CIRCULAR ECONOMY AND CARBON FOOTPRINT MITIGATION IN VITICULTURE; Special Session: Sustainable Strategies for Reducing COâ,, and Non-COâ,, Greenhouse Gas Emissions

Topic: Sustainable Strategies for Reducing COâ,, and non-COâ,, Greenhouse Gas Emissions (II)
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Agriculture operates both as a source of greenhouse gas emissions and as a potential carbon sink through sustainable management In a context where climate change poses major challenges, this study asks to what extent circularâ€‘economy practices, particularly residue valorisation and composting, can mitigate the carbon footprint of viticulture by comparing conventional and organic production systems, and quantifies the partial carbon footprint and the avoided partial carbon footprint attributable to circularity.

We estimate the annual partial carbon footprint of the vine growth cycle for both systems using environmentally extended Inputâ€“Output modelling. Specifically, we implement a Leontiefâ€‘based analysis to quantify direct and indirect COâ„‚e emissions associated with upstream supply chains and onâ€‘farm activities, drawing on EXIOBASE as a harmonised multiâ€‘regional database and environmental extension for emission factors and sectoral linkages. The agricultural stage is disaggregated into key operations (site preparation, vineyard maintenance, plant protection, harvesting and postâ€‘harvest flows), and mapped to 45 economic sectors consistent with national accounts classifications to allocate intermediate inputs and primary factors. Activity data at plot level (e.g., tractor hours, diesel consumption per pass, and quantities of inputs per hectare) parameterise the technical coefficients for both systems. The analysis focuses on the vineyard phase prior to winery processing, reporting results in kgCOâ„‚e per hectare and per unit of final demand. In parallel, we compile remotely sensed indicators of carbon fixation (net primary productivity) to characterise ecosystem functioning, though the core mitigation metric is the Inputâ€“Outputâ€‘based partial footprint and its avoided component.
The dataset combines: (i) sectoral monetary flows and environmental extensions from EXIOBASE to construct the Leontief inverse and emission intensities; and (ii) plotâ€‘level activity records for conventional (VC) and organic (VE) vineyards, including timeâ€‘andâ€‘fuel use of machinery per task, diesel prices and volumes, and quantities of agroâ€‘inputs (e.g., Nâ€‘Pâ€‘K fertiliser, sulphur, fungicides) per hectare. Expenditure items are consolidated into the relevant sectors driving emissions in our boundary (notably refined petroleum products, chemicals, and agricultural machinery/vehicles).

Preliminary results show that organic viticulture reduces COâ„‚e emissions by over 95% relative to conventional management in the agricultural stage. The most salient drivers of mitigation are: a) Circularâ€‘economy practices, onâ€‘farm composting and residue reuse that replace mineral fertilisers and external inputs, together with b) Lower reliance on synthetic agroâ€‘chemicals and c) Comparable or reduced machinery use across operations. At the sector level, emission cuts are concentrated in refined petroleum products (through reduced diesel demand) and chemicals (through substitution with compost and lower fungicide/fertiliser loads), with a smaller contribution from machinery/vehicles due to fewer or more efficient passes. Given that Castillaâ€“La Mancha accounts for roughly half of Spainâ€™s vineyard area, the potential regional abatement from scaling organic practices is substantial. Coâ€‘benefits include improved soil health and enhanced carbon sequestration capacity, consistent with multiple SDG targets (notably SDG 13 and SDG 12).
The contribution is twofold: first, it quantifies a partial, productionâ€‘stage avoided carbon footprint grounded in circularâ€‘economy substitutions within viticulture; second, it integrates economic Inputâ€“Output modelling supported by EXIOBASE with fineâ€‘grained, operationâ€‘level activity

data for alternative production systems. This design provides a transparent accounting of where mitigation occurs along the vineyard supply chain, isolating the role of residue valorisation and composting in emissions avoidance.