Global Environmental Change 60 (2020) 102025

Contents lists available at ScienceDirect

Global Environmental Change

journal homepage: www.elsevier.com/locate/gloenvcha

The operationalisation of sustainability: Sustainable aquaculture production as defined by certification schemes

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ARTICLE INFO

Keywords:
Sustainability standards
Certification
Aquaculture
Reference model
Multidisciplinary approach

ABSTRACT

Sustainability certification has become an increasingly important feature in aquaculture production, leading to a multitude of schemes with various criteria. However, the large number of schemes and the complexity of the standards creates confusion with respect to which sustainability objectives are targeted. As a result, what is meant by 'sustainability' is unclear. In this paper, we examine the operationalisation of the concept from the vantage point of the certifying authorities, who devise standards and grant or withhold certification of compliance. We map the criteria of eight widely-used certification schemes using the four domains of the Wheel of Sustainability, a reference model designed to encompass a comprehensive understanding of sustainability. We show that, overall, the sustainability certifications have an overwhelming focus on environmental and governance indicators, and only display scattered attempts at addressing cultural and economic issues. The strong focus on governance indicators is, to a large degree, due to their role in implementing and legitimising the environmental indicators. The strong bias implies that these certification schemes predominantly focus on the environmental domain and do not address sustainability as a whole, nor do they complement each other. Sustainability is by definition and by necessity a comprehensive concept, but if the cultural and economic issues are to be addressed in aquaculture, the scope of certification schemes must be expanded. The Wheel of Sustainability can serve as a valid lexicon and asset to guide such efforts.

1. Introduction

Aquaculture production is often praised for its ability to produce nutritious seafood in a highly efficient manner (Klinger and Naylor, 2012; Sprague et al., 2016), but is also often criticised for unsustainable production practices, especially concerning use of feed (Ytrestøyl et al., 2015) and its negative impact on local environmental conditions (Klinger and Naylor, 2012; Osmundsen et al., 2017). The public is increasingly aware that aquaculture carries environmental risks (Alexander et al., 2016; Morton and Routledge, 2016; Olsen and Osmundsen, 2017) and that the seafood they consume may originate from unsustainable sources. Assuring consumers that the seafood they purchase is sustainable has become a rapidly growing business and has resulted in an abundance of certification schemes and eco-labels (Derkx and Glasbergen, 2014), which consumers find difficult to navigate (Gutierrez and Thornton, 2014) and which may ultimately reduce the credibility of the aquaculture industry (Parkes et al., 2010; Roheim et al., 2018; Washington and Ababouch, 2011). In addition, there are other limitations to sustainability certification, such as a narrow focus confined to production sites, exclusion of smallholders, and democratic deficit lacking representation from those who are affected by certification (Aguayo and Barriga, 2016; Amundsen et al.,

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https://doi.org/10.1016/j.gloenvcha.2019.102025
Received 25 April 2019; Received in revised form 2 December 2019; Accepted 12 December 2019

2019Bush et al., 2013).

The effectiveness of certification is often questioned (Kalfagianni and Pattberg, 2013), and many point to the adverse impact it can have on smaller firms and sectors, and those in less developed countries (Gulbrandsen, 2009; Marschke and Wilkings, 2014; Sampson et al., 2015; Vandergeest and Unno, 2012). However, the popularity of certification is rising, and there is evidence that consumers are willing to pay more for products with labels separating sustainable products from the less sustainable (Ankamah-Yeboah et al., 2016; Asche et al., 2015). The proliferation of such schemes and labels, and their interpretation of what sustainable production should be, determines what sustainable aquaculture production has come to be (Alfnes et al., 2018). *[W]hat is counted usually counts* (Miller, 2004, p. 382) as standards are not only epistemological categories, but also ontological devices that bring worlds into being (Busch, 2017, 2011; Hicks et al., 2016).

This makes it important to understand how certifications define sustainability, and the purpose of this paper is thus to understand the scope of these schemes in their operationalisation of sustainability. It is not an aim of this paper to assess the schemes to determine which scheme is superior to the others. To reach an understanding of how the schemes define sustainability, we treat metrics (which are used to assess sustainability) as a proxy for operationalising sustainability, thus creating a *de facto*, practical definition of sustainability. Analysing these schemes necessitates a multidimensional understanding of sustainability. This requires two things. First, understanding and analysing aquaculture production as both a supply and value chain, running from the production of feed through to the provision of the end product to the consumer (Ahi and Searcy, 2015). Secondly, while the fundamental activity of an aquaculture producer is to produce food, the company and its activities should be understood as interlocked with the surrounding social, political, natural, and economic environment (Christiansen and Jakobsen, 2017). Generally, there seems to exist a consensus that sustainability should be interpreted in such a broad manner, often conceptualised as the triple-bottom line. In practice, however, both as research perspectives and policy responses, a much narrower definition is applied (Ballet et al., 2011; Béné et al., 2019; Eakin et al., 2017; Foran et al., 2014), also within the realm of aquaculture (Andreassen et al., 2016; Costa-Pierce and Page, 2013; Osmundsen et al., 2020).

The consequences of applying a narrow perspective of sustainability lie in the inherent limits of a confined agenda for action. Paying foremost attention to environmental issues, without considering how these are sustained or even contradicted by social or economic structures, engenders political responses set up for failure (Tlusty and Thorsen, 2017). Moreover, there exists an economic literature indicating that firms and industries will only implement sustainability measures if it is profitable Roheim et al., 2018), and while there is limited empirical work on societal sustainability and how this can be operationalised, its importance is increasingly recognised (Kittinger et al., 2017). Given the need to take such a broad perspective, a reference model which combines research-based conceptual categories with existent applications can provide a useful basis for analysis.

The Circles of Sustainability model developed by James (2015), and his understanding of how sustainability is circumscribed and defined, is here adapted to provide a reference model for aquaculture production, entitled the Wheel of Sustainability. Rather than applying the three dimensions as do those categorizations of sustainability that follow the Rio declaration (UNCED, 1992), the model has four domains labelled economics, environment, governance, and culture. Each domain has seven subdomains representing the many components necessary for sustainable aquaculture production (see Supplements). This reference model is applied to the coding of 1916 indicators of eight of the most widely used certification schemes (see Table 1), providing crucial insight into how certification has defined what sustainable aquaculture has come to mean.

These certification schemes were selected based on those adopted by the aquaculture industry in Norway, Chile, and Scotland. Some of the schemes, such as SSPO and RSPCA, are popular with the aquaculture industry in Scotland, but not used in Norway and Chile. ASC, GlobalG.A.P, GAA, FOS, and BRC are adopted in all the three countries. IFS, however, is only in use in Norway and Chile. Geographical spread of the selected schemes is illustrated in Table 2. The choice was also based on a desire to include schemes applicable for different parts of the production cycle, encompassing the process from cradle to crate. For more information on how the various schemes target different parts of the production process, see Nilsen et al., 2018.

In the next section, we will present the development of the applied reference model and our material. Subsequently, the findings of the mapping of these certification schemes and their particular interpretation of sustainability is presented. In the discussion, we explore the skewed understanding of sustainability found in these schemes, and suggest further avenues for application of our reference model.

2. Materials and methods

2.1. Reference model

The methodological foundation for the below findings is the development and application of a reference model, the Wheel of Sustainability. An analysis of sustainable aquaculture production warrants a comprehensive understanding of its complexity, but also an abstract representation that is valid across practitioner and stakeholder communities (Reiter et al., 2013). Our model provides an overview of relevant topics to consider and the significant relationships between these topics, but stops short of valuation. Reference models do not specify the importance, weight, or value attached to individual topics or their combination (MacKenzie et al., 2006). A reference model is a valuable method in that it provides a common vocabulary that serves to unify the many elements of sustainable aquaculture production, thereby informing decision-making processes (Olander et al., 2018). By creating distinguishable entities of the many complexities of sustainable aquaculture production, one may focus on a particular set of issues, while also seeing these in connection with the larger whole. This allows the identification of both targeted and unintended outcomes of implemented initiatives, as the model provides an understanding of competing issues and tensions (Olander et al., 2016). It is worth noting that the development of such a model necessarily implies simplification of a complex reality, including difficult choices as to the designation of boundaries. We have, therefore, chosen to design a model comprising subdomains with broad descriptions as well as concrete examples, making the model both universal and applicable.

2.2. Working group

The Wheel of Sustainability is the result of collaboration by a multidisciplinary team working extensively over a three-year period. The team includes four professors, three senior researchers, and two junior researchers within fields such as political science, public and environmental governance, marine social science, organisational research, anthropology, marine biology, natural resource economics, sociology, and eco-system modelling. All project members have in-depth research experience with the aquaculture sector, both from their countries of origin and through research stays abroad in Norway, Chile, Scotland, USA, Colombia and Australia. The collaboration process included four multi-day workshops and continuous communication throughout the three-year period.

2.3. Process

Through an initial brain-storming session during the first project workshop, the team opted to identify all relevant issues of sustainable

Table 1
Chosen certification schemes and standards

Certification scheme	Standard	Version[a]	Intent/ambition
Aquaculture Stewardship Council (ASC)	Salmon	v1.0	Minimise or eliminate the key negative environmental and social impacts of salmon farming, while permitting the industry to remain economically viable
GLOBALG.A.P.	Aquaculture/ GRASP	v5.0/v1.3	Economically, ecologically, socially and culturally responsible agriculture (and aquaculture)
Friend of the Sea (FOS)	Marine Aquaculture	v1.1	Conserve the marine environment while ensuring sustainable fish stocks for generations to come
International Featured Standards (IFS)	Food	v6.0	Quality assurance and food safety
BRC Global Standards (BRC)	Food Safety	v7.0	Food safety, quality and operational criteria in food manufacturing
Royal Society for the Prevention of Cruelty to Animals (RSPCA)	Farmed Atlantic Salmon	*09/2015*	Animal welfare, sustainability, traceability, biosecurity
Global Aquaculture Alliance (GAA)	BAP Salmon	v2.3	Food safety, social welfare, environmental, animal health and welfare
Scottish Salmon Producers' Organisation (SSPO)	Code of Good Practice - Seawater Lochs	*02/2015*	Balance between industry activities and regulatory detail or bureaucracy, assurance of quality, high minimum standard and continuous improvement

[a] Version number and/or date corresponds with the name given the version by the certification schemes, and refers to the most current version available for coding at the time of writing.

Table 2
Adoption of schemes by country.

	Chile	Scotland	Norway
Aquaculture Stewardship Council (ASC)	x	x	x
GLOBALG.A.P.	x	x	x
Friend of the Sea (FOS)	x	x	x
International Featured Standards (IFS)	x		x
BRC Global Standards (BRC)	x	x	x
Royal Society for the Prevention of Cruelty to Animals (RSPCA)		x	
Global Aquaculture Alliance (GAA)	x	x	x
Scottish Salmon Producers' Organisation (SSPO)		x	

aquaculture production by gathering its many definitions and understandings. In the attempt to unify these into a reference model, we sought to go beyond the common 3-dimensional understanding of economic, environmental, and social sustainability, as it proved inadequate in representing the many different elements of sustainable aquaculture production. The reference model, the Wheel of Sustainability, is thus an adaptation of the Circles of Sustainability model developed by James (2015).

The Circles of Sustainability method is designed for urban development, and is as such not directly applicable to the domain of aquaculture production. However, James' understanding of sustainability as derived and created by social life and practice is a strong argument for choosing this model as our point of departure. The four domains of social practice chosen as primary in his method is understood as the minimal number of domains that together are useful for giving a complex sense of the whole of social life. These domains include economics, ecology, politics, and culture. The author is explicit about the need to understand that all of these are a part of social life and human activity and thus influenced by humans, and must be seen in relation to each other and to nature. All four domains are divided into seven subdomains designed to capture the key aspects of each.

Assessing urban sustainability is of course quite different from assessing aquaculture production, so we have made some important alterations. For one, we have replaced the category of ecology in the original model with environment. We do acknowledge that the intersections between the social and natural realms are blurry, and that human activity such as aquaculture production is both placed within nature and modifies nature. These are both sound arguments for using ecology as a label for this domain. However, to replace ecology with environment in the context of aquaculture production is to acknowledge that the environment is an entity in its own regard, where the influences of aquaculture production may cause permanent modifications. Much of the controversies regarding aquaculture production are precisely about the extent of impact caused to the environment. We have also chosen to replace the label politics with governance. Politics in general is of course relevant for aquaculture production, but we find that the impact of how the industry is governed either by national rules or regulations, or by norms and expectations arising from society, or the industry itself, is of higher relevance (Vigneau et al., 2015).

The Wheel of Sustainability was developed through an iterative process between the deliberations of the multidisciplinary project team and the coding of specific certification schemes. Each domain was discussed and compared to relevant research, and a list of topics relevant for sustainable aquaculture production was compiled. Following the first workshop, a suggested list of subdomains was created based on these topics, with each subdomain described and exemplified. The preliminary model was reviewed by each project member and suggestions for revisions and clarifications were communicated by email.

Author 2, Amundsen, with the aid of author 1, Osmundsen, applied the suggested domains and subdomains to a preliminary coding of the indicators in one of Aquaculture Stewardship Council's (ASC) standard. The coding was conducted in N-VIVO, with each suggested subdomain given an individual coding node. All indicators that did not pertain to any of the subdomains were coded as *Not Applicable*. These indicators were then grouped together under new possible subdomains based on their commonalities. This coding, thus, made redundant items and further specifications of the preliminary model apparent, allowing a more elaborate version to be presented to the project team at the second workshop.

During the second workshop, all subdomains within and across all four domains were discussed, over a two-day session. The group further deliberated on what other topics would be essential for achieving a sustainable industry, each drawing on their respective expertise area. Subdomains were refined, aiming to reflect the complexity of each of the topics, until the model was at a more elaborate stage. After the second workshop, Amundsen, with the aid of Osmundsen, recoded ASC, and a range of other certification scheme standards. These included GLOBALG.A.P., Global Aquaculture Alliance (GAA), BRC Global Standards (BRC), International Featured Standards (IFS), Scottish Salmon Producers' Organisation (SSPO), Royal Society for the Prevention of Cruelty to Animals (RSPCA), and Friend of the Sea (FOS), comprising a total of 1916 indicators. All these standards pertain to aquaculture production. For those schemes that have species-specific standards, we chose the version applicable to salmon aquaculture, reflecting the dominance of this industry in Norway, Scotland, and Chile. Although species-specific, issues addressed by these standards are applicable across others systems of aquaculture. The list of chosen standards was the result of a joint discussion and investigation identifying the most prevalent certification schemes for aquaculture in these countries. The inclusion of other countries and then perhaps other schemes could have produced a different result. On the other hand, the majority of aquaculture companies in these countries portray themselves as global organisations, and the schemes selected also have a global reach.

This coding session served to verify, refine or disprove the already defined subdomains, while also revealing which indicators did not fit in this preliminary version. The coding resulted in a new list of *Not Applicable* indicators, which were again grouped together according to topic. These new potential subdomains were presented at a third project workshop, resulting in a new version of the model. To ensure relevance and robustness, this version was also presented and discussed during an open and interactive stakeholder workshop in Montpellier, France, during the Aqua2018 conference. The participants included professors, researchers, students, and consultants from Scotland, USA, Sweden, Italy, Israel, and Brazil, who confirmed the validity of the chosen domains and subdomains. All eight certification standards were thus recoded according to the model, forming the empirical data for this paper. For complete dataset, see data paper by Amundsen and Osmundsen, 2018.

An inevitable challenge of attempting to put a complex reality into a simplified model is that many issues will have aspects relevant for several subdomains. The model takes this into account, and the subdomains of our model are therefore not mutually exclusive. For this reason, each indicator was coded according to all relevant subdomains. The strength of this flexible approach is in allowing the inclusion of all aspects of a complex issue. Labour issues are, for instance, multifaceted and touch upon several topics. In this model, labour issues are therefore coded according to three different subdomains: **Labour & employment** (economics) which concerns economic compensation for labour, e.g. overtime, minimum wages, and seasonal employment. **Social assurance** (governance) which concerns basic rights of employment, such as freedom of association, contracts, and health and safety. **Employee interests & well-being** (culture) which transcends these basic rights, and includes issues such as development of expertise and career opportunities.

3. Findings

The mapping of the certification schemes shows that GLOBALG.A.P has the most extensive standard, covering 24 of 28 subdomains in the Wheel of Sustainability, closely followed by ASC (21 of 28) and GAA (20 of 28). The FOS standard is predominantly in the environmental domain as it covers all seven environmental subdomains, although it also touches somewhat upon issues within the economic and governance domains. The SSPO standard covers 13 of 28 subdomains, predominantly focusing on the environment and governance domains. RSPCA covers 11 subdomains, but being an animal welfare standard, 417 of its 468 indicators are within the subdomain of Fish Health and Welfare. IFS covers 10 subdomains and BRC, as the least extensive standard, covers 6 of 28 subdomains.

As seen in Fig. 1, there is an overwhelming focus across all schemes on environmental and governance indicators, while far fewer indicators attempt to measure impact in the domains of economics and culture (for further details, see Supplements). While 46% of the indicators fall into the environmental domain and 50% fall into the governance domain, only 3% and 1% of the indicators were identified as relevant for the economic and cultural domains, respectively.

The environmental domain focuses on the interconnections between human activity and the surrounding ecosystem. Environmental conditions range from the untouched to the modified, and this domain emphasises humans' responsibility to limit their impact on nature, while still acknowledging their place in it. The subdomains identified as most prevalent were **fish health and welfare, biotic effects**, and **abiotic effects**, in descending order. **Fish health and welfare** concerns the health and welfare of the produced species (e.g. salmonid species), as well as other species employed in production (e.g. wrasse and lumpfish used for biological delousing). The prevalence of fish health and welfare is augmented by the presence of RSPCA, a fish health standard. Omitting results from this standard, the number of indicators under fish health and welfare is reduced by 51.6% (from 808 to 391 indicators). The subdomain of **biotic effects** includes monitoring, and regulative and corrective actions to ensure minimal impact on native species and biodiversity in surrounding areas. **Abiotic effects** includes the impact aquaculture production may have on all non-living things in an ecosystem. This includes the extent to which such impacts are monitored, and preventive and corrective actions are planned for and instituted both at a company and on a national regulatory level.

The governance domain emphasises basic issues of social power through the regulation and provision of public goods and services. This includes how the industry is regulated on a public level, but encompasses also norms and practices initiated on a company-level. The subtopics that receive most attention across the certification schemes are **transparency and traceability, food safety, accountability and enforcement**, and **social assurance**, in descending order. The subdomain of **transparency and traceability** pertains to documenting how the production impacts other domains, especially that of the environment, ensuring traceability of certified fish and transparency in contracts and wage setting for workers. It is of utmost concern for a food producer to ensure that the food they produce is safe for consumption, hence the subdomain of **food safety**. The prevalence of food safety is due to the presence of two food safety standards, the IFS and BRC. Omitting results from these standards diminishes the prevalence of food safety by 88.6% (from 492 to 56 indicators). Covered by the subdomain of **accountability and enforcement** are measurements of whether the company acknowledges and assumes responsibility for its activities, whether the producer demonstrates compliance with national regulatory rules, performs internal audits, and amends and changes operations when sanctions are imposed, or errors detected. The subdomain of **social assurance** involves measurements regarding how the employer assumes responsibility for workers, and their health and safety. It includes, for example, whether the firm abides by national and international (ILO) rules concerning rights for workers, and actively works to create a healthy working environment through proper training, protective gear, and first aid.

The economic domain concerns the impact a commercial actor has on the surrounding community, through economic contribution and responsible use and management of resources. Hence, this domain refers to issues beyond the profitability of the certified firm and includes economic effects on a larger scale. In this domain, the subdomains of **investments in technology and innovation** and **labour and employment** occur most frequently. The former includes investments in research and innovation projects that may lead to development of new technology, as well as continuous maintenance and calibration of existent technology. The subdomain of **labour and employment** concerns issues related to salaries, contracts, and overtime. One of the subdomains developed as part of the reference model, **indirect effects on economic activity**, did not correspond to indicators from any of the schemes. This subdomain considers the ripple-effects of aquaculture production, i.e. its economic and employment-related significance in the local community and for the business sector at large. Examples include professional consulting and technical services, and construction activities leading to improved socio-economic conditions, as described by Filipski and Belton (2018).

The cultural domain addresses issues relating to the role of the organisation in society, acknowledging that business actors like other actors in the community bear a responsibility for the wider social fabric of their communities. The subdomains of **employee interest and well-being** and **respect for native culture** are most prevalent here. The subdomain of **employee interest and well-being** includes how the company can be seen to take responsibility for its workers, in ensuring that they have opportunities to lead a valuable life, both professionally and socially. This includes providing opportunities to learn and advance in their jobs, as well as foreseeing that grievances can be freely

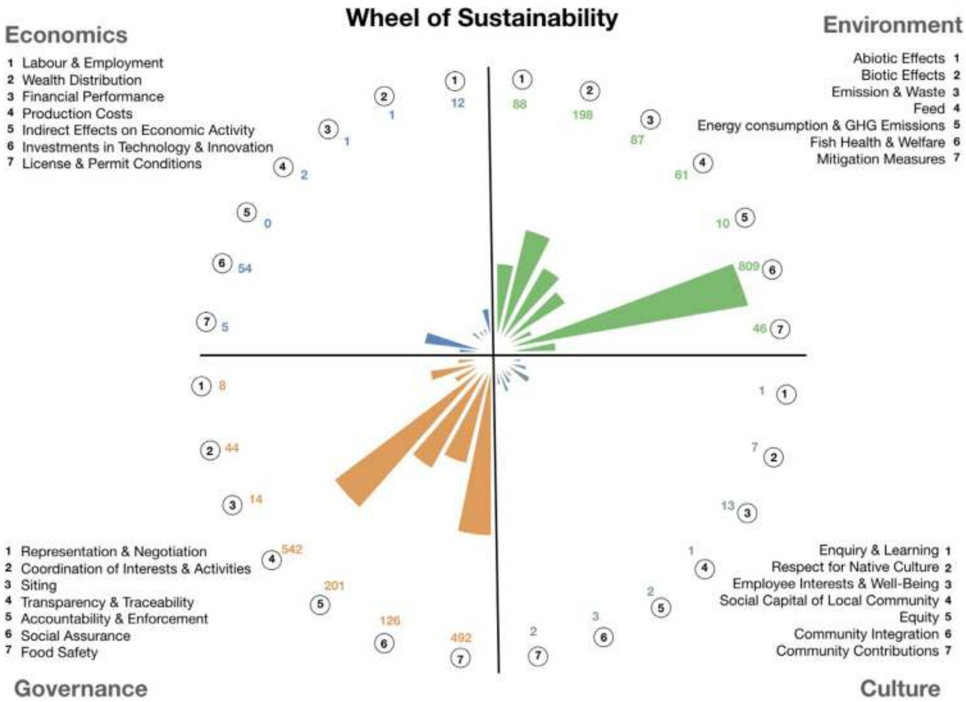

Fig. 1. Distribution of indicators across the subdomains of the Wheel of Sustainability. Coloured numbers denote the total indicators per subdomain.

communicated. **Respect for native culture** covers measurements of how the aquaculture producer can be seen to respecting, valuing, and promoting indigenous culture through consultation processes and established agreements.

4. Discussion

4.1. A skewed understanding of sustainability

Certification schemes for sustainable aquaculture production address the concept of sustainability in a practical manner by requiring aquaculture producers to comply with a predefined set of indicators. Through the indicators they measure, certification schemes define and give meaning to sustainability. As a relatively new and swiftly growing industry, aquaculture seems to hold much promise to meet the protein demands of an increasingly affluent and expanding world population. However, its rapid growth, its expansion into marine areas used by other stakeholders, the occasional crash of the production of specific species within the industry, and the multitude of claims as to the benefits of the industry have led to skepticism in some quarters. International third-party certification schemes uniquely provide a way of meeting the resulting challenges: they offer concert operationalisations of the abstract concept of sustainability, provide clear roadmaps to achieving sustainability, give producers a way to communicate their standards and values to distant consumers, and provide confidence to concerned consumers and activists by providing clear criteria and monitoring by neutral parties. However, by taking on these roles, the schemes acquire a high degree of structural power. By devising the standards and operationalisations, and granting or withholding certification of compliance, the schemes give concrete meaning to the concept of sustainability and become the arbitrators of what sustainability means.

While these schemes do to some degree focus on different issues, they do not complement each other in addressing the many different aspects of sustainability. The findings show that eight of the most widely used certification schemes predominantly emphasise issues relevant for environmental concerns and governance. The heavy weight of indicators in the environmental domain was to be expected mainly for two reasons. Firstly, the concept of sustainability arose from the environmental movement and is historically rooted in issues concerning environmental conservation (Dresner, 2012). Secondly, controversies around aquaculture production predominantly focus on environmental impacts (Forseth et al., 2017; Olsen and Osmundsen, 2017; Schlag, 2010; Taranger et al., 2015; Vollset et al., 2018).

The strong prevalence of indicators in the governance domain may be interpreted as also reinforcing the emphasis on environmental indicators, as the tools to improve environmental sustainability can be obtained from governance systems. Such tools are frequently referred to in the standards as ‘presence of document and evidence’, that demonstrate sampling of e.g. water quality, diseases, type and number of therapeutants, and impact on biodiversity. The main function of the subdomains occurring most frequently in the governance domain (transparency and traceability, food safety and accountability and enforcement) is to implement and legitimise environmental indicators by demonstrating control and overview of production and its potential impact. Governance also reinforces other domains and subdomains, but to a lesser extent. Looking at the coding, indicators in the governance domain overlap with the environment domain in 368 occurrences, while this is the case for only 62 indicators in the economics domain, and 19 in the cultural domain (see Table 2 in Supplements). In sum, the heavy weight of indicators in the environment and governance domain reinforces the finding that the certification schemes mainly focus on the environmental domain. The indicators for both economic and cultural sustainability are few and far between as compared to the other two domains. While this is somewhat surprising if one is concerned with sustainability in general, it is in accordance with the observations of other studies addressing social and economic sustainability (Asche et al., 2018; Kittinger et al., 2017). These studies and others (Anderson et al., 2015; Hicks et al., 2016) point to how the hegemony of environmental issues is coupled with a limited conceptual understanding of how aquaculture production also impacts the livelihoods of people and communities (Sanchez-Jerez et al., 2016).

Despite the broad character of the sustainability concept as promoted by global actors such as the UN, it seems to have developed into a narrower concept in practice, at least in terms of how certification schemes define sustainability. The concept as defined by these schemes does not capture the intricate reality of aquaculture production, but rather promotes a skewed definition that largely ignores the economic and cultural aspects that are central to a panoptic perspective on sustainability. One reason may be that certification scheme standards are drafted to respond to the most apparent and publicly discussed risks related to aquaculture production, e.g. food safety, transparent and traceable production, and environmental impact (Osmundsen and Olsen, 2017). Indeed, Roheim et al. (2018) argue that risk management is one of the main motivations for retail chains to engage in ecolabels.

The concept of sustainability as advanced by these schemes also has a bearing on how regulatory authorities, aquaculture producers, retailers, and the general public understand and interpret sustainability, as these schemes serve as ontological devices that advance one interpretation of sustainability above others. Consequently, they influence what aquaculture producers choose to focus on, where efforts for improvements are targeted, and which issues are considered less important. For other stakeholders, such as the public, how sustainable the aquaculture industry is perceived to be is equated with environmental impact as long as other topics are downplayed.

Such a skewed or lopsided perspective on sustainability in an industry that so clearly has a key role to play in global food production may limit the development of the industry (Alexander and Abernethy, 2019). For instance, it can overlook the crucial role aquaculture companies play as an employer in rural communities, and as a global food supplier. And while such positive impacts should be accentuated in a more complete understanding of sustainability, the disregard of these issues also leads to a limited understanding of how sustainability should be achieved. The mutual dependence between issues and impacts in the environment, economic, culture, and governance domains needs to be highlighted in order to create solutions that are truly sustainable. Disregarding a broad definition of sustainability means ignoring the difficult questions and choices that society needs to face when promoting sustainable food production, which in turn can have significant implications for policy decisions. Efforts to make the industry more sustainable require a broad perspective of sustainability, not because environmental impacts are unimportant, far from it, but because trade-offs and dependencies between issues must be acknowledged. As the analysis of the different schemes has shown, this complexity is not well reflected in the schemes.

While the findings presented here point to clear limitations of these certification schemes, it is important to remember that certification is only part of a larger global governance regime and our expectations of their reach must reflect that. The various segments of aquaculture production are also subject to public regulations by their respective national authorities, in addition to the companies' own commitments to self-regulate. Furthermore, certification will have innate limitations in terms of the nature of their criteria, as metrics must be measurable, transferable, and comparable in order to allow remote assessment and compliance validation. Issues that are beyond the control of the companies are necessarily also precluded, such as the indirect effects, both positive and negative, that the industry has on local economic activity. These predetermined limitations must be taken into account when discussing certification.

4.2. Applying the wheel of sustainability

The Wheel of Sustainability as a reference model, i.e. an abstract framework that specifies the objects (or in this case subdomains) that comprise the model and their relationship to one another, has potential for broad application in improving sustainable aquaculture production. It presents a comprehensive overview of the many interconnected elements of the industry, thereby identifying the complexity that characterises the many issues to be addressed. The purpose of the model is threefold.

Firstly, it provides a valid lexicon that can serve as an asset for business managers, public administrators, scientists and others who seek to understand and grapple with sustainability in aquaculture production. It breaks up what sustainable aquaculture production entails into entities (domains/subdomains), and is an explicit recognition of concepts that many people already share. In defining how these concepts differ from, and relate to, one another, the model can improve communication between individuals involved in using these concepts.

Secondly, it functions as a tool for comparison. Although sustainability is spoken of as a widely encompassing project, both from business leaders and politicians alike, instigated initiatives of improvement are rarely equally broad. Similarly to what has been done here, the model can help contrast different schemes, initiatives, or agencies, identifying gaps and overlaps in challenges that are addressed. Furthermore, by breaking up the complexities of aquaculture production into basic concepts, the Wheel of Sustainability can be used to examine potential consequences of planned policies and practices, seeing how different priority areas may impact other aspects of the industry. In doing so, the component parts of a strategy can be discussed in relation to one another, accommodating the necessary complexity of the issues at hand.

Thirdly, the model can aid in considering trade-offs in intuitive and socially relevant terms, in that it provides an overview of relevant topics for consideration in the endeavour to achieve a more holistic form of sustainability. In contrast to the definition of sustainability provided by the certification schemes discussed in this article, the Wheel of Sustainability is a flexible framework that ensures a broad understanding of sustainability. The reference model thus reclaims the power of defining what sustainable aquaculture production is, and provides the potential for a holistic discussion and applicability of the concept.

5. Conclusion

Certification schemes have taken on the role of guiding consumers and the general public towards making sustainable choices. And while some of these standards have labels that are recognised by consumers, seldom do consumers comprehend what the standards require and how this relates to what sustainability is and should be. The main reason is the large number of schemes, and the complexity of their standards and numerous indicators. In this paper, we have investigated eight of the most widely used certification schemes for aquaculture, and shown that the scope of these schemes mostly focuses on environmental impact, while other issues pertaining to the concept of sustainability are largely ignored. The Wheel of Sustainability, as discussed in this paper, can represent a reference model for improving these certification schemes towards standards that encompass a comprehensive understanding of sustainability. Furthermore, by providing such a comprehensive overview of the many issues of sustainable aquaculture, the model can contribute to the general understanding of how to improve the industry, as well as influence initiatives in other industries.

Data availability

The data that support the findings of this study are also available in an open source database: https://sustainfish.wixsite.com/sustainfishproject/search-indicator-database

Credit authorship contribution statement

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Declaration of Competing Interest

The authors declare that they have no competing interests.

Acknowledgements

This work has been conducted as part of the SustainFish project, funded by the Norwegian Research Council, grant no. 254841. We are grateful to the three anonymous reviewers and the editor providing valuable feedback. We thank Marie Nilsen for graphical assistance with figures.

Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.gloenvcha.2019.102025.

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