or expert judgement to conduct the quick scan VCA.

Value chains consist of primary activities. These activities relate directly to the physical creation, sale, maintenance and support of a product or service. The five primary activities for the quick scan VCA of each blue economy sector/activity include[8]:

- **Inbound logistics**: Refers to goods obtained from suppliers and ready to be used for producing the end-product.
- **Operations**: The raw materials and goods obtained are manufactured into the final product. Value is added to the product at this stage as it moves through the production line.
- **Outbound logistics**: Once the products are manufactured, they are ready to be distributed to distribution centres, wholesalers, retailers or customers.
- **Marketing and Sales**: Marketing must make sure that the product is targeted towards the correct customer group. The marketing mix is used to establish an effective strategy; any competitive advantage is clearly communicated to the target group by the use of the promotional mix.
- **Services**: After the product/service has been sold, services relate to the support an organisation has to offer. This may come in the form of after sales training, guarantees and warranties.

These primary functions are supported by a set of four supporting activities, namely[9]:

- **Firm infrastructure:** Every organisation needs to ensure that their finances, legal structure and management structure works efficiently and helps drive the organisation forward.
- **Human resource management:** The organisation will have to recruit, train and develop the correct people for the organization if they are to succeed in their objectives. Staff will have to be motivated and paid the 'market rate' if they are to stay with the organisation and add value to it over their duration of employment.

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[7] Pallaoro, R. (2017). Value chain. Retrieved December 6, 2019, from Quizlet website: https://quizlet.com/it/253412570/value-chain-flash-cards/

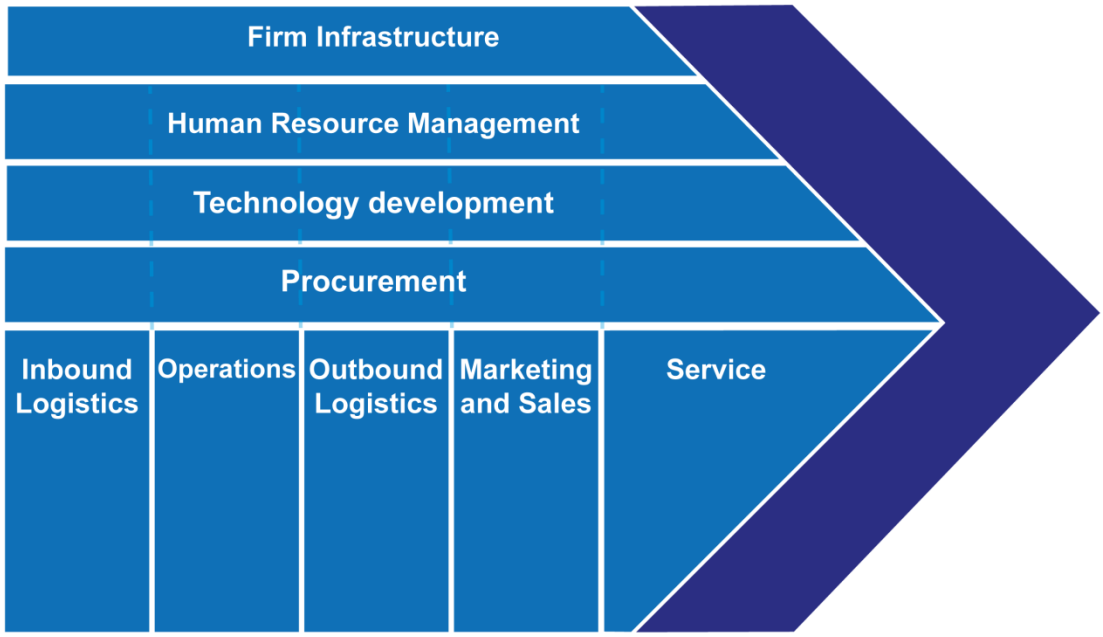
[8] De Silva, 2011; Porter, 1985

[9] Ibid.

- **Technology development:** The use of technology to obtain a competitive advantage within the organisation. Technology can be used in production to reduce cost and thus add value, or in research and development to develop new products, or via the use of the internet so customers have access to online facilities.
- **Procurement**: This department must source raw materials for the organisation and obtain the best price for doing so. For the price they must obtain the best possible quality.

The original VCA theory of Porter focuses on the level of the firm or company. In the sections below the focus is primarily on the level of blue economy sectors.

Figure 3: Overview of primary activities and support activities for the VCA



Source: based on Porter, 1985

Based on the theoretical background as described above, the quick scan VCA can be conducted by the end-user using the two templates below (Table 6 and Table 7). It is advised that each table is accompanied with a short descriptive text that explains the content of the tables. Also, the end user is advised to include a flow chart summarising the main segments of the primary activities. Below an example is provided originating from the case study on the Norwegian salmon sector.

Table 6: Template to characterise primary activities of a blue economy sector

Segment	Short description of segment	Opportunities for sustainability	Constraints for sustainability
a. Inbound logistics			
b. Operations			
c. Outbound logistics			
d. Marketing and sales			
e. Service			

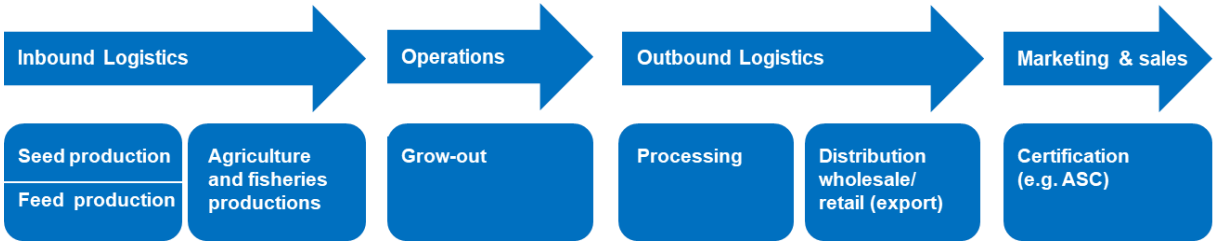
Table 7: Template to characterise support activities of a blue economy sub-sector

Segment	Short description
1. Sector infrastructure	
2. Human resource development	
3. Technology development	
4. Procurement	

Example of conducting a quick scan VCA - Salmon farming in Norway

The value chain of salmon farming in Norway, consists of brood stock production, grow-out, processing and distribution via wholesale and retail. The details of the segments can be found in Table 8 and Figure 4. The main sustainability opportunities for inbound logistics consist of further reducing antibiotics and chemical use and continuing to lower the Feed Conversion Ratio. It also includes the use of responsible feed ingredients. A constraint in this segment is the potential environmental impact of sea lice treatment. For the operations segment, the main sustainability opportunities are offshore production, Integrated Multi-Trophic Aquaculture (IMTA) and Semi-Closed Containment Systems. The constraints in this segment include the technical and economic feasibility of these innovations. In the outbound logistics the opportunities consist of innovations in processing, such as packaging and a longer shelf life. Constraints are that the logistics still involve large amounts of carbon emissions. For marketing and sales, opportunities include the streamlining of certification and the inclusion of the topic of governance in certification schemes, which is currently a constraint. For the support activities in this case (Table 9), it can be noted that Norway has a very effective licensing system that is increasingly focusing on sustainability. Human resource development is also very efficient and aquaculture is part of many educational programmes. The same applies to technological development; Norway is a frontrunner regarding innovations such as artificial light in hatcheries and lasers to combat sea lice.

Figure 4: Example of segments of the primary activities of salmon farming in Norway



Source: Own elaboration, 2020

Table 8: example of primary activities of salmon farming in Norway

Segment	Short description of segment	Opportunities for sustainability	Constraints for sustainability
1. Inbound Logistics	Seed production	(Semi) closed systems with high control. Recirculating aquaculture systems (RAS) are increasingly popular (control of growth & environmental factors)[i]	Hatcheries on land can cause competing claims for land
	Chemical production, including antibiotics, pesticides, antifoulants, disinfectants	Antibiotics Norway represents the lowest level of antibiotic use in world-wide salmon farming[ii]	Antibiotics Antibiotic use is still industry-wide, applied more than once a year[iii]
		Pesticides Further decrease in use as non-chemical methods become more prominent[iv]	Pesticides Salmon lice is currently the biggest threat to salmon farming in Norway[v]
	Feed production	Salmon feed is responsible for more than 50% of production costs and is an important aspect of carbon emissions (95%)[vi]	Feed protein must be produced sustainably, but also from sustainable origins (e.g. sustainable soy not involving deforestation)[vii]
2. Operations	Grow out	(Semi) Closed Containment Systems (S)CCS, prevent escapes, decrease lice infestation through water treatment. Also, higher FCR (as no food is wasted) & sludge can be collected thus lower environmental footprint[viii]	(S)CCS also at risk for diseases, mass deaths and high costs[ix]
3. Outbound Logistics	Processing	Fish rendered unconscious, killed, cleaned packed in EPS (Expanded PolyStyrene) boxes[x]	High CO2 emissions for refrigeration and cooling, and a lot of waste/catch discarded that is over quotas (8%)[xi]
	Distribution of fish via wholesale / retail. Exporting companies	Refrigerated transport: longer shelf life[xii]	Refrigerated transport: heavier transport, more CO2 emissions[xiii]
4. Marketing and Sales	Certification	Many different certification standards are followed, covering many sustainability aspects in the value chain[xiv]	Certification of aquaculture needs to scale up and include a governance dimension, as there is much criticism towards certification schemes. Traceability and information sharing should be more emphasized[xv]
5. Services	n.a.		

Table 9: example of support activities of salmon farming in Norway.

Segment	Short Description
1. Sector infrastructure (finance, legal, management)	Licensing system is central. Used to be 1 farm(er), 1 license, facilitating regional development. Now shift on competing in world market and the owner-operator system is relaxed.
2. Human resource development	Educational training becomes quickly outdated and 2/3 of employees lack relevant training. In the EU a plan exists to pilot overarching curriculum to raise education standards.
3. Technology development	Aquaculture is prominent in all Norwegian universities. Vocational training also in several schools. Research funding for aquaculture originates from both public and private sources (e.g. tax on exports).
4. Procurement	Norwegian government aims to balance sectoral growth with sustainability using green and development licenses and proposed implementation of predictable system.

Step 4: Apply the relevant criteria and indicators

The relevant criteria and indicators should be first selected from the indicator database. A condensed set of indicators will contain the 20 key indicators and the sector-specific indicators. A more elaborated set will contain 44 common indicators supplemented by the sector-specific indicators.

Table 11 below provides an example matrix to conduct the analysis based on the selected criteria and indicator set, followed by an illustrative application to the case study on *Salmon farming in Norway* (Table 12: Example application of the relevant criteria and indicators to case study – *Salmon farming in Norway*).

Table 10: Example application of BESF to case studies

Coding	Criteria	Indicator	Value (year)	Units	Details
C.EC.6	Economic viability	Turnover		mEUR/year	
C.EC.7	Employment	Direct and indirect jobs		No. of direct and indirect jobs x1000 persons/year	
	Criteria x	*Indicator x*			

Table 11: Example application of BESF to a specific case study over different timelines

				Case study		
Coding	Criteria	Indicator	Units	Value Year 1	Value Year 2	Value Year x
C.EC.6	Economic viability	Turnover	mEUR/year			
C.EC.7	Employment	Direct and indirect jobs	No. of direct and indirect jobs x1000 persons/year			
	Criteria x	*Indicator x*				

Table 12: Example application of the relevant criteria and indicators to case study – *Salmon farming in Norway*[10]

ENVIRONMENTAL					
Coding	**Criteria**	**Indicator**	**Value**	**Unit**	**Details**
C.EN.1	Mitigation	Gross value or percentage of revenue invested in environmental causes related to the sector's activities directly (e.g. mitigation, restauration, monitoring) or indirectly (offsetting).	No data available	m EUR/year or % of revenue/year	
C.EN.2	Emissions to Air	Emissions of CO2	1.7 (2007)	Tonnes of CO2-eq/year	As recorded by the Life Cycle Impact Assessment (LCA)[11] by Pelletier et al. (2009) for the production of one live-weight tonne of Salmon in Norway in 2007[xvi].
C.EN.3	Impact on ecosystems	Extent of coastal and marine habitat positively/negatively impacted	No data available	Area of positively and negatively impacted habitat in hectares	
C.EN.4	Impact on ecosystems	Threatened species (IUCN red list) of known species	Only qualitative data available	%	Globally, Atlantic salmon (*Salmo salar*) itself is considered as "Least Concern" by the IUCN red list. However, its status has not been assessed since 1996.[xvii] In Europe, the species was assessed as Vulnerable in 2015.[xviii] The wild salmon population is affected by e.g. escape events, disease and discharges of veterinary drugs and nutrient waste from sea farming (See *Case study 4 - Reviewing the sustainability of Salmon Farming in Norway* for details).
C.EN.5	Impact on ecosystems	Support given to local entities working on the protection, conservation and management of local biodiversity and landscapes	No data available	• % of turnover dedicated to such support or • If in-kind support (such as making manpower or machinery available free of charge, or donating land), describe	

[10] This table presents data collected for the case study No. 4 - *Reviewing the sustainability of Salmon Farming in Norway* of the separate deliverable *Blue economy development framework – Case studies applying the sustainability criteria for the Blue Economy.*

[11] Weighted average calculated using 2007 production volumes of 626, kilotonnes live weight for Norway.

ENVIRONMENTAL					
Coding	**Criteria**	**Indicator**	**Value**	**Unit**	**Details**
C.EN.6	Level of energy consumption	Energy consumption	988,822 tonnes[12] of oil eq. (2010)	Tonnes of oil equivalent/year	Recorded for the total industrial energy input for production of farmed salmon (2010). 95% of the industrial energy input was used for harvest, production and transport of feed ingredients and feed[xix].
C.EN.7	Level of energy consumption	Energy demand met by renewable energy	No data available	% total primary energy supply	
C.EN.8	Energy efficiency	Measures taken to increase energy efficiency	Yes	Yes / no. If yes, specify	Various measures, including underwater feeding (using deep water in pipes as a mechanism to reach the fish rather than using compressed air[13]), replacing halogen pen lights with LED lights, water-to-water heat pumps, reduction of power demand on feed barges through peak shaving with battery packs.[xx]
C.EN.9	Waste / waste water management	Waste generated	540,000-624,000 (2016)	Million tonnes	Organic Matter to water from salmon farming (National, Salmon)[xxi]
C.EN.10	Waste / waste water management	Technology available for solid waste and wastewater treatment	Yes	Yes/ No. If yes: specify	Various technologies. Fish farms in Norway are responsible for water treatment, yet there is no national requirement regarding outlet water treatment. Solid waste is often collected (via sedimentation or microscreen filtration) and used as a fertilizer.[xxii] For land-based farming, both 'Flow Through Systems' and 'Recirculation Aquaculture Systems' are used.[xxiii]
SAQ.EN.1	Chemical use	On-farm documentation available with detailed information on chemicals use, compliant with regulations (including anti-biotics)	Only qualitative data available	Yes/no. If yes: specify	In a global context, Norway uses a relatively low level of antibiotics in salmon farming.

[12] Original value = 41 400 TJ

[13] In an underwater feeding system, the fish are fed at 7 meters deep where they are less exposed to lice. The feed is transported through regular feeding hoses by pumping deep water into the main pipe. This reduces the energy demand of the underwater feeding system in comparison to the regular feeding system which uses compressed air to transport the feed.

ENVIRONMENTAL					
Coding	**Criteria**	**Indicator**	**Value**	**Unit**	**Details**
SAQ.EN.2	Supply chain	Existence and effective implementation of a company policy to ensure inputs/raw materials are obtained from sustainable sources	No data available	Score: 1. Policy does not exist 2. Policy exists but not implemented 3. Policy exists and implemented	
SAQ.EN.3	Farm management	Mortalities reduction program exists and implemented	Variable	Yes/no. If yes: specify	Varies by company. For example, some farmers have considered producing larger post-smolt (weighing up to 500 grams) to increase survival rates.[xxiv]
SAQ.EN.4	Farm management	Number of escape events	No data available	No. of escapes / year	
SAQ.EN.5	Farm management	Number of escaped fish	290,000 (2019)	No. of escaped fish / year	National level data[xxv]. Stringent requirements are set for all main components, construction parts for mooring and additional equipment. However, concerns remain of a moderate-to-high risk for genetic introgression on wild populations of salmon from farm-escaped fish[14].
SAQ.EN.6	Water quality	Measures taken to reduce nutrient eutrophication	Only qualitative data available	No. and type of measures taken	The risk of nutrient eutrophication and organic load beyond the production area of the farm is considered to be low in Norway.
SAQ.EN.7	Water quality	Phosphorous (P) and nitrogen (N) concentrations	No recent data available	mg/L	156.52 mg/L nitrogen per month per farm between May 2010 and December 2013.[xxvi]
SAQ.EN.8	Impact on ecosystems	Refuge effect for species	No data available	Yes/no, if yes: specify	

[14] Fish that escape from net pens and enter rivers to spawn can potentially result in genetic introgression (the movement of a gene from one species into the gene pool of another) and reduced fitness of wild salmon.

ECONOMIC					
Coding	**Criteria**	**Indicator**	**Value**	**Unit**	**Details**
C.EC.1	Concentration of businesses	Existence of clusters	Yes (2017)	Yes/No	'Seafood Innovation Cluster' and 'Norway's Fish and Fish Products Cluster'[xxvii].The Seafood Innovation Cluster is the most prominent of the national seafood clusters and was designated as Norwegian Centre of Expertise with the objective to support business clusters with growth potential.
C.EC.2	Economic benefits	Total revenues generated by local enterprises	No data available	% total revenues generated by local enterprises	
C.EC.3	Economic benefits	Local public revenue generated through time (taxes, fees, etc.)	No data available	m EUR/year	
C.EC.4	Economic viability	Gross value added (Size of the national / regional sector)	2.54 billion EUR/year (estimated value for 2018)[15]	m EUR/year	National level data for 2018.[xxviii]
C.EC.5	Economic viability	Sector specific investments	Only partial data available	m EUR/year	Five of the largest players in the Norwegian salmon sector have plans to spend a combined 661 million EUR[16] on salmon investments over 2020, reflecting strong confidence in the sector[xxix]. However, the value for the total amount of investments in the sector was not found.
C.EC.6	Economic viability	Turnover	6,173[17] (2019)	m EUR/year	First-hand value of farmed salmon in Norway[xxx].
C.EC.7	Employment	Direct and indirect jobs	6,128 (Production) and 2,175 (Hatcheries and/or fingerling production)	No. of direct and indirect jobs x1000 persons/year	2018 statistic data; Statistic Norway.[xxxi]

[15] Value-added contribution of the national aquaculture industry in 2018 was 34.9 billion NOK, with salmon accounting for more than 80 percent of the total Norwegian aquaculture production (converted on 03/22/1010).

[16] 718 million USD converted on 21/02/2020

[17] First-hand value of 67,990 million NOK converted on 03/11/2020

ECONOMIC					
Coding	**Criteria**	**Indicator**	**Value**	**Unit**	**Details**
			(2018)		
C.EC.8	Financial viability	Additional streams of finance/investment attracted	Only qualitative data available	m EUR/year	Land-based salmon farming struggles to receive external financing (2019). Credit institutions largely do not provide any financing for land-based production taking place in Norway. Some projects have however managed to raise equity financing in recent years.[xxxii]
C.EC.9	Financial viability	Financial returns reinvested in local activities	80% (2016)	% financial returns reinvested in local activities	Since the establishment of the Aquaculture Fund in 2016, 80% of the revenue from the sales of new fish farm licences goes to the local municipalities while 20% is kept by the state[xxxiii].
C.EC.10	Financial viability	Financial self-sustainability of supported activities	Only partial data available	Number of years required to achieve the full financial self-sustainability of supported activities (e.g. debt-to-equity ratio)	With a sales price of EUR 5.7/kg (average price in Norway 2014-2018), the payback time for the original investments for a standard site consisting of 4 licenses has been estimated at around 11.5 years. This estimate is sensitive to sales price, licence cost and economic feed conversion ratio.[xxxiv]
C.EC.11	Funding	Public/private funding	Data not available in requested unit	% of turnover	Public funding is targeted at research and development of sustainable technologies and practices. Various public funds for research and development of the aquaculture technologies have been identified, including 2.2 m EUR by the government in R&D and protection of coastal waters[xxxv] (announced in 2019), 1m EUR in algae bloom responses (2019), ~1m EUR in management models to reduce escape events (2017-2018) [xxxvi].
C.EC.12	Costs	Average personnel costs	Data not available in requested unit	x1000 EUR / year	0.41 EUR[18] per kilogram of fish in sea-based salmon farming (2018)[xxxvii]
C.EC.13	Costs	Maintenance costs	No data available	M EUR/year	

[18] 4.3 NOK converted on 23/02/2021

ECONOMIC					
Coding	**Criteria**	**Indicator**	**Value**	**Unit**	**Details**
SAQ.EC.1	Economic viability	Average size of farms	12 ha (2016)	Hectares of land or water	National data (including moorings)[xxxviii]
SAQ.EC.2	Economic viability	Production 'farmed fish' (weight)	1.364 m (2019)	Landings weight in tonnes/year	Information from Statistics Norway for 2019[xxxix].
SAQ.EC.3	Economic viability	Production 'farmed fish' (monetary)	No data available	m EUR/year	
SAQ.EC.4	Feed management	Realised Feed Conversion Ratio	1.30 1.21 (on dry matter basis) (2016)	FCR (relationship between feed given and weight gain)	National data[xl]
SAQ.EC.5	Economic viability	Stocking density	Data not available in requested unit	No. of fry / m^2	The maximum stocking density in Norway for farmed salmon is 25 kg/m^3, and 10 kg/m^3 for organic salmon (regulation from 2008).[xli]

SOCIAL					
Coding	**Criteria**	**Indicator**	**Value**	**Unit**	**Details**
C.SO.1	Employment conditions	Average wage of employees compared to sector average or national average	Data only available for the aquaculture and seafood sector as a whole	EUR/year	28,801 EUR/year[19] for an aquaculture and seafood farmer[xlii], compared to 60,947 EUR/year[20] national average[xliii] (2021).
C.SO.2	Employment conditions	Presence and level of activity of labour unions in the company/sector	Yes[xliv]	Yes/no	

[19] 303,000 NOK converted on 23/02/2021

[20] 641,189 NOK converted on 23/02/2021

SOCIAL					
Coding	**Criteria**	**Indicator**	**Value**	**Unit**	**Details**
C.SO.3	Employment conditions	Informal employment	No data available	% informal employment of total employment	
C.SO.4	Health and safety management	Frequency of auditing by external health & safety experts	No data available	No. of audits by external health and safety experts, including evidence of application in practice, such as technical measures, regular medical screenings, etc.	
C.SO.5	Health and safety management	Existence of policies and measures to combat occupational diseases and accidents	Only qualitative data available	Yes/no, if yes: specify	Norwegian companies perform well against risk factors related to safety and security in the working environment: sickness absence in the aquaculture industry is lower than the average sickness absence in Norway, but proportion of work-related absences due to strain injuries is high.
C.SO.6	Inclusiveness	Employees with no post-school diploma	No data available	%	
C.SO.7	Inclusiveness	Employment rate of vulnerable groups	Only qualitative data available	% vulnerable workers of total work force per social category (see guideline). For every social category define: • Gender (% male/female/other) • Average age	Foreign migrant workers are employed, particularly in some remote areas[xlv].
C.SO.8	Fairness in remuneration	Evidence of unequal pay between social categories for equal work	No data available	Yes/no, if yes: explain evidence, type of work and social categories affected, degree of discrimination in pay	
C.SO.9	Level of acceptance by stakeholders	Acceptance of environmental, economic and social impact by stakeholders	No data available	No. of reported actions of stakeholders against environmental, economic or social impacts	

GOVERNANCE					
Coding	**Criteria**	**Indicator**	**Value**	**Unit**	**Details**
C.GO.1	Permits	Typical permitting regime followed prior to operations	Score 3	Score: 1. No permitting or environmental administration required 2. Permit procedure required, but below EIA threshold; 3. Permit with EIA procedure;	Strong environmental legislation is in place, enforced via two principles: the use of licenses (permits) and the regulation of localities (sea space or sites)[xlvi].
C.GO.2	Impact assessment	Environmental Impact Assessment, Strategic Environmental Assessment and Socio-Economic Assessment conducted and enforced via monitoring and evaluation	Only qualitative data available	Score: 1. No EIA/SenA/SecA conducted, 2. EIA/SenA/SecA conducted but not implemented/enforce 3. EIA/SenA/SecA conducted and enforced via monitoring and evaluation	Environmental Impact Assessments are required for new, large salmon aquaculture operations[xlvii]. However, no information found on the extent of enforcement, monitoring and evaluation.
C.GO.3	Nature-Based Solutions	Application of Nature Based Solutions	No data available	Score 1. Relevant, but not applied 2. Applied to some extent [example] 3. Frequently applied [example] 4. Not applicable to the company/sector activities	
C.GO.4	Risk management	Existence/implementation of risk management plans taking into account the precautionary principle	Variable	Score: 1. No risk management plan 2. Risk management plan exist 3. Risk management plan exists, includes precautionary principles and is implemented	Risk management strategies vary per company. [xlviii] The Aquaculture Act has a special environmental clause which states that aquaculture must be established, run and 'wound down' in an environmentally responsible manner. The precautionary principle comes into play in evaluating the concept of environmental responsibility, entailing that, where there is a risk of serious or irreversible damage to nature, ignorance may not be used as an excuse for delaying or avoiding the initiation of proportionate and cost-effective measures.[xlix]
C.GO.5	Strategy and vision	Integration of SDGs in the company's strategy and operations	Only qualitative data available	% of activities covered by SDG reporting	The UN Sustainable Development Goals (SDGs) have been identified in the strategic documents of the Norwegian Seafood Federation – Aquaculture 2030[l] as well as in various companies (e.g. Cermaq; Mowi).[li]

GOVERNANCE					
Coding	**Criteria**	**Indicator**	**Value**	**Unit**	**Details**
C.GO.6	Climate change	Measures taken for climate change adaptation	Yes	Yes/no. If yes: specify	For example, new measures to reduce salmon lice reproduction (numbers of which are likely to increase in higher temperatures), increasing the weight threshold to transfer smolt to sea (thereby reducing the 'sea phase' period of production, and consequently the duration of which fish are exposed to temperature changes and its impacts), increased farming in northern Norway.[lii]
C.GO.7	Innovation	Attention to innovation (or investment in R&D)	Only qualitative data available	% revenue invested in R&D	Norway is a frontrunner regarding innovations such as artificial light in hatcheries and lasers to combat sea lice.
C.GO.8	Certification and labelling	Existence of a sustainability label or certificate	Score: 3	Score: 1. No sustainability label or certification 2. Sustainability label(s) or certification exists/awarded (please specify) 3. Sustainability label(s) or certification applied	Although certification is on voluntary basis, many Norwegian fish farming companies are certified under one or more standards (such as the GLOBAL GAP standard, Aquaculture Standard, Aquaculture Stewardship Council standard as well as organic certification[21]). Certification is applied throughout the entire value chain.
C.GO.9	Supply chain	Existence of supply chain policy	Variable	Yes/no. If yes: specify	Some Norwegian fish farming companies have strategies for making their supply chains more climate and environment friendly.
C.GO.10	Supply chain	Existence of Life Cycle Assessment policy	No data available	Yes/no. If yes: specify	
C.GO.11	Level of stakeholder engagement	Mechanism for stakeholder engagement	Score: 3	Score: 1. No stakeholder involvement 2. Occasional consultation with stakeholders, focused on public actors 3. Specific mechanisms for stakeholder engagement besides public actors	Various stakeholders have been identified to contribute to the planning and development of the aquaculture sector activities in along the coastline of Norway: – Coastal zone area plans follow a governance model of inclusion of all stakeholders. (2017). [liii] – Application for new business is subject to rigorous municipal hearings with affected stakeholders.[liv] At many companies (e.g. Cemarq) stakeholder groups share knowledge, information to enhance performance (2017-2020).[lv]

[21] All providers of organic products in Norway are certified by Debio in accordance with the Norwegian "Regulations on the Production and Labelling of Organic Agricultural Products" which is based on Regulation (EC) 834/2007.

GOVERNANCE					
Coding	**Criteria**	**Indicator**	**Value**	**Unit**	**Details**
C.GO.12	Education on sustainability	Participation in information and training sessions about sustainability	Yes	Yes/no, if yes specify	Human resource development in the sector supported as aquaculture is part of many educational programmes[lvi].

Important considerations in the application of the relevant indicator set

The following sections provide general and specific considerations to take into account when applying the BESF for a sustainability review of an activity. It begins by outlining the general considerations to take account of during the data collection process, and then looks at the practical aspects that facilitate the comparability of case studies.

1. Comparable time periods

Data collection

This text box addresses general considerations in the data collection methodology:

1. The data can be collected through a comprehensive literature review on the specific activity to provide quantitative and qualitative data relative to the indicators of a set sustainability indicators – covering economic, environmental, social and governance dimensions. The scope of the literature study can include relevant scientific papers, official reports, websites and other publications for example from organisations and companies relating to the activity or (sub-)sector of interest. Reaching out to the actors involved in the activity is another useful source of data.
2. It is to be expected that data gaps will be encountered where information for the respective indicators cannot be found. In some cases, the data is outdated or not fully comparable due to methods used to generate it or the difference in the time periods. Where possible, data and information from sources relevant for the different cases to compare (time period or spatial scales) are used in order to ensure methodological coherence.
3. It is important to clearly identify those gaps and notify them in the assessment. If data are not available, it does not mean that indicators should not be presented. 'No data available' represents a lack of data for the specified indicator. While indicators that have no reliable data (such as different scales, methodologies or metrics or lack of adequate sources) can be excluded in the tables, it is advised to mention those exclusions at the end of the assessment.

When populating the indicators, the data should refer to the same or similar time period, whenever possible. This will provide an overall reference situation for the application or case study.

2. Comparable spatial scale

The indicators in the BESF are defined in a way that can be applied to different spatial scales, e.g. local, national, regional. However, for a given application of the BESF, it is advisable that all indicators are applied at the same spatial scale.

⇨ Example:

ENVIRONMENTAL			
Code	**Criteria**	**Indicator**	**Unit**
C.EN.5	Impact on ecosystems	Local companies actively supporting protection, conservation and management of local biodiversity and landscapes	%

⇨ Example:

ECONOMIC			
Code	**Criteria**	**Indicator**	**Unit**
C.EC.2	Economic benefits	Total revenues generated by local enterprises	% total revenues generated by local enterprises

The term "local" is determined by the spatial scale of the application. The glossary offers guidance on what can considered local, however the BESF does not provide a definition of what a scale entails - rather, this needs to be identified by the user of the BESF.

⇨ Example:

SOCIAL			
Code	**Criteria**	**Indicator**	**Unit**
C.SO.1	Employment conditions	Average wage of employees compared to sector average or national average	EUR/year

In this case, average wage of employees should be compared to sector average or national average, depending on the scale of the application (local or national).

3. Consistency in units

i. Units expressed in monetary terms

The units of some indicators, in particular economic indicators, are expressed in Million Euros.

⇨ Example:

ECONOMIC			
Code	**Criteria**	**Indicator**	**Unit**
C.EC.4	Economic viability	Gross value added (Size of the national / regional sector)	m EUR/year

⇨ Example:

ECONOMIC			
Code	**Criteria**	**Indicator**	**Unit**
C.EC.8	Financial viability	Additional streams of finance/investment attracted	m EUR/year

The monetary unit can be adapted as required by the location of the activity, given that monetary units in the BESF are coherent and consistent.

ii. Calculation methods for unit conversions

For some indicators, unit conversion calculations are required.

⇨ Example:

ENVIRONMENTAL			
Code	**Criteria**	**Indicator**	**Unit**

C.EN.2	Emissions to air	Emissions of CO_2, Sox Nox, and P.M.[22]	Tonnes of CO_2 equivalent / year Tonnes of SO_2 equivalents / year Tonnes of NO_2 equivalents / year Tonnes of pollutant / year

The units of the common indicator on emissions to air (C.EN.2) include:

- Carbon dioxide equivalents, commonly expressed as tonnes of carbon dioxide equivalents (TCDE). The carbon dioxide equivalent for a gas is derived by multiplying the tonnes of the gas by the associated global-warming potential (GWP)[23]:

TCDE = (tonnes of a gas) * (GWP of the gas). The list of GWP values can be found here.

For example, the GWP for methane is 28 and for nitrous oxide 265. This means that emissions of 1 tonne of methane and nitrous oxide, respectively, is equivalent to emissions of 28 and 265 tonnes of carbon dioxide.

- Sulphur dioxide equivalents. In order to describe the acidifying effect of substances (acidification potential), their acid formation potential (ability to form H+ ions) is calculated and set against a reference substance, SO_2. The SO_2 equivalence factor[24] is assigned to acid producers (in air) as a conversion factor.

⇨ Example:

ENVIRONMENTAL			
Code	**Criteria**	**Indicator**	**Unit**
C.EN.6	Level of energy consumption	Energy consumption	Tonnes of oil equivalent (TOE) /year

Tonne(s) of oil equivalent, abbreviated as TOE, is a normalized unit of energy. By convention it is equivalent to the approximate amount of energy that can be extracted from one tonne of crude oil. It is a standardized unit, assigned a net calorific value of 41 868 kilojoules/kg and may be used to compare the energy from different sources. The conversion factors for other energy carriers into TOE can be found here.

⇨ Example:

ENVIRONMENTAL			
Code	**Criteria**	**Indicator**	**Unit**
C.EN.9	Waste / waste water management	Waste generated and recycled	Tonnes of waste generated and recycled per year

In order to monitor the trend in the fraction of waste recycled, this can be expressed as a % of waste generated.

4. Normalization to allow for direct comparison

In certain instances, such as the application of the BESF for assessing the evolution of a case over time, some indicators could be normalized by indicators measuring sector-

[22] P.M. is short for particulate matter

[23] https://www.ghgprotocol.org/sites/default/files/ghgp/Global-Warming-Potential-Values %28Feb 16 2016%29_1.pdf

[24] https://ec.europa.eu/environment/waste/pdf/study/annex5.pdf

specific production, such as production of marine aggregates (weight) (SEM.EC.1), production of 'oil and gas' (tonnes) (SEOG.EC.3) and fresh water produced (SDE.EC.2).

⇨ Example:

ENVIRONMENTAL			
Code	**Criteria**	**Indicator**	**Unit**
C.EN.2	Emissions to air	Emissions of CO_2, Sox, Nox, and P.M.	Tonnes of CO_2 equivalent / year Tonnes of SO_2 equivalents / year Tonnes of NO_2 equivalents / year Tonnes of pollutant / year

ECONOMIC			
Code	**Criteria**	**Indicator**	**Unit**
SEOG.EC.3	Economic viability	Production oil and gas	Tonnes of oil equivalent/year

The emissions to air (C.EN.2) are then normalized by the production of oil and gas (SEOG.EC.3), resulting in an indicator on the emissions to air per unit of oil and gas produced.

⇨ Example:

ENVIRONMENTAL			
Code	**Criteria**	**Indicator**	**Unit**
C.EN.6	Level of energy consumption	Energy consumption	Tonnes of oil equivalent (TOE) /year

ECONOMIC			
Code	**Criteria**	**Indicator**	**Unit**
SDE.EC.2	Infrastructure capacity	Fresh water produced	m^3/day

The level of energy consumption (C.EN.6) is then normalized by the fresh water produced (SDE.EC.2), resulting in an indicator on the energy consumption per unit of fresh water produced.

Other relevant indicators that are not included in the BESF

The BESF builds on a database of more than 500 relevant blue economy indicators, which were identified based on the critical review of existing frameworks. The rigorous selection of indicators to be included in the BESF implied that some relevant indicators could not be taken into consideration.

Some externalities or induced impacts of a sub-sector were not always covered by the indicators. For example, in the case of tourism, the additional spending of tourists in other sectors also contributes to employment and revenue. Similarly, the increase in pricing due to tourism and emissions to air from transportation of tourists also have economic and environmental implications. However, in order to keep the list of indicators concise, such aspects were not always covered.

"Impact on ecosystems" is assessed through the common indicators C.EN.3, C.EN.4 and C.EN.5, and other sector-specific indicators (e.g. SDE.EN.1, SDE.EN.2, SRE.EN.1). The measurement of the types of impacts on ecosystems from different activities is not straight-forward as the impacts are broad in scope, both positive and negative and can include cumulative impacts. To this effect, the proposed indicators do not cover all possible direct and indirect impacts. For example, the impact on seafloor integrity, hydrographical conditions etc., were not included.

Other indicators, such as the underwater noise resulting from activities, were considered to be relevant. However, the corresponding criterion and indicator were not included as part of the BESF, as indicators on this topic are still in the development stage.

Combining "horizontal" and "vertical" sustainability

The combination of both the VCA and the sustainability framework will allow conclusions to be drawn on the broad activities embedded in a particular case study. The opportunities identified when conducting the VCA provide an assessment on horizontal sustainability aspects in all the segments of the value chain of a blue economy sector. This is complemented by the opportunities identified by the application of criteria and indicators to each of the four dimensions for a vertical, in-depth and quantitative approach. Those opportunities will be considered in their totality in order to formulate possible actions. Table 13 provides an illustrative example for the case study *Salmon farming in Norway*.

Table 13: Example application of the combination of VCA and sustainability framework to case study – *Salmon farming in Norway*

Segment	Short description of segment	Opportunities for sustainability	Constraints for sustainability	Relevant Criteria
1. Inbound Logistics	Seed production	• (semi)-closed systems with high control. Recirculating aquaculture systems (RAS) are increasingly popular (control of growth and environmental factors)	• Hatcheries on land *can cause competing* claims for land	• Supply chain (SAQ.EN.2)
	Chemical production, including antibiotics, pesticides, antifoulants, disinfectants	Antibiotics • Norway represents lowest level of antibiotic use in world-wide salmon farming	Antibiotics • Antibiotic use is still industry-wide, applied more than once a year	• Chemical use (SAQ.EN.1)
		Pesticides • Further decrease in use as non-chemical methods become more prominent	Pesticides • Salmon lice is currently the biggest threat to salmon farming in Norway	
	Feed production	• Salmon feed is responsible for more than 50% of production costs and is an important aspect of carbon emissions (95%)	• Feed protein must be produced sustainably, but also from sustainable origins (e.g. sustainable soy not involving deforestation)	• Supply chain (SAQ.EN.2)
2. Operations	Grow out	• (Semi) Closed Containment Systems (S)CCS, prevent escapes, decrease lice infestation through water treatment. Also, higher FCR (as no food is wasted) and sludge can be collected thus lower	• (S)CCS also at risk for diseases, mass deaths and high costs	• Farm management (SAQ.EN.3; SAQ.EN.4; SAQ.EN.5) • Water quality (SAQ.EN.6 SAQ.EN.7) • Feed management (SAQ.EC.4)

Segment	Short description of segment	Opportunities for sustainability	Constraints for sustainability	Relevant Criteria
		environmental footprint		• Waste / waste water management (C.EN.9, C.EN.10)
3. Outbound Logistics	Processing	• Fish rendered unconscious, killed, cleaned packed in EPS (Expanded PolyStyrene) boxes	• High CO2 emissions for refrigeration, cooling, and a lot of waste/catch discarded that is over quotas (8%)	• Processing conditions (SFP.EC.3) • Waste management (SFP.EN.2)
	Distribution of fish via wholesale /retail. Exporting companies	• Refrigerated transport: longer shelf life	• Refrigerated transport: heavier transport, more CO2 emissions	• Emissions to air (C.EN.2) • Energy efficiency (C.EN.8)
4. Marketing and Sales	Certification	• Many different certification standards are followed, covering many sustainability aspects in the value chain	• Certification of aquaculture needs to scale up & include a governance dimension, as there is much criticism towards certification schemes. Traceability and information sharing should be more emphasized	• Certification and labelling (C.GO.8)
5. Services	n.a.			

Outlook for sustainability

The identification of opportunities and constraints finally leads the user to formulate possible actions. These are highly dependent on the context and objectives of the user. Some guiding questions to formulate actions include:

- How does the sustainability differ among timeframes/cases?
- Where are the low-hanging fruits?
- Which indicators require the most actions?
- Which dimension of sustainability is not balanced for a sustainable management?

Finally, the recommendations and actions can be formulated for the short, medium and long-term.

Glossary of terms

- ***Certification and labelling**:* formal attestation or confirmation of the achievement of certain characteristics

  ⇨ *Example*:

GOVERNANCE			
Code	**Criteria**	**Indicator**	**Unit**
C.GO.8	Certification and labelling	Use of certification and labelling	Yes/No. If yes: specify

Examples of certification and labelling schemes relevant to blue economy sectors include, but not limited to:

Environmental Management System (EMS): An Environmental Management System (EMS) is a set of processes and practices that enable an organization to reduce its environmental impacts and increase its operating efficiency[25]

Fair Trade: Fair Trade is a global movement made up of a diverse network of producers, companies, shoppers, advocates, and organisations that focus on social compliance, health and safety while putting human capital, community, and sustainability first.[26]

Marine Stewardship Council (MSC): The Marine Stewardship Council (MSC) fisheries and MSC Chain of Custody (CoC) standards help companies and organisations to promote and identify wild caught fish as sustainable and well managed. The MSC certification process covers fish caught from 'vessel to plate' and across the whole supply chain[27]

Aquaculture Stewardship Council (ASC): standards for responsible aquaculture addressing the key environmental impacts of farming, set requirements for workers' rights and protect communities surrounding certified farms[28]

Energy Efficiency Design Index (EEDI) for new ships is the single most important technical measure aimed at promoting the use of more energy efficient equipment and engines. The EEDI requires a minimum energy efficiency level per capacity mile (e.g., tonne mile) for different ship type and size segments. It provides a specific figure for an individual ship design, expressed in grams of carbon dioxide (CO2) per ship's capacity-mile (the smaller the EEDI the more energy efficient ship design) and is calculated by a formula based on the technical design parameters for a given ship[29]

Energy Efficiency Operational Indicator (EEOI): a monitoring tool for managing ship and fleet efficiency performance over time. The EEOI enables operators to measure the fuel efficiency of a ship in operation and to gauge the effect of any changes in operation, e.g. improved voyage planning and more frequent propeller cleaning, or

[25] Retrieved from https://www.epa.gov/ems

[26] Retrieved from https://www.fairtradecertified.org/

[27] Retrieved from https://www.msc.org

[28] Retrieved from https://www.asc-aqua.org

[29] Retrieved from https://www.dnvgl.com/maritime/energy-efficiency/eedi-and-eeoi.html

the introduction of technical measures such as waste heat recovery systems or a new propeller[30]

Environmental Ship Index (ESI): identifies seagoing ships that perform better in reducing air emissions than required by the current emission standards of the International Maritime Organization (IMO)[31]

Emission at Berth Index (EBI): calculated based on four reported factors (equipment, age of the motor and other reduction techniques, type of fuel used, energy efficiency and an ESI score equal or above 25 points
The higher your score is, the more discount a cruise ship receives on the port dues[32]

Clean Shipping Index (CSI): an independent and holistic labelling system of vessels' environmental performance; a practical tool for differentiating port- and fairway fees or choosing more sustainable shipping alternative[33]

Environmental Port Index (EPI): founded upon a sophisticated calculation and reporting tool for the environmental impact of ships, developed in collaboration with DNV GL[34] and numerous shipping industry experts with the aim of empowering ship owners and port operators to increase their operational efficiency while reducing their impact on the environment[35]

Engine International Air Pollution Prevention (EIAPP) certificate: issued for each engine showing that the NOx level complies with the Annex VI to MARPOL 73/[36]

- ***Informal employment:*** Defined by ILO (2012) as the "total number of persons whose main job is considered informal, i.e. lacks basic social or legal protections or employment benefits and may be found in the formal sector, informal sector or households"[37]. In the context of Blue Economy, informal employment contributes to the informal economy through, for example[38]:
  - own-account workers in survival-type activities (e.g. seasonal beach cleaners, tour guides, beach vendors);
  - "disguised wage workers" in production chains (e.g. informal fisheries market chains, shipbreaking yard workers);
  - self-employed in micro-enterprises operating on their own or with contributing family workers or sometimes apprentices/employees (e.g. small-scale, subsidiary and artisanal fisheries, tourist accommodation);

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[30] Retrieved from https://www.dnvgl.com/maritime/energy-efficiency/eedi-and-eeoi.html

[31] Retrieved from https://www.environmentalshipindex.org/

[32] Retrieved from https://www.amsterdamcruiseport.com/discounts-for-cleaner-sea-cruise-vessels-per-january-1st-2020/

[33] Retrieved from https://www.cleanshippingindex.com/

[34] DNV GL is an international accredited registrar and classification society headquartered in Høvik, Norway

[35] Retrieved from https://epiport.org/

[36] Retrieved from https://www.wartsila.com/encyclopedia/term/eiapp-statement-of-compliance

[37] ILO. (2012). Statistical update on employment in the informal economy. International

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[38] Retrieved from https://tel.archives-ouvertes.fr/tel-02096333/document; https://www.researchgate.net/publication/249023202_The_Tourism_Workforce_and_Policy_Exploring_the_Assumptions_using_Crete_as_the_Case_Study; https://www.e-unwto.org/doi/pdf/10.18111/9789284416158; https://shipbreakingbd.info/overview-of-ship-breaking/

- criminal activities (such as drug trafficking, human trafficking and money laundering) and illegal activities (such as deliberate tax evasion), as is the case of Illegal, Unreported and Unregulated (IUU) fishing.

⇨ *Example:*

SOCIAL			
Code	**Criteria**	**Indicator**	**Unit**
C.SO.3	Employment conditions	Informal employment	% informal employment of total employment

- ***Innovation:*** the use of new ideas, products or methods where they have not been used before[39]. Examples of innovation in the context of blue economy include investment in R&D, circular approaches e.g. IMTA (aquaculture), increased automation at port and distribution centres (transport infrastructure) etc. Note that although in the BESF innovation is included under the governance pillar, it is transversal

⇨ *Example:*

GOVERNANCE			
Code	**Criteria**	**Indicator**	**Unit**
C.GO.7	Innovation	Attention to innovation (or investment in R&D)	% revenue invested in R&D

- ***Kind of fuel:*** This includes the 3 types of marine fuels. Heavy Fuel Oil (HFO), Low Sulphur Fuel Oil (LSFO) and diesel oil, as well as alternative fuels: Liquefied natural gas (LNG), Hydrogen, Biofuel[40]

⇨ *Example:*

ENVIRONMENTAL			
Code	**Criteria**	**Indicator**	**Unit**
STS.EN.2 SCS.EN.1	Emissions to air	Average fuel Sulphur content per bunkering	% avg, fuel Sulphur content per kind of fuel
		Use of low Sulphur Heavy Fuel Oil	Yes/No
STS.EN.5 SCS.EN.7	Level of fuel consumption	Fuel consumption	Tonnes/kind of fuel/year

- ***Life Cycle Assessment (LCA):*** an internationally standardised methodology (ISO 14040 ff). LCA helps to quantify the environmental pressures related to goods and services (products), the environmental benefits, the trade-offs and areas for achieving improvements taking into account the full life-cycle of the product41

⇨ *Example:*

GOVERNANCE

[39] Retrieved from https://ec.europa.eu/eurostat/statistics-explained/index.php/Glossary:Innovation

[40] Retrieved from https://epiport.org/how-the-epi-works/

Code	Criteria	Indicator	Unit
C.GO.10	Supply chain	Existence of Life Cycle Assessment policy	Yes/No. If yes: specify

- ***Local*:** in relation to the geographic area/ spatial scale of the application which is defined at the start of the application of the BESF (see Table 2). This unit of analysis is determined on a case-by-case basis subject to the problematic at hand that is analysed through the application of the BESF (e.g. assessment of sustainability of a company, the performance of a sector in a locality/town/city, at the national or regional/multi-country level etc). It also determines the scale at which the data is to be collected and the indicators populated. For those indicators that refer to "local" the level at which they are best applicable is indicated below, using the following numbering:

  a. Company
  b. Locality town/city
  c. National
  d. Regional/multi-country

  ⇨ *The indicators using the term "local" are provided below.*

ENVIRONMENTAL			
Code	**Criteria**	**Indicator**	**Unit**
C.EN.5	Impact on ecosystems	Support given to local entities working on the protection, conservation and management of local biodiversity and landscapes (a, b, c)	• % of turnover dedicated to such support or • If in-kind support (such as making manpower or machinery available free of charge, or donating land), specify.

ECONOMIC			
Code	**Criteria**	**Indicator**	**Unit**
C.EC.2	Economic benefits	Total revenues generated by local enterprises (b, c, d)	% total revenues generated by local enterprises
C.EC.3	Economic benefits	Local public revenue generated through time (taxes, fees, etc. – b, c, d)	m EUR/year
C.EC.9	Financial viability	Financial returns reinvested in local activities (a, b, c, d)	% financial returns reinvested in local activities

SOCIAL			
Code	**Criteria**	**Indicator**	**Unit**
SFP.SO.1	Social balance	Effect of fish input purchases on: • local prices • local harvesters • users of fish (b, c)	Yes/no, if yes specify for each category

GOVERNANCE			
Code	**Criteria**	**Indicator**	**Unit**
STO.GO.2	Development control	Existence of visitor taxes and fees with the aim of re-investing in mitigating or reversing negative effects on the local ecosystems and community (a, b, c)	Yes/no, if yes specify

- ***Nature-based solutions:*** solutions that make use of natural processes and ecosystem services for functional purposes, such as decrease flood risk, improve water quality[42] or provide refuge effect[43]

  ⇨ *Example:*

GOVERNANCE			
Code	**Criteria**	**Indicator**	**Unit**
C.GO.3	Nature-Based Solutions	Application of Nature-Based Solutions	Score 1.Not applied 2.Applied to some extend [example] 3.Frequently applied [example]

- ***Occupational diseases:*** any disease contracted primarily as a result of an exposure to risk factors arising from work activity[44]

  ⇨ *Example:*

SOCIAL			
Code	**Criteria**	**Indicator**	**Unit**
C.SO.5	Health and safety management	Existence of policies and measures to combat occupational diseases.	Yes/no, if yes: specify

- ***Particularly Sensitive Sea Area:*** an area that needs special protection through action by International Maritime Organization (IMO) because of its significance for recognized ecological or socio-economic or scientific reasons and which may be vulnerable to damage by international maritime activities [45]

[42] https://www.deltares.nl/en/publication/implementing-nature-based-flood-defenses/#:~:text=Nature%2Dbased%20solutions%20make%20use,risk%20or%20improving%20water%20quality.

[43] Refuge effect: presence of fish and other marine creatures in the shelter and hard-substrate habitat provided by the infrastructure'

[44] Retrieved from https://www.who.int/occupational_health/activities/occupational_work_diseases/en/

[45] Retrieved from http://www.imo.org/en/OurWork/Environment/PSSAs/Pages/Default.aspx

⇨ *Example:*

ENVIRONMENTAL			
Code	**Criteria**	**Indicator**	**Unit**
SCS.EN.8	Impact on ecosystems	Sewage discharge in Particularly Sensitive Sea Areas	Yes / no

- ***Red List:*** The International Union for Conservation of Nature Red List of Threatened Species is the world's most comprehensive inventory of the global conservation status of biological species[46].

⇨ *Example:*

ENVIRONMENTAL			
Code	**Criteria**	**Indicator**	**Unit**
C.EN.4	Impact on ecosystems	Threatened species (IUCN Red list) of known species	%

- ***Refuge effect:*** a concept in ecology in which an organism obtains protection from predation by hiding in an area where it is inaccessible or cannot easily be found. Due to population dynamics, when refuges are available, populations of both predators and prey are significantly higher, and significantly more species can be supported in an area[47]. The concept also includes the provision of hard-substrate habitats by the man-made infrastructure as a suitable habitat in an otherwise unsuitable environments (e.g. species that need a hard substrate to cling on to and find it in a platform or turbine foundation).

⇨ *Example:*

ENVIRONMENTAL			
Code	**Criteria**	**Indicator**	**Unit**
SEOG.EN.5 SAQ.EN.8 SRE.EN.2 SCD.EN.3	Impact on ecosystems	Refuge effect for species	Yes/no, if yes: specify

- ***Social categories:*** a collection of people who do not interact but who share similar characteristics. Example: people from immigrant and ethnic minority backgrounds, disabled people, people nearing retirement age. This may include country-dependent relevant ethnic, religious or social categories.

⇨ *Example:*

SOCIAL			
Code	**Criteria**	**Indicator**	**Unit**
C.SO.7	Inclusiveness	Employment rate of vulnerable groups	% vulnerable workers of total work force per social category

[46] Retrieved from https://www.iucnredlist.org/

[47] Retrieved from https://en.wikipedia.org/wiki/Refuge(ecology)

			For every social category define: • Gender (% male/ female/other) • average age

- ***Stakeholder:*** is used to describe a person or organisation perceiving themselves to have a stake in something. It is mostly used here in reference to organised and representative[48] interest groups. Profiles of stakeholders include industry, non-governmental organizations and other social groups and users, including, 'users of natural resources like farmers/fishers/foresters', 'local inhabitants' (e.g. living near a coastal tourist project), 'consumers', 'property owners', 'retailers and other service providers'.

  ⇨ *Example:*

SOCIAL			
Code	**Criteria**	**Indicator**	**Unit**
C.SO.9	Level of acceptance by stakeholders	Acceptance of environmental, economic and social impact by stakeholders	No. of reported actions of stakeholders against environmental, economic or social impacts

- ***Engagement*:** an umbrella term to describe any process that involves contact with the public, from providing information to running formal consultation processes.

  ⇨ *Example:*

GOVERNANCE			
Code	**Criteria**	**Indicator**	**Unit**
C.GO.11	Level of stakeholder engagement	Mechanism for stakeholder engagement	Score 1. Specific mechanism for stakeholder engagement besides public actors 2. Occasional consultation with stakeholders, focused on public actors 3. No stakeholders involvement

- ***Supply chain policy****:* a policy or procedure with a defined first activity and a final activity, a customer, and a supplier; and consisting of a network of activities, produces a value-adding result at the end; and is repeated time and again. Any supply chain policy or procedure involves teamwork rather than assembly lines. Supply chain policies are largely a matter of coordination between people, that is, agreement between individuals who cooperate[49], and agreement about parameters

[48] Dialogue by Design, 2012. Found at: http://www.mspguide.org/sites/default/files/resource/dialogue_by_design_handbook_stakeholder_engagement_-_andrew_acland.pdf

[49] Retrieved from https://www.supplychaindigital.com/supply-chain/7-things-you-should-consider-writing-any-supply-chain-policy

or rules about how these activities must be carried out, what is acceptable or not, minimum quality requirements etc.

⇨ *Example:*

GOVERNANCE			
Code	**Criteria**	**Indicator**	**Unit**
C.GO.9	Supply policy chain	Existence of supply policy chain	Yes/No

This indicator provides more insights on whether the enterprises and entities check that none of their suppliers are linked directly to repressive regimes, use child or slave labour, trade in uncertified tropical timber or soy from deforestation, ensure that their purchases, where applicable, are fair trade certified etc.

- ***Tonnes of oil equivalent*:** a normalized unit of energy. By convention it is equivalent to the approximate amount of energy that can be extracted from one tonne of crude oil. It is a standardized unit, assigned a net calorific value of 41 868 kilojoules/kg and may be used to compare the energy from different sources.

⇨ *Example*:

ECONOMIC			
Code	**Criteria**	**Indicator**	**Unit**
SEOG.EC.3	Economic viability	Production oil and gas	Tonnes of oil equivalent/year

- ***Vulnerable groups:*** include employees at risk of having their workplace entitlements denied, or who lack the capacity or means to secure them[50]; "employment of social categories which have difficulty getting into the labour market or staying there, e.g. people from immigrant and ethnic minority backgrounds, disabled people, people nearing retirement age, etc".

⇨ *Example:*

SOCIAL			
Code	**Criteria**	**Indicator**	**Unit**
C.SO.7	Inclusiveness	Employment rate of vulnerable groups	% vulnerable workers of total work force per social category (see guideline). For every social category define: • Gender (% male/ female/other) • average age

- ***Waste management:*** includes the activities and actions required to manage waste from its inception to its final disposal or recycling/reuse, and comprises of the collection, transport, treatment and disposal of waste, together with the monitoring and regulation of the waste management process[51]. In the context of the BESF, it

[50] Retrieved from https://www.hse.gov.uk/vulnerable-workers/

[51] Adapted from: https://en.wikipedia.org/wiki/Waste_management

also includes e.g. the reuse and management of brine produced from desalination, use of nitrogen from the sediment for agricultural purposes in relation to aquaculture etc.

⇨ *Example:*

ENVIRONMENTAL			
Code	**Criteria**	**Indicator**	**Unit**
SFP.EN.2	Waste management	Use of recycled packaging materials	Yes/No
STS.EN.4	Waste management	Waste management systems (sludge handling) available and functioning	Yes/No

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[iii] SeafoodWatch (2017). Norway: Marine net pens. Retrieved from https://www.seafoodwatch.org/-/m/sfw/pdf/reports/s/mba_seafoodwatch_farmednorwaysalmon_report.pdf on 15-03-2020.

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