Book Review

A Review of the Book by Amon (2023) Entitled "Developing Circular Agricultural Production Systems"

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1. CIRCULAR AGRICULTURE PRODUCTION SYSTEM AS PART OF TRANSITIONING FOOD SYSTEMS

Globally, agriculture is confronted with enormous challenges. Agriculture needs to increase food and biomass supply to meet demands from the fast-growing global population while remaining within planetary boundaries (Steffen et al. 2015). A synergistic combination of measures will be needed to ensure a high quality of water, soil, and air for future generations (Conijn et al. 2018; Springmann et al. 2018).

Circular agriculture (CA) is a component of circular food systems, where plant biomass is used for humans first to minimize feed-food competition, by-products are recycled and animals are used for converting human inedible biomass into food (de Boer and van Ittersum 2018). Hence, developing CA production systems not only includes agriculture but also requires changes in human diets with fewer animal proteins (Van Zanten et al. 2019) and other types of food (Parodi et al. 2018). Food also has many cultural connotations and can be part of the identity of people; hence, a transition is only possible when those aspects are also considered. The required transformation of the food system has therefore many dimensions and includes social, economic, technical, legal, and governance aspects (Termeer and Metze 2019). Secondly, CA affects how biomass can be used. Circular biomass use should safeguard ecosystems, avoid losses and waste, recycle waste where possible, and minimize energy needed in the system (Muscat et al. 2021).

The book of Amon (2023) focusses mostly on the technological aspects of circular agricultural systems to close nutrient cycles. Unfortunately, the role of human (and pet animal) diets, effects on energy use and GHG emissions, and other socio-economic aspects are not thoroughly discussed. Agriculture is an important human activity with social, economic, and cultural aspects. Changes affect farmers, rural communities, and employees working in a highly optimized processing chain, strongly complicating transitions (Termeer and Dewulf 2019; Termeer and Metze 2019). For example in Europe, exemptions for feed products from the import levy for grains was a key driver of regional specialisation (Schut et al. 2021). This resulted in large feed imports and EU nutrient surpluses (Leip et al. 2015) that persist due to current policies (Schuh et al. 2022) and system lock-ins (Williams et al. 2024). Some insights into the local context and drivers of farm and regional specialisation are needed to understand how e.g. small wins (Silvius et al. 2023), and alternative practices may contribute to the transition of farming systems.

2. CONTENT OF BOOK CHAPTERS

The book of Amon (2023) has four distinct parts. Part one discusses general concepts of CA and closed-loop systems (CLS). Part two discusses waste processing. Part three focusses on the production of valuable products from agricultural waste streams. In part four, two case studies are presented for a closed-loop dairy value chain and an aquaponic system where hydroponic crops and fish are combined. The book contains valuable chapters that provide a useful introduction to how circular economy concepts apply to agricultural systems, supplemented with more in-depth descriptions and analyses of important technologies which may help moving towards improved circularity. Most chapters discuss concepts related to improved recycling and reducing losses in the

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current agricultural system. The detailed analyses that are provided focus primarily on technological innovations, which merely include end-of-pipe solutions to improve recycling. Stronger transformative solutions are discussed but not analysed in detail. A detailed analysis of nutrient flows at the regional (Papangelou and Mathijs 2021; Tamsma et al. 2024; Vingerhoets et al. 2023) or EU scale (Simon et al. 2024) could have been a relevant addition to the book to illustrate what can be achieved with technology at a systems level. All parts contain valuable sections that indicate relevant literature for further reading, directing interested readers to specific literature.

The four parts are connected, yet in our view it is not clearly discussed how these components fit into the broader concept of CA, which includes both human diets and production of food. The introduction of the book would have been a good place to elaborate more on connecting the different parts of the book and explaining how different concepts relate to each other. For example, CA and CLS are used interchangeably yet the difference between CA, circular agriculture systems, and CLS is not clearly discussed. The introduction mentions “circular agriculture”, “closed loop systems”, “closed loop nutrient cycles”, “closed loop chains”, “recycling waste” but how these terms are related or where they differ is not clearly explained. For example, Schröder et al. (2003) and Bremmer et al. (2020) used a definition that includes multiple loops, which was cited in Chapter 2, whereas the closed loop definition of Feagre (2016) and others cited in Chapter 4 primarily focusses on the re-use of humanure and urine in agriculture to replace fertilizers.

Both CA and CLS provide options to reduce leaks in nutrient cycles and can be applied at a range of scales. However, systems suffer from diffusive biomass streams at every processing and/or collection point, which means that a truly closed-loop system is an elusive concept. The cycles have a clear spatial and temporal component and may be best considered as a series of connected and nested regional cycles (Koppelmäki et al. 2021) with imperfections and leaks.

The first chapter discusses important concepts needed to understand the context of the more detailed chapters later in a clear manner. A lovely introduction is given to how research and policy around circular agriculture originated from earlier circular economy principles.

Chapter 2 presents a conceptual framework for analysing nutrient cycling in agri-food systems, with a major focus on the agricultural part of the food system. Vellinga clearly shows the impacts of large densities of humans and animals in specialised regions. These are key components and drivers of the current, strongly linear, food system that heavily depends on external resources where food production and humanure, a lovely term to express its potential value, are disconnected. The chapter emphasises the need to redistribute nutrients in consumed food and feed to crop producers, highlighting the need for strong governance to do so. Unfortunately, the proposed crop-livestock interactions via transport do not account for the need to reduce N surpluses, energy use, greenhouse gas emissions, and need to operate within planetary boundaries which are currently exceeded in many places (Schulte-Uebbing et al. 2022).

In Chapter 3, the focus is on cycles on, and between individual farms. In this chapter, Taube et al. discuss how integrated crop-livestock systems (ICLS) could be a key component of future dairy farming systems. ICLS addresses many challenges at once, as shown in Figure 6, where a strong relationship between nitrogen use and GHG footprints per kg of milk is presented. It essentially shows an important trade-off where one finite resource (energy) is replaced by another (land). The discussion about grass/legume leys as part of arable rotations is interesting, especially in relation to the environmental impacts of future farming systems.

Chapter 4 suddenly focusses on improving resource use efficiency by discussing the potential for connected sensor-, and artificial intelligence technologies on farm decisions, mostly related to irrigation. This is a deviant chapter and while suggested by the authors, it cannot be linked to closed-loop systems (at best to less leaky systems). Improving efficiency by reducing losses is very relevant, yet a focus on efficiency in specific components of the system may result in externalising losses to other components (De Vries et al. 2015) without the desired efficiency benefits at systems level. Such issues can only be accounted for with systems analysis at multiple scales (Tamsma et al., 2024).

In Chapter 5, the focus is on utilisation of crop residues and co-products from industrial processing, mainly discussing the value of residues from the bio-energy industry. The importance of recycling and the composition and feeding value of specific biomass streams are discussed. It remains open how much of current residue streams can be diverted to feed, in many regions most will already be valorised as feed product or as component of concentrates. Other aspects of biogas production, such as competition for land by growing crops as biogas feedstock and assessments of net GHG when digesting various feedstock options with life cycle analysis are missing.

Chapter 6 discusses aspects of slurry manure processing, including acidification and digestion with or without pre- and post-treatment. Key considerations concerning pollution swapping are presented in clear summarizing tables. Examples of integrated solutions are described that minimize overall environmental impact. This provides a good overview for newcomers of existing knowledge on emissions from manure management at field and farm level. Yet, these solutions are directly linked to specialised regions with a few large crops for processing and intensive animal systems where feed demand is high and large amounts of manure are present. This chapter doesn't discuss how such innovations may fit into farming systems with much lower animal densities that may not be based on housing systems that produce slurry manure but on e.g. housing systems with straw bedding that produce liquid and solid farmyard manures.

Chapters 7 and 8 continue with manure and focus on processing techniques to improve the value of manure as fertilizer and source of energy. These chapters offer a lot of detail and insights. Yet, for those interested in the presented end-of-pipe techniques, the information provided may be hard to find in this book. Chapter 7 was nicely illustrated with clear graphics, yet many points were already mentioned in previous chapters. Chapter 8 discusses a wide range of risks associated with organic sources of fertilizer, which may hinder recycling potential. The risks and regulatory background of manure and bio-fertiliser are a relevant addition to the presented options for processing biobased waste (including manure). Yet, such end-of-pipe solutions may not be needed in more circular systems. These chapters would have benefited from a detailed analysis of other solutions that require less energy and technology. For example, a more local recoupling of crop and livestock systems; the use of alternative crops and crop rotations that better fit local food needs; and how nature-based solutions can be used in circular systems.

Chapter 8 explores the interplay between health, food safety, and agricultural biomass management. However, some discussed risks for biobased fertilizers would be better discussed elsewhere, as these are general issues of concern and reasons why closed-loop or circular concepts have emerged. For example, the discussed issues related to reactive N and P losses are not limited to biobased fertilizers alone. In our view, these issues are better discussed as generic topics. The third part diverges from closed-loop systems as these chapters focus on the use of organic resources for biobased products.

The book tries to bridge the gap between circular agriculture and circular economy with chapters 9–12. This is highly relevant and when studying circular agriculture we cannot only focus on providing biomass for food. This is briefly highlighted in chapter 9. However, we quickly dive into very specific details of different components from a range of biomass feedstocks. These chapters contain interesting aspects, yet may not get much attention from an audience focused on agricultural or food systems. In our opinion, these chapters are also a missed opportunity: biorefineries can play an important role in future food systems to utilize available biomass for food and feed, which cannot be used at this moment. Yet, the connection between the case studies and the food system is poorly described. For example, chapters 11–12 on bioplastics and polyphenols are very detailed, but in our view out of scope for a general audience interested in circular agriculture. When starting from a circular agricultural system with a food system perspective, focussing on only closing loops in one supply chain seems odd as the chapter misses links to an overall more circular food system.

Chapters 13 and 14 are part of Part 4, case studies. Chapter 13 focusses on improving circularity in the dairy processing chain, providing examples of better use of co-products, recycling of waste, and decision-support tools. It provides some interesting general insights, but for a case study chapter more detailed examples of specific situations could be expected. The chapter has some overlap and could have been better linked to earlier chapters that discuss aspects of the processing industry. For example, a waste hierarchy which indicates how to prioritise utilisation options for waste, was also introduced in Chapter 10. Chapter 14 discusses aquaponics. It is a useful introduction for those not familiar with the topic, yet it reads as a stand-alone chapter because many details specifically related to fish and hydroponic crop production are also included. Coupling fish and crops to better utilize nutrients in a closed system is circulating nutrients, yet is at the same time a very linear system depending on external inputs. This chapter would in our view have been stronger when embedded in concepts of circular food systems.

AUTHOR CONTRIBUTIONS

A.G.T. Schut: Conceptualization, Writing – original draft, Writing – review and editing
W.J. Vonk: Conceptualization, Writing – original draft, Writing – review and editing

DECLARATIONS

Competing interests The authors declare no competing interests.

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