

Animal Welfare in Circular Agriculture



COUNCIL ON
ANIMAL AFFAIRS

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Procedure

This advisory report from the Council on Animal Affairs (*Raad voor de Dierenaangelegenheden*, RDA) was prepared by a working group composed of RDA members Prof.dr.ir. I.J.M. de Boer (chair), Dr.ir. G.B.C. Backus, W.T.A.A.G.M. van den Bergh, Prof.dr.ir. J.W. Erisman, J.A.M. Huijbers and Prof.dr.ir. B. Kemp. The working group was expanded to include Dr.ir. R.A. Jongeneel, Wageningen University and Research (Agricultural Economics and Rural Policy Group), and Dr. L.M. Stadig, Young RDA.

The working group was assisted by Ir. R. Pothoven, deputy secretary, and Ir. M.H.W. Schakenraad, secretary of the RDA team.

For the purpose of preparing the report, the working group held four meetings, conducted individual interviews with the experts listed in Annex 1 and held an expert meeting with the experts listed in Annex 2.

The draft advisory report was submitted to the entire Council and Young RDA for assessment. This advisory report therefore is a product of the RDA as a whole.

Structure of the document

This advisory report begins with an introductory chapter on the reason, the central question and the guiding principles applied (Chapter 1).

In Chapter 2 we discuss the objective and principles of circular agriculture, the role animals can play in it and the interface between circular agriculture and animal welfare.

This is followed by a discussion of the possible consequences of a transition to circular agriculture for animals (Chapters 3-6).

The report ends with a concluding analysis (Chapter 7) and conclusions and recommendations for further actions (Chapter 8).

1. Introduction

1.1 *Background and reason*

In the past decade, the Dutch agricultural sector has focused on increasing production and reducing costs. This has compromised the quality of public values, such as biodiversity, soil, air, water, nature, landscape, climate and animal welfare. The wish has now been expressed to take the next step in the development of agriculture and our food system in a manner that prevents the further erosion of, and even restores, the quality of those public values. In her vision document 'Agriculture, nature and food: valuable and connected' published in September 2018, the Minister of Agriculture, Nature and Food Quality, Carola Schouten, states that it is essential to transition to circular agriculture (LNV, 2018). Even though this vision for the future is widely shared, it also raises numerous questions. What exactly is circular agriculture? Do animals play a role in circular agriculture, and if so, how can we protect and improve animal welfare in circular agriculture? Is animal welfare sufficiently on the radar in the discussions on circular agriculture?

The livestock farming sector forms an explicit part of the debate on the implementation of circular agriculture. On the one hand, it is clear that the current form of livestock farming is a serious drain on raw materials (land and water) and significantly contributes to environmental problems, such as acidification, eutrophication, climate change and loss of biodiversity (Poore and Nemecek, 2018). On the other hand, the livestock farming sector can specifically contribute to closing cycles because animals can convert biomass that humans are unable or unwilling to eat (brewers' grains, food waste, grass and hay) into food, manure and other ecosystem services, and thus recycle nutrients and carbon that would otherwise be lost to the food system (Van Zanten et al., 2018; 2019). This applies not only to 'traditional' animals, such as cows, sheep, pigs and chickens, but also to insects, for instance. Insects can live on biomass that is unsuitable for human or animal consumption and subsequently serve as a source of protein for humans or animals.

The discussions on the transition to circular agriculture, which is currently being considered, are in full swing. However, the RDA has found that in the various schools of thought, studies and visions insufficient light has been shed on the consequences for animals to date. Despite the increasing attention paid to animal welfare in recent years, that attention largely seems to be lacking in the discussions on circular agriculture. This has prompted the RDA to examine the effects of circular agriculture on animals.

1.2 Objective and question

The RDA aims to develop a vision on how the transition to circular agriculture can bring about an improvement in animal welfare (including health), in which animals constitute the starting point. By developing and disseminating that vision, the RDA aims to seek attention for the consequences of a transition to circular agriculture for animals.

The central question in this advisory report was:

"What implications will the transition to circular agriculture have for animal welfare?"

1.3 Guiding principles

The RDA's argumentation focuses on the animal's perspective and puts the animal first. The RDA has its own plan and planning schedule, but will actively approach the parties concerned to ensure that the RDA makes a useful contribution to the discussion on circular agriculture.

The following guiding principles were applied in this advisory report:

- *The focus initially lies on current farm animals (production animals).* A transition to circular agriculture is also likely to have consequences for wildlife. A further question is what the optimisation of cycles in agriculture and food production means for the countless domestic and hobby animals. For the sake of keeping the topic manageable, the RDA has initially limited its scope to the current farm animals, including animals that can be farmed in the foreseeable future (e.g. insects).

- *Animals will play a role in our food system in the years ahead.*

We have not discussed the ethical question whether we should keep animals at all for the production of our food in the context of this advisory report, but assume that animals can play a role in our food system. However, keeping animals for food production should in no way have consequences for animal welfare.

2. Circular agriculture

The circularity concept has its origins in both agro-ecology and industrial ecology and is aimed at preserving and managing natural resources for future generations. In a strict sense, the circularity concept focuses on the **ecological dimension** of sustainability (De Boer en Van Ittersum, 2018). Therefore circular agriculture is a form of agriculture aimed at producing food while maintaining public ecological values, such as fertile soil, clean air, pure water, a healthy climate, preserving the quality of the landscape, nature and biodiversity. It offers a promising perspective for one of the greatest present-day challenges: how can we produce sufficient, safe and healthy food for everyone within the Earth's carrying capacity? However, circular agriculture cannot focus solely on the ecological dimension of sustainability. Circular agriculture should also be economically viable (the **economic dimension** of sustainability) and socially responsible (**social dimension** of sustainability). A socially responsible food system fits into the socio-cultural context, produces food with respect for people and animals, and contributes to a fair distribution of raw materials (De Boer, 2012). Animal welfare is an element within the social dimension of sustainability rather than within the ecological dimension.

In this advisory report we explore the possibility of both implementing circular agriculture and improving animal welfare. To that end, we will begin by describing the interface of the circularity concept and animal welfare. The information used for this purpose has been derived from the literature, interviews with a number of experts (see Annex 1), and an expert meeting (see Annex 2).

As described in Denkkader Dierenwelzijn (Conceptual Framework Animal Welfare, RDA, 2018), not only animal health but also the opportunity to display species-specific behaviour and the emotional status of the animal are important for animal welfare. *'Animal welfare is the quality of life as it is experienced by the animal itself'* (Bracke et al., 1999). *An animal will experience a positive state of well-being if it is free to engage in normal behaviours that are typical of its species and if it is able to respond effectively to the challenges posed by the circumstances in which it finds itself* (RDA, 2018). We have also used this definition of animal welfare in our advisory report.

De Boer and Van Ittersum (2018) have formulated four principles for the concept of circularity in agricultural production (see box). According to principle 4, animals play a role in the cycle by **converting biomass that humans are unable or unwilling to eat into food, manure and other ecosystem services, such as the preservation of soil, biodiversity or the landscape**. Van Zanten et al. (2018; 2019) have shown that if

animals are fed solely on residual streams from the production of plant-based food (crop residues, food industry by-products, food waste) and grass, fewer natural resources will be needed worldwide to produce our food than at present.

Principles of the circularity concept in agricultural production

(De Boer and Van Ittersum, 2018; Van Zanten et al., 2019)

- (1) Plant biomass constitutes the basis for circular agriculture; and should be used primarily to produce food that is suitable for direct human consumption.
- (2) Avoid food losses and waste. Existing food losses should initially be used for the production of human food (e.g. De Verspillingsfabriek¹).
- (3) Residual streams arising from the production and consumption of plant-based and animal food unsuitable for direct human consumption (such as sugar beet leaves, straw, sugar beet pulp, leftover pulp from oilseeds², slaughterhouse waste), food waste unsuitable for human consumption, and animal and human excreta should be reused in the food system, or as manure for the soil or as animal feed. These organic residual streams contain valuable nutrients that must be retained in the food system.
- (4) Animals can convert these residual streams and grass³ into high-quality food and manure, and can also contribute to other ecosystem services, such as maintaining soil quality, nature or the landscape.
- (5) Use natural resources responsibly and sparingly, such as soil, water, air, biodiversity and nature (see also Erisman and Verhoeven, 2019). Choose the agricultural methods that contribute to fertile soil (e.g. mixed crops), minimise emissions from nutrients and carbon compounds into the air, water and soil (e.g. precision agriculture, shortening supply chains) and contribute to biodiversity (e.g. dairy farming on herb-rich grassland with trees and hedges).

Despite having reached agreement on these principles of the circularity concept in agricultural production, the pathway towards it is not yet clear. Two frequently asked questions and points of discussion are briefly explained below. This advisory report does not aim to elaborate on these questions in full.

1. On what scale should we close cycles? The optimum scale on which we intend to close cycles of nutrients and biomass streams will be determined by various factors. For example, certain areas are more suitable for producing certain products (e.g. north-

¹ See www.deverspillingsfabriek.nl

² Leftover pulp from oilseeds includes leftover sunflower seed pulp, leftover rapeseed/colseed pulp and leftover soybean pulp. From an economic viewpoint, leftover soybean pulp is not a by-product but a primary product (Mottet et al., 2017).

³ Where the term 'grass' is used in this document, it includes the Poaceae grass family and herbs.

west Europe has good grasslands suitable for dairy farming) because of differences in agro-ecological and socio-economic conditions between regions. These advantages may environmentally outweigh transport emissions, which means that local production may not always be the best option from an environmental perspective. This means, for instance, that we import kiwifruit, chocolate and coffee and export cheese. However, local production increases the transparency on where our food comes from and supports the local economy. Moreover, many countries consider a certain level of self-sufficiency important, which promotes shorter supply chains. The optimum scale on which we intend to close cycles therefore is context-specific and requires a comprehensive analysis of the above factors.

2. Does circular agriculture also mean that people should also eat less animal products? Van Zanten et al. (2019) have shown that if animals are fed solely on residual streams from the production of plant-based food (crop residues, food industry by-products, food waste) and grass, European consumption of animal products should almost be halved. The availability of residual streams and grass (animal feed) determines herd size, and therefore the availability of animal food. Some people emphasise that every human being ultimately individually determines how many animal products they want to eat. If European consumers would opt to eat more animal products, this means that feed would actively have to be produced on fertile arable land (that is also suitable for growing human food). However, technological developments may also reduce the role of animals in circular agriculture in the future. Future technology could enable us to produce the 'perfect meat substitutes', and to convert by-products and grass into high-quality food for human consumption without animal involvement. The ultimate consumption of animal products will be determined by a large number of interacting factors, such as technology, the market, tax arrangements, consumer behaviour and education.

Most of the experts acknowledge that animals will play a role in circular agriculture, in any event in the near future, and endorse the above principles (see Annex 1). Minister Schouten has also drawn inspiration from the principles of De Boer and Van Ittersum (2018) in drawing up her Plan of action 'The Dutch government's plan to support the transition to circular agriculture' (Ministry of Agriculture, Nature and Food Quality, 2019).

The Plan of action states, for example that we should increase the share of residual streams as a raw material for animal feed, and should obtain the raw materials from less distant regions". We should also make better and different use of residual streams and try to use raw materials and resources more efficiently by extracting nutrients from animal and human excreta.

The Plan of action also states that an important condition is that residual streams contribute to good feed for healthy animals and that no risks arise for the health of people, animals and the environment. **However, as the RDA, we argue that animal welfare, and not just animal health, should be a requirement for the development of circular agriculture.**

In the following chapters we describe the most important interfaces (in terms of opportunities and threats) between the circularity concept and animal welfare. We focus primarily on the role of animals as processors of residual streams and grass. The RDA is very well aware, however, that animals fulfil a far wider role in the larger agro-ecosystem and are essential for preserving soil quality, biodiversity, nature and water and nutrient cycles. In many low-wage countries animals moreover fulfil the function of tractive power (ploughing the land), or social or financial capital, for instance (bank function).

3. Feeding animals in circular agriculture

Residual streams occur in each step of the food value chain (Figure 1), during crop production and harvesting, during storage, during food processing, and in food retail and consumption. What does the use of these residual streams mean for animal health, species-specific behaviour and emotional status (feeling hungry, satiation, boredom and a positive state of mind)?

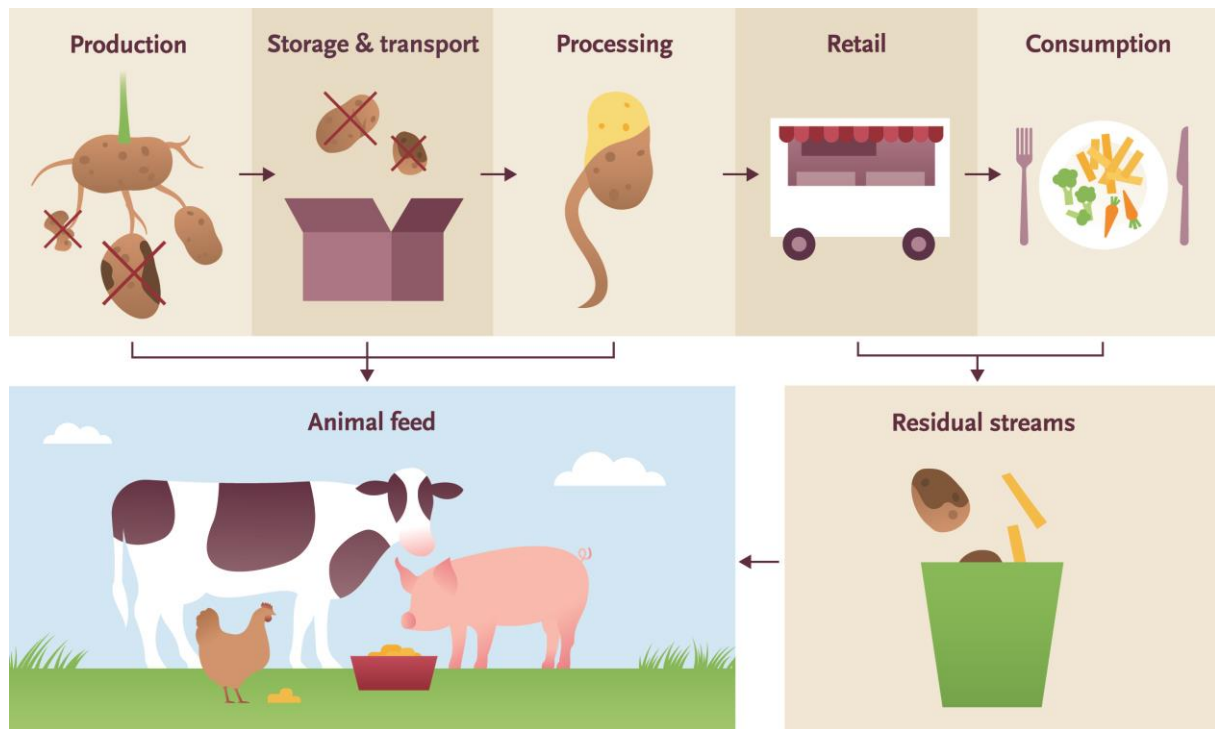


Figure 1. Residual streams occurring in the food value chain.

Various experts highlighted the importance of the safety of residual streams, primarily in relation to human and animal health. The presence or absence of physical residues (including plastics), chemical residues (including heavy metals, medicines, biocides such as disinfectants, preservatives, such as pesticides), or biological infections (including bacteria, viruses and prions) determine the safety of residual streams. Examples given by the experts in this context include the risk of foot-and-mouth disease (FMD), classical swine fever (CSF) and mad cow disease (BSE) when animals are fed with swill. The risk of these diseases arises when feeding swill as a result of feeding household animal food waste (or household waste contaminated with an animal product) to cattle, pigs or chickens, which is currently prohibited by law. In order to feed swill safely to animals, plant and animal residual streams could be completely separated in the future.

DNA technology could be used (such as polymerase chain reaction) to guarantee that certain residual streams are entirely plant-based. The plant-based residual streams could subsequently be fed to various animal species, the animal residual streams could be fed only to farmed fish or insects, for example. We could also opt to heat swill centrally at 70-80 °C, which will destroy the viruses that cause FMD/CSF, but will not neutralise the prions that cause BSE. The feed cannot subsequently be fed to cows (to prevent BSE) but it can be fed to pigs, poultry, farmed fish or insects. The above shows that safely feeding swill, for example, to animals requires all links in the chain to think in terms of circularity and to work together.

Apart from swill, many residual streams are already being used as animal feed, such as bakery waste, leftover pulp from oilseeds⁴, sugar beet pulp or potato steam peel. In addition to using residual streams in animal feed, we could also use animals to remove crop residues or post-harvest losses from the land (e.g. allow cattle or chickens to 'graze' on harvested grain fields). However, the digestibility and nutritional value of these crop residues and any potential contaminants they may contain will need to be taken into consideration.

Table 1. Examples of animal health risks arising from the use of current residual streams in animal feed, identified during the expert interviews (Annex 1).

Physical residues	<ul style="list-style-type: none"> • Plastic from unpacked retail products • Soil
Chemical residues	<ul style="list-style-type: none"> • Mycotoxins in grain/maize/straw • Aflatoxin in leftover pulp from oil crops
Biological residues	<ul style="list-style-type: none"> • From swill: foot-and-mouth disease, classical swine fever, BSE • From soil in feed: Listeria/Clostridium

Source: Expert interviews, and <https://www.gddiergezondheid.nl/bijproducten-voeren>.

Table 1 provides an impression of the animal health risks associated with the current use of residual streams. If the share of residual streams in animal feed increased as a result of circular agriculture, this may also mean that the health risks could increase. New, currently unknown, health risks could also arise.

⁴ Leftover pulp from oilseeds includes leftover sunflower seed pulp, leftover rapeseed/colseed pulp and leftover soybean pulp. From an economic viewpoint, leftover soybean pulp is not a by-product but a primary product (Mottet et al., 2017).

There currently is insufficient insight into the increasing risks of the share of plastic, for instance, in animal feed. Feeding animals with more residual streams requires that we start thinking in cycles both for processing, collecting and during quality control.

Not only is the safety of residual streams important, the nutritional quality is equally important. The experts pointed out that some residual streams may contain fewer nutrients than needed, and that a diet based only on residual streams could lead to nutrient deficiencies, causing sickness or disease (e.g. osteoporosis in the event of a shortage of phosphorus, or the animal may display harmful and aggressive behaviour in the event of a shortage of certain digestible amino acids (Van der Meer et al., 2017)). A shortage of nutrients could potentially be supplemented with supplements consisting of minerals/essential amino acids. Adapting the production process by optimising the quality of both the primary product and the residual streams is another suggestion put forward for improving the quality of residual streams used for animal feed. Various experts also stated that we would need to adjust the animal's production level and probably the breed as well in line with the quality and quantity of the available residual streams/grass. A cow that is only fed with grass and residual streams may produce less milk. This means that we will produce fewer animal products per animal but that production will be in line with public values. Moreover, lower production per cow often means fewer production-related reproduction problems and metabolic disorders, which is positive for animal welfare. However, this is subject to the condition of keeping animals that also have a lower production level, genetically (See Chapter 6).

Not only safety and nutritional value, but also the flavour and digestibility of the feed may affect animal welfare. An expert pointed out, for example, that food that is too easily digestible by pigs may cause bowel disease, such as ileitis (commonly referred to as PPE), which is caused by the *Lawsonia intracellularis* bacterium. Health problems such as ileitis can be prevented by using pre-fermented feed, which reduces pH levels and therefore inhibits bacterial growth (Van der Meulen and Van der Peet-Schwering, 2007). Other experts stated that residual streams are voluminous and may have a relatively high fibre content. This property of some residual streams means that animals may have a lower feed intake and consequently absorb fewer nutrients, but it may also have a positive effect on well-being. Feed that is digested more slowly and has more volume promotes satiety and increases the time for feed intake (less boredom and a lower risk of harmful behaviour (Rodenburg et al., 2013 and Van Krimpen et al., 2008)).

One final point stated by various experts is the fact that the supply of residual streams is discontinuous and is not of consistent quality. A constant uniform supply of feed may

therefore be more difficult to achieve. Should that be the case, we may also need to select animals that are more resistant to fluctuations in the supply and quality of feed. A system in which the fluctuating quality and quantity of feed causes animals to feel hungry, become ill or compete for food is undesirable. The number of animals in such a system must be properly aligned with the availability of residual streams and grass.

In conclusion, a complete overview of the effects of feeding residual streams to animals on health and behaviour is currently not available. Furthermore, the current agro chain is specialised, and has not been designed from the perspective of the circularity concept. In industrial design, reuse and zero waste are already factored into product design process. This principle could also be more rigorously applied in the agro food chain. This requires a redesign of our food system, in which the reduction of losses and optimum use of the various streams in food production have already been factored into its structure and the production aspects.

4. The value of manure in circular agriculture

For circular agriculture it is essential that manure from animals, which feed on biomass that is unsuitable for humans, is used to produce crops that extract nutrients from the system. For this reason, the manure must be of the highest possible quality and it must be optimally used in the food production system. Nutrient losses represent additional leaks from the cycle. The question is what effects the optimisation of manure use and manure quality could potentially have on animal welfare.

Experts primarily highlight the importance and the opportunities for utilizing animal manure more effectively in agriculture. Insects could also play a role in this process. The importance of reusing nutrients in human excreta was only mentioned a few times. However, research has revealed that the non-reuse of nutrients in human excreta leads to significant losses of phosphorus, for example, a nutrient that is extracted from phosphorus ore, a finite raw material. Minister Schouten states the importance of extracting nutrients from human excreta in her Plan of action but has not linked any concrete actions to it. The reuse of human excreta in the food system imposes special requirements on collection, processing and reuse to prevent contamination. The effect of medicine residues on soil life and aquatic life in surface water (including fish) is an aspect that should be considered for the reuse of both human and animal excreta.

Various experts stressed the importance of separating urine and solid manure at the source by designing and applying new stable concepts ('put an end to slurry manure/the manure basement'). It is easier to process these separate products into fertilisers for the production of our food. The separation of urine from manure can also significantly reduce ammonia emissions, which may have a favourable effect on the environment and the stable climate (positive for human and animal health and welfare). Where animals have outdoor access, this may mean that outdoor access may need to be redesigned because some of the manure is also deposited there.

5. Animal housing in circular agriculture

The principles of the circularity concept as described in the box in Chapter 2, focus primarily on the preservation and management of natural resources, and provide scope for making choices in housing and business operations. The diversity in possible solutions is essential, and also provides scope for entrepreneurship. The guiding principle of the RDA is that animal welfare should be guaranteed in every housing system.

Some experts automatically think of housing animals outside to a greater extent in circular agriculture and have identified the associated opportunities for and threats to animal welfare. The main opportunities they have identified are: a positive contribution to animal welfare, because animals will be able to display their natural behaviour (such as grazing, rooting and roaming around), there will be greater variation in the environment/freedom of choice and they will be able to experience the outside air. Another aspect identified was the contribution to landscape management of cows grazing on pastures and the preservation of biodiversity. The main threats they have identified are health risks, such as bird flu in poultry, tetanus/Weil's disease/skin burn in pigs and liver fluke in cattle grazing in wet pasture.

Housing systems without outdoor access can also be used in circular agriculture. Animal welfare should be central to the design of such a housing system. An example is an egg production poultry farm with an animal welfare-friendly stable, and a covered outdoor run (such as an inside garden), where the animals are only fed with residual streams from the bakery and oil industries. Furthermore, farmers are free to choose the size of the farming business or the degree to which technology is used in circular agriculture. The guiding principle for any form of agriculture, including circular agriculture, applied by the RDA is always 'production with respect for animal welfare' in line with public values. The RDA considers it the government's duty to clearly establish guiding principles for good animal welfare in circular agriculture, and the duty of the RDA to provide advice.

The wide range of potential housing systems described by the experts clearly shows that shifts exist, for instance, between the environment and animal welfare. A prime example described by one of the experts is the pen stable/straw stable used in dairy farming. Litter stables are generally positive for animal welfare but can lead to relatively higher greenhouse gas emissions from the stable. Conflicts may also exist within the theme 'environment'.

Compared to slurry manure, the use of deep stable manure is favourable for the amount of organic matter in the soil, for instance, but is unfavourable for ammonia emissions, if badly managed. A stable system ultimately is a component of a farming system and the performance of the entire farming system will need to be assessed in line with the quality of public values (Pijlman et al., 2018).

6. What animals are suitable for circular agriculture?

Animals differ in terms of their ability to convert residual streams and grass into high-quality food and other ecosystem services. That ability is influenced by factors including the animal species, the breed and the production level. Experts highlighted the unique role of ruminants in circular agriculture because they can utilise grass and grass products and thus contribute to the production of high-quality food for humans (milk and meat), manure and other ecosystem services. Chickens can convert high-quality residual streams (such as bakery waste) into eggs and chicken meat in a highly effective manner. The potential of using pigs as animals in circular agriculture was also stated. Pigs can also digest most types of human food, and seem to be able to digest liquid feed (wet feed) properly. However, food waste is also extremely suitable for farming insects, which humans should subsequently eat. Feeding these insects to animals is less efficient from an ecological point of view (this is an additional step in the food chain), which constitutes an argument in favour of the direct human consumption of insects. However, insects can also utilise residual streams that other farm animals are unable to utilise effectively, if at all. The answer to the question of what combination of animal species can most effectively convert specific types of residual streams into high-quality food is not yet known.

Apart from the animal species, the breed and the production level additionally affect the animal's ability to utilise residual streams and grass. High-yielding cows need sufficient energy and digestible protein. Feeding a cow that is genetically capable of producing high yields of milk only on residual streams and grass means that it will be unable to reach its production potential, which may cause animal welfare problems. In this context, various experts have pointed out that we would need to adjust the maximum production level of the animal in line with the quality and quantity of the available residual streams/grass. A cow that is only fed with grass and residual streams, for example, is likely to produce less milk. The average annual milk production in New Zealand, which operates an entirely pasture-based farming system, is 5,000 kg per cow (compared to 8,684 kg in the Netherlands in 2018). Only feeding residuals streams and grass therefore influences the choice of breed and breeding programme as well. The choice for a lower yielding and more robust animal, however, can also be positive for animal welfare (fewer reproduction problems in dairy cows, fewer leg problems/cardiovascular problems in broiler chickens, lower piglet mortality among pigs due to smaller litters). The physiology of the animal is the guiding principle in this quest for the appropriate utilisation of residual streams and grass by various animal species. A diet that is suitable for the animal's physiology will also lead to improved animal welfare. In addition, biological (the use of moulds) or

technological processes (innovative industrial techniques) can improve the utilisation of residual streams for animals. However, new technological processes can also be applied to make residual streams fit for direct human consumption.

It is currently not clear what types of residual streams and grass products are available, where they are in the world, and what animals with what production level are the most suitable. However, the research on this question is well underway (see, for example, Van Hal et al., 2019; Van Zanten et al., 2019). Experts also pointed out that the speed with which farming businesses can switch to a new breed/lower-yielding animal, varies. Poultry and pig farms can switch to another breed faster than dairy farms as dairy cows have a longer lifespan than poultry and pigs. The question is whether it would make sense to set up a separate breeding goal for breeding animals that are suitable for circular systems, or whether we can use the existing breeds or cross-breeds in the world.

7. Concluding analysis and conclusions

According to the RDA, animals play an important role in circular agriculture. Animals can utilise and convert residual streams and grass into high-quality human food, and thus utilise nutrients and carbon that would otherwise be lost to our food system. In addition to food production, animals (particularly ruminants) can also contribute to other ecosystems, such as maintaining the landscape or biodiversity, and improving soil quality.

The circularity concept is themed around “*life within the Earth’s carrying capacity*”, in other words the ecological dimension of sustainability (planet). Therefore, the aim of circular agriculture is to produce food while maintaining public ecological values, such as fertile soil, clean air, pure water, a healthy climate, the quality of the landscape, nature and biodiversity. Furthermore, circular agriculture should clearly be economically viable (profit) and embrace the social values of society (people). Animal welfare is an important theme within the social dimension of sustainability and therefore does not fall within the ecological dimension.

Good animal welfare practices (and not just animal health) should be a guiding principle for any form of agriculture, including circular agriculture. Given that animal welfare is not automatically included in the circularity concept, it requires separate attention. People are treating animals with greater respect and do not want to see animals suffer (RDA, 2019). Any new agricultural system, including circular agriculture, should also lead to an improvement in animal welfare. The RDA considers it the government’s duty to clearly establish guiding principles for animal welfare in circular agriculture, and the duty of the RDA to provide advice.

By extension, the RDA believes that it also is the government's duty to provide clarity on the future environmental operating space for food production in the Netherlands (emission limits, biodiversity preservation requirements at both national and regional level). Providing insight into the environmental operating space in the long term, along with fundamental animal welfare principles, will enable farmers to choose various context-specific solutions for circular agriculture (shown in Figure 2 as the *Safe and just operating space for food production*), and will foster entrepreneurship.

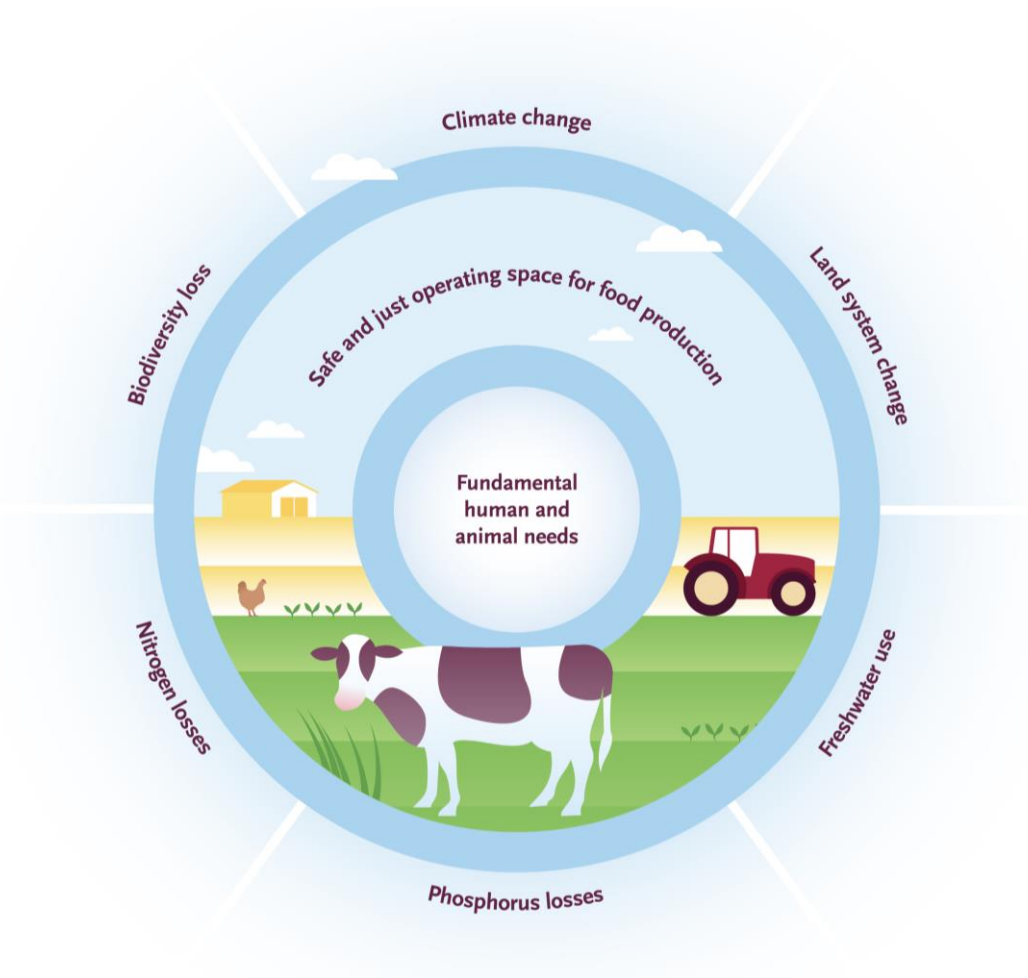


Figure 2. Determining safe and just operating space for sustainable food systems (De Boer et al., 2019). The operating space for agricultural entrepreneurs is determined by the ecological ceiling (such as nitrogen losses and loss of biodiversity), on the one hand, and by the social foundations, our social values (such as animal welfare and working conditions), on the other.

Conclusions

The most relevant conclusions of this advisory report are as follows:

- The improvement of animal welfare (*including health*) will not occur automatically in circular agriculture. In the RDA's opinion, circular agriculture that includes a role for animals will only be successful if good animal welfare practices are a requirement.
- Circular agriculture poses both opportunities for and threats to animal welfare. This applies to animal feed, housing and suitability in particular. Little is known to date about these specific opportunities and threats.
- Circular agriculture calls for a redesign of our food system, in which all dimensions of sustainability (people, planet and profit) are already factored into its structure and the production aspects.

8. Recommendations

Based on this advisory report, the RDA has formulated the following recommendations:

1. **Put animal welfare first in the transition to circular agriculture** and translate concepts of 'positive animal welfare' to livestock farming systems. Utilise the transition to move forward in building a humane livestock farming sector. The RDA believes it also has a role to play in this regard and will consider the nature of such a humane livestock farming sector and the pathway leading to it.

2. **The transition to circular agriculture represents a system change and requires time. The government, the business sector and NGOs should utilise that time to take a number of necessary steps to protect and improve animal welfare:**
 - Invest in a research agenda and provide multi-year financing.
 - Establish a Centre of Expertise for Animal Welfare (source of information, knowledge exchange) for entrepreneurs who want to embark on the transition to circular agriculture.
 - Appoint an advisory committee (or assign that role to the RDA) to improve and protect animal welfare in circular agriculture, with participation of various stakeholder representatives (the business sector, NGOs and the government). The advisory committee can work on various tasks, including the following:
 - formulating innovation tasks and questions relating to animal welfare and circular agriculture for the Knowledge and Innovation Agenda of the Agri & Food Top Sector;
 - identifying the parameters for monitoring animal welfare;
 - advising on protecting animal welfare, potentially institutionally.

3. **Strengthen the network and coordination in Europe in order to develop circular agriculture with a focus on animal welfare in a European context as well.**

A level playing field is required within Europe and this implies that European support must be sought. Utilise the European animal welfare bodies, where possible.

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Annexes

Annex 1: Interviews with experts

Sixteen interviews were conducted with various experts (18 people in total).

The following experts were interviewed:

Johan van Arendonk, Hendrix Genetics

Saskia Arndt, Utrecht University

Herman van Bekkem, Greenpeace

Iris Boumans, Wageningen Livestock Research

Marc Bracke, Wageningen Livestock Research

Joep Driessen, Cow Signals

Martin Houben, Houbensteyn Varkens

Leo van Raamsdonk & Elise Gerrits, Wageningen Food Safety Research

Frits van der Schans, CLM

Frederieke Schouten, Caring Vets

Arjan Stegeman, Utrecht University

Karel van der Velden, Nijsen Granico

Frank Verhoeven, Boerenverstand

Cynthia Verwer & Jan-Paul Wagenaar, Louis Bolk Institute

Inge Vleemigh, De Goed Gevulde Spaarvarkens

Carel de Vries, Stichting Courage

Each expert considered and answered the interview questions based on their own area of expertise and provided their views on what circular agriculture might look like. The primary objective of the interview session was to gather information on the potential risks and opportunities for animals in the transition to circular agriculture (questions 1-6 below). In addition, the experts were asked a number of questions focusing on the broader context and a possible follow-up process (questions 7-11).

Interview questions

GENERAL

1. What will the significance of livestock be in circular agriculture and what position could/should animals occupy in it?

FOCUS

2. What are the critical factors for animals in the transition to circular agriculture? Are the potential risks to animal welfare and health different in the short term to those in the long term?
3. What does feeding residual streams mean for animal welfare and health?
4. What does circular agriculture mean for the introduction of animal diseases and for animal husbandry-related public health risks (e.g. zoonoses, food safety)?
5. What animals with what specific characteristics are suitable for circular agriculture? What animals are not?
6. What animal husbandry systems are the most suitable for circular agriculture? What animal husbandry systems are not?

INTERPRETATION

7. Are there consequences for animal breeding, food and husbandry?
8. What will the consequences be of a transition to circular agriculture for non-farmed animals (e.g. meadow birds, soil life)?
9. Have the national agriculture-related research agendas sufficiently taken animals into account in circular agriculture?
10. What is the most effective allocation of roles (between the business sector, NGOs and the public authorities) in the transition to circular agriculture for achieving an improvement in animal welfare and health?
11. Have the risks to animals in circular agriculture been reduced to a sufficient extent?

1 *Role of livestock farming in circular agriculture*

A considerable number of experts regard circular agriculture more as a development direction rather than an objective in itself. Each of the interviewees believe that there is a role for animals in circular agriculture: at present, animals are the only way of closing the cycle. They can convert low-value plant-based proteins into high-value protein that is suitable for human consumption. In addition, the role of animals could consist of providing ecosystem services, cultural/landscape value (cows and sheep grazing on pastures), manure and other by-products (e.g. leather). The connection between the presence of the food industry and in particular pigs in the Netherlands was also highlighted; as long as there is a food industry, there will be numerous residual streams. Where pigs are linked to the presence and use of residual streams, cows are mainly linked to the presence of pastures. However, some experts see a distant future in which the emergence of meat substitutes and/or technological developments will reduce the need for animals for the utilisation of low-value plant-based residual streams.

2 *Risks and opportunities for animal welfare and health*

2.1 Food

The most frequently stated risks to animal welfare and health concern the expected changes in their food. This is not surprising as circular agriculture largely encompasses the use and reuse of plant-based residual streams, either originating from the human food system, or from crops that are unsuitable for direct human consumption. Although many residual streams are currently also used as animal feed, this will increase significantly in circular agriculture. At the same time, crops grown specifically for animals will decline, if preference is given to using arable land for growing crops for human consumption. Depending on the extent to which the experts expect these developments to occur, they expect more or fewer food-related risks to animals. The risks mainly relate to the expected changes in the quantity, quality and continuity of feed.

The potential risks identified are as follows:

- The accumulation of undesirable substances in the cycle and as a result in animal feed in the longer term. New raw materials could also currently contain as yet unknown undesirable substances.
- Any toxins and pathogens in residual streams pose a risk. Feeding residual streams (with undetected meat waste, e.g. from processed products) may involve the risk of transferring CSF. If the use of swill is reintroduced, a water-tight system will be required for pre-treatment/heating.

- Mainly health problems arising from switching to different feed. This could primarily occur in the short term when using the current breeds of animals because they may be extremely sensitive to them. In that case, this will also have consequences for animal breeding and the choice of breed.
- The focus on raising efficiency abolishes the 'insurance premium' of giving something extra. This may lead to animals receiving insufficient minerals and vitamins, especially when fed with low-value residual streams, but more intensive systems also pose risks as a result of focusing on efficiency and reducing emissions (e.g. bone disorders caused by a shortage of phosphorus. Insufficient protein can affect fertility and resistance, and reduce the animal's life (which is less efficient). This risk will occur primarily in the transition period (comparable with transitioning from conventional to organic agriculture).
- If animals cannot meet their energy needs, this will have consequences for their welfare.
- If pigs are fed with too much easily digestible feed (insufficient structure), they will run the risk of bowel disease (PIA).
- The lack of structure for high-yielding cows, if they are fed with large quantities of residual streams. This will reduce their lifespan.
- Many residual streams are difficult to preserve (moist, moulds), which reduces the quality and causes diarrhoea in pigs for example.
- Pigs kept outside (less hygienic environment) have a higher risk of diseases, such as tetanus and Weill's disease.
- If pig farmers mix feed from residual streams themselves, errors may occur (e.g. too much salt). Wet residual streams also vary in quality and composition. Excess protein causes diarrhoea. If the nutrient ratio is incorrect, the animal will produce more (or another composition of) fat and less meat; it is not known whether this makes the animal feel better or worse.
- Liquid feed for pigs is acidified and can cause tooth decay. This is not noticeable in pigs fattened for eating (porkers) because they are slaughtered when they are still young. If liquid feed is also fed to sows, this could be a problem.
- Ruminants may not be fed with animal protein through residual streams (the cause of BSE in the past).
- In an extensive natural husbandry and feeding system, animals may be hungry for part of the year. Insufficient feed can also cause animals to compete for feed. In that case, veal farming will not be viable, posing the risk of the same problem occurring as day-old male chicks (surplus production of young animals with no commercial value).
- Eating means more for an animal than simply digesting feed. Herd animals eat and sleep as a group simultaneously. Eating also has a function for mobility and a mental

aspect. Animals can also digest food better if they move around more and eat unprocessed feed. Can animals in circular agriculture still explore and forage in order to meet their natural needs?

- In principle, freedom of choice in eating is favourable for animal welfare, but animals could also make choices that are not good for them (e.g. overeating).
- The quality of plant-based residual streams is too low if the producer regards it as waste. The producer will also need to recognise a residual stream as a product.

Changes in feed can also improve animal welfare and health:

- Greater variation and more volume in feed could lead to improved animal welfare (possibility to choose, spending time foraging to avoid boredom, eating according to the animal's needs, more natural behaviour).
- The welfare of a cow that only eats grass to produce milk may well improve.
- If circular agriculture becomes more extensive than at present, it will probably be better for animal welfare (more natural behaviour).
- Fewer problems with salmonella and enteritis because the pH in liquid feed for pigs is lower (pH 4).
- Replacing feed grain with food residues would be an improvement because feed grain contains moulds and suchlike.
- Fermenting pig feed will improve bowel health, which will reduce the need for antibiotics.

2.2 Animal husbandry systems

With a view to animal welfare and health, it is important to know whether a transition to circular agriculture will also lead to other farming systems (stable types, keeping animals inside or outside and suchlike). The experts expect that a different type of manure collection system that separates urine and manure will be introduced mainly for cows: "The end of slurry manure and the manure basement". This could have a favourable effect on animal welfare as a result of a better stable climate. Whether pigs or chickens will spend more time outside than at present is regarded as a discussion separate from circular agriculture by some of the experts. They believe that there are various disadvantages to providing animals outdoor access (e.g. the risk of bird flu), which in their view really is undesirable. If animals are primarily kept inside for that reason, particular attention will need to be paid to animal welfare.

An overview of expected (or desired) developments:

- There often is tension between animal welfare and the environment. In dairy farming, for instance, pen and straw stables are the best options for animal welfare, but they

have an adverse impact on the environment (emissions). A livestock farmer is therefore unlikely to choose these types of stables.

- Digitalisation can create an animal husbandry system that constantly monitors how the animal feels. Animals should preferably be monitored individually rather than as a group.
- No more separate end-of-pipe measures but more integrated sustainable farming systems.
- Large-scale and small-scale farming systems will continue to exist.
- The rise of mobile systems for small-scale animal husbandry systems that can be moved and follow the harvest residues.
- More extensive farming systems, in which animals can eat their food in a more natural manner.
- Large-scale stables can be extremely well engineered for the environment and climate, but will not provide animals outdoor access because animals that live outside are more difficult to manage in terms of emissions and food safety.
- Keeping smaller numbers of animals and feeding them with various residual streams to avoid 'epicentres' occurring if something goes wrong.
- A system will be created with many local processors based on past practices, while retaining the current safety levels.
- Open dairy stables without air washers because cows need a dry resting area and a dry floor to prevent mastitis and lameness. Air washers are likely to cause more sickness in cows, which may result in higher methane emissions per kg of milk produced due to cows' shorter lifespan.

The experts have also identified potential risks and opportunities associated with other animal husbandry systems.

Risks:

- In an effort to reduce emissions, there is a risk that the current technology (e.g. air washers with problems such as the risk of fire and poorer air quality in the stable) will also be used for cows, goats and calves.
- Many of the current dairy stables and cow mats already pose a high risk of lameness and related injuries (thick soles) and metabolic disorders. These stables should no longer be used in the future.
- In new farming systems where animals live outside, sufficient shelter facilities should be provided (overhead roofing).

- Animals will be kept outside in an uncontrolled environment, which is undesirable from a risk management, control and monitoring point of view (unknown food intake, risk of animal disease, sunburn in pigs).
- If low-grade straw is used in stables, it may contain high levels of mycotoxins. High levels of certain mycotoxins can cause various health problems.
- If poultry are kept outdoors, there is a high risk of elevated dioxin levels in eggs (due to the ingestion of soil). This is actually a public health risk.

Opportunities:

- New animal-focused housing systems can be developed so that they can accommodate animals' needs and their ability to adapt naturally.
- Considerable gains can be made in animal health by providing better housing systems for cows (deep straw bedding instead of cow mats, stress-free calving line, feeding space of at least 70 cm per cow, more water, air and light).
- Pigs like slurping their food and the use of residual streams is appropriate for a liquid feeding system. Liquid feed also saves energy and drinking water because there is no need to dry the feed beforehand.
- A mixed farm including nature would be appropriate for circular agriculture. However, this would need to be more intensive in the Netherlands than only using marginal land for livestock.
- The stable climate could be improved by preventing emissions at the source with the separation of manure and urine (better for animal welfare, the environment/climate and public health).

2.3 Animal species, breeds and breeding

It can generally be argued that the more natural the farming system is the more the animals will need to be able to keep themselves alive. Many of the desired animal characteristics identified are associated with this: robust, slower growing, dual purpose, strong gastrointestinal system, greater genetic diversity, placid. Of the various production animals, chickens were mainly identified as the least tolerant to different feed. The dairy farming experts primarily regard cows as the ideal animal in circular agriculture (it processes grass and some residual streams). The pig farming experts primarily regard pigs as the most suitable. While some experts regard insects, rather than pigs, as residual stream processors in the future, other experts believe that insect farming systems will be unviable due to their high energy requirement.

Expected developments:

- Dual-purpose animals will be used more; old breeds and genetics should again be used.
- More robust animals are needed that are more tolerant to variable feed and can keep themselves alive (can withstand bad weather, give birth naturally without intervention).
- Greater focus on lifespan to reduce losses.
- Slightly lower production level, slightly slower growth.
- Greater genetic diversity.
- Animal health and welfare will become more important in animal breeding.
- Animals will also need to adapt to new housing systems.
- The ratio between animal species (numbers) will change.
- The use of insects to produce protein.
- Economic need: animals that have a high carcass utilisation.

Potential risks:

- The usual manner of working more efficiently is to make animals grow faster and/or higher animal production levels. The expected animal welfare and health problems arising from fast growth are already known (e.g. cardiovascular and leg problems in pigs, breastbone injury in chickens, high pig mortality rate caused by larger litter size).
- Waiting too long to change to a more suitable breed poses risks to the welfare and health of the animals kept at that time.

Opportunities:

- A dairy farmer in circular agriculture will also endeavour to produce as much milk as possible with the least possible phosphorus rights (if they still exist in the future). The farmer will maintain fewer young livestock but will need to ensure they are well-cared for. Ageing cows are in the farmer's interests and he will therefore need to ensure that they too are well-cared for.

3 Risks of animal disease and public health risks

The RDA has also endeavoured to obtain a picture of the potential risks of animal disease and the public health risks. In this respect, circular agriculture in itself does not need to entail more risks, but other risks may potentially arise. Various experts have pointed out that these types of risks strongly depend on the feeding and farming systems that will be created. There may also be counteractive effects. A circular agriculture system with more extensive forms of farming and a lower total number of animals, for instance, could

reduce the spread of diseases due to the lower livestock density. In principle, the more local the cycle is, the lower the risk will be of introducing animal diseases

These advantages would be negated, if higher numbers of animals are given outdoor access, because they will face a higher risk of contracting an animal disease. Moreover, broadly speaking, the full extent of the microbial safety of feed, manure and animal products is currently not yet known and requires further research.

A number of specific risks identified in this context are as follows:

- Animals in circular agriculture should not become a waste disposal facility and therefore an effective control system will need to be put in place for residual streams (by the government).
- The prevailing views on litter stables for dairy cows are far too favourable. Litter stables produce other types of emissions (methane, CO₂). Bacteria (thermophilic spore-forming bacteria) and suchlike can be blown outside when air is blown through the straw in these types of stables. Various requirements currently exist in this area for goat farming; the risks in dairy litter stables are of a similar nature.
- If the waste stream from humans is integrated into the system (mainly on land), risks are attached (medicine residues, hygiene).
- If manure is transported to other areas, bacteria and suchlike will also be transported.
- Veterinary risks may arise if insufficient attention is paid: FMD, ASF, BSE
- If wet natural areas (marshlands) are integrated into the circular system, this will pose additional risks to animals (liver fluke, salmonella) and humans (if they use these areas for recreational activities).

Possible reasons for fewer risks:

- Circular agriculture can lead to a more diverse animal system with a lower risk of disease.
- Small-scale farms that use residual streams are often closed systems where fewer 'encounters with outsiders' occur and fewer new animals are supplied.

4 Consequences for non-farmed animals

The RDA has decided to focus only on the consequences for the current production animals in this advisory report for the time being. However, during the interviews the experts were also asked to identify any potential consequences for non-farmed animals for exploratory purposes. That question proved to be more difficult for most experts to answer than for production animals, which produced a limited 'yield'.

The potential consequences identified were as follows:

- If circular agriculture leads to extensivisation (possibly on part of the agricultural land), this could be beneficial to non-farmed animals.
- If more straw stables are used, this would be better for meadow birds and soil life.
- It could create greater competition for food, which could also lead to the diversification of animals. Animals could be hungry, if there is insufficient food, but that is not an animal welfare issue at population level, but at an individual animal level.
- If marginal soil types deteriorate as a result of intensive use, soil life could diminish.
- If circular agriculture leads to more arable land (for the cultivation of plant-based food) and less grassland, this will mean a deterioration in organic matter and soil water-holding capacity with negative consequences for soil and biodiversity.
- The risk inherent in circular agriculture is that it will be detrimental to biodiversity because farmers want to or have to work as efficiently as possible.
- Our non-farmed animals often are hemerophiles. If areas used for certain crops change, the hemerophiles will also change.

5 The animal in research agendas

Many of the experts interviewed feel that the current national research agendas pay insufficient attention to animal welfare and health. If animal-related research is conducted, it rarely is about the animal itself, but almost always about the animal husbandry system as such and raising animal efficiency levels (e.g. lower feed conversion). Currently, the research questions are usually based on animal-related issues that need to be resolved (while the cause is usually not eliminated). If a new system of circular agriculture is now defined as the goal, animal welfare should play a central role in it.

Financially, there still is much to be desired. The majority of the funds made available by the Ministry of Agriculture, Nature and Food Quality for applied research has been allocated to Wageningen University & Research, while other institutions also possess relevant knowledge of animals specifically for a circular agriculture research agenda. As a result of the far-reaching privatisation of research programmes, hardly any research is currently being conducted on animal welfare because hardly any market players are interested in it. Therefore this is a task for the government.

New research agendas could focus on the potential role of animals as a supplier of ecosystem services. In this context various ecosystem services should be optimised. This requires another, broader approach than that currently applied in most cases.

Attention should also be paid to what type of farmer and what values are important for implementing a sustainable form of agriculture such as circular agriculture.

6 *Allocation of roles between stakeholders*

The majority of experts interviewed agree that a transition to circular agriculture requires all stakeholders to collaborate (government, farmers, partners in the agricultural chain and NGOs). A vision shared by all stakeholders (objectives, direction) is required. Based on this vision, all parties will contribute in their own way. The public authorities and partners in the chain will facilitate and reward by providing direction. Farmers will contribute by changing/delivering results, monitoring/rendering account. The business sector should not be limited to farmers, but other parties in the chain, such as supermarkets and the food industry, also need to take their responsibility and contribute to circular agriculture.

Not only the parties that have designed the current system should be asked to contribute their ideas, but also those parties who have previously not been involved. Moreover, the timing of their involvement is an important factor. Currently, NGOs, for instance, often have only been asked to contribute ideas on developing a solution, whereas the parties concerned should jointly determine what the actual problem is at an earlier stage. In addition, leaving issues unaddressed (such as reducing the national herd size) is considered fatal to the process (and therefore the result). It should be noted that most of the NGOs are one-issue organisations. This is not in keeping with circular agriculture and therefore NGOs should also take a more comprehensive view.

The government primarily does what the market does not do (properly). In the past decade, the parties who focused on animal welfare were primarily NGOs. A larger role for the government would be appropriate, after all, the government should serve the public interest and farmed animals form an integral part of society. The government, NGOs and animal welfare researchers should jointly consider how a new system should be designed. With regard to the amendment of legislation, the government should also more actively pursue greater flexibility so that new scientific insights and societal developments can be incorporated into legislation at a faster pace. The government also has an important role in ensuring that a reward or a value is assigned to ecosystem services. Clarity on laws and regulations in the coming years is required in order to provide farming businesses sufficient certainty for investing in the transition to circular agriculture.

7 *Experts' comments*

During the interviews, a number of experts also provided more general comments, which are shown separately below:

- The possible consequences for animal welfare and health have not yet been sufficiently examined. As relatively little is known about the consequences, often the relationship between the cause and effect is not clear either.
- The effects at farming business level have their own dynamic: even if the number of animals were reduced, an individual farmer will always pursue the most intensive (= highest return) system. If that is not what we as a society want, there will need to be another driving force to direct this (e.g. rewards).
- When 'waste' is used as animal feed, the feed could still be of high quality and the current intensive systems and animals would still be appropriate. However, from a holistic perspective (integrated sustainability), which also takes account of improving animal welfare, biodiversity, reducing the environmental impact and social and cultural value and maintaining breeds, a more extensive system would also be appropriate and a transition to more robust breeds which are more tolerant to weather conditions and variable feed quality is to be expected.

8 *Experts' recommendations*

Recommendations were regularly made during the interviews and were often formulated in the following manner "You should really...". These recommendations contain interesting thoughts on future policy, actions, regulations and suchlike. A number of those recommendations are shown below:

- Endeavour to maintain a holistic view as far as possible, because you often do not know what else will change, if you change one thing. If you only deal with and optimise one part of the cycle, undesirable side effects will often arise.
- Change the way of thinking, because otherwise the system will always become more intensive and sooner or later new animal welfare problems will arise. Design the system in such a manner that it won't pay to 'forget' animal welfare. It is not yet clear how this should be designed, but it is clear that there should be more emphasis on/recognition for integrity as a necessary pre-condition.
- Protect and improve animal welfare based on a "circular welfare economy": integrity, open and honest, freedom of expression, the obligation to listen and substantiate, open debate, think for yourself, allow people to make mistakes, take, rather than shift responsibility. Do not focus only on nutrients, but also ensure that knowledge, opinions, etc. are exchanged between farmers and citizens. This requires a culture change, but how do you do that with the current earnings model?

- Ensure that sufficient attention is paid to the risks. The role of animals in circular agriculture will be different. It will take time for animals to become accustomed to their changing role.
- Evaluate and review the system every five years to identify the risks, which may potentially increase.
- The more distant animals are to human beings, in light of nutritional risks, a broader feed regime might be applicable. In this context, a distinction should be made between ruminants, pigs, chickens, fish and insects.
- Start working on an Animal Welfare/Animal Health Delta Plan now. Initiate a dialogue on animal welfare/animal health and what circular agriculture means for these two aspects. Start with the sector itself to achieve changes from the bottom up.
- Producers of residual streams should also regard their residual stream as a product and optimise their production process for a better quality residual stream.
- Look at old systems, such as a mixed farm, with modern eyes and redevelop them.
- Divide residual streams from human consumption into two categories: with and without animal protein. Determine how these streams will be managed. Separate the processing of these streams into time and space. Use the right processes for killing pathogens and preserving residual streams.
- In permits, prioritise integrated sustainable systems, in which both animal welfare and circular agriculture are included. Increase the focus on environmental quality targets at system level rather than on resources and instruments. Also formulate target criteria for animal welfare.
- Build new dairy stables not along the roadside but in the middle of the countryside (permission should be granted in a permit) so that animals have maximum access to pastures.
- Ensure that government policy also focuses on integrated sustainability if the agricultural sector is required to pursue integrated sustainability, including improving animal welfare. Concurrently pursue sustainability at government level (in government policies) and at support institutions (set the right example).
- A shared vision is required: fair, humane and sustainable. Animal welfare must be part of every sustainability strategy.

9 *Conclusions drawn from the interview session with experts*

Animal welfare “does not work”, as stated by one of the interviewees, referring to the tension between closing cycles and improving animal welfare. That is precisely the crux of the theme ‘Animal Welfare in Circular Agriculture’: for those who are thinking of closing cycles, reducing emissions and the more efficient use of raw materials, animal welfare does not really fit into the picture.

A closed cycle would seem to be in line with a more natural way of life and that presents opportunities for animal welfare. However, this is not the case by definition. Unilateral optimisation, whether related to production efficiency or closing cycles, may also pose risks to animal welfare. In other words, the necessary improvements in animal welfare will in a considerable number of cases lead to less efficient production. This may perhaps also explain why very few people in the discussion on circular agriculture have considered animals and the consequences for animals.

The experts agree without exception that the guiding principle should be: if we keep animals, we should look after them properly. If you decide to use animals as food, the least you can do is to provide a decent level of animal welfare. However, this does not automatically form part of circular agriculture and this is explained as follows:

- Animal welfare is an objective in itself, and it may perhaps be of a different nature to the various objectives (e.g. climate or water) of circular agriculture. Moreover, animal welfare should not be an objective that you can easily 'trade-off' with other objectives.
- Animal welfare and circularity are the two axes of sustainability as it were: if you want to improve both, you will end up with another system than if you want to improve one of the two.

Annex 2: Participants in the expert meeting held on 14 January 2020

Johan van Arendonk, Hendrix Genetics
Saskia Arndt, Utrecht University
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Sandra Beuving, Dierencoalitie
Johan Bongers, NVWA
Iris Boumans, Wageningen Livestock Research
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