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22

More meat, milk and fish by and for the poor *December 2016*

Using the life cycle assessment approach to assess the environmental impacts of fish production

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Key features

- Life cycle assessment (LCA) is a well-established ISO-certified bottom-up environmental framework designed to quantify impacts at product level.
- LCA was originally intended for industrial systems, detailing economic and environmental flows throughout value chains, thus largely disregarding socio-ecological conditions.
- Meaningful LCA results are resource demanding.

Overview

LCA dates back to the 1970s and was built around the need for a framework that could quantify the environmental impacts of different production chains and aggregate these towards a unit of reference (functional unit). Today the tool is supported by its own ISO standard (ISO 14044 2006), a number of different software packages (e.g. SimaPro and openLCA) and databases (e.g. ecoinvent), and numerous detailed guidelines (e.g. ILCD 2010).

LCA is flexible in that it can evaluate a wide variety of environmental impacts for most value chains using different impact assessment methods, including: global warming, eutrophication, acidification, water use, land use, freshwater ecotoxicity, human toxicity, among others. There are also some impact categories developed more specifically for food production systems, including biotic resource use that captures the required underlying net primary production needed to support production chains (Papatryphon et al. 2004).

In accordance with ISO, an LCA consists of four phases: 1) goal and scope; 2) life cycle inventory; 3) life cycle impact assessment; and 4) interpretation.

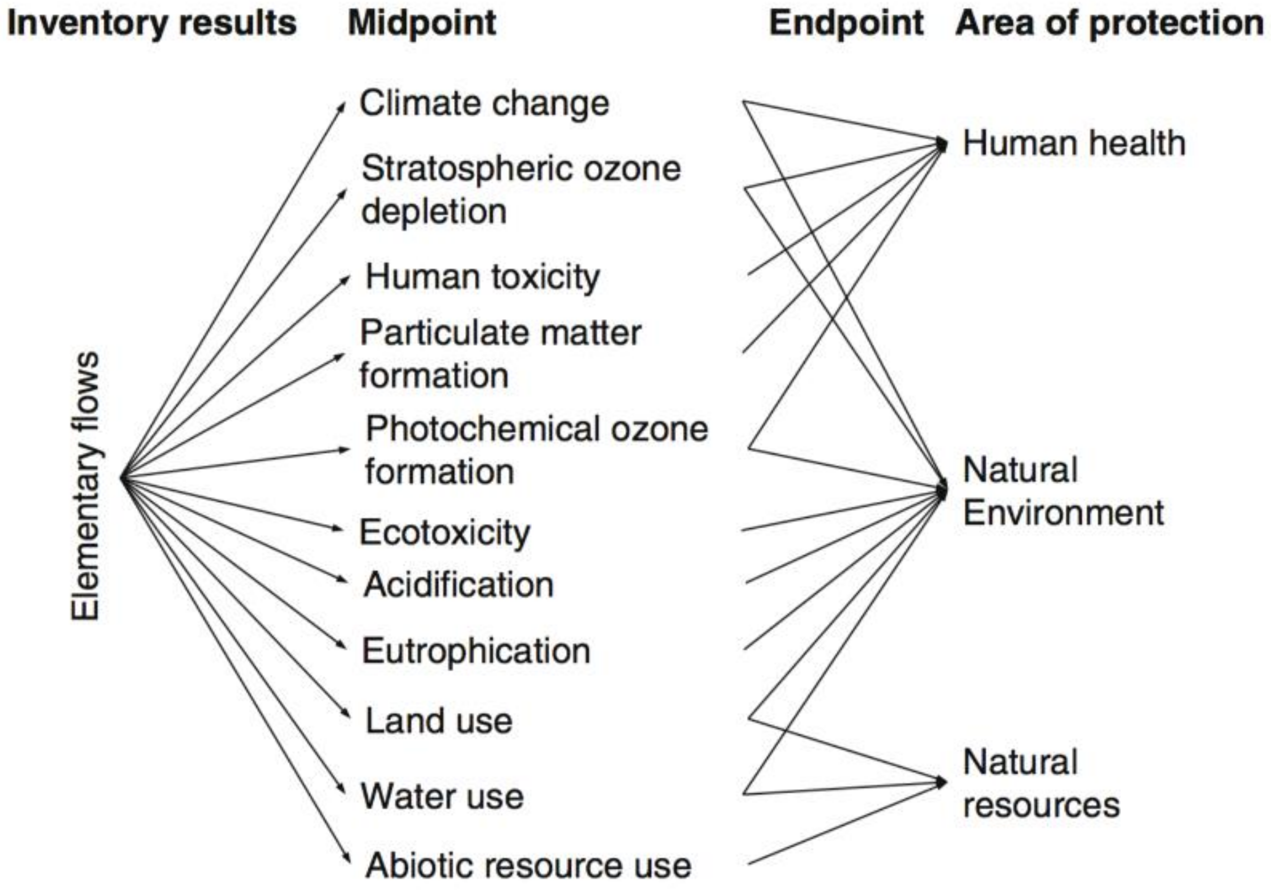
In the goal and scope, the reasons for carrying out a study and its intended audience are presented, alongside methodological choices, assumptions and other relevant information necessary for a transparent interpretation.

Next, the life cycle inventory describes the environmental and economic flows that enter and exit the product lifecycle. This could be, for example, kg of methane, kg of phosphorus, m^3 of freshwater or m^2 of annual land (m^2a). However, since the technosphere is reliant on all of its components (e.g. a factory is reliant on other factories to build it, which in turn is reliant on a new set of factories, etc.), and since modelling the whole technosphere would be impossible, a system boundary is set. The system boundary, thus, defines which processes are included in the life cycle inventory.

In the subsequent lifecycle impact assessment, the inventory flows are classified and characterized into environmental impacts (Figure 1). These impacts can be either midpoint or endpoint indicators, with accumulating uncertainty along the cause and effect chain. This could be, for instance, methane into global warming, phosphorus into eutrophication or m^3 into water scarcity footprints.

Finally, the outcomes are interpreted with regards to environmental hotspots in the production chain, and/or comparisons of products or services.

Figure 1: Relationship between inventory/elementary flows, midpoint and endpoint impact assessment indicators. From: Hauschild and Huijbregts (2015).



Constraints of LCA

Although LCA applies a comprehensive vertical coverage and addresses a wide set of impact categories, it also has many shortcomings. Inventory flows are, for example, usually scaled to a functional unit consistent with a volume (e.g. kg) or a service (e.g. transporting a tonne one km), meaning that the temporal scales of impacts are largely lost. Impacts also rarely take spatial considerations into account, thus generally disregarding the sensitivity of the receiving environment.

Even in cases where geographically specific characterization factors are available (Pfister et al. 2009; Brandão and Canals 2013), the origin of many products entering the production chain will remain unknown. For instance, many feed resources are traded on global markets, with exports and re-exports at best limiting the traceability back to the country of origin. It would be impossible to trace the origin of the products used on a farm, as for example for the fertilizers used on agricultural farms from which the feed resources come.

LCA also has limitations in capturing interactions between the techno- and biosphere, resulting in difficulties in addressing many food production systems in developing countries. For example, grazing cattle may only have limited impacts on grazing land, as their manure may in part act as fertilizers in proximate aquaculture ponds. In such situations, it remains difficult to attribute impacts to a functional unit. It may similarly be difficult to attribute the impacts of inorganic fertilizers between integrated agricultural crops and fish as they benefit disproportionally, or the impacts of pelleted feed between pellet-fed fish and filter feeders in polyculture systems (e.g. tilapia and bighead carp).

With the many user-friendly software and inventory databases available today, new users could perform an LCA in a day or less. However, the quality of such LCAs would be poor given the reliance on generic data and lack of insight into methodological decisions.

An inherent trait of LCA is also that the scale of impacts is directly correlated with the detail of the model, as more processes are being included within the system boundary. Choices in data sourcing may result in large uncertainties, as may methodological choices. Collectively, these discrepancies easily aggregate into an order of magnitude difference of results describing the same product of the same origin. Thus, despite extensive efforts towards a harmonized framework (e.g. the Product Environmental Footprint initiative by the European Commission), LCA results will always remain relative (Henriksson et al. 2015).

Potential uses of the framework

LCA has already extensively been used for livestock, aquaculture and a range of other food commodities. Its strength in these analyses has been its ability to highlight the most environmentally relevant processes throughout value chains and eventual trade-off among different environmental impacts.

While no consensus has been reached around a number of methodological choices, with no solution in sight, the long history of the tool means that the pivotal choices have been identified and explored in literature. For example, co-product allocation (the division of impacts among several products originating from the same process) of environmental impacts has a strong influence on many food relevant processes, including livestock and aquaculture. Thus the process 'farming of cow' would yield milk, meat, leather and calves, and 'processing of fish' would yield fillets and by-products. Moreover, many feeds used in both the systems are agricultural by-products.

As no consensus can be expected for this choice that is strongly influenced by personal preferences, one can only require the solution to be applied consistently and using an established allocation factor. To date, the most commonly used allocation methods are based on mass, monetary value, gross energy content and system substitution (Flysjö et al. 2011). The latter builds upon a more elaborate set of assumptions that also factor in market changes.

Read a related brief explaining how LCA was used by WorldFish as part of its work on fish value chains in Egypt (Henriksson and Dickson 2016).

Credits and more information

This brief was produced as part of a synthesis activity of the CGIAR Research Program on Livestock and Fish. It focuses on *ex-ante* environment impact assessment work carried out between 2012 and 2016 and supported by the Program and other investors.

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