|  |  |
| --- | --- |
| cetlogo ***CHEMICAL ENGINEERING TRANSACTIONS*** ***VOL. , 2023*** | A publication ofaidiclogo_grande |
| The Italian Associationof Chemical EngineeringOnline at www.cetjournal.it |
| Guest Editor: Sauro PierucciCopyright © 2023, AIDIC Servizi S.r.l.**ISBN** 978-88-95608-98-3; **ISSN** 2283-9216 |

sLCA methodology and standards applied to bio-based fertilizers from fisheries/aquaculture wastes

Jean-François Fabrea,\*, Claire Viallea, Caroline Sablayrollesa

aLaboratoire de Chimie Agro-Industrielle, LCA, Université de Toulouse, INRAE, Toulouse,

\*jeanfrancois.fabre@toulouse-inp.fr

* 1. Introduction

Fish and aquaculture production has constantly grown following demographic evolution. According to the FAO (FAO, 2022), the production of these sectors should reach 202 million tons in 2030, with aquaculture increasing its proportion to about half. Even if food/fish loss is not taken into account, a large quantity and diversity of wastes is generated such as fish sludges, bones, viscera and heads, mollusc shells …

Even if wastes may be reduced by different technological improvements as a better nutrient recycling (Campanati et al., 2022), a lot of initiatives have emerged to valorize the by-products of fisheries and aquaculture, fostered by the emergence of the circular economy and blue economy (Barroso et al., 2022; Lee et al., 2020) concepts. New european recommandations gradually encourage it even if the scope of valorization may be limited (Regueiro et al., 2022). Thirty years ago, the use of aquaculture by-products was already perceived as a way to increase its sustainability (Folke and Kautsky, 1992). The variety of wastes leads to a variety of applications (Fraga-Corral et al., 2022). Human and Animal feeding are valorization ways (Stevens et al., 2018) but may not absorb all the variety of the wastes and by-products. Proteins seem yet to constitute a large part of valorizable wastes (López-Pedrouso et al., 2020). Associated with minerals, the protein-rich wastes could help fertilizing soils or stimulate plant growth, replacing then partially the use of fossil-sourced chemicals which can impact human health (Sharma and Singhvi, 2017) or soil health (Pahalvi et al., 2021) and microbiology (Tripathi et al., 2020). The use of aquaculture wastes and by-products for agriculture fertilization has already been the subject of different studies (Chiquito-Contreras et al., 2022) and biofertilizers have already been perceived as an important pillar of sustainable agriculture (Bhardwaj et al., 2014) even if it can still be difficult to introduce them when short term vision of high production yields is prevalent on soil quality (Atieno et al., 2020). Since 2021, 26 different academic and industrial partners have been collaborating in European H2020 Program (Sea2Land) to produce a variety of bio-based fertilizers from the side-streams of fisheries and aquaculture. This four-year project aims to contribute both to a more sustainable agriculture and to the independence and security in the supply of nutrients in Europe. Seven pilots are being developed in six different maritime areas : Baltic sea, Mediterranean Sea, Adriatic Sea, North Sea, Atlantic Ocean and Cantabrian Sea. The project is divided in 9 closely related workpackages (Figure 1). One workpackage (WP7) is dedicated to the sustainability assessment of the developed products. Indeed, to ensure a good acceptance of the produced BBFs, the impacts of their entire lifecycle on the environmental, economic and social parts of sustainability must be determined. This should allow the selection of the most sustainable products and the reduction of the impacts of the hotspots identified in their lifecycle. The 2030 sustainable development goals (SDG) were created in 2012 to set 17 ambitious objectives to provide good living conditions for future generations. Quite all these SDGs generally encompass environmental and social objectives such as SDG 1, concerning the creation of sustainable business models, SDG 2 on sustainable agriculture, SDG3 on health and well-being… The Sea2Land project will align with these goals as well as with different international ambitions on sustainability such as, for example, the Paris Climate agreement, Blue Growth Strategy, Circular economy action plan (Barroso et al., 2022), EIP Agri Focus Group Recycling (EIP-AGRI Focus Group, 2017), Updated Bioeconomy strategy 2018 (European Union, 2018).



Figure 1. SEA2LAND Project organisation

* 1. Methodologies of Social Life Cycle assessment

The integration of social impact within the pillars of sustainability now seems obvious for everyone and seems unavoidable for achieving the various SDGs (Haryati Zainal et al., 2021). The earliest methods aiming at assessing social impacts in a heuristic consideration of a process or product date back to the early 1970s with the United States and the National Environmental Policy Act (NEPA) which required a rationalized approach to integrate social science into planning decisions that impact the environment (Taylor et al., 1990). However, real social assessment research was not really developed until the early 80s. For example, in New Zealand, the project of a thermal power station raised important social issues (Fookes, 1978). A guide “Social Impact Assessment in New Zealand : a practical approach” was then written in 1985 (Conland, 1985) but various guides were published from different countries and agencies during the 1980s until an internationally recognized methodology “The Guidelines and Principles for social Impact Assessment” was published in 1994 by the Interorganizational Committee on Principles and Guidelines for Social Impact Assessment (ICGP, 1994). Although sometimes considered as a low interest co-study in the NEPA (Burdge 2003), different methodologies were developed in the 90s and 2000s (Becker and Henk Becker University of Utrecht, 2014; Becker and Vanclay, 2003; Rietbergen-McCracken and Narayan-Parker, 1998; Taylor et al., 1990). However, it is still difficult to remain in an objective and scientifically sounded methodology to assess social impacts (Grubert, 2018) as the perception of human well-being can differ from one assessor, sociologist or psychologist to another and is therefore difficult for a scientist to pretend to be able to deliver an absolutely relevant assessment. Environmental and economic impacts of a product will be mainly based on the different processes used but social impacts will depend more on the companies and the places of their production. While the environmental and economic impacts of technological processes can be assessed in a prospective way from the extrapolation of data gathered for low scale pilots, social impacts are less easily extrapolated if there are changes in the companies and locations of final production. Despite all these difficulties, many efforts have been made over the past decade to propose guidelines for social impact assessments.

Today, while different initiatives are still in active development to construct a more robust methodology, (Goedkoop M.J. et al., 2020; Wulf et al., 2019), the most consensual guidelines seem to come from UNEP/SETAC with the collaboration of different experts in life cycle assessment (Benoit Norris et al., 2020; Benoît-Norris et al., 2011; Traverso, M., et al., 2021). Two approaches are described here, the reference scale approach (Type I approach) and the impact pathway approach (Type II approach). Data availability and levels of confidence in the cause-and-effect models may guide the final methodology adopted. Five stakeholder categories are considered: Workers, Local Community, Value chain actors, Society and Children, and different impact categories are also proposed but are not exclusive. Different guidelines, such as UNEP, encourage stakeholder participation at different stages of the sLCA (De Luca et al., 2015; Mathe, 2014; Sureau et al., 2019) in order to obtain data. Starting form the definition of the goal and scope of the sLCA, the main participatory steps usually performed are the choice of stakeholder categories (to be considered in the following steps), the choice of impact categories and the choice of indicators whose values will be subsequently collected. Each impact category is associated with one or several indicators. These indicators can be quantitative, semi-quantitative or qualitative. Some are proposed by UNEP’s methodological sheets (Benoît-Norris et al., 2011) but it is difficult to remain consistent for any case study, regardless of location or sector (Tokede and Traverso, 2020). Several examples can be found in other methodological studies (Kruse et al., 2009; Kühnen and Hahn, 2017; Martin et al., 2018). It is also important to consider sLCA studies in sectors that are identical of close to those assessed in the Sea2Land project. For example, in the fisheries/aquaculture sector (Kruse et al., 2009; McGrath et al., 2015; Ruiz-Salmón et al., 2021), chemicals or fertilizers (Martínez-Blanco et al., 2014; Vavra et al., 2015) and agriculture (Delcour et al., 2015; Iofrida et al., 2018; Muthu, 2019).

While some data are really specific to companies, many depend on the regulatory frameworks in which they find themselves based on the governance that sets the laws, conventions, standards, audits, certifications. Indeed, even ignoring the company that is going to develop a product, if the country and the sector or the company are known, many social conditions can be evaluated according to the different laws and rules that companies have to follow and respect in this sector/country but also on the efficiency of the different monitoring and evaluation authorities. These data can be used in a prospective analysis when the final process scale and company are not known and can be obtained through different databases and sources. Similarly, if the companies are known, some semi-specific data can be obtained considering public documents communicated by the company or press documents (standards followed, labels and certifications obtained) or by other stakeholders depending on them (local community, chain value actors…).

* 1. Evaluation of impact categories

Several methods can be followed to assess an impact category with a set of indicators. In a type I approach, reference scales will be constructed. The levels of these scales can be based on different considerations. The gap between the indicator value and recognized recommendations/standards is one example but it can also take into consideration the surrounding social context and efforts made by the organisations involved to meet or exceed basic requirements (Ramirez et al., 2014). To assess the impacts of organisations working in the aquaculture/fishing, transformation/formulation and agriculture sectors it is therefore important to refer to both general and sector-specific recommendations. The identification of certifications, labels obtained or commitments made in programs or charters aimed at improving sustainability can be a good starting point for estimating the social impacts of several categories.

* + 1. General benchmarks

First of all, the 1948 Universal Declaration of Human Rights of 1948, referring to the “Déclaration des droits de l’homme et du citoyen” written during the French revolution (1789), is certainly the greatest advance in history for the consideration of social rights and its evolution is today the basis of many international conventions. It was yet not exhaustive in the social impact categories and working conditions benefit from other conventions such as the International Labour Standards, developed since 1919 and which cover several areas of protection defined in sLCA, as for example, freedom of association (N87), Forced labour (N29), Occupational Safety and Health (N155). The United Nations have also been involved in the elaboration of numerous resolutions on social aspects, for example, the international covenant on civil and political rights adopted in 1966. A commission for social development is held every year and adopt different resolutions. There are several other global social recommendations, standards and guidelines as The Global Social Compliance programme, the OECD guidelines (OECD, 2022, 2011), SA8000 standards (Social Accountability International, 2014), ISO 26000 (ISO, 2010), AA1000 accountability principles (AccountAbility, 2018), GRI standards (GRI, 2022a) and World Bank standards (The World Bank, Washington, DC, 2016). The Global Social Compliance programme attempts to define the best practices for social interactions along a supply chain. It gathers together hundreds of stakeholders from 70 countries to address social issues. The OECD guidelines are valuable tools to determine whether key social recommendations from governments are being implemented by companies. The latest recommendation on the social and solidarity economy and social innovation discussed in 2022 with 9 pillars to help improving the social economy is an example. The SA8000 standards combine the respect of the Universal Declaration of Human Rights, ILO conventions and national laws in a certification standard. Obtaining this label encourages companies to improve good social practices. Nine requirements, quite identical to the impact categories assessed in sLCA are asked for this standard regarding child labour, forced labour, health and safety, freedom of association and collective bargaining, discrimination, disciplinary practices, working hours, remuneration and management system. ISO 26000 is another standard about social responsibility of organisations but does not lead to certification and is merely a guidance on how to reach good social practices. It is also built on some key points of social responsibility as “Accountability, Transparency, Ethical Behavior, Respect for stakeholder interests, the rule of law, international norms of behavior and human rights”. The 2008 AA1000 accountability standard covers all aspects of sustainability. It is based on three principles: inclusivity as a founding principle, materiality and responsiveness. Inclusivity means the participation of all stakeholders affected by the activities of a company in the elaboration of solutions to improve sustainability. Companies must therefore be aware of all the different stakeholders impacted by their activities and their different needs. The GRI (Global Reporting Initiative) standards also take into account the different aspects of sustainability and consider many social impact categories as corruption (GRI 205), health and safety (403), discrimination (406), forced labour (409), respect of local communities (413). Standards can be grouped by economic sector or by thematic area. It is there more recommendations for companies to evaluate and communicate on their impacts than precise social values to which they must conform. The world Bank’s standards like IFC’s performance standards consider eight points: Risk Management, Labour, Resource Efficiency, Community, Land Resettlement, Biodiversity, Indigenous Peoples and Cultural Heritage and thus merge different aspects of sustainability. Regarding Community Health and Safety, one criteria address, for example, the management of hazardous substances that could impact the community.

* + 1. Sectoral Standards

The Sea2Land project will mainly involve three activity sectors: Fishing/Aquaculture, Transformation /Formulation and Agriculture. The reference scales used for a semi-quantitative social assessment can be built according to the above-mentioned general standards but also to sectoral ones. For example, for fisheries and aquaculture, we find different frameworks for social responsibility. For example, the global G.A.P. which is the world leader in certification on good aquaculture practices (Masood and Brümmer, 2014) encompasses many social impact categories such as health and safety with the requirement for all workers to have a training in this area. There are also the GRI 13 standards for agriculture, aquaculture and fishing sectors (GRI, 2022b) that considers food and health, human rights and communities, employment, ethics and governance, equitable livelihoods as social impact categories, the SSCI benchmark requirements for fisheries, agriculture and land-based aquaculture (CGF Sustainable Supply Chain Initiative, 2021) and then various other certifiable standards (Potts et al., 2016) such as ASC (aquaculture stewardship council) with obligations regarding health and safety, child labour, workers’ rights, respect of local communities (ASC, 2023), “Friend of the Sea” (Friend of the Sea, 2023), MSC (Marine Stewardship Council) fisheries standards 3.0 (Marine Stewardship Council, 2023) and BAP (Best Aquaculture Practices, 2023).

Regarding transformation/formulation, the scope is more general as it can be considered within general chemical sector. SUSCHEM (The European Technology Platform for Sustainable Chemistry, 2019) covers a quite exhaustive range of chemical sectors and is particularly involved in socially oriented SDGs 3 (Good Health and Well Being) and 8 (Decent work and economic growth). The CEFIC organisation (European Chemical Industry Council) is developing a sustainability assessment framework with different criteria for social aspects of the production of chemical products in Europe, as Well-Being, Employment, Skills and knowledge (associated with good information to local communities and consumers) and basic rights and needs (englobing good working conditions, security, discrimination…) (CEFIC, 2019). ECOVADIS is a global sustainability rating platform on the respect of different impact categories (labour and human rights, fair business practices, sustainable procurement) (Ecovadis, 2023). These latter frameworks are also a source of generic data on social indicators. Other initiatives exist to define standards in chemistry as ICCA (International Council of chemical associations) with one goal is to help companies to improve their sustainability performances (ICCA, 2020) through its “Responsible Care Initiative” mainly focused on health and safety, “Together For Sustainability” which develops an audit program on good sustainability practices in chemical companies (TFS, 2023). The ISC3 (International Sustainable Chemistry Collaborative Centre, 2023) can also be mentioned as an institution that aims to bring together all chemical companies concerned with improving sustainability (International Sustainable Chemistry Collaborative Centre, 2023). To be still more focused on sectors involved in fertilizers, the International Fertilizer Association (IFA) is developing certifications on sustainability as the IFA’s Protect & Sustain certification to protect workers, mainly in the Health & Safety impact category but also local communities (International Fertilizer Association, 2023).

The agriculture sector is also widely covered by different certification organisms even outside the scope of organic farming. Obviously, the FAO standards are certainly the most important. There are also the GLOBAL GAP and GRI sectoral standards for agriculture. The IISD (International Institute for Sustainable Development) Standards and Investments in Sustainable Agriculture also provides a fairly comprehensive list of standards in sustainable agriculture and their differences in how they assess and address different impact categories (Vivek Voora et al., 2022).

* 1. Example of a particular case study

It is possible to consider one of the seven case studies to be assessed in the Sea2Land project. A concrete example of expected BBF production can be taken. For example, the Atlantic case study with a fertilizer production from a French aquaculture, a transformation company implanted at a short distance and farmers.

* + 1. Data collection and participatory approach

The aquaculture company is known but other or larger scale aquaculture companies can be approached at the industrial level. The company developing the technology will not be the final company exploiting it at a high scale. The final farmers are not yet known and will depend on the results of field testing of the fertilizers. Hence, social data collection protocol will not be the same for the three involved sectors, particularly for specific and semi-specific data. Regarding the aquaculture sector, specific data on the social impacts of the current aquaculture company as semi-specific data from local (departmental) experts on agriculture as the CAPA (Chambre d’Agriculture des Pyrénées-Atlantiques), partner in the project, can be obtained. For Transformation/Formulation sector, it is possible to get specific data on the impact categories related to the technological constraints of the process developed in the CATAR (Centre d’Application et de Traitement des Agroressources) organisation, which will mainly impact working conditions and health and safety. Finally, for agriculture, it is again possible to obtain semi-specific data from CAPA and a European expert on organic farming in Europe (FiBL), partners in the project. The process of specific data collection will be done in three steps as mentioned above:

Choice of stakeholder categories and subcategories

This step is carried out with the participation of the different stakeholders of the Sea2Land project. The stakeholder categories proposed are basically the same as those recommended by the UNEP methodological guidelines. The subcategories can be populated with the views of experts in that sector. Google forms have been created a nd circulated between June 2022 and February 2023 for respondents to indicate the stakeholder categories they judge potentially impacted in each lifecycle step of the BBFs production. Partners are then directly involved (Mathe, 2014). Excerpts of a questionnaire are available in the supplementary documents.

Choice of impact categories

Different impact categories will be proposed according to the UNEP methodology and different examples in the literature to people related to the previously chosen stakeholder categories (stakeholders, experts or representatives)

Choice of indicators

As in the previous steps, proposals will be made and validated by the concerned stakeholders. They will then provide qualitative or quantitative data. These data will be compared to the requirements of defined standards and European averages for the sector and stakeholder category concerned in order to obtain semi-qualitative data.

* + 1. Balance between specific/semi-specific and generic data

Although specific and semi-specific data will be collected from a few stakeholders, the majorly prospective side of the assessment will require collection of a large majority of indicators from generic data. The environmental LCA and life cycle costing done in parallel may tend to take a hybrid approach between Type I and Type II LCA and consider both mid-point and end-point impacts. To obtain generic social impacts for these three sectors, different databases can be used. For example, the Social Hotspot Database (SHDB) can be integrated into the same framework as LCC and LCA for a Type I approach and also provides a risk mapping tool allowing a type II approach with a 6 level-scale (no data, no evidence, low, medium, high, very high) to assess social impact hotspots endorsed by the French population in different impact categories which are Labor Rights and Decent Work, Health and Safety, Society, Governance, Community. Only a few indicators are sectorized and some stakeholder categories such as value chain actors, users/consumers are not taken into account. The impact assessment on these two last categories can be helped by some studies for chain value actors (Benoit-Norris et al., 2012) and users/consumers (Falcone and Imbert, 2018). Regarding local communities, a study of impacts of chemicals is also of high interest (Vavra et al., 2014) for the processing/formulation stage.

The databases of social generic data from Global, European, Governmental and Non-Governmental sources are really multiple (UNICEF, International Labor Organization, World Health Organisation, World Bank, OECD, FAO, Eurofound, Eurostat…) and are largely included in the UNEP methodological sheets. They will not be detailed here although consulting them should make it possible to obtain relevant values at the sectoral, temporal and spatial level for each social indicator value sought.

* 1. Conclusions

The social life cycle assessment of bio-based fertilizers produced from fisheries/aquaculture side-streams in pilots implemented in the framework of a European project (Sea2Land), although largely prospective, will benefit from a participatory approach to help delineate data collection in the three main sectors involved. The general and more specific standards proposed here will serve as the basis for an essentially semi-quantitative evaluation of the different categories of social impact. Together with environmental and economic assessments, they will contribute to the selection of the most sustainable bio-based fertilizers to promote the circular and blue economy in Europe.

Acknowledgments

This project has received funding from the European Union’s Horizon 2020 Research and Innovation Programme under Grant Agreement N°101000402. Laure Candy, Clément Chastrette, William Tapia and Christine Raynaud from CATAR (Toulouse, France) organisation and Jean-Luc Lafargue and Patrice Mahieu from CAPA (Pau, France) are acknowledged for their help in the social data collection for the Atlantic case study. Felix Harrer and Jan Landert from FiBL (Switzerland) are acknowledged for supervising the Sea2Land workpackage on sustainability assessment and Diogo L. Teixeira and Helena I. Monteiro from ISQ (Portugal) are acknowledged for their active participation in the socio-economic assessment task.

References

AccountAbility, 2018. AA1000 - Accountability principles.

ASC, 2023. Certifying environmentally and socially responsible seafood [WWW Document]. www.asc-aqua.org. URL https://www.asc-aqua.org/

Atieno, M., Herrmann, L., Nguyen, H.T., Phan, H.T., Nguyen, N.K., Srean, P., Than, M.M., Zhiyong, R., Tittabutr, P., Shutsrirung, A., Bräu, L., Lesueur, D., 2020. Assessment of biofertilizer use for sustainable agriculture in the Great Mekong Region. Journal of Environmental Management 275, 111300. https://doi.org/10.1016/j.jenvman.2020.111300

Barroso, S., Pinto, F.R., Silva, A., Silva, F.G., Duarte, A.M., Gil, M.M., 2022. The Circular Economy Solution to Ocean Sustainability: Innovative Approaches for the Blue Economy, in: Management Association, I.R. (Ed.), Research Anthology on Ecosystem Conservation and Preserving Biodiversity. IGI Global, Hershey, PA, USA, pp. 875–901. https://doi.org/10.4018/978-1-6684-5678-1.ch044

Becker, H., Henk Becker University of Utrecht, Netherlands., 2014. Social Impact Assessment, 0 ed. Routledge. https://doi.org/10.4324/9781315072432

Becker, H., Vanclay, F., 2003. The International Handbook of Social Impact Assessment. Edward Elgar Publishing. https://doi.org/10.4337/9781843768616

Benoit Norris, C., Traverso, M., S. Neugebauer, Ekener, E., Schaubroeck, T., Russo Garrido, S., Berger, M., Valdivia, S., Lehmann, A., Finkbeiner, M., Arcese, G., 2020. UNEP, Guidelines for Social Life Cycle Assessment of Products and Organizations.

Benoit-Norris, C., Cavan, D.A., Norris, G., 2012. Identifying Social Impacts in Product Supply Chains:Overview and Application of the Social Hotspot Database. Sustainability 4, 1946–1965. https://doi.org/10.3390/su4091946

Benoît-Norris, C., Vickery-Niederman, G., Valdivia, S., Franze, J., Traverso, M., Ciroth, A., Mazijn, B., 2011. Introducing the UNEP/SETAC methodological sheets for subcategories of social LCA. Int J Life Cycle Assess 16, 682–690. https://doi.org/10.1007/s11367-011-0301-y

Best Aquaculture Practices, 2023. BAP Program Standards [WWW Document]. www.bapcertification.org.

Bhardwaj, D., Ansari, M.W., Sahoo, R.K., Tuteja, N., 2014. Biofertilizers function as key player in sustainable agriculture by improving soil fertility, plant tolerance and crop productivity. Microb Cell Fact 13, 66. https://doi.org/10.1186/1475-2859-13-66

Campanati, C., Willer, D., Schubert, J., Aldridge, D.C., 2022. Sustainable Intensification of Aquaculture through Nutrient Recycling and Circular Economies: More Fish, Less Waste, Blue Growth. Reviews in Fisheries Science & Aquaculture 30, 143–169. https://doi.org/10.1080/23308249.2021.1897520

CEFIC, 2019. Social responsibility in the European chemical industry.

CGF Sustainable Supply Chain Initiative, 2021. Sustainable supply chain initiative opens benchmark for social compliance schemes in fishing, agriculture and aquaculture sectors.

Chiquito-Contreras, R.G., Hernandez-Adame, L., Alvarado-Castillo, G., Martínez-Hernández, M. de J., Sánchez-Viveros, G., Chiquito-Contreras, C.J., Hernandez-Montiel, L.G., 2022. Aquaculture—Production System and Waste Management for Agriculture Fertilization—A Review. Sustainability 14, 7257. https://doi.org/10.3390/su14127257

Conland, J., 1985. Social Impact Assessment in New Zealand : a practical approach. Town and Country Planning Directorate, Ministry of Works and Development.

De Luca, A.I., Iofrida, N., Strano, A., Falcone, G., Gulisano, G., 2015. Social life cycle assessment and participatory approaches: A methodological proposal applied to citrus farming in Southern Italy: A New Methodological Proposal for Social-LCA. Integr Environ Assess Manag 11, 383–396. https://doi.org/10.1002/ieam.1611

Delcour, A., Van Stappen, F., Burny, P., Goffart, J., Stilmant, D., 2015. Assessment and contributions of different Social Life Cycle Assessments performed in the agribusiness sector. Biotechnologie Agronomie Société et Environnement 19, 402–414.

Ecovadis, 2023. The World’s Most Trusted Business Sustainability Ratings [WWW Document]. ecovadis.com/suppliers/. URL https://ecovadis.com/suppliers/

EIP-AGRI Focus Group, 2017. Final report EIP-AGRI focus group on nutrient recycling

European Union, 2018. A sustainable Bioeconomy for Europe: Strengthening the connection between economy, society and the environment.

Falcone, P.M., Imbert, E., 2018. Social Life Cycle Approach as a Tool for Promoting the Market Uptake of Bio-Based Products from a Consumer Perspective. Sustainability 10. https://doi.org/10.3390/su10041031

FAO, 2022. The State of World Fisheries and Aquaculture 2022. FAO. https://doi.org/10.4060/cc0461en

Folke, C., Kautsky, N., 1992. Aquaculture with its environment: Prospects for sustainability. Ocean & Coastal Management 17, 5–24. https://doi.org/10.1016/0964-5691(92)90059-T

Fookes, T.W., 1978. Social and economic impact of the Huntly Power Station, New Zealand. Ekistics 45, 200–206.

Fraga-Corral, M., Ronza, P., Garcia-Oliveira, P., Pereira, A.G., Losada, A.P., Prieto, M.A., Quiroga, M.I., Simal-Gandara, J., 2022. Aquaculture as a circular bio-economy model with Galicia as a study case: How to transform waste into revalorized by-products. Trends in Food Science & Technology 119, 23–35. https://doi.org/10.1016/j.tifs.2021.11.026

Friend of the Sea, 2023. Certified sustainable products and companies contributing to marine conservation [WWW Document]. friendofthesea.org/. URL https://friendofthesea.org/

Goedkoop M.J., de Beer, I.M., Harmens, R., Saling, P., Morris, D., Florea, A., Hettinger, A.L., Indrade, D., Visser, D., Morao, A., Musoke-Florer, E., Alvarado, C., Rawat, I., Schenker, U., Head, M., Collotta, M., Andro, T., Viot, J.-F., Whatelet, A., 2020. Handbook for Product Social Impact Assessment.

GRI, 2022a. GRI 13: Agriculture, Aquaculture and Fishing Sectors.

GRI, 2022b. GRI 13: Agriculture, Aquaculture and Fishing Sectors 2022.

Grubert, E., 2018. Rigor in social life cycle assessment: improving the scientific grounding of SLCA. Int J Life Cycle Assess 23, 481–491. https://doi.org/10.1007/s11367-016-1117-6

Haryati Zainal, Subramaniam Vijaya, Zainon Noor Zainura, Loh Soh Kheang, Abd Aziz Astimar, 2021. Complementing Social Life Cycle Assessment to Reach Sustainable Development Goals - A Case Study from the Malaysian Oil Palm Industry. Chemical Engineering Transactions 83, 331–336. https://doi.org/10.3303/CET2183056

ICCA, 2020. ICCA: Responsible Care® and Our Contributions to Sustainability.

Guidelines and principles for social impact assesment: Interorganizational Committee on Guidelines and Principles, 1994. Impact Assessment 12, 107–152. https://doi.org/10.1080/07349165.1994.9725857

International Fertilizer Association, 2023. Protect&Sustain [WWW Document]. www.ifacultureofexcellence.org.

International Sustainable Chemistry Collaborative Centre, 2023. ISC3 [WWW Document]. www.isc3.org.

Iofrida, N., De Luca, A.I., Strano, A., Gulisano, G., 2018. Social Life Cycle Assessment for agricultural sustainability: comparison of two methodological proposals in a paradigmatic perspective. Italian Review of Agricultural Economics 223-265 Pages. https://doi.org/10.13128/REA-22801

ISO, 2010. ISO 26000 - Guidance on social responsibility, ISO 26000.

Kruse, S.A., Flysjö, A., Kasperczyk, N., Scholz, A.J., 2009. Socioeconomic indicators as a complement to life cycle assessment—an application to salmon production systems. Int J Life Cycle Assess 14, 8–18. https://doi.org/10.1007/s11367-008-0040-x

Kühnen, M., Hahn, R., 2017. Indicators in Social Life Cycle Assessment: A Review of Frameworks, Theories, and Empirical Experience: Indicators in Social Life Cycle Assessment. Journal of Industrial Ecology 21, 1547–1565. https://doi.org/10.1111/jiec.12663

Lee, K.-H., Noh, J., Khim, J.S., 2020. The Blue Economy and the United Nations’ sustainable development goals: Challenges and opportunities. Environment International 137, 105528. https://doi.org/10.1016/j.envint.2020.105528

López-Pedrouso, M., Lorenzo, J.M., Cantalapiedra, J., Zapata, C., Franco, J.M., Franco, D., 2020. Aquaculture and by-products: Challenges and opportunities in the use of alternative protein sources and bioactive compounds, in: Advances in Food and Nutrition Research. Elsevier, pp. 127–185. https://doi.org/10.1016/bs.afnr.2019.11.001

Marine Stewardship Council, 2023. The Fisheries Standard 3.0 [WWW Document]. www.msc.org. URL https://www.msc.org/standards-and-certification/fisheries-standard/version-3

Martin, M., Røyne, F., Ekvall, T., Moberg, Å., 2018. Life Cycle Sustainability Evaluations of Bio-based Value Chains: Reviewing the Indicators from A Swedish Perspective. Sustainability 10, 547. https://doi.org/10.3390/su10020547

Martínez-Blanco, J., Lehmann, A., Muñoz, P., Antón, A., Traverso, M., Rieradevall, J., Finkbeiner, M., 2014. Application challenges for the social Life Cycle Assessment of fertilizers within life cycle sustainability assessment. Journal of Cleaner Production 69, 34–48. https://doi.org/10.1016/j.jclepro.2014.01.044

Masood, A., Brümmer, B., 2014. Determinants of worldwide diffusion of GlobalGAP certification. GlobalFood Discussion Papers.

Mathe, S., 2014. Integrating participatory approaches into social life cycle assessment: the SLCA participatory approach. Int J Life Cycle Assess 19, 1506–1514. https://doi.org/10.1007/s11367-014-0758-6

McGrath, K.P., Pelletier, N.L., Tyedmers, P.H., 2015. Life Cycle Assessment of a Novel Closed-Containment Salmon Aquaculture Technology. Environ. Sci. Technol. 49, 5628–5636. https://doi.org/10.1021/es5051138

Muthu, S.S. (Ed.), 2019. Social Life Cycle Assessment: Case Studies from Agri and Food Sectors, Environmental Footprints and Eco-design of Products and Processes. Springer Singapore, Singapore. https://doi.org/10.1007/978-981-13-3236-4

OECD, 2022. Recommendation of the Council on the Social and Solidarity Economy and Social Innovation, OECD/LEGAL/0472.

OECD, 2011. OECD Guidelines for Multinational Enterprises, 2011 Edition. OECD. https://doi.org/10.1787/9789264115415-en

Pahalvi, H.N., Rafiya, L., Rashid, S., Nisar, B., Kamili, A.N., 2021. Chemical Fertilizers and Their Impact on Soil Health, in: Dar, G.H., Bhat, R.A., Mehmood, M.A., Hakeem, K.R. (Eds.), Microbiota and Biofertilizers, Vol 2. Springer International Publishing, Cham, pp. 1–20. https://doi.org/10.1007/978-3-030-61010-4\_1

Potts, J., Wilkings, A., Lynch, M., MacFatridge, S., 2016. State of sustainability initiatives review: standards and the blue economy. International Institute for Sustainable Development, Winnipeg, Manitoba.

Ramirez, P.K.S., Petti, L., Haberland, N.T., Ugaya, C.M.L., 2014. Subcategory assessment method for social life cycle assessment. Part 1: methodological framework. Int J Life Cycle Assess 19, 1515–1523. https://doi.org/10.1007/s11367-014-0761-y

Regueiro, L., Newton, R., Soula, M., Méndez, D., Kok, B., Little, D.C., Pastres, R., Johansen, J., Ferreira, M., 2022. Opportunities and limitations for the introduction of circular economy principles in EU aquaculture based on the regulatory framework. J of Industrial Ecology 26, 2033–2044. https://doi.org/10.1111/jiec.13188

Rietbergen-McCracken, J., Narayan-Parker, D., 1998. Participation and social assessment: tools and techniques. International Bank for Reconstruction and Development/World Bank, Washington, D.C.

Ruiz-Salmón, I., Laso, J., Margallo, M., Villanueva-Rey, P., Rodríguez, E., Quinteiro, P., Dias, A.C., Almeida, C., Nunes, M.L., Marques, A., Cortés, A., Moreira, M.T., Feijoo, G., Loubet, P., Sonnemann, G., Morse, A.P., Cooney, R., Clifford, E., Regueiro, L., Méndez, D., Anglada, C., Noirot, C., Rowan, N., Vázquez-Rowe, I., Aldaco, R., 2021. Life cycle assessment of fish and seafood processed products – A review of methodologies and new challenges. Science of The Total Environment 761, 144094. https://doi.org/10.1016/j.scitotenv.2020.144094

Sharma, N., Singhvi, R., 2017. Effects of Chemical Fertilizers and Pesticides on Human Health and Environment: A Review. Intern. Jour. of Agricul., Environ. and Biotech. 10, 675. https://doi.org/10.5958/2230-732X.2017.00083.3

Social Accountability International, 2014. Social Accountability 8000, SA8000.

Stevens, J.R., Newton, R.W., Tlusty, M., Little, D.C., 2018. The rise of aquaculture by-products: Increasing food production, value, and sustainability through strategic utilisation. Marine Policy 90, 115–124. https://doi.org/10.1016/j.marpol.2017.12.027

Sureau, Lohest, Van Mol, Bauler, Achten, 2019. Participation in S-LCA: A Methodological Proposal Applied to Belgian Alternative Food Chains (Part 1). Resources 8, 160. https://doi.org/10.3390/resources8040160

Taylor, C.N., Goodrich, C.G., Bryan, C.H., 1990. Social assessment: theory, process and techniques. Centre for Resource Management, [Lincoln] N.Z.

TFS, 2023. together for sustainability [WWW Document]. www.tfs-initiative.com.

The European Technology Platform for Sustainable Chemistry, 2019. Strategic Innovation and Research Agenda - Innovation Priorities for EU and Global Challenges.

The World Bank, Washington, DC, 2016. World Bank Environmental and Social Framework.

Tokede, O., Traverso, M., 2020. Implementing the guidelines for social life cycle assessment: past, present, and future. Int J Life Cycle Assess 25, 1910–1929. https://doi.org/10.1007/s11367-020-01814-9

Traverso, M., Valdivia, S., Luthin, A., Roche, L., Arcese, G., Neugebauer, S., Petti, L., D’Eusanio, M., Tragnone, Tragnone B.M., Mankaa, R., Hanafi, J., Benoît Norris, C., Zamagni, A., 2021. Methodological Sheets for Subcategories in Social Life Cycle Assessment (S-LCA ), United Nations Environment Programme (UNEP). ed.

Tripathi, S., Srivastava, P., Devi, R.S., Bhadouria, R., 2020. Influence of synthetic fertilizers and pesticides on soil health and soil microbiology, in: Agrochemicals Detection, Treatment and Remediation. Elsevier, pp. 25–54. https://doi.org/10.1016/B978-0-08-103017-2.00002-7

Vavra, J., Munzarova, S., Bednarikova, M., 2015. Assessment of Social Impacts of Chemical and Food Products in the Czech Republic, in: Muthu, S.S. (Ed.), Social Life Cycle Assessment, Environmental Footprints and Eco-Design of Products and Processes. Springer Singapore, Singapore, pp. 147–197. https://doi.org/10.1007/978-981-287-296-8\_5

Vivek Voora, Cristina Larrea, Gabriel Huppé, Francesca Nugnes, 2022. IISD’s State of Sustainability Initiatives review: Standards and investments in sustainable agriculture : Standards and Investments in Sustainable Agriculture.

Wulf, C., Werker, J., Ball, C., Zapp, P., Kuckshinrichs, W., 2019. Review of Sustainability Assessment Approaches Based on Life Cycles. Sustainability 11, 5717. https://doi.org/10.3390/su11205717