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Towards comprehensive sustainability assessment of global bioeconomy value chains

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 $B_{\rm growth}$ is increasingly promoted by governments and companies worldwide as a viable strategy to achieve sustainable economic growth. Its objective is threefold: To enhance industries competitiveness by reducing production costs while delivering high value products, to alleviate resource scarcity and reduce negative impacts from agro-industrial production and to create jobs and welfare. These are aligned with the economic, environmental and social dimensions of sustainability, respectively. There is broad agreement, however, that bioeconomic transformation is not necessarily sustainable; it can imply greater reliance on bio-based raw materials, hence on other limited resources such as land and water. There is a risk of mirroring the problems associated to first-generation biofuels when other bioeconomic sectors will develop besides bioenergy. A comprehensive evaluation of the actual sustainability of bioeconomy requires a multi-disciplinary approach, also addressing cascading processes, integrated biorefineries and circular life cycles. The present paper first reviews alternative approaches to assess sustainability in global value chains. Life Cycle Assessment provides detailed information on the impacts generated at the product level, capturing the influence of technological innovation. Further development is needed though to account for international trade and associated transfers of environmental burdens, decisive for land use change. Partial and General Equilibrium (PE, CGE) models have been used to quantify market-mediated emissions at the expense of detail at product and supply chain levels. In contrast, environmentally extended Multi-Regional Input-Output (MRIO) databases are very detailed and therefore well-regarded for environmental footprint accounting, including land. A new kind of traceability platform on bioeconomy-related commodities is also taken into account, including extensive data on specific traders, manufacturers, retailers and investors with fine-scale spatial resolution. We discuss the potential and pitfalls as well as necessary steps towards aligning these approaches based on a comparison of methods, data and results. Our goal is to identify robust ways for the integrated application of these methodologies. Results are expected to contribute to future methodological harmonization, crucial to assist decision making in the emerging field of bioeconomy.

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