Natural biotic resources in LCA: towards an impact assessment model for sustainable supply chains

Serenella Sala
European Commission, Joint Research Centre, Directorate D – Sustainable Resources, Bio-Economy Unit (D1)

The European Commission’s science and knowledge service
Joint Research Centre
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Introduction on Bioeconomy

Biotic resources: challenges for their evaluation at LCI and LCIA
The bioeconomy

Bioeconomy “encompasses
the production of renewable biological resources and
the conversion of these resources and waste streams
into value-added products, such as food, feed, bio-
based products and bioenergy”

It includes the sectors of agriculture, forestry, fisheries, food, pulp and paper, as well as parts of
tochemical, biotechnological and energy industries.
Bioeconomy policies around the World
Bioeconomy in the EU

- 36% of biomass produced in EU is used for bio-based material and bioenergy
- Most important sectors (with turnover increase between 2008 and 2014):
  - liquid biofuels (+25% turnover),
  - bio-based chemicals, pharmaceuticals, plastics and rubber (+22%),
  - forestry sector (+21%)
- Several options for the valorisation of bio-based and by-products/waste, still little exploited

The EU political framework

2009

Waste Framework Directive (WFD)
- Introduced the waste hierarchy and the use of LCA to select the most preferable option for waste management

2012

Bioeconomy strategy
- Referred to the conversion of bio-resources and waste into value-added products. Promoted the use of LCA

2015

Circular economy package
- Calls to assess the contribution of bioeconomy to circular economy

Circular economy action plan

EU strategy for plastics in a circular economy

Proposal for amendment of the WFD

2017 - 2018

Bioeconomy strategy update (adopted in October 2018)
- Assesses the contribution of bioeconomy to circular economy

‘...the bioeconomy strategy supports the development of an agreed methodology for the calculation of environmental footprints, e.g. using life cycle assessments (LCAs)’
Bioeconomy Knowledge Centre dealing with the information overload
Bioeconomy Knowledge Centre

Creating, managing and making sense of collective scientific knowledge for better EU policies

- BKC Website (statistics, reports, factsheet and news publications)
- Data collection at geographical level
- Environmental sustainability factsheets based on LCA
- Study of the EU bio-based industry
- Visualisation of the bioeconomy (e.g. Sankey diagrams of biomass flows)
- Inclusive biomass estimates
- Macroeconomic modelling of the bioeconomy

https://biobs.jrc.ec.europa.eu/
The JRC Biomass Assessment study

Supply chains end products & demands
Current EU and global biomass supply chains of primary and secondary products; biomass flows, environmental impacts and sustainability assessments. EU and global demands of biomass end products; trends, competitions and synergies among sectors and uses.

Modelling and future prospects
Set up and implementation of the modelling framework for the prospective analysis of future biomass supply and demand and their respective impacts with short term (2020) and medium term (2030) perspectives.

The LCA group activities at the JRC

- European Platform on LCA
- Environmental Footprint (PEF and OEF)
- LCA of bio-based vs fossil based plastics
- Making biotic resource count in LCA
- Accounting for food waste, and possible valorisation streams
- Environmental impact of EU consumption
- Testing Ecoinnovation scenarios
- SDGs and LCA
- LCA for the impact assessment of policies
- Training on LCA for policy officers
Which are the sustainability challenges posed by natural biotic resources to be assessed with LCA?

- Crucial role in local and global supply chains; used in many sectors (e.g. food, pharmaceutical, furniture, etc.)
- Severe biodiversity loss associated to overexploitation of resources
- Several methodologies have been developed to take into account the environmental, social and economic relevance of natural biotic resources in a context of resource depletion
- Current LCA frameworks miss a specific focus on natural biotic resources, from both inventory and impact assessment side.
Open challenges

• Make biotic resources relevant in LCA

• Improving the current impact assessment of biotic resource in LCA, starting from improving the modelling at midpoint level.

• Integrating ecologically relevant features about **three main building blocks**, to support the evaluation of supply chains towards sustainability:
Making biotic resource count in LCA

Collection of data at global scale on natural occurring biotic resources used for commercial purposes

Boundaries between ecosphere and technosphere

Focus on naturally occurring biotic resources, i.e. resources commercially valuable proceeding from biological sources that are caught or harvested from ecosphere as input material for human purposes.

Essential "production factors" coming from nature that we are not accounting for.

LCIA framework

Environmental Footprint LCIA method: updates for land use, water use, PM, resources, toxicity

Developments ongoing to better address ecosystem services in LCA
Improvements needed in the impact assessment

• Addressing *biotic resource* in impact assessment

• Improving *land use* impact assessment

• Improving impact assessment for terrestrial organism (e.g. *pollinators*)

• Improving *climate metrics*, e.g. for modelling carbon stock and its dynamic

• Improving modelling of *ecosystem services*, especially those critical to biotic resource provision
Rethinking impact assessment pathways

Renewability rate of natural biotic resource

- Algae
- Aquatic invertebrates (e.g. molluscs, crustaceans)
  - Terrestrial small fur mammals (i.e. squirrels, beavers)
  - Marine fish (i.e. sharks, cods)
  - Terrestrial medium/small game animals (i.e. hares, grouse)
- Marine & freshwater fishes (including sp. from herrings to sharks)
- Terrestrial medium/small fur mammals (e.g. fox, mink)
- Aquatic reptiles and mammals

Renewal time in years (logarithmic scale)

- Population doubling time
- Population size/stock recovery time
- Population cycle
- Biomass recovery time
- Regeneration time
- Rotation period

Vulnerability of species

e.g. red list IUCN
Land use: improving impact assessment

Current methods are covering different impact pathways

Land use: Environmental Footprint LCIA method

4 indicators from LANCA model

- Biotic production
- Erosion resistance
- Groundwater replenishment
- Mechanical filtration

Dissipation of resource

Abiotic and biotic resource are part of biogeochemical cycles, so from a thermodynamic point of view there is, in principle, no dissipation. However, when an element or a material is in a certain form (quality) and provides a certain function, loosing the function may represent a dissipation.
Impacts on insect pollinators

- Land occupation and transformation
- Ecotoxicity (e.g. use of pesticides)
- Invasive alien plants
- Invasive alien pollinators and predators
- Pests and diseases
- Electro-magnetic pollution
- GMO crops

Insect pollinators in the current LCIA framework

Impact categories within the current LCIA framework:
- Climate change
- Ecotoxicity
- Land occupation & transformation
- Invasive alien species
- Pests & pathogens
- Electro-magnetic pollution
- GMO crops

Midpoint indicators:
- GHG (based on models of fate, exposure and effect to be assessed)
- Soil organic carbon
- Increase in temperature
- Toxic sub-lethal and lethal effects
- Habitat loss and modifications
- Ecological community alteration
- Increase in pollinator vulnerability to other stressors
- Pollinator behavioral changes
- Potentially toxic sub-lethal effects and habitat modification

Endpoint indicators:
- Reduction in: pollinator abundance, pollinator diversity
- Endpoint targeting the Area of Protection of "Ecosystem Quality" to be implemented

Possible cause-effect chain to be modelled:
- Tbd

Towards a characterization framework for ecotoxicity

Development of a characterization framework for ecotoxicological impacts of pesticides, to be implemented in e.g. USEtox:

I. defining the main exposure pathways for pollinators potentially exposed to pesticides
II. developing an exposure model to pesticides for pollinators

Honeybees chosen as target species

Crenna et. al (in preparation) Characterizing exposure and ecotoxicity of insect pollinators to pesticides in life cycle impact assessment
Assessing nexus with LCA: food, feed, energy, land, materials, water

Ensuring the sustainability of bioeconomy requires the assessment of nexus between food, energy, water, and land.

Assessing complexity of interactions between different human uses and ecosystem services to find positive and negative relationships

### SYNTHESIS MATRIX for ECOSYSTEM-WATER-FOOD-ENERGY NEXUS

(Modified after CICES V3 and V4.3)

<table>
<thead>
<tr>
<th>ECOSYSTEMS’ PROVISIONING SERVICES</th>
<th>Nutriton</th>
<th>Materials</th>
<th>Energy</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>BioM</td>
<td>PoW</td>
<td>BioM</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>WATER FOOD ENERGY SERVICE FLOWS</th>
<th>WATER (GW&amp;SW) FOR FOOD (withdrawn, consumed, returned)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water for drinking</td>
<td>*</td>
</tr>
<tr>
<td>Water for irrigation</td>
<td>*</td>
</tr>
<tr>
<td>Available soil water (green water) for crop production</td>
<td>*</td>
</tr>
<tr>
<td>Water for livestock fattening</td>
<td>*</td>
</tr>
<tr>
<td>Water for slaughter house</td>
<td>*</td>
</tr>
<tr>
<td>Water for managing farms</td>
<td>*</td>
</tr>
<tr>
<td>Water for agri-industrial productions (agricultural machineries, fertilizer, pesticides, herbicides, etc.)</td>
<td>*</td>
</tr>
<tr>
<td>Water for viticulture</td>
<td>*</td>
</tr>
<tr>
<td>Water for fisheries</td>
<td>*</td>
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<tr>
<td>Water for aquaculture</td>
<td>*</td>
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<tr>
<td>Water for forest farming/agroforestry</td>
<td>*</td>
</tr>
<tr>
<td>Water for horticulture</td>
<td>*</td>
</tr>
<tr>
<td>Water for transferring foods (inland navigations)</td>
<td>*</td>
</tr>
<tr>
<td>Water for manufacturing, refining, packing the foods</td>
<td>*</td>
</tr>
<tr>
<td>Water for washing vegetables, fruits etc., by end-users (eg., at home, restaurants and hotels)</td>
<td>*</td>
</tr>
<tr>
<td>Water for prepare food at home, restaurants, hotels, refectories etc.</td>
<td>*</td>
</tr>
<tr>
<td>Water for cleaning food remains by end-users</td>
<td>*</td>
</tr>
<tr>
<td>Water for waste treatment</td>
<td>*</td>
</tr>
</tbody>
</table>


<table>
<thead>
<tr>
<th>Direct positive (Op)</th>
<th>Supporting (S)</th>
<th>Direct negative (Dn)</th>
<th>Conflicting (C)</th>
<th>Op or S/ Dn or C</th>
<th>Op or C/ Dn or S</th>
<th>Neutral</th>
<th>Not clear</th>
</tr>
</thead>
</table>

Nexus, rebound effects, and dynamic considerations

Bioeconomy and SDGs

A sustainable bioeconomy may contribute to achieve several SDGs and to win-wins solutions among them.

Bioeconomy offers opportunity to address inter-connected societal challenges such as:

- food security,
- natural resource scarcity,
- fossil resource dependence,
- climate change,

while aiming at achieving sustainable economic growth.

TESTING BIO-BASED ALTERNATIVES

- At micro scale: e.g. from lab to industrial system ➔ need of prospective LCA, direct and proxy inventory data of chemical and biochemical pathways

- At macro scale: systemic changes, rebound effects ➔ need of integration of more consequential thinking in both LCI and LCIA

Vivanco D., Sala S., McDowall W., (2018) Roadmap to rebound: how to address rebound effects from resource efficiency policy, Sustainability 2018, 10
Conclusion

LCA is fundamental for the sustainability assessment of natural biotic resources, including for bioeconomy and circular economy.

Several open challenges should be tackled:
• at the inventory
• at the impact assessment, including ecosystem services and nexus
• improving the modelling of circular systems
• addressing explicitly SDGs and the interplay among them
• improving the assessment of ecoinnovations at low Technological Readiness Level
• clear guidance to LCA results interpretation when comparing bio-based and fossil/mineral-based products
Special volume on LCA interpretation has been launched in the International Journal of LCA Interpretation of LCA Studies for Decision Support: State of the Art and Way Forward

Deadline for sending papers: 15th of December 2018!

Guest editors: Sala S., Laurent A., Vieira M., Van Hoof G.
Thanks

Questions?

serenella.sala@ec.europa.eu

EU Science Hub: ec.europa.eu/jrc
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