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cowfootR: An R Package for Dairy Farm Carbon Footprint Assessment

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Software

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Summary

The cowfootR package is an open-source R package designed for comprehensive carbon footprint assessment of dairy farms, implementing internationally recognized methodologies including Intergovernmental Panel on Climate Change (IPCC) Guidelines and International Dairy Federation (IDF) standards. The package enables transparent and reproducible estimation of carbon emissions from dairy production systems through modular functions that estimate emissions from five key sources: enteric fermentation, manure management, soil nitrogen dynamics, energy consumption, and purchased inputs, supporting both Tier 1 and Tier 2 IPCC methodologies. Key features include standardized intensity metrics (kg CO eq per kg of fat-protein corrected milk, per hectare), batch processing capabilities for multiple farms, and regional benchmarking tools. By transforming complex carbon accounting into accessible workflows, cowfootR empowers researchers, agricultural consultants, and policymakers to evaluate mitigation strategies, monitor environmental progress, and enhance the sustainability of dairy operations while addressing the critical need for standardized, reproducible carbon assessment in agricultural systems.

Statement of need

The environmental impact of milk production is a subject of growing global concern due to the sector's share of anthropogenic greenhouse gas (GHG) emissions. One of the key indicators in an environmental impact assessment is the carbon footprint (CF), which determines the total greenhouse gas emissions attributed to a particular product or process, expressed in terms of the carbon dioxide equivalent (CO e or CO eq). As far as milk production is concerned, the carbon footprint includes emissions from, e.g., enteric fermentation, fertiliser management, feed production, use of outside inputs, and energy consumption (Stolarski et al., 2025). The dairy industry contributes approximately 4% of global greenhouse gas emissions, with carbon footprint values ranging from 0.78 to 3.20 kg CO eq kg ¹ of milk across different production systems (Flysjö et al., 2011; Stolarski et al., 2025). The Intergovernmental Panel on Climate Change emphasizes that livestock production systems require accurate quantification methods to support effective mitigation strategies and policy development (IPCC, 2019). Similarly, the International Dairy Federation has established comprehensive guidelines for standardized carbon footprint assessment, recognizing the critical need for consistent methodologies that enable fair comparison across different dairy systems while accounting for regional variations (International Dairy Federation, 2022). With increasing regulatory pressure from initiatives like the EU Green Deal and Corporate Sustainability Reporting Directive, there is urgent need for standardized, accessible tools to quantify dairy farm carbon footprints (The European Parliament and of the Council, 2022). Current life cycle assessment (LCA) software solutions have significant limitations: most are expensive commercial packages requiring specialized training, methodological inconsistencies limit result comparability (Pirlo, 2012), and many lack transparency or regional adaptation capabilities. These barriers prevent widespread adoption of

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standardized practices, particularly among smaller farms and developing regions. The cowfootR package addresses these gaps by providing an open-source, standardized toolkit implementing IPCC Guidelines and IDF standards. The package features modular emission calculations covering the five key sources identified in dairy systems, flexible system boundaries, multiple calculation tiers following IPCC methodology, batch processing capabilities, and regional adaptation with location-specific emission factors. By ensuring methodological consistency while remaining accessible to researchers, consultants, policymakers, and farmers, cowfootR fills a critical gap in agricultural LCA software and enables broader adoption of standardized carbon assessment practices.

Usage

With cowfootR, users can estimate emissions for dairy farms using a systematic, modular approach. The package follows a standard workflow **??**: defining system boundaries, calculating emissions by source, aggregating total emissions, and computing intensity metrics.

Workflow

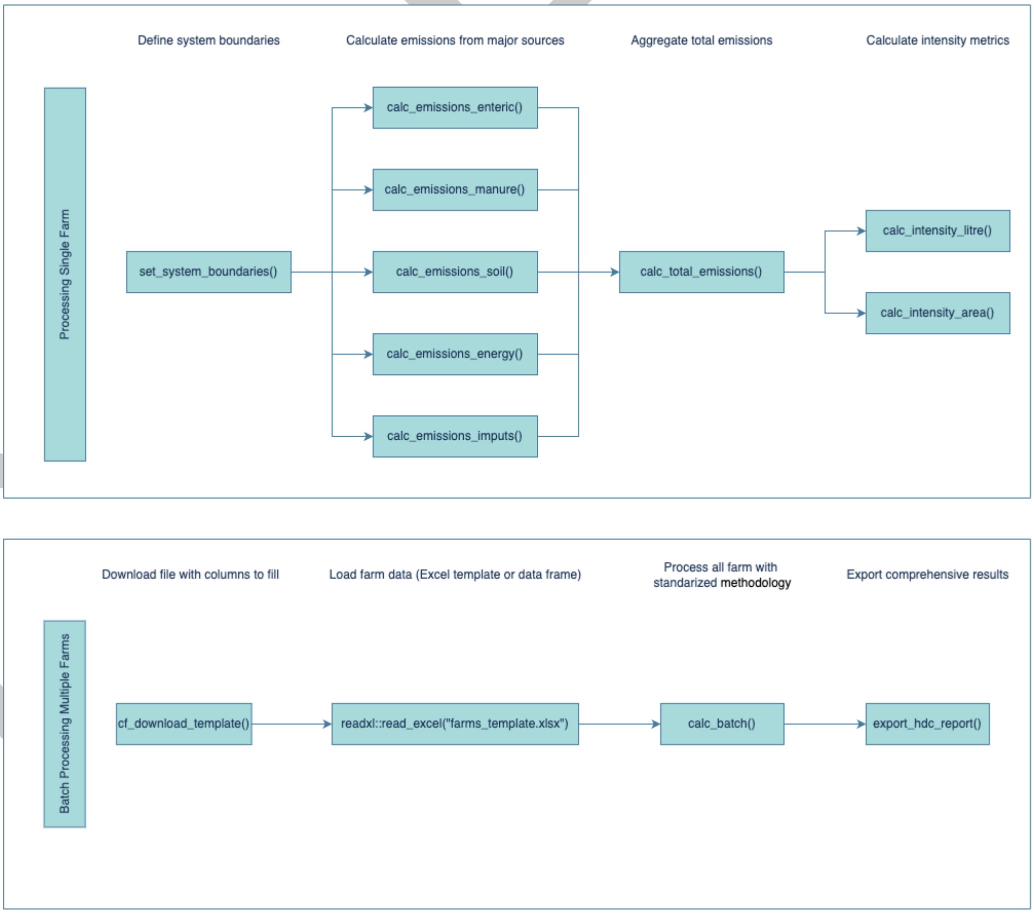

Figure 1: Workflow of the cowfootR package.

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Availability

The cowfootR package is freely available on both CRAN and GitHub. Comprehensive documentation, including vignettes and reproducible examples, is provided to facilitate adoption and integration into research and sustainability assessment workflows. cowfootR package is available on GitHub (https://github.com/juanmarcosmoreno-arch/cowfootR). Documentation, including vignettes and examples, is provided to facilitate adoption.

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