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Bohnes, Florence Alexia; Hauschild, Michael Zwicky; Laurent, Alexis

Published in:
Proceedings of the 11th International Conference on Life Cycle Assessment of Food 2018 (LCA Food) in conjunction with the 6th LCA AgriFood Asia and 7th International Conference on Green and Sustainable Innovation (ICGSI)

Publication date:
2018

Document Version
Publisher's PDF, also known as Version of record

LCA Food 2018 and LCA AgriFood Asia 2018: *(1-A) LCA Methods*

Methodological choices of LCA applied to aquaculture systems: Critical review & recommendations

Florence Alexia Bohnes[1]*, Michael Zwicky Hauschild[1], Alexis Laurent[1]

[1] *Division for Quantitative Sustainability Assessment (QSA), Department of Management Engineering, Technical University of Denmark (DTU), Kgs. Lyngby, Denmark*

Keywords: *aquaculture; seafood; fish; LCA methodology; critical review.*

**Corresponding author. Tel.: +4545254807*
E-mail address: flbo@dtu.dk

1. Introduction

Seafood is a main diet component in many countries. Until recently, its production came predominantly from fisheries, but with a majority of fish stocks being now fished at full or unsustainable capacities, seafood production is turning to aquaculture (FAO 2016). However, seafood farming has several potential impacts on the environment and human health, such as eutrophication of surrounding water bodies, climate change, water consumption or land transformation (Naylor et al. 2000; Diana 2009). It is therefore important to ensure that aquaculture development takes place in a sustainable way.

In that context, life cycle assessment (LCA) has been widely applied to aquaculture production systems over the last decade. However, how has the LCA methodology been applied? Which methodological choices did the authors take, and to what extent were they appropriate to answer their research questions? To answer these questions, a critical literature review, new in its coverage of studies and depth of analysis was conducted, whose objectives were to analyze the relevance of methodological choices in relation to the research goals of the studies, and establish a set of recommendations for LCA practitioners to improve the quality and comparability of future studies.

2. Materials and methods

Only peer-reviewed scientific literature written in English was considered in the study. All articles and reports conducting an LCA on at least one aquaculture or aquafeed production system entered the scope of the review. The life cycle impact assessment (LCIA) phase needed to include at least two impact categories for inclusion of the study. The studies were evaluated using as reference the ISO requirements and ILCD technical guidance (ISO 2006; EC 2010). In this presentation, we specifically develop 4 key aspects: the functional unit (FU), the handling of process multifunctionality, the delimitation of system boundaries and the impact coverage.

3. Results

The review included 65 studies, 55 of them assessing aquaculture production systems and 10 of them assessing aquafeed production systems. In comparison, past reviews encompassed a maximum of 20 studies on aquaculture and aquafeed (Parker 2012).

3.1. Functional unit

Two third of the reviewed LCA studies defined their functional units based on a live-weight mass of product. This reflects that most authors adopted a production point of view, where the function of the system is defined based on the producer needs and benefits, in opposition to a consumption perspective, where the function is built on the consumer needs. However, most of the studies position their research goals around food security and the need of producing seafood for direct human

consumption, thus calling for a FU relying on nutritional criteria instead of mass basis. Future studies should therefore adopt the latter recommendation.

3.2. Multifunctionality handling

As illustrated in Figure 1, more than half of the LCAs applied allocation in cases where system expansion was possible, and a quarter of the studies did not specify how they handled multi-functional processes. These studies are therefore not compliant with the ISO 14044:2006 hierarchy (ISO 2006). LCA practitioners should therefore be more transparent and consistent with the ISO standards. Examples, where system expansion can be applied are provided.

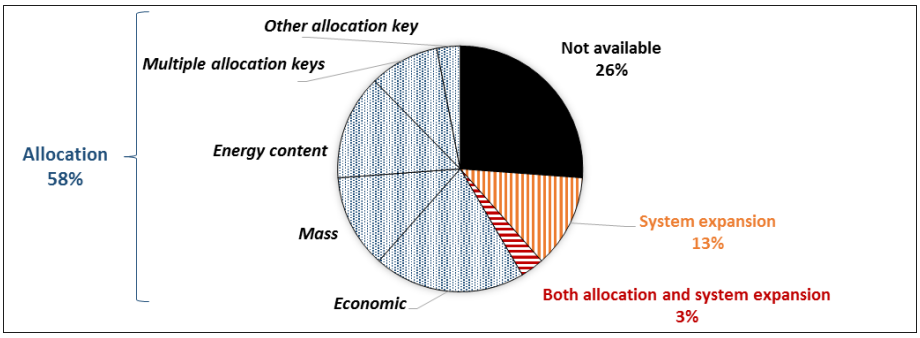

Figure 1: Multifunctional handling in the 65 LCAs reviewed

3.3. System boundaries

Most past studies conducted a "cradle-to-farm-gate" assessment, considering only the life cycle stages up to the farming of the seafood, and neglecting processing, packaging, transport, distribution, consumption and end-of-life. The studies, which considered these stages, however generally found that they had important contributions to the final results. Additionally, a great majority of studies unarguably excluded chemical use and production, and infrastructures and equipment, while these are typically found to be a non-negligible. Recommended system boundaries, with a categorization of the different system components, are therefore provided for better scoping of the LCA studies.

3.4. Impact coverage

Most studies included climate change, eutrophication, acidification and energy use, but neglected all other impact categories. In particular, toxicity-related impacts or water use impacts were included in only ca. 25% of the studies, albeit being of great relevance for aquaculture. Practitioners should therefore include a broader impact coverage in future studies.. Additionally, methods for impacts specific to aquaculture systems, such as antimicrobial resistance or invasive species damages to biodiversity, should be developed.

4. Conclusion and recommendations

Out of the 65 LCA studies reviewed, important inconsistencies were observed, thus calling for rigor in the application of LCA to aquaculture systems. Recommendations and examples for better practice were provided on key aspects.

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