Spatialization continuum – An innovating conceptual framework to consider system spatial characteristics in LCA

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Spatial issues for Territorially Anchored Systems (TAS) LCA

LCA presents limits to assess environmental performances of Territorially Anchored Systems (TAS). Indeed, such systems show many interactions with the territories/regions where they take place and operate. The framework of LCA is not suitable to use System Spatial Characteristics (SSC).

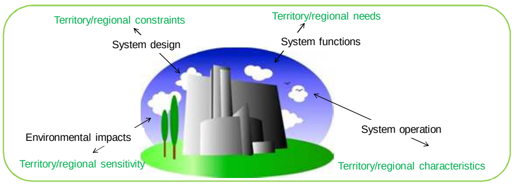

Fig 1: Principles of TAS

A solution: the spatialization continuum concept

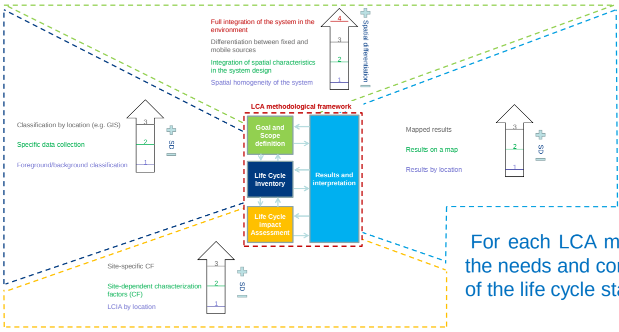

Fig 2: Conceptual framework of spatialization continuum

The spatialization continuum is an innovating conceptual framework which allows the consideration of SSC throughout the LCA approach.

It consists in the account of the interactions between the studied system and the territory where it takes place and operates in a homogenous and continuous way all over the four LCA methodological steps.

For each LCA methodological step, the practitioner should integrate required SSC: the consideration of the needs and constraints of the territory to define the most relevant function of the system, the localization of the life cycle stages, spatialized characterization factors and therefore impacts results.

LCA of a collective biogas plant – A case study for spatialization continuum with a focus on eutrophication

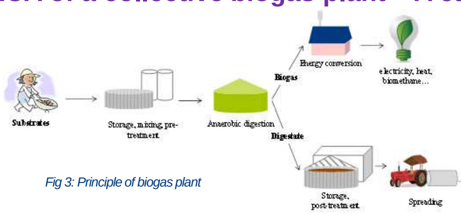

Fig 3: Principle of biogas plant

Biogas plant aims to realize the anaerobic digestion of organic residues and produce renewable energy (biogas) and an organic fertilizer (digestate). Due to the local characteristics of organic residue deposit, renewable energy consumption, digestate spreading and nitrogen and phosphorus emissions, the eutrophication potential of this case study turns out to be highly territorially/regionally dependent.

Goal and scope definition

Life Cycle Inventory

Thanks to a territorial systemic approach, a more precise TAS modeling for a more accurate and relevant environmental assessment.

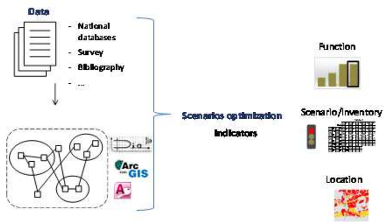

Fig 4: Territorial systemic approach to model the TAS/territory couple

Life Cycle Impact Assessment

$CF = CF_{CML-IA} \cdot SF$

Use of sensitivity factor (SF) based on the concentration of chlorophyll$_a$ in sea and fresh water

With f = frequency of threshold crossing of chlorophyll$_a$ for each hydrographic sector, d = distance of release source to the impacted sea sector and dmax = maximal distance of fresh water system to the sea in France

$$SF = 1 + f$$

for direct releases in fresh water and sea water

And

$$SF = 1 + f(1-d/dmax)$$

for indirect releases in sea water (throughout fresh water system)

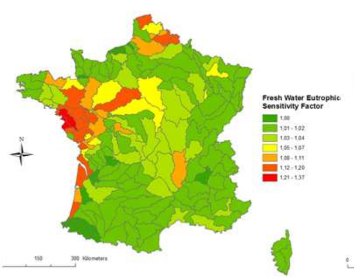

Fig 5: Map of SF for fresh water sectors in France

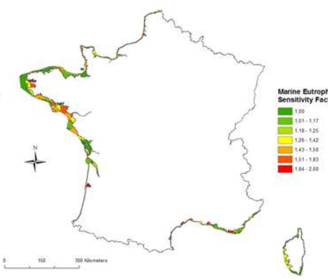

Fig 6: Map of SF for sea water sectors in France

Results and interpretation

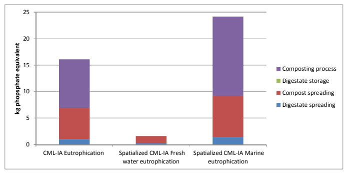

Fig 7: LCIA results for eutrophication of main responsible life cycle steps with and without spatialization

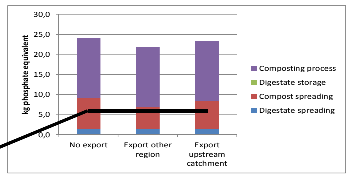

Fig 8: LCIA results for spatialized marine eutrophication with or without the compost export to a less sensitive area

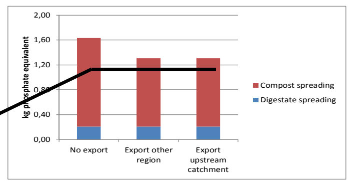

Fig 9: LCIA results for spatialized fresh water eutrophication with or without the compost export to a less sensitive area

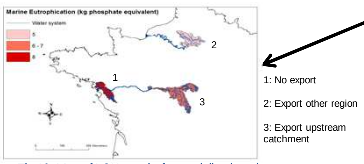

Fig 10: Map of LCIA results for spatialized marine eutrophication for the compost export and spreading

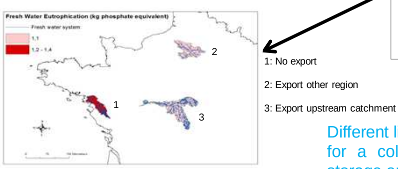

Fig 11: Map of LCIA results for spatialized fresh water eutrophication for the compost export and spreading

Different life cycle steps are responsible of eutrophication for a collective biogas plant: compost and digestate storage and spreading and the composting process.

Composting process is the main responsible of spatialized marine eutrophication So even if the compost is exported to a less sensitive area, results of spatialized marine eutrophication are high.

Conclusion and outlooks

Spatialization continuum is a relatively new mind creation in a perspective of advanced LCA to the LCM of a system/territory couple. It requires some research years and many applications to be judged doable and robust.

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