

Towards a robust decision tool for ecosystems services in the industrial systems: A case study of Distributed recycling for additive manufacturing

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Ecosystem services (ES) is a powerful conceptual framework to put in evidence the benefits that humans received from nature, most of time for free. The problem is that it is complex to link between the local ecosystem services of an urban territory and the industrial systems placed within it identifying the priority interactions (as synergy and impacts). From a decision-maker perspective, there is no a aid decision tool to guide a multicriteria evaluation at early development stages of industrial systems. There have been major efforts in the valuation of ES given by ecosystems (terrestrial, aquatic, atmospheric) to the human well-being (Costanza et al. 2017, 1997; Groot et al. 2012; MEA 2005), and great advances in the developing of a standard ES baselines such as Common International Classification of Ecosystem Services (CICES)(Roy Haines-Young and Potschin 2018). However, few researches have been addressed the alignment the territorial priorities in terms of ES for planning and urban development with the supply/demand of ES by industrial systems. In the industrial side, Life cycle thinking have been a major assessment tool putting a great attention in the quantification of the environmental impact of industrial interventions, and helping in the comparison of different scenarios in each aspect stage of the product life (Mahmud et al. 2021; Pryshlakivsky and Searcy 2021). Recently, several research efforts reported accounts for the dependence systems by explicitly accounting for the demand that technological systems place on ecosystems and the supply of ecosystem services that nature can provide to a process or product at multiple spatial scales (Liu and Bakshi 2019). This techno-ecological synergy (TES) (Liu and Bakshi 2019; Bakshi, Ziv, and Lepech 2015) to reflect its emphasis on establishing mutually beneficial or synergistic relationships between technological and ecological systems, with the ultimate goal of achieving harmony between human activities and nature. The purpose of this article is to propose a methodological approach in order to include ecosystem services in regarding the territorial and industrial endeavors. This prioritization is based on the connection of urban ES services and the techno-ecological synergy. The results of are step forwards to create techno-ecological synergies between ecological and industrial systems. This methodological steps will applied to the case of distributed recycling via additive manufacturing (DRAM) to highlight the relevant ES from the CICES framework of this industrial system for the territory of Nancy, France. The technical advancements of recycling approaches using additive manufacturing are promising technical interventions to foster plastic recycling at a local level. This study seeks to address the following questions:

- What are the main ecosystem services from a urban territorial perspective that DRAM can improve?.
- How to make the connections of ES with the industrial systems?.
- How to connect the territorial issues and the industrial issues using the CICES framework to prioritize?

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