



From Blind Spot to Crucial Concept: On the Role of Animal Welfare in Food System Changes towards Circular Agriculture

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Abstract

Agriculture in Western Europe has become efficient and productive but at a cost. The quality of biodiversity, soil, air, and water has been compromised. In the search for ways to ensure food security and meet the challenges of climate change, new production systems have been proposed. One of these is the transition to circular agriculture: closing the cycles of nutrients and other resources to minimise losses and end the impact on climate change. This development aims to address existing problems in food production but also raises questions about animal health and welfare. Although the role animals can play in this development is not ignored, the animal welfare dimension of circular agriculture seems to be overlooked. We argue that this is a problem both for the success of circular agriculture and for the animals involved. To substantiate this claim, we analyse the background to this lack of attention, which we find in (a) the way circular agriculture is conceptualised; (b) the institutional hurdles related to the legal, political and economic context; and (c) the concept of animal welfare, which requires further innovation. By analysing these aspects, we develop stepping stones for an animal-welfare inclusive concept of circular agriculture. These stepping stones include: recognising the animal as a participant with its own interests in the innovation towards circular agriculture; using a dynamic concept of animal welfare; a concept of circularity that provides space for social values, including animal welfare; and attention to institutional innovation by improving public engagement and building trust.

Keywords Sustainability · Food transition · Livestock farming · Climate change · Public engagement

Introduction

Agriculture in Western Europe has become highly efficient and productive during the last decades (Benton & Bailey, 2019). However, this development has come at a cost. The quality of biodiversity, soil, air and water has been compromised (e.g., Dudley and Alexander, 2017; Parris, 2011). Climate change and resource scarcity further complicate this situation and require farmers and other chain partners in the agri-food sector to rethink their production practices. A transition to circular agriculture appears to be a promising answer to these questions: closing the cycles of nutrients and other resources to minimise losses and end the impact on climate change (Ministry of Agriculture, Nature and Food Quality, 2018; 2019; Van Berkum and Dengerink, 2019). However, circular agriculture does not only answer questions, it also raises new ones. These include: At what scale should cycles be closed? What is the impact of this change on the consumption patterns of consumers in different parts of the world? (De Boer et al., 2019; Poore & Nemecek, 2018) And does it have an impact on the perception of farmers? (Dagevos & De Lauwere, 2021). In addition, this transition has implications for animals and their health and welfare. On the one hand, current forms of livestock production contribute to climate change and biodiversity loss and are therefore part of the reason for finding more sustainable forms of agriculture. On the other hand, it has been argued that animals can play an important role in circular agriculture, for example by converting organic matter that humans cannot or do not want to eat, thus helping to close cycles (Van Zanten et al., 2018; Zanten et al., 2019). Although the role that animals can play is not ignored, the animal welfare dimensions of circular agriculture receive very limited attention (Buller et al., 2018). This is reflected in recent policy reports on circular agriculture (e.g. Ministry of Agriculture, Nature and Food Quality, 2019). Recent academic literature on circular agriculture also shows very limited attention to animal welfare, even when animals are discussed (e.g. Tagarakis et al., 2021; Shurson and Urriola, 2022; Grumbine et al., 2021; Bianchi et al., 2020). Few publications systematically address animal welfare (Bracke et al., 2023). This is remarkable given the broad consensus in animal ethics that animals are part of our moral community and that there is a strong moral imperative to take animal welfare seriously in all contexts (Haynes, 2011; Knight et al. (eds.) 2023). Furthermore, empirical data show that the European public considers animal welfare to be increasingly important (EC, 2016; Schukken et al., 2019; Randler et al., 2021).

We argue that this lack of attention to animal welfare is a potential problem both for the success of the development of circular agriculture and for the animals involved. Taking animal welfare as a key concept in the transformation of agriculture allows (a) to take animal interests seriously in the discussion on circularity, (b) to anticipate challenges when animals play a role in circular agriculture and (c) to look for ways to mitigate problems that arise when animal welfare conflicts with other public values. To support this assertion of the importance of animal welfare for the development of circular agriculture, we analyse the background to the current lack of attention. We discuss three reasons: the position of animals and how circular agriculture is framed; the institutional hurdles related to the legal, political and economic context for including animal welfare; and the concept of animal welfare, which requires fur-

ther innovation. Based on this analysis, we outline what an ‘animal welfare inclusive’ approach to circular agriculture might look like.

The Circularity Concept and the Role of Animals

The first reason for the relative silence about animals in the discussion lies in the roots of the concept of circularity. It has its origins in both agro-ecology and industrial ecology and it aims to conserve and manage natural resources for future generations. This means that the concept of circularity focuses on the ecological dimension of sustainability (De Boer en Van Ittersum, 2018) where future generations are often defined as future humans. Therefore, circular agriculture is a form of agriculture that aims to produce food while preserving ecological values, such as fertile soil, clean air, pure water, a healthy climate, preserving the quality of the landscape, nature and biodiversity. While this account is promising for addressing pressing issues in contemporary agriculture, it has its shortcomings. In general, it does not specify which values and public goods should be protected or promoted by closing cycles. As a result, while the concept of circular agriculture does not by definition exclude attention to animal welfare, it does not yet include a consideration of whether animal interests should be taken into account in the discussion on how to develop circular agriculture. In addition, as circular agriculture focuses on the ecological dimension and animal welfare is mainly an element within the social dimension of sustainability, it easily is left out in the transition towards closing cycles. This issue is also recognized more broadly in discussions on the role of animals in sustainability (e.g., Scherer et al., 2018; Tallentire et al., 2019). Finally, an optimisation in the context of closing cycles seems to hinder the inclusion of animal welfare in the transition, as it has been claimed that improving animal welfare leads to less efficient production (Dawkins, 2016).

This easily leads to a situation where attention to animals depends mainly on their instrumental role in closing cycles. It has been convincingly argued that animals can play an important role in circular agriculture (van Zanten et al., 2019; Rööös et al., 2017). For example, they can convert low-value plant proteins into high-value proteins suitable for human consumption. They can also convert organic matter that humans are unable or unwilling to eat into valuable resources for food or manure. In addition, the role of animals in circular agriculture could consist of providing ecosystem services, such as maintaining soil quality, nature and water or the landscape or contribute to cultural and landscape values (e.g., cows and sheep grazing on pastures). Some of these roles, such as providing ecosystem services or converting biomass into resources for food are not restricted to the animals we traditionally use in farming, such as pigs or chickens, but includes also insects (Torgerson et al. 2021; Ojha et al., 2020). This is in addition to the social and cultural roles that animals play, for example in low-wage countries, where animals play an important role as tractive power or as social or financial capital (Gwaka & Dubihlela, 2020; Umaru et al., 2013; Mboungho et al., 2018).

Although animals can play an important role, this rather instrumental view of animals as functional parts in closing cycles is problematic. It easily ignores what has

been convincingly argued by many authors that animals are morally considerable for their own sake and that humans can have duties towards other animals (cf. Callicott, 1980; DeGrazia, 1996; Korsgaard, 2005; Midgley, 1983; Nussbaum, 2006; Regan, 2004; Singer, 1995; Warren, 1997). These duties at least include a non-harm principle that is a minimal form of paying attention to animal welfare and requires that animal interests should be included in the debate about the design of circularity.

Legal and Economic Frames

A second reason for the relative silence on animal welfare lies in the current legal and economic frames of agriculture and food production. Legislation can be an effective tool to address and protect animal welfare. In line with the ethical arguments mentioned above, animal welfare has also been recognised as a relevant issue in politics and policy and translated into animal welfare legislation (e.g. Tanzanian Government, 2008; Costa Rica, 1994). In Europe in particular, attention to animal welfare has been embedded in treaties, directives and national legislation for several decades (EC, 2007; 2014). However, despite the increasing attention to animal welfare in national and European legislation, there are still several unresolved issues regarding the legal status of animals. For instance, in many countries where animal welfare legislation is in place, animals are still commodities with less legal protection than humans. Even when the underlying value framework for animal welfare is explicitly mentioned in the legislation, such as the intrinsic value or dignity of an animal (e.g., the Netherlands Animals Act and the Animal Welfare Act of South Korea) or by including the dignity of all living beings in constitutional law, such as in Switzerland, questions remain about how to make animal welfare operational, and these are often difficult to answer. This ambiguity regarding the position of animals in legislation and the conceptualisation of their welfare in practice can easily lead to the neglect of the animal welfare dimension or to trade-offs between human and animal interests where human interests can easily trump animal welfare, for example when measures to combat climate change have negative impacts on animal welfare. This underlines the importance of further attention to the place of animals in legislation, but also of systematic reflection on the practical consequences of the existing recognition of animals as significant for their own sake.

From a market perspective, the question of what role animals should play in circular agriculture is traditionally answered in terms of supply and demand. From this perspective, the transition to circular agriculture takes place in a world where there is an expected growth in global consumption of animal proteins with an increase of 14% by 2030 compared to period average of 2018–2020 (OECD/FAO, 2021, 164–165). In line with these expected consumption rates global meat supply is expected to expand to 374 million metric tonnes by 2030 (OECD/FAO, 2021: 164). Meat production is expected to increase in China, Brazil and the United States in particular, with a significant increase in poultry production. Therefore, from a traditional market perspective, animals still play, and will continue to play, an important role in the discussion on circular agriculture due to consumer demand for meat. However, within this context of animals being used for food production attention to animal welfare is complex. The commodification of animals is mainstream, but the commodification of animal

welfare is less well developed. Improving the welfare of farm animals is difficult to evaluate from a purely economic perspective (Fernandes et al., 2021). As a result, it is still not easy to make money from raising welfare standards. More generally, there is a lack of market consensus on the importance of animal welfare and minimum animal welfare standards that could guide animal welfare issues at the international level and across different production systems (Horgan & Gavinelli, 2006; Buller et al., 2018). This is particularly problematic as European agricultural policy is no longer characterised by strong state control and market partners can no longer look only to governments for animal welfare. This leads to new dynamics between government and market actors, and to more market-based governance (Vogeler, 2019).

The legal ambiguity about how to protect animals and ensure their welfare, combined with the apparent inability to make animal welfare an argument in its own right from a market perspective, contributes to the silence about animal welfare in the development of circular agriculture. It also contributes to the process that we have already identified in the discussion on the concept of circularity: animal welfare is only considered, if at all, when animals already play a role in agriculture. However, in the discussion on how to design and develop the transition to circular agriculture, the impact on animals and their interests is overlooked.

Animal Welfare as a Complex Concept

A final reason that may explain why animal welfare remains under the radar in the discussions on circular agriculture has its origins in the concept of animal welfare itself. Animal welfare is a complex concept with many definitions (Lawrence et al., 2019; Von Keyserlingk & Weary, 2017). Since the 1960s animal welfare has been defined in terms of the five freedoms (Brambell, 1965), which is still reflected in many legal and policy documents and in teaching for professionals (De Briyne et al., 2020; Mench, 2022). At the same time the shortcomings of this welfare concept have been widely discussed (McCulloch, 2013; Ohl & van der Staay, 2012). In particular, the importance of considering positive emotions, which seem to be missing in the Five Freedoms model, has been highlighted (Mellor & Beausoleil, 2015), but also critically discussed (Lawrence et al., 2019). Furthermore, animal welfare has been defined as a function of adaptation, resulting in a dynamic concept of animal welfare (Ohl & van der Staay, 2012), which has been further modified and extended (Arndt et al., 2022). It is not the aim of this paper to review the animal welfare literature of the last decades, but the academic debate shows profound differences in the way welfare is conceptualised. Furthermore, animal welfare concepts are influenced by ethical considerations, such as views on the moral status of animals and the importance of welfare as such (Meijboom, 2017). This is well reflected in Fraser's quality of life concerns (Fraser et al., 1997), and again shows a diversity of views on why welfare is important and what welfare means for animals.

As a result, it is not self-evident what it implies taking animal welfare into account in the transition towards circular agriculture. Different questions and concerns will arise depending on one's view of animal welfare. To illustrate this point: suppose that an animal is fed a different type of feed as a result of circular farming. From a classical five freedoms approach or Fraser's 'biological function' view, this situation

is mainly a question of sufficient nutrients, whereas a dynamic concept of welfare will ask whether the new feed fits within the adaptative capacity of the animal to adequately respond to this new situation and if it allows the animal to experience the novel situation as positive.

A further complication is that closing cycles focus on collectives rather than on individuals. This easily conflicts with the view on animal welfare that is traditionally associated with individual entities rather than to systems or collectives (Broom, 2010). Addressing welfare at a collective level is not entirely new. Several initiatives have been developed, such as the Welfare Quality® project to assess animal welfare at the farm level (Keeling, 2009). However, the move towards circular agriculture has a focus that goes beyond the level of individual farms and strives for system change. This entails that the level of aggregation is also no longer at the level of the individual animal or individual farm. As a result, a project such as Welfare Quality® cannot be applied one-to-one to integrate animal welfare into the development of circular agriculture. Initiatives such as the One Welfare approach (Pinillos et al., 2016) are more promising in this context, as they propose an integrated account that combines animal welfare, human well-being and the environment. However, this higher level of aggregation complicates the well-known problems of determining net welfare and evaluating a welfare state as positive or negative (Lawrence et al., 2019). This requires the development of (a) indicators that allow the comparison of the effects of different forms of circular agriculture in terms of animal welfare, and (b) a method that helps to aggregate these indicators in a way that allows animal welfare to be assessed. However, this has not been done so far and is a complex task (Sandøe et al., 2019).

In summary, the lack of attention to animal welfare in the transition to circular agriculture is not the result of mere indifference towards animals and their interests. Even if it is accepted that animal welfare is a relevant consideration in circular agriculture, it requires attention at the level of the concepts of circularity in agriculture and animal welfare, and calls for a critical discussion of the current legal and economic frameworks.

An animal welfare-inclusive approach to circular agriculture (a) needs to include animal welfare at the design stage and not just for the instrumental role of animals in closing cycles, (b) should come with a view of animal welfare that fits the integrated approach to circular agriculture that goes beyond individual welfare, and (c) needs to find better ways to integrate animal welfare into the legal and market frameworks of agriculture. In the next section, we propose some building blocks for an animal welfare inclusive approach to circular agriculture.

Towards an Animal Welfare Inclusive Approach of Circular Agriculture

The background of the limited attention paid to animal welfare in the transition to circular agriculture shows that the problem will not solve itself. It requires change and innovation in the way animals are valued, in the concepts of animal welfare and circular agriculture, and in the legal and market infrastructure. In this part of the paper we propose a number of building blocks that contribute to an animal-welfare inclusive approach to circular agriculture. The proposals are inspired by the line of

thought first presented in an advisory report by the Dutch Council on Animal Affairs (RDA, 2020).

Towards Animals as Participants

Changing attitudes towards animals is an important first building block. In line with the above-mentioned moral status of animals, and recognising that animals have a role to play in the transition to circular agriculture, it is important to consider animals as involved interest groups that should be taken seriously for their own sake in this transition. Recognising animals as being part of the transition does not deny that animals can cause problems that underlie the need for circular agriculture or that they can be part of the solution to a current problem, but it prevents animals from being evaluated only in instrumental terms for their potential role in closing cycles. In their many potential roles animals are an indispensable part of the process towards circular agriculture. Therefore, they should be approached as participants in the sense of beings with interests who are also involved in the transition. And animals, as sentient beings, have interests, including an interest in good welfare. Therefore, the concept of circularity should take into account the interests of humans, the environment *and* animals in an interspecies approach (cf. Bergmann, 2019; Nieuwland, 2020). This means that animal welfare must be taken into account at the design stage and not only when implementing solutions that use the function of animals.

It is important to emphasise that this position is a building block, rather than a fully developed ethical view of what we owe to animals. In this paper, we focus on the need to pay more attention to animal welfare, but this does not deny that our duties to animals go beyond animal welfare (Bovenkerk & Nijland, 2017). Furthermore, this attitude towards animals does not exclude the ethical possibility that animals may play a role in future agriculture and that there will be products of animal origin in circular agriculture. However, recognising animals as part of the innovation and as having their own interests, including their welfare, requires that animals are taken into account from the outset of the discussion, which will require a change in many current animal husbandry practices.

Animal Welfare: A Dynamic Concept

At the level of the concept of animal welfare three building blocks seem to be relevant for an animal welfare inclusive approach. Again, the first step starts with the attitude towards animals as engaged beings with interests in the design process. From this point of view, animals do not correspond to their functional role. Therefore, an approach that focuses only on the functional dimensions of welfare, such as growth and offspring, is not sufficient. What is needed is a welfare concept that takes into account positive welfare and the animal's ability to adapt to new situations, as envisaged in the design of circular agriculture. Under these conditions, a classical 5 Freedoms approach is not sufficient as it lacks both the attention to positive welfare (Yeates & Main, 2008) and the ability to take into account the adaptive capacity of animals. A more dynamic concept of animal welfare that takes the adaptive capacity of animals as a central dimension (Ohl & Van der Staay, 2012; Arndt et al., 2022) is a

promising start to integrate animal welfare in the design phase. This allows the question to be raised as to which scenarios for circular agriculture are possible within the limits of the adaptive capacities of the animals or animal species involved, in order to ensure that the closing of cycles leads to a situation that can be assessed as positive by the animals involved.

A further building block starts with the need to reflect on the relationship between the individual animal and its position as a member of a group (e.g., Ohl and Putman, 2014). This is necessary because the debate on animals in circular agriculture cannot be framed as a simple distinction between either starting with individual welfare or in a systems approach. Although animal welfare is primarily related to the individual (Richter & Hintze, 2019) most animals need groups and systems to experience welfare. As a result, innovative systems can be designed in a way that takes into account the interests of animals, but this requires innovation in animal welfare science (Buller et al., 2018). Among other things, it requires that the used concept of animal welfare can address existing and anticipated problems associated with circular agriculture. For example, circular agriculture as a way of dealing with the effects of climate change raises additional animal welfare issues because of the potential impact of climate change on animal welfare. The living conditions of animals are affected by climate change through more extreme weather conditions, whether warm, cold, dry or wet. However, little is known about these impacts. Further research is needed to examine existing circular farming scenarios from an animal welfare perspective, taking into account the impact of climate change on animal welfare from the start.

A final building block is the ability to deal with ethical dimensions related to animal welfare. The transition to circular agriculture raises quite complex ethical issues. This starts with a view of the moral status of animals, as we highlighted in the first building block. Recognising animals as beings with moral status who should be included in our moral reasoning excludes the idea that animals are just instrumental parts of the transition. They are involved in the transition and have their own interests, including an interest in positive welfare. This means not only potential conflicts between humans and animals but also between animals.

Therefore, the transition to circular agriculture will need to address issues of balancing the overall welfare of the animals involved with the welfare of the animals that are least well off.

For example, if closing nutrient cycles leads to a change in feed for pigs, this may affect their health. Suppose that this risk is taken seriously and the composition of the diet is adjusted so that most, but not all, of the pigs' health problems are addressed. As a result, on average, pigs living on this new diet will have no welfare problems due to the change in diet. However, a small proportion of pigs - which in practice is a relatively large number of animals - develop health problems and have to be treated or killed prematurely. Whether this situation is acceptable from an animal welfare perspective is not self-evident and requires ethical reflection. In this process of reflection animal welfare science is essential to help determine what the most negative impact on the welfare of an individual animal could be as a result of a decision to close cycles. Applying a 'maximin strategy' is the next step that aims at minimizing the possible loss to animals in that worst-case scenario (cf. Rawls, 1972). This principle implies that scientific input is needed to find ways to mitigate these serious welfare

problems as much as possible. Based on these two steps, it is possible to determine which potential welfare problems are still on the table and cannot be accommodated. As a third step, a transparent process of making an ethical assessment is needed that is explicit about how animal welfare is aggregated and how it is weighed against other relevant interests and values (e.g. Tallentire et al., 2019).

Circularity with Room for Animal Welfare

The next step relates to the concept of circular agriculture. As discussed above, the ecological dimension of sustainability has been dominant in closing cycles. It is important to stress that this ecological dimension already offers opportunities for animal welfare, for instance in terms of a more natural way of life. However, a further conceptual step is necessary. In addition to the ecological dimension of sustainability, circular agriculture should also take into account the economic and social dimensions of sustainability. In other words, it should be economically viable and socially responsible (Fig. 1). This broader approach to circular agriculture allows for the inclusion of animal welfare as an element within the social dimension of sustainability rather than within the ecological dimension. This implies that animal welfare is not automatically part of circular agriculture and that good animal welfare practices should be a separately formulated and monitored requirement for the development of circular agriculture.

Institutional Innovation: Public Engagement and Trust

With an animal welfare concept that is responsive to circular agriculture and with an account of circular agriculture that encompasses attention to animal welfare, we

Fig. 1 Determining safe and just operating space for sustainable food systems (De Boer et al., 2019). The operating space for agricultural entrepreneurs is determined by the ecological ceiling (such as nitrogen losses and loss of biodiversity), on the one hand, and by the social foundations, our social values (such as animal welfare and working conditions), on the other



have not yet addressed the more institutional problems that are rooted in the current legal and economic frameworks. If these remain unaddressed, animal welfare will still not be taken into account. The final part, therefore, focuses on this institutional dimension. Changing the legal and economic context is complex and cannot be the task and responsibility of just one party (Fernandes et al., 2019). However, there are opportunities. Circular agriculture requires a redesign of our food system that takes into account all dimensions of sustainability (people, planet and profit). This requires input from many parties, including government, business and NGOs. This includes those in a position to shape and reshape the political, regulatory and market conditions of food production. This transition will take time. This is not only a risk, but also an opportunity. Institutional frameworks do not change overnight. It is therefore important to use this time to address the institutional dimension and to embed animal welfare. As a result, good animal welfare practices should become a requirement rather than an issue dependent on the goodwill of individual farmers or NGOs. This may be part of government policy or embedded in a private certification system. The rise of private animal welfare labels and standards shows that joint market initiatives can result in new ways to improve animal welfare (Heerwagen et al., 2015; Vogeler, 2019). However, just as the traditional legal infrastructure does not provide much space for animal welfare, innovation is also needed in the economy to give animal welfare a more robust position (RDA, 2017) that can be applied in the context of circular agriculture. There is also a need for a level playing field within Europe. This requires the strengthening of networking and coordination in Europe in order to develop circular agriculture also in a European context. The European Farm to Fork Strategy as part of the European Green Deal could serve as an important platform here (EU, 2020), as well as initiatives such as the OECD's decision to include animal welfare standards in the OECD Guidelines for Multinational Enterprises on Responsible Business Conduct (OECD, 2023). These possible routes all show that the problems at the infrastructure level require a multi-stakeholder approach. Firstly, this need is a consequence of the complexity of the institutional or economic challenges associated with integrating animal welfare, which means that neither governments nor market actors can address them alone. In addition, the need for a multi-stakeholder approach has a normative dimension: food and animal production, as well as climate, are matters of public interest and concern to society. Therefore, how animal welfare is implemented as part of the transition to circular agriculture requires public engagement. This means more than just raising awareness among consumers and civil society about the impact of their consumption on future agriculture (De Olde et al., 2020) or engaging only with technical experts. The former does not lead to real engagement, and the latter risks limiting the debate to dominant perspectives (Kayumova et al., 2019). Two-way public engagement is crucial for two reasons. First, it leads to a stakeholder approach that includes all relevant perspectives on circular agriculture, including the ability to reflect on necessary changes in the institutional infrastructure. Second, public engagement helps to build trust, which is essential for innovation in agriculture, including animal welfare (Kjærnes et al., 2022). This need for trust is not limited to (individual) consumers. The complexity at stake means that no actor in the innovation towards circular agriculture is able to act without relying

on the competence and motivation of others. It is therefore important that governments, professional organisations of farmers and veterinarians, retailers and animal- and consumer-related NGOs work together to find a concept of circularity that takes into account the interests of people, the environment *and* animals.

Conclusion

In this paper we elaborated on the claim that the lack of attention to animal welfare in the development of circular agriculture is problematic both for the successful implementation of this innovation of agriculture and for the animals involved. It is problematic for circular agriculture because it would exclude animals as a relevant stakeholder and would ignore animal welfare as a social value that plays a role in the design of more sustainable forms of agriculture. It is problematic for animals because the lack of attention to their welfare can lead to situations that may be sustainable from an environmental perspective, but are not sustainable for the animals involved.

We have shown that circularity and animal welfare are not mutually exclusive. However, the relationship is not self-evident. Including animals and their welfare in the transition to circular agriculture requires innovative steps in the concepts of circularity and animal welfare, as well as in the legal and market infrastructure. To address the current lack of attention, we propose to start from (a) the recognition of the animal as a participant with interests in the innovation towards circular agriculture, (b) the use of a dynamic concept of animal welfare, (c) a concept of circularity that provides space for social values, including animal welfare, and (d) innovations in the legal and market infrastructure of food production.

These proposed innovations will not solve all animal welfare problems in the context of circular agriculture. They may even complicate the situation. There will be economic consequences of taking animal welfare into account, there are public health risks associated with improving animal welfare, there are animal welfare issues in reducing greenhouse gas emissions, and there are still conflicts between animal welfare and biodiversity protection that require careful assessment and debate. This should not be seen as an argument against including animal welfare in the debate. Circular agriculture is characterised by many complex issues and this complexity is not limited or even exclusive to animal welfare issues.

By including animal welfare as one of the central concepts from the outset of the transformation of the food system, it can do justice to the moral position of animals, better anticipate potential challenges and look for ways to mitigate problems that may arise when animal welfare conflicts with other public values. This will require time and energy, as well as an attitude of transparency and trust on the part of all stakeholders to critically discuss the concept of animal welfare in the light of circular agriculture and to critically reflect on how circular agriculture can include animal welfare. This will accelerate the process in the long term and enable the development of a food system that can address with the impacts of the pressing challenges of climate change, population growth and biodiversity loss, *and* include animals and their welfare as a crucial concept of circular agriculture.

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Data Availability Not applicable.

Code Availability Not applicable.

Declarations

Conflicts of interest FLBM reports having no conflicting interests. JS reports having no conflicting interests. RP reports having no conflicting interests.

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References

- Arndt, S. S., Goerlich, V. C., & van der Staay, F. J. (2022). A dynamic concept of animal welfare: The role of appetitive and adverse internal and external factors and the animal’s ability to adapt to them. *Front Anim Sci*, 3, 908513. <https://doi.org/10.3389/fanim.2022.908513>.
- Benton, T., & Bailey, R. (2019). The paradox of productivity: Agricultural productivity promotes food system inefficiency. *Global Sustainability*, 2, E6. <https://doi.org/10.1017/sus.2019.3>.
- Bergmann, I. M. (2019). Interspecies sustainability to ensure animal protection: Lessons from the thoroughbred racing industry. *Sustainability*, 11(19), 5539.
- Berkum, S. (2019). *Transition to sustainable food systems: The dutch circular approach providing solutions to global challenges*. Wageningen. Report 2019-082DengerinkJ.
- Bianchi, F., van Beek, C., de Winter, D., & Lammers, E. (2020). *Opportunities and barriers of circular agriculture*. Den Haag: NWO-WOTRO Science for Global Development.
- Bovenkerk, B., & Nijland, H. J. (2017). The pedigree dog breeding debate in ethics and practice: Beyond welfare arguments. *Journal of Agricultural and Environmental Ethics*, 30, 387–412. <https://doi.org/10.1007/s10806-017-9673-8>.
- Bracke, M. B. M., Boumans, I. J. M. M., Nijland, H. J., & Bokkers, E. A. M. (2023). Connecting circularity to animal welfare calls for a ‘novel’ conceptual framework based on integrity. *Animal*, 17/2, <https://doi.org/10.1016/j.animal.2022.100694>.
- Brambell, F. W. R. (1965). *Report of the Technical Committee to Enquire into the Welfare of Animals kept under intensive livestock Husbandry Systems, the Brambell Report*. London, UK: HMSO.
- Broom, D. M. (2010). Animal Welfare: An aspect of Care, sustainability, and Food Quality required by the Public. Animal Welfare in Education and Research. *Journal of veterinary medical education*, 37, 83–88.
- Buller, H., Blokhuis, H., Jensen, P., & Keeling, L. (2018). Towards farm animal welfare and sustainability. *Animals*, 8(6), 81. <https://www.mdpi.com/2076-2615/8/6/81>.
- Callicott, J. B. (1980). Animal Liberation: A Triangular Affair. *Environmental Ethics*, 2–4, 311–338.
- Costa Rica (1994). Bienestar de los Animales (Law 7451 on Animal Welfare), https://www.animallaw.info/sites/default/files/stcrlaw7451_welfare.pdf.
- Dagevos, H., & Lauwere, C. (2021). Circular Business Models and Circular Agriculture: Perceptions and Practices of Dutch Farmers. *Sustainability*, 13, 1282. <https://doi.org/10.3390/su13031282>.

- Dawkins, M. S. (2016). Animal welfare and efficient farming: Is conflict inevitable? *Animal Production Science*, 57(2), 201–208.
- De Boer, I. J. M., & Van Ittersum, M. K. (2018). *Circularity in agricultural production, scientific basis for Mansholt lecture 2018*. Wageningen University & Research.
- De Boer, I. J. M., Van Der Linden, A., & De Olde, E. M. (2019). How to handle trade-offs and synergies in our search towards a sustainable food system? In: Book of Abstracts of the 70th Annual Meeting of the European Federation of Animal Science, 26–30 August, Ghent, Belgium. p. 345.
- De Briyne, N., Vidović, J., Morton, D. B., & Magalhães-Sant'Ana, M. (2020). Evolution of the teaching of animal welfare science, ethics and law in European veterinary schools (2012–2019). *Animals*, 10(7), 1238. <https://doi.org/10.3390/ani10071238>.
- De Olde, E. M., Van der Linden, A., Bolhaar, O., L.D., & De Boer, I. J. M. (2020). Sustainability challenges and innovations in the Dutch egg sector. *Journal of Cleaner Production*, 258, 120974.
- DeGrazia, D. (1996). *Taking animals seriously. Mental life and moral status*. Cambridge: Cambridge UP.
- Dudley, N., & Alexander, S. (2017). Agriculture and biodiversity: A review. *Biodiversity*, 18, 2–3. <https://doi.org/10.1080/14888386.2017.1351892>.
- EC European Commission (2016). EU barometer on Animal Welfare, <https://europa.eu/eurobarometer/surveys/detail/2096> (last accessed 9 June 2023).
- European Commission (EC) (2020). Farm to Fork strategy. For a fair, healthy and environmentally-friendly food system, [f2f_action-plan_2020_strategy-info_en.pdf](https://ec.europa.eu/food/sites/food/files/f2f_action-plan_2020_strategy-info_en.pdf) (europa.eu).
- European Commission (EC) 2014 40 Years of Animal Welfare, https://ec.europa.eu/food/sites/food/files/animals/docs/aw_infograph_40-years-of-aw.pdf (last accessed 9 June 2023).
- European Commission (EC) (2007). Treaty of Lisbon amending the Treaty on European Union and the Treaty establishing the European Community, signed at Lisbon, 13 December 2007.
- Fernandes, J., Blache, D., Maloney, S. K., Martin, G. B., Venus, B., Walker, F. R., Head, B., & Tilbrook, A. (2019). Addressing animal welfare through collaborative stakeholder networks. *Agriculture*, 9, 132. <https://doi.org/10.3390/agriculture9060132>.
- Fernandes, J. N., Hemsworth, P. H., Coleman, G. J., & Tilbrook, A. J. (2021). Costs and Benefits of Improving Farm Animal Welfare. *Agriculture* 2021, 11, 104. <https://doi.org/10.3390/agriculture11020104>.
- Fraser, D., Weary, D. M., Pajor, E. A., & Milligan, B. N. (1997). A scientific conception of animal welfare that reflects ethical concerns. *Animal Welfare*, 6, 187–205.
- Grumbine, R. E., Xu, J., & Ma, L. (2021). An overview of the problems and prospects for circular agriculture in sustainable food systems in the Anthropocene. *Circular Agricultural Systems*, 1(1), 1–11.
- Gwaka, L., & Dubihlela, J. (2020). The resilience of Smallholder Livestock Farmers in Sub-Saharan Africa and the Risks Imbedded in Rural Livestock Systems. *Agriculture*, 10, 270. <https://doi.org/10.3390/agriculture10070270>.
- Haynes, R. P. (2011). Competing conceptions of Animals Welfare and their ethical implications for the treatment of non-human animals. *Acta Biotheoretica*, 59, 105–120.
- Heerwagen, L. R., Mørkbak, M. R., Denver, S., Sandøe, P., & Christensen, T. (2015). The role of quality labels in market-driven animal welfare. *Journal of Agricultural and Environmental Ethics*, 28(1), 67–84. <https://doi.org/10.1007/s10806-014-9521-z>.
- Horgan, R., & Gavinelli, A. (2006). The expanding role of animal welfare within EU legislation and beyond. *Livestock Science*, 103(3), 303–307.
- Kayumova, S., McGuire, C. J., & Cardello, S. (2019). From empowerment to response-ability: Rethinking socio-spatial, environmental justice, and nature-culture binaries in the context of STEM education. *Cultural Studies of Science Education*, 14(1), 205–229.
- Keeling, L. (2009). *An overview of the development of the Welfare Quality® Assessment Systems. Welfare Quality® reports no 12*. Cardiff University, UK.
- Kjærnes, U., Borgen, S. O., & Thorjussen, C. B. H. (2022). Behind a fluttering veil of trust: The dynamics of public concerns over farm animal welfare in Norway. *Sociologia Ruralis*, 62, 763–781. <https://doi.org/10.1111/soru.1240>.
- Knight, A., Phillips, C., & Sparks, P. (Eds.). (2023). *Routledge Handbook of Animal Welfare*. Taylor & Francis. ISBN 9781032022062.
- Korsgaard, C. (2005). Fellow creatures: Kantian ethics and our duties to animals. *The Tanner Lectures on Human Values*, 25, 77–110.
- Lawrence, A. B., Vigors, B., & Sandøe, P. (2019). What is so positive about positive Animal Welfare? —A critical review of the literature. *Animals*, 9, 783. <https://doi.org/10.3390/ani9100783>.

- Mboungho, N. O., Ibrahim, M., & Solefack, D. (2018). Evaluating constraints to animal Traction Development and sustainability in the Upper Noun Valley, North West Region Cameroon. *Asian Journal of Agriculture and Rural Development*, 8(1), 50–63. <https://doi.org/10.18488/ajournal.1005/2018.8.1/1005.1.50.63>.
- McCulloch, S. P. (2013). A critique of FAWC's five freedoms as a framework for the analysis of animal welfare. *Journal of Agricultural and Environmental Ethics*, 26, 959–975. <https://doi.org/10.1007/s10806-012-9434-7>.
- Meijboom, F. L. B. (2017). Ethics and the changing attitudes towards animals and their welfare, chap. 2. In F. Ohl (Ed.), R. Putman and members of DWM Utrecht. 2017. *The Biology and Management of Animal Welfare*. Dunbeath: Whittles Publishing.
- Mellor, D. J., & Beausoleil, N. J. (2015). Extending the 'Five domains' model for animal welfare assessment to incorporate positive welfare states. *Animal Welfare*, 24, 241–253. <https://doi.org/10.7120/09627286.24.3.241>.
- Mench, J. A. (2022). Animal Welfare: Science, Policy, and the Role of Veterinarians. Ethics in Kipperman B, Rollin, B.E. (Eds.): *Veterinary Practice: Balancing Conflicting Interests*, 21–41. <https://doi.org/10.1002/9781119791256.ch2>.
- Middleley, M. (1983). *Animals and why they matter: A journey around the Species Barrier*. Athens: University of Georgia Press.
- Ministry of Agriculture, Nature and Food Quality. (2019). *Plan of Action. The dutch government's plan to support the transition to circular agriculture, the Hague*. The Netherlands, Link: Plan of action - supporting the transition to circular agriculture | Policy note | Government.nl.
- Ministry of Agriculture, Nature and Food Quality of the Netherlands. (2018). *Agriculture, nature and food: Valuable and connected, the Netherlands as a leader in circular agriculture, the Hague, Link: The Netherlands, Agriculture, nature and food. valuable and connected - The Netherlands as a leader in circular agriculture | netherlandsworldwide.nl*.
- Nieuwland, J. (2020). *Towards an interspecies health policy: great apes and the right to health*, Doctoral dissertation, Leiden: Leiden University.
- Nussbaum, M. C. (2006). *Frontiers of justice. Disability, nationality, species membership*. Cambridge: Harvard University Press.
- OECD. (2023). *OECD Guidelines for multinational enterprises on responsible business Conduct*. Paris: OECD Publishing. <https://doi.org/10.1787/81f92357-en>.
- OECD/FAO. (2021). *OECD-FAO Agricultural Outlook 2021–2030*. Paris: OECD Publishing. <https://doi.org/10.1787/19428846-en>.
- Ohl, F., & Putman, R. J. (2014). Animal Welfare at the Group Level: More than the Sum of Individual Welfare? *Acta Biotheoretica*, 62, 35–45. <https://doi.org/10.1007/s10441-013-9205-5>.
- Ohl, F., & van der Staay, F. J. (2012). Animal welfare: At the interface between science and society. *Veterinary Journal*, 192, 13–19. <https://doi.org/10.1016/j.tvjl.2011.05.019>.
- Ojha, S., Bußler, S., & Schlüter, O. K. (2020). Food waste valorisation and circular economy concepts in insect production and processing. *Waste Management*, 118, 600–609. <https://doi.org/10.1016/j.wasman.2020.09.010>.
- Parris, K. (2011). Impact of Agriculture on Water Pollution in OECD Countries: Recent Trends and Future prospects. *International Journal of Water Resources Development*, 27(1), 33–52. <https://doi.org/10.1080/07900627.2010.531898>.
- Pinillos, R. C., Appleby, M. C., Manteca, X., Scott-Park, F., Smith, C., & Velarde, A. (2016). One welfare—a platform for improving human and animal welfare. *Vet Record*, 179, 412–413. <https://doi.org/10.1136/vr.i5470>.
- Poore, J., & Nemecek, T. (2018). Reducing food's environmental impacts through producers and consumers. *Science*, 360, 987–992.
- Randler, C., Ballouard, J. M., Bonnet, X., Chandrakar, P., Kumar Pati, A., Medina-Jerez, W., Pande, B., & Sahu, S. (2021). Attitudes Toward Animal Welfare Among Adolescents from Colombia, France, Germany, and India, *Anthrozoös*, 34:3, 359–374, <https://doi.org/10.1080/08927936.2021.1898212>.
- Rawls, J. (1972). *A Theory of Justice*. Oxford: Oxford University Press.
- RDA. (2017). *Advisory Report - Animal welfare for sale!* The Hague: Council on Animal Affairs (RDA).
- RDA. (2020). *Advisory Report - Animal Welfare in Circular Agriculture*. The Hague: Council on Animal Affairs (RDA).
- Regan, T. (2004). *The case for animal rights*. The University Press Group Ltd.

- Richter, S. H., & Hintze, S. (2019). From the individual to the population—and back again? Emphasising the role of the individual in animal welfare science. *Applied Animal Behaviour Science*, 212, 1–8. <https://doi.org/10.1016/j.applanim.2018.12.012>.
- Röös, E. B., Bajželj, P., Smith, M., Patel, D., Little, & Garnett, T. (2017). Greedy or needy? Land use and climate impacts of food in 2050 under different livestock futures. *Global Environmental Change*, 47, 1–12.
- Sandøe, P., Corr, S. A., Lund, T. B., & Forkman, B. (2019). Aggregating animal welfare indicators: Can it be done in a transparent and ethically robust way? *Animal Welfare*, 28, 67–76. <https://doi.org/10.7120/09627286.28.1.067>.
- Scherer, L., Tomasik, B., Rueda, O., & Pfister, S. (2018). Framework for integrating animal welfare into life cycle sustainability assessment. *International Journal Of Life Cycle Assessment*, 23, 1476–1490. <https://doi.org/10.1007/s11367-017-1420-x>.
- Schukken, Y. H., van Trijp, J. C. M., van Alphen, J. J. M., & Hopster, H. (Eds.). (2019). *The state of the animal in the Netherlands*. Den Haag: Raad voor Dierenangelegenheden.
- Shurson, G. C., & Urriola, P. E. (2022). Sustainable swine feeding programs require the convergence of multiple dimensions of circular agriculture and food systems with one health. *Animal Frontiers*, 12(6), 30–40.
- Singer, P. (1995). *Practical Ethics*, 2nd edition, Cambridge: Cambridge University Press.
- Tagarakis, A. C., Dordas, C., Lampridi, M., Kateris, D., & Bochtis, D. (2021). A smart farming system for circular agriculture. *Engineering Proceedings*, 9(1), 10.
- Tallentire, C. W., Edwards, S. A., Van Limbergen, T., & Kyriazakis, I. (2019). The challenge of incorporating animal welfare in a social life cycle assessment model of european chicken production. *The International Journal of Life Cycle Assessment*, 24, 1093–1104. <https://doi.org/10.1007/s11367-018-1565-2>.
- Tanzanian Government (2008). *Animal Welfare Act*, 2008.
- Torgerson, K. L., Meijering, J. V., Sok, J., Dicke, M., & Lansink, O. (2021). A.G.J.M. Towards circular agriculture – exploring insect waste streams as a crop and soil health promoter, *Journal of Insects as Food and Feed*, 2021; 7(3): 357–368, <https://doi.org/10.3920/JIFF2020.0095>.
- Umaru, M. A., Dalhatu, M., Bello, A., & Nawawi, H. (2013). Animal traction as source of farm power in rural areas of Sokoto state. *Nigeria Health Safety and Environment*, 1(1), 23–28.
- Van Zanten, H. H. E., Herrero, M., Van Hal, O., Röös, E., Muller, A., Garnett, T., Gerber, P. J., Schader, C., & De Boer, I. J. M. (2018). Defining a land boundary for sustainable livestock consumption. *Invited review in Global Change Biology*, 24, 4185–4194.
- Van Zanten, H. H. E., Van Ittersum, M. K., & De Boer, I. J. M. (2019). The role of farm animals in circular food systems. *Global Food Security*, 21, 18–22.
- Vogeler, C. S. (2019). Market-based governance in farm animal welfare—A comparative analysis of public and private policies in Germany and France. *Animals*, 9(5), 267.
- Von Keyserlingk, M. A. G., & Weary, D. M. (2017). A 100-year review: Animal welfare in the Journal of dairy science—the first 100 years. *Journal Of Dairy Science*, 100, 10432–10444. <https://doi.org/10.3168/jds.2017-13298>.
- Warren, M. A. (1997). *Moral Status: Obligations to persons and other living things*. New York: Oxford University Press Inc.
- Yeates, J. W., & Main, D. C. (2008). Assessment of positive welfare: A review. *The Veterinary Journal*, 175(3), 293–300.

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