Online resource 3

Applicability of VEC relative to mandatory LCIA elements according to ISO 14044:2006.

4.4 Life cycle impact assessment (LCIA)

4.4.2 Mandatory elements for LCIA

4.4.2.2 Selection of impact categories, category indicators and characterization models

4.4.2.2.1

According to the ISO requirements, related information and sources shall be referenced when applying new impact categories, category indicators or characterization models. For VEC, this implies referring to the assessments made by the IUCN Red List Categories and Criteria (www.iucnredlist.org) or, if applicable, national assessments. It is also vital to include a species list from the discard assessment for transparent results.

As the selection of impact categories shall reflect a comprehensive set of environmental issues related to the product system, including assessments of discard impacts in terms of potential effect on Threatened fish species (i.e. VEC) is essential in seafood LCAs.

4.4.2.2.2 Necessary components of the LCIA related to VEC

Environmental mechanism:

<table>
<thead>
<tr>
<th>Term</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Impact category</td>
<td>Threatened fish discard impact potential (VEC)</td>
</tr>
<tr>
<td>LCI results</td>
<td>Amount of threatened fish discarded per functional unit</td>
</tr>
<tr>
<td>Characterization model</td>
<td>A quantification of the amount of fish species listed as threatened by the IUCN Red List Categories and Criteria that are directly impacted from being discarded. National Red Lists assessments, if available, should be prioritized over the global Red List assessments, as a higher assessment resolution gives a more robust result.</td>
</tr>
<tr>
<td>Characterization factor</td>
<td>Quantification of the amount of fish that is categorised as Vulnerable (VU), Endangered (EN) or Critically Endangered (CR) according to the IUCN Red List (VEC/kg or individual of fish species discarded). VU, EN, CR-species = weight or number x 1 Other species = weight or number x 0</td>
</tr>
<tr>
<td>Category indicator result</td>
<td>Kilo or individuals of VU, EN and CR fish species discarded per FU.</td>
</tr>
<tr>
<td>Category endpoint</td>
<td>Marine ecosystems</td>
</tr>
<tr>
<td>Environmental relevance</td>
<td>Seafood production that affects threatened fish species by discarding practices is a proxy for possible irreversible depletion of fish species. This impedes effective rebuilding of fish stocks and deteriorates ecosystem structure and function.</td>
</tr>
</tbody>
</table>
4.4.2.2.3 The VEC approach in relation to further recommendations for impact categories, category indicators and characterization models:

a) The IUCN Red List of Threatened Species™ is an internationally recognized approach that categorizes species in terms of conservation status. Using their assessments as characterization model may therefore be considered as robust.

b) one of the outputs in fishing operations is discards, which could consist of threatened species. This method is therefore covering one of the known environmental impacts of seafood production systems.

c) value-choices and assumptions are avoided by utilizing a common and standardized framework (IUCN Red List) for assessing all fish species that are discarded.

d) discard in seafood production is a local impact with several environmental mechanisms. In order to minimize risks of double-counting, it is important to state in the goal and scope which of the impacts that will be included in the study (discard weight, primary production requirements and/or threatened species).

e) the characterization model utilizing the IUCN Red List Categories and Criteria is scientifically and technically valid, and by assessing discards in terms of VEC, the environmental mechanism is direct.

f) it has been identified in the related study to this document that the current assessment unit for the Red List (i.e. species), is less appropriate than assessing fish at stock level. Utilizing national Red Lists in general gives a higher level of threat than global assessments.

g) the category indicators are highly environmentally relevant, as the occurrence of threatened fish species is directly linked to overexploitation caused by fishing.

4.4.2.2.4 The environmental relevance of VEC in terms of endpoint

a) the ability of the category indicators (VU, EN, CR) to reflect the consequences of the LCI results on the category endpoint is, in theory, related to potentially disappeared fraction of species (PDF) and damage to AoP Natural Environment and/or AoP Natural Resources.

b) in an LCA of capture fisheries utilizing VEC, spatial and temporal aspects should be discussed, if known. Ideally, the fishing operation is directly assessed, which in this case directly links the landed part to the discarded part. The reversibility of this impact is depending on discard mortality (which should be discussed) and possible recent trends in population estimates for VEC species identified.

4.4.2.3 Classification

During classification, the assignment of LCI results to VEC

a) is not exclusive to one impact category, as Biotic Resource Use in terms of Primary Production Required also uses fish species lists from discards derived from LCI.

b) if discards impacts are assessed in PPR, VEC and weight in kilos, these different impacts are based on the same LCI results. It could be seen as these different impacts are parallel mechanisms, all related to a combined impact on the endpoint marine ecosystem structure and function. PPR and weight of discards may be impacts more related to resource use, at an
ecosystem level, whereas VEC is to a greater extent concerning sensitivity of the different species that are directly impacted, at a species level. Loosing key stone species could also affect the functioning of the ecosystem, which also makes the approaches intertwined.

4.4.2.4 Characterization

The characterization model makes a distinction between different fisheries discarding different species, based on their relative level of threat. As the LCI result is fish species in weight or numbers, this gives a numerical result. The Red List assessment behind species threat status is well documented, including the assumptions used (www.iucnredlist.org).

Discard data is most often scarce, and if there are no records available at a species level, this should be stated in the goal and scope. Ideally, due to the importance of this impact, if there are no data available this data collection should be performed during LCI.

Geographical region could affect the accuracy of the impact category VEC, as coverage of Red List assessments of fish species differ between areas. Time of assessment could also vary. These possible influences on results should be tested or at least discussed in a sensitivity analysis.

4.4.2.5 Resulting data after characterization

Discard outputs of seafood production systems that are not covered by VEC or PPR should, if available, be included as LCI results. These outputs would comprise of by-catches of marine mammals, birds, reptiles and non-commercial invertebrates.

By-catch impacts in fisheries: utilizing the IUCN Red List Categories for enhanced product level assessment in seafood LCAs. Environmental Management. Sara Hornborg\textsuperscript{ab*}, Mikael Svensson\textsuperscript{c}, Per Nilsson\textsuperscript{b} & Friederike Ziegler\textsuperscript{a}

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