

Extended Abstract

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Paper/Poster Title	Assessing circularity on mixed crop and livestock farming systems
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Abstract prepared for presentation at the 98th Annual Conference of The Agricultural Economics Society will be held at The University of Edinburgh, UK, 18th - 20th March 2024.

Abstract	<i>200 words max</i>
<p>Given the present circumstances of a growing global population and the rising need for food, coupled with limited resources and the effects of climate change, the concept of circular economy (CE) offers a promising approach to promote the development of environmentally sustainable agricultural systems. The concept of CE, or circularity, describes a process in which elements form closed loops or cycles, an alternative to the linear process paradigm. While the implementation of CE strategies has gained traction in various industrial sectors over the last decade, the adoption of circularity principles in agricultural systems and practices is relatively less developed. Indeed, the linear and specialised structure of current agricultural production systems poses a challenge to defining, measuring, and fostering circularity at the farm level. Additionally, there exists ambiguity regarding the specific conditions that constitute circularity. Inspired by the circular bio economy principles developed by Muscat et al. (2021), this research paper aims to address this knowledge gap and devise a suite of farm level indicators to evaluate circularity on mixed farm systems for dairy production.</p>	
Keywords	Circularity; Agricultural data
JEL Code	Q100 Agriculture: General
Introduction	<i>100 – 250 words</i>
<p>The concept of circular economy (CE), or circularity, describes a process in which elements form closed loops or cycles, an alternative to the linear process paradigm. Industrial ecology research emphasizes the importance of circularity in transitioning towards more sustainable and resource-efficient production systems. It serves to highlight the disparity with linear production systems, found for instance in the currently predominant model of globalised agriculture based on intensive and specialised production systems. Owing to this, defining and measuring circularity at the farm level can be challenging (Van Loon et al., 2023) and there exists ambiguity regarding the specific conditions that constitute circularity.</p> <p>The DairyMix project aims to support a more sustainable and circular mixed farming system for dairy production, and to minimize the use of external inputs while also providing farmers with decision support tools. In line with this overarching goal, this paper aims to identify relevant indicators to assess farm level circularity on a range of case study dairy farms in Europe and Argentina. These case farms were selected to</p>	

represent a range of pedo-climatic operating conditions crop-livestock integration levels. Expanding upon the more prevalent environmental focus of established circularity assessments, this study applies a multi-disciplinary approach in the development of circularity indicators to be cognizant to the economic, environmental and social elements of agricultural production. In this way, it provides a more holistic and thorough assessment of farm level circularity. We propose building these indicators around the five fundamental concepts of the circular bio-economy described by Muscat et al. (2021), namely safeguarding, avoiding, recycling, prioritising, and entropy. In turn, farm circularity performance will be assessed against a range of economic, environmental, and social sustainability indicators to examine the relationship between agricultural circularity and sustainability.

Methodology

100 – 250 words

In autumn 2022, a multidisciplinary team of economists, environmental and animal scientists, agronomists, and sociologists collaborated through online workshops to define and measure farm circularity. This effort was part of a larger project centered on mixed crop and livestock farms for dairy production, which informed the selection of indicators relevant to these farming systems. Applying the bio-economic principles of Muscat et al. (2021) as a theoretical framework, a literature review was conducted to identify studies from academic works on the subject of the circular economy for agricultural systems, with the purpose of identifying established indicators, such as nutrient use efficiency and recycling rate of manure. The results from the literature review were discussed amongst group members to adjust and develop suitable circularity indicators for dairy production. Socio-economic data gaps in circularity assessment literature were addressed through the development of attitudinal indicators, which provided a broader perspective of farm level circularity. Comprising both qualitative and quantitative elements, these circularity indicators were categorised between the bio-economy principles of safeguarding, avoiding, recycling, prioritising, and entropy. Then, each indicator underwent validation by project partners to ensure its relevance for assessing circularity at the farm level.

Based on identified circularity indicators, a survey tool for data collection was created, termed the DairyMix data template. This template encompasses a diverse range of variables related to operations in dairy farms with mixed crop and livestock enterprises, socio-economic data, and attitudinal statements regarding farm circularity. In addition, collaboration among the multi-disciplinary team produced a suite of economic, environmental, and social sustainability indicators, tailored to assess the sustainability of case study farms.

Results

100 – 250 words

Twenty-eight case study dairy farms were selected to represent different pedo-climatic operating conditions in Europe and in Argentina, as well as varying levels of crop-livestock integration in early 2023. The data collection phase was carried out from April to October 2023. The data validation process was completed in December 2023, with data analysis due to commence in January 2024. From the specialised variables incorporated in the DairyMix data collection template, this study will model annual



nutrient flows within each farm based on substance flows analysis. This procedure will require an in-depth assessment of the feed requirements for each case study farm, as well as determining the primary nutrient inputs and outputs, estimating key internal nutrient flows, as well as an evaluation of energy consumption on each farm. Utilising the multi-disciplinary circularity variables in the data collection template, indicators representative of the five bio-economy principles will be calculated, and will provide scores of circularity for specific environmental, economic and social elements. In addition to attaining information on levels of farm circularity, a sustainability assessment tool, based on the framework proposed by Wilfart et al. (2024) which aggregates environmental sustainability, economic efficiency and socio-economic effects, will be developed to provide a multi-criteria assessment of mixed farming systems. This will facilitate a comparative analysis between a farm's level of circularity and its performance in terms of economic, environmental, and social sustainability.

Discussion and Conclusion

100 – 250 words

The shift from the predominant model of intensive and specialised agricultural production to a circular model requires significant transformations across all levels of agri-food systems, particularly at the farm level. The DairyMix project places significant emphasis on achieving key goals such as the development of more sustainable and circular mixed farming systems for dairy production. This entails a reduction in the reliance on external inputs and ensuring that farmers have access to management and decision-support technologies. Furthermore, evaluating the circularity performance of the case study farms across various economic, environmental, and social sustainability indicators will offer valuable insights into the interplay between agricultural circularity and overall sustainability. When the data analysis is completed, the results from the multi-disciplinary circularity indicators, as well as additional models and tools, will be incorporated into the DairyMix information platform. This multi-actor knowledge hub is designed to increase understanding and knowledge of sustainable dairy production systems, and to enhance the communication and dialogue between farmers, science, stakeholders and policy.

References:

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