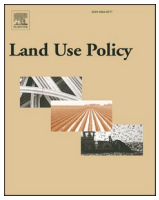
Land Use Policy 120 (2022) 106253

Contents lists available at ScienceDirect

Land Use Policy

journal homepage: www.elsevier.com/locate/landusepol



The influence of behavioural factors and external conditions on Dutch farmers' decision making in the transition towards circular agriculture

Carolien de Lauwere [a,*], Monique Slegers [b], Marieke Meeusen [a]

[a] Wageningen Economic Research, Innovation Risk and Information Management, P.O. Box 35, 6700 AA Wageningen. Visiting address: Droevendaalsesteeg 4, 6708 PB Wageningen, the Netherlands
[b] Netherlands Food and Consumer Product Safety Authority, Ministry of Agriculture, Nature and Food Quality, P.O. Box 43006, 3540 Utrecht, The Netherlands

ARTICLE INFO

Keywords:
Circular agriculture
Behavioural factors
External conditions
Farmers' decision making

ABSTRACT

A transition towards a circular food system whereby the agricultural food chain changes from a linear production chain to a more circular system with minimal unnecessary losses could be the answer to a range of global challenges, such as climate change, diminished water quality and biodiversity, and food insecurity. This paper focuses on behavioural factors and external conditions that influence the decisions of Dutch farmers in the transition towards circular agriculture (CA). This study consists of a literature review, 13 semi-structured, qualitative, in-depth interviews with farmers who contributed to CA and a survey of 429 farmers representing a range of farm types and sectors. Structural Equation Modelling showed that attitude and intrinsic and extrinsic motivation are significant predictors of the intention to take measures that contribute to CA, behavioural beliefs, perceived risk and uncertainty, and intrinsic and extrinsic motivation are all significant predictors of attitude; and intention, perceived behavioural control and subjective knowledge are significant predictors of the relative number of farmers that contribute to CA. Univariate analyses showed that farmers who took more measures that contribute to CA were motivated more by social and environmental values, while farmers who took fewer measures that contribute to CA were motivated more by economic values. In the in-depth interviews, knowledge, resistance from the environment and unsuitable legislation were the barriers mentioned most often. These insights may prove helpful for policymakers and other advisors who influence farmers' decision making regarding CA. Some examples of what these insights can be used for include: persuasive communication aimed at influencing motivations, beliefs and attitudes; framing directed towards motivating pro-environmental and social values to increase intrinsic motivation; economic incentives to increase extrinsic motivation; providing information for decreasing farmers' perception of risk and uncertainty, provided that how information is offered is adapted to individual situations. Social pressure may not be helpful in this stage of the transition as there is still a lot of resistance to CA among farmers following a linear approach.

1. Introduction

1.1. Towards a circular food system

Global food systems are facing major challenges. Farmers are being confronted with increasing pressures on land, concerns about greenhouse gasses and emissions of ammonia and minerals in relation to climate goals, water quality and animal welfare in relation to human health (Arora, 2018; Fresco et al., 2021). If current production systems continue as they are, pressure on the environment is expected to increase as the global population grows (Ritchie and Roser, 2020; Hollander et al., 2016). A transition towards a circular food system in which the agricultural food chain changes from a linear production chain with a beginning, ending and leaks to a circular food system with minimal unnecessary losses could be the answer to some of these challenges (LNV, 2018). However, the transition towards a circular food system is complex. Radical changes are needed in both social and technological systems (Termeer, 2019). This means changing the dominant paradigm of maximising production and minimising costs, and changing the convictions and routines of actors at every step in the production chain. Actors across companies, scales and sectors need to cooperate, and there needs to be a redistribution of responsibilities

* Corresponding author.
E-mail address: carolien.delauwere@wur.nl (C. de Lauwere).

https://doi.org/10.1016/j.landusepol.2022.106253
Received 26 July 2021; Received in revised form 16 June 2022; Accepted 17 June 2022
Available online 2 July 2022

between politics, society and the private domain. Finally, the position of farmers, consumers and other actors involved in the agricultural systems needs to shift, and new technologies and knowledge, policies and regulations and other financial constructions and business models need to be introduced (Termeer, 2019, van Eijk, 2015).

In this paper, we focus on Dutch farmers and how they are dealing with the challenges they are facing in the transition towards a circular food system. The Dutch Minister of Agriculture, Nature and Food Quality has created an agenda to realise a circular agriculture (CA). In this agenda, five principles are mentioned to realise CA: (1) healthy soil forms the basis, (2) use as much animal manure instead of artificial fertilizer as possible, (3) use residual flows from the food industry as feed for animals, (4) food production should improve nature, the environment and the climate, and (5) cooperation within regions and agricultural chains is important (LNV, 2019). These principles describe the steps necessary to realise CA. The starting point is that the intention to change behaviour not only depends on behavioural factors, but also on external conditions that influence the step from intention to action (Wilson and Dowlatabadi, 2007; Ellis-Iversen et al., 2010; Niedderer et al., 2014; Meijer et al., 2015). Examples of behavioural factors include attitude, injunctive and descriptive social norms, perceived behavioural control and perceived risks, and uncertainty (Ajzen, 1991; Nolan et al., 2008; Fishbein and Ajzen, 2010; Ogurtsov et al., 2008; Sok et al., 2016). External conditions include influences beyond the individual's sphere of influence, such as legislation on technological factors, cultural differences and available knowledge.

To assess the extent to which farmers contribute to CA, the Critical Performance Indicators created by Erisman and Verhoeven (2020) are used as a foundation. These are elaborated on further in Section 2.2.2. and 3.1.

We explored what behavioural factors could be important in the transition to CA on the basis of five shifts. These, according to Raworth in her book *Doughnut Economics* (2017), are important to realise a circular (or 'doughnut') economy. We added these factors to Ajzen's (1991) Theory of Planned Behaviour (TPB) – if they were not included already. We also added other behavioural factors that we assumed would be important according to the literature. These will be elaborated on further in the theoretical background section. We first elaborate on behaviour we assume to be important based on Raworth (2017) (1.2.1). After that, we elaborate on other behavioural factors and external conditions (1.2.2). At the end of the section, we present our hypothesis and conceptual framework (1.2.3). The aim of our study is to find out what behavioural factors and external conditions influence Dutch farmers' decision making in the transition towards CA. These insights can provide new perspectives when designing tailor-made interventions for farmers and other agents to motivate them to take steps towards CA (Edwards-Jones, 2006; Greiner et al., 2009; Herzfeld and Jongeneel, 2012; Garforth, 2015). This can be important for policymakers as well as other advisors wishing to influence farmers' decision making.

1.2. Theoretical background

1.2.1. Behavioural factors that could be important in CA

In her book *Doughnut Economics* (2017), Raworth distinguishes five shifts that are important to realise a circular economy: (1) from self-interested to socially reciprocating, (2) from fixed preferences to fluid values, (3) from isolated to interdependent, (4) from calculating to approximating, and (5) from dominant over nature to dependent on and deeply embedded in nature. According to Raworth, these shifts are represented in every individual but should be emphasised more in a circular economy. In the next sections, we elaborate on how these five shifts could be expressed in CA.

1.2.1.1. Social norms and cooperation. Based on Raworth's first (p. 102–106) and third shift (p. 109–111), it seems plausible that social norms and cooperation play a more important role in CA because more interdependencies would exist in a circular food system. After all, in a linear system, the decisions of a single actor affect outcomes for other actors, but cooperation can be limited. However, for a system to become circular and to remain so, cooperation between actors within the food system is essential, since there are multiple feedback loops between the actions of all actors in the system that need to be incorporated in every actor's behaviour (van Eijk, 2015). Different examples of descriptive and injunctive social norms – referring to what others do and what others expect respectively (Nolan et al., 2008; Fishbein and Ajzen, 2010) – positively affecting farmers' adoption of sustainable practices are mentioned in a review paper by Dessart et al. (2019). These include a positive influence of descriptive social norms on participation in agri-environmental schemes in livestock and arable farming (Defrancesco et al., 2008), and a positive influence of injunctive social norms on organic farming practices in livestock farming (Läpple and Kelley, 2013).

1.2.1.2. Values and intrinsic and extrinsic motivation and embeddedness in nature. The second shift of Raworth's doughnut economy (p. 106–109) emphasises values, extrinsic and intrinsic motivation and, in the fifth shift (p. 114–116), embeddedness in nature. Raworth explains that values can be grouped around two key axes. One axis represents openness to change, with openness (concerning independence and novelty) and conservation (concerning self-restriction and resistance to change) being juxtaposed; the other axis represents self-enhancement (concerning status and personal success) and self-transcendence (being concerned for the wellness of all). The distinction between self-enhancement and self-transcendence is echoed in the contrast between extrinsic and intrinsic motivation (Raworth, 2017, p.109). Extrinsic motivation moves people forward because they can earn more money or status, or improve their image; intrinsic motivation moves people forward because they feel responsible, find something important, want to do something good etc. (also see Deci and Ryan, 2012). Therefore, we assume that looking at values and intrinsic and extrinsic motivation could also be helpful for understanding the behaviour of farmers in a circular context. According to Mills et al. (2016), understanding farmers' motivations for undertaking voluntary environmental activities can help with the development of advice and information strategies for enhancing environmental management and in framing appropriate messages for the adoption of specific practices. Greiner and Gregg (2011) state that farmers' predominant type of motivation influences their stated barriers to the adoption of new and/or additional conservation activities. According to the authors, aspirations and motivations serve as a lens through which farmers assess options and justify decisions, and that there appears to be a particular neglect of the non-financial motivations that govern farmers' decision making processes, this being a particularly the strong stewardship ethic, which intrinsically motivates many farmers to undertake conservation activities on their land. Muranko et al. (2018) use 'pro-circular values' (P-CVs) in their pro-circular change model. They distinguish social, economic and environmental values and state that these values can reflect either intrinsic or extrinsic goals. We also assume that farmers engaged in circular initiatives are more embedded in nature. Several examples of farmers engaged in such initiatives for whom embeddedness in nature is an important aspect of their farming system are mentioned by Hoes et al. (2020). Lokhorst et al. (2014) found that connectedness to nature is a key factor that influences the intention to participate in nature conservation, besides perceived behavioural control and self-identity.

1.2.1.3. Time-varying discount rates. In the fourth shift mentioned by Raworth (p. 111–114) – from calculating to approximating – another dimension of circular behaviour is emphasised, which seems to be related to the role that time-varying discount rates may play in a circular

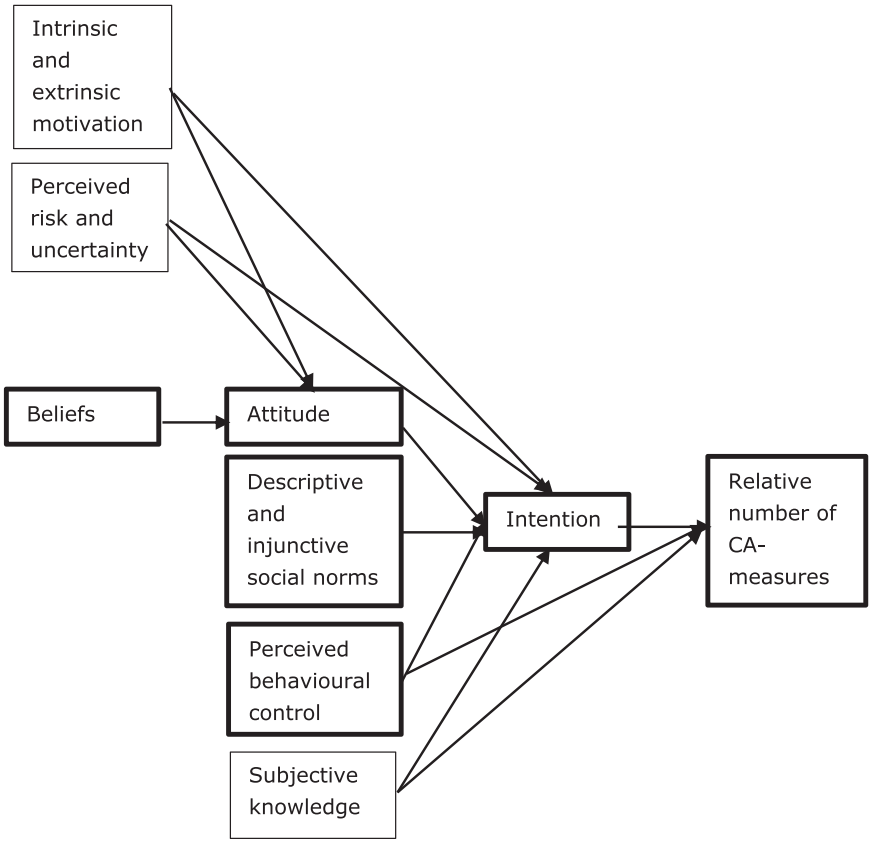


Fig. 1. Conceptual framework to understand farmers' decision making in circular agriculture (CA); TPB constructs are outlined with a thicker line.

context. Time-varying discount rates mean that individuals use a higher discount rate over a longer time horizon than over a shorter time horizon (Holcomb and Nelson, 1992 cf. Pollitt and Shaorshadze, 2013). If farmers have to decide whether to contribute to more sustainable production methods or not, time-varying discount rates (that assign less value to things further away in the future) may play a role if it takes some time before farmers see the effects of the measures taken to improve sustainability on their farms. The idea that this kind of 'delayed' effect can prevent farmers from taking measures is mentioned by Bruijnis et al. (2016) and Gilbert and Rushton (2018), for example, for decisions regarding animal health. In these examples, the time span between taking the decision and performing the pro-environmental behaviour and seeing its effects was still relatively short (one or a few production cycles). In a circular context and depending on the scale of the circularity (on farm or economy-wide), this time span can be much longer, and the effects of some of the actions taken may only become apparent in the far future (Jackson, 2005; p.35).

1.2.2. *Other behavioural factors*

Other behavioural factors that we have included in our study are mainly based on the Theory of Planned Behaviour (TPB) (Ajzen, 1991). According to TPB, a person's intention to perform a certain behaviour depends on their attitude towards and beliefs about the behaviour, the attitude and behaviour of important other people within their social network (social norm), the person's motivation to comply with these other people and the person's perceived behavioural control (i.e. does the person think they are still in control if they change their behaviour?). TPB has been developed to understand consumer behaviour, but it has also proven useful in understanding farmers' sustainability choices (Lokhorst et al., 2014; Jones et al., 2015; van Dijk et al., 2016; Senger et al., 2017; Bijttebier et al., 2018; de Lauwere et al., 2020). In our study, we split up social norms into descriptive and injunctive social norms, referring to what others do and what others expect respectively (see 1.2.1). In addition, we include perceived risk and uncertainty in our study because farmers who perceive more risks can be less willing to adopt measures that contribute to CA (Kunreuther et al., 2001; Ogurtsov et al., 2008; Sok et al., 2016; Trujillo-Barrera et al., 2016). We also include subjective knowledge in our study because we believe that it may also influence farmers' decision making concerning CA (Flynn and Goldsmith, 1999; Dessart et al., 2019). Dessart et al. (2019) mention that the adoption of specific sustainable practices is higher when farmers have sufficient knowledge and competences related to these practices, and when they think these practices create environmental or financial benefits with limited risks. According to Ajzen (1991), it is possible to include additional variables in TPB if they capture a significant proportion of the variance in intention or behaviour after the theory's current variables have been taken into account (van Dijk et al., 2016).

1.2.3. *Hypothesis and conceptual framework*

Based on the above-mentioned literature, our hypothesis is that social norms and cooperation are more important as farmers are more engaged in CA, that farmers who contribute more to CA are more intrinsically motivated and motivated more by social and environmental values and less by economic ones, and that farmers who are more engaged in CA are less affected by time-varying discount rates. In addition, we hypothesise that farmers who are more engaged in CA, have a more positive attitude towards and more positive beliefs about CA, perceive more control and less risk and uncertainty about CA, think that they have more knowledge about CA and are less affected by external conditions such as the availability of knowledge, money and suitable legislation than farmers who are less engaged in CA.

The conceptual framework is shown in Fig. 1. In this conceptual framework, the TPB is chosen as a basis with attitude, descriptive and injunctive social norms (referring to what others do and what others expect respectively) and perceived behavioural control as predictors of the intention to take measures that contribute to CA, beliefs as predictors

Table 1
Overview of measures that were presented to the surveyed farmers in the question about which CA-measures they took (N/A = not applicable).

measures	Arable farmers	Dairy farmers	Pig farmers	Farmers with mixed farms and multifunctional farms
Grow own feed	N/A	+	+	+
Buy feed locally (within a 20 km radius)	N/A	+	+	+
Use residual or side products from the humane food industry	N/A	+	+	+
Use more animal manure instead of artificial fertiliser within legal frameworks	N/A	+	+	+
Use manure on own land or within a 20 km radius	N/A	+	+	+
Feed dairy cows according to the protein norm (not over it)	N/A	+	+	+
Buy concentrate that contains raw materials that cause less greenhouse gasses and ammonia emissions	N/A	+	+	+
Direct breeding programmes more towards robust animals	N/A	+	+	+
More permanent grassland	N/A	+	+	+
Herb-rich grassland	N/A	+	+	+
Split manure into fixed and fluid fractions	N/A	+	+	+
Grow more combine harvested and break crops and less root crops and flower bulbs	+	N/A	N/A	+
Field margins with herbs and flowers	+	N/A	N/A	+
Use green manure crops	+	N/A	N/A	+
Use of harvest residuals and other residual products for biobased products	+	N/A	N/A	+
measures to keep CO_2 in the soil	+	+	+	+
produce sustainable energy with solar panels or wind turbines	+	+	+	+
save energy	+	+	+	+
use more leguminous crops	+	+	+	+
measures to prevent or reduce soil compaction	+	+	+	+
precision techniques for plant protection or fertilisation	+	+	+	+

of attitude, and perceived behavioural control and intention as predictors of the relative number of measures taken by the farmers. In addition to these basic TPB elements, perceived risk and uncertainty, intrinsic and extrinsic motivation and subjective knowledge are included as additional factors that probably influences farmers' decision making regarding CA. In the conceptual framework, intrinsic and extrinsic motivation are included as behavioural factors that we assume to be important in CA on the basis of Raworth's five shifts (see 1.2.1). The same is true of social norms, but this behavioural factor is part of the original TPB. We assume that values and embeddedness in nature of farmers were reflected in intrinsic and extrinsic motivation. Cooperation, external conditions and time-varying discount rates are not included as separate constructs in the conceptual framework. To the best of our knowledge, no theoretical constructs exist for these factors. However, propositions about cooperation are included in the construct behavioural beliefs, and propositions about external conditions are included in the construct perceived behavioural control. In addition, we added five propositions to get an impression of the effects of time-varying discount rates, the possibility that it will be necessary to cooperate more in CA and the possibility that mutual dependency between actors involved could increase would withhold farmers to take measures that contribute to CA.

2. Material and methods

To get insight into behavioural factors and external conditions that influence farmers' decision making in the transition towards CA, we performed a mixed-method study consisting of 13 semi-structured, qualitative, in-depth interviews with farmers engaged in circular initiatives, and we disseminated a survey among 133 arable farmers, 80 dairy farmers, 79 pig farmers, 59 farmers with mixed arable and livestock farms, 43 farmers with multifunctional farms, 19 farmers engaged in initiatives that contribute to CA and 16 farmers from other sectors. The following subjects were included in the questionnaires for both the qualitative and quantitative part of the study:

- Characteristics of the farm
- Actual behaviour: what measures do the farmers take to contribute to CA?
- Attitude, beliefs and perceptions about CA
- Intrinsic and extrinsic motivation to contribute to CA and values
- Cooperation and social norms, influence of the environment
- Perceived obstacles and external conditions

2.1. Qualitative exploration

From a sample of 225 farmers previously used by Hoes et al. (2020), 13 farmers were selected in a way that facilitated insight into the whole range of possibilities that contributed to CA. Examples include farmers who took measures that contribute to CA – such as closing farm-level nutrient cycles, ceasing imports of concentrate from abroad and keeping no more animals than can be fed from the own land – and farmers who chose technological solutions to contribute to CA – such as by applying technology to reduce emissions of ammonia and greenhouse gasses. 12 of the interviews were performed by telephone due to COVID-19 restrictions. One interview took place at the farm of a respondent upon his request. The interviews were recorded and analysed by the researchers. 11 of the interviews were recorded and transcribed, and two were not because the recordings failed. Interview reports were sent back to the interviewees for feedback and approval. The interviews lasted between one and a half and two hours.

2.2. Quantitative study

2.2.1. Performance of survey and respondents

To test insights of the interviews, an online survey was conducted among 4584 farmers, of which 119 farmers were engaged in initiatives that contributed to CA. These farmers with circular initiatives were found through the websites of biodynamic farmers (www.stichtingdemeter.nl), a group of farmers who call themselves 'caring farmers'

(https://caringfarmers.nl/) and a group of farmers who call themselves 'landscape farmers' (www.delandschapsboeren.nl). Overlapping email addresses from these lists were removed. The email addresses of the other farmers were collected by the marketing and consultancy agency MSI. 15 digital gift vouchers of 100 EUR were raffled among the respondents to increase the response rate.

Based on theory and the interviews, a structured questionnaire with pre-programmed response categories was prepared. Questions about behavioural factors were presented to the farmers as propositions to which they could respond on a seven-point scale, with 1 being the most negative answer (e.g. 'totally disagree', 'very unlikely'), 4 being the neutral score and 7 being the most positive answer (for example 'totally agree', 'very likely'). The survey was tested by a biodynamic dairy farmer, a researcher with a background in dairy farming and a researcher with a background in arable farming before it was finalised.

2.2.2. Measures taken by the farmers who contribute to CA (CA-measures)

To determine to the extent to which the surveyed farmers contributed to CA and to get an impression of how 'circular' they were, we composed a list of 21 measures based on the critical performance indicators for CA created by Erisman and Verhoeven (2020) – hereafter referred to as 'CA measures' (Table 1).[1] We asked the surveyed farmers whether they had already taken these CA measures or were planning to do so within five years. Since not all measures were applicable in every sector, we divided the number of measures taken by the maximum number of measures that the surveyed farmers could possibly take, based on the sector and the farm properties. In the analysis, we distinguished between farmers who took 50% of the measures they could take on average (CA-low), farmers who took 70% of the measures they could take on average (CA-medium) and farmers who took 90% of the measures they could take on average (CA-high).

2.2.3. Measures to learn more about farmers' beliefs, values and perceptions concerning CA

In our survey, propositions regarding the behavioural factors were mainly based on TPB. This concerns intention, attitude, behavioural beliefs, injunctive social norms (referring to what others expect), descriptive social norms (referring to what others do) and perceived behavioural control. Besides the propositions based on the TPB, we included propositions regarding perceived risk and uncertainty, intrinsic and extrinsic motivation and subjective knowledge. We also added three propositions to test whether time-varying discount rates influenced the surveyed farmers' intentions to contribute to CA, and two propositions to find out whether a potential necessity to cooperate and a potential increased mutual dependency influenced the farmers' decisions to contribute to CA. Lastly, we tried to get an impression of the values and embeddedness in nature of the surveyed farmers by asking them to divide 20 points over 11 goals: (1) farm expansion, (2) being financially successful, (3) working with machinery and technology, (4) being a good employer, (5) working with plants, animals and nature, (6) producing good and safe food, (7) passing the land in a good condition to the next generation, (8) maintain the tradition, (9) taking good care for the environment, biodiversity and the surroundings, (1) being independent/autonomous, and (11) work pleasure. All constructs and separate propositions on which they are based are shown with some descriptive statistics in Appendix I.

[1] The 21 measures used in the survey are a more concrete expansion of the ten critical performance indicators used in the in-depth interviews. We choose this approach because we were able to ask the farmers what measures they took during the in-depth interviews but not during the survey. As such, we decided to present them with a longer list with concrete measures. It should be considered that although the Erisman's and Verhoeven's (2020) critical performance indicators are very useful for on-farm measures, CA is also seen as a system change and therefore certain components of CA might be overlooked.

2.2.4. Statistical analysis

The statistical analysis consisted of three steps. The first step was to test whether separate propositions could be combined into valid constructs. To achieve this, we checked the internal consistency of the constructs by estimating Cronbach's alpha (CB). This is a measure expressed as a number between 0 and 1. If Cronbach's alpha is greater than 0.70, it is assumed that a construct is valid (Tavakol and Dennick, 2011).

Subsequently, using the Shapiro-Wilk test (Razali and Bee Wah, 2011), we checked whether the created constructs were distributed normally. The null hypothesis of this test was that the population was normally distributed, thus if the p value was less than 0.05, then the null hypothesis was rejected, and there was evidence that the data tested were not normally distributed. As this appeared to be the case for most constructs, we performed Kruskall Wallis tests to find differences between CA-low, CA-medium and CA-high farmers.

Finally, we performed Structural Equation Modelling to test which constructs significantly predicted attitude and intention to take (more) measures that contribute to CA and the relative number of CA measures taken. We took the TPB elements as a basis and extended the model with perceived risk and uncertainty, intrinsic and extrinsic motivation, and subjective knowledge. To test for a good model fit, we looked at the Root Mean Square Error of Approximation (RMSEA), the Standardized Root Mean Square Residual (SRMR) and the Comparative Fit Index (CFI). For an acceptable model fit, RMSEA and SRMR should have been lower than 0.08, and CFI should have been 0.90 or higher. (Hair, 1998, p. 635; Schermelleh-Engel et al., 2003).

3. Results

The results section is divided into two parts. First, the results of the in-depth interviews are presented with emphasis on the behavioural factors and external conditions that we assumed would play a role in CA (3.1 and 3.2). Subsequently, the results of the survey are presented (3.3, 3.4 and 3.5). In this paper, we try to avoid describing farmers as 'conventional farmers' as much as possible when comparing farmers who take measures that contribute to CA to differing degrees. This does not do justice to the diversity that exists within agriculture (Sumberg and Giller, 2022). However, we cannot avoid the use of this description if we quote the interviewed farmers or if we refer to literature that uses this description.

3.1. The interviewed farmers and their farms

The group of 13 farmers interviewed contributed to CA in various ways. Their farms varied from a pig farmer with a one-star Better Life Label awarded by the Dutch Society for the Protection of Animals[2] and who produced sustainable energy to a biodynamic (BD) multifunctional farm with livestock, crops, nature conservation, a farm shop and/or web shop and care. We also interviewed a broiler farm with high-tech solutions for reducing ammonia emissions, a pig farmer who used residuals flows of the food industry, a cooperation between livestock and arable farmers, a BD dairy farm and an organic mixed farm with dairy cattle and arable crops, a farm with special livestock, an outdoor pig farm and a BD pig farm and a nature-inclusive mixed farm with dairy cattle and arable crops, and a community farm.[3] Based on the critical performance indicators for CA identified by Erisman and Verhoeven (2020), seven farms contributed to soil preservation, eight farms contributed to closing of nutrient cycles, six farms contributed to reduction of greenhouse gasses (CO_2, CH_4, N_2O) and ammonia (NH_3), eight farms produced sustainable energy (by solar panels or fermentation), nine farms contributed to maintenance of biodiversity, six farms (more or less)

[2] https://beterleven.dierenbescherming.nl/zakelijk/en/

[3] We cannot specify these farms any further for reasons of anonymity.

contributed to nature conservation, 12 farms (more or less) contributed to animal welfare, 12 farms contributed to animal health (by minimising the use of antibiotics), five farms used residual flows from the food industry to feed their animals and ten farms contributed to the regional economy and the vitality of the rural area by means of a web shop, farm shop, care for people or organising workshops or by providing other educational activities. In addition, four farms were certified as biodynamic and one farm as organic. Three other farmers said that they did fulfil the conditions for organic or biodynamic farming but did not want to certify to avoid costs and the associated administrative burden. The number of FTEs working at the farms varied from 1 FTE to more than 10 FTE. Most farmers interviewed addressed at least five critical performance indicators (cpis). Only the three intensive livestock farms (two with pigs and one with broilers) addressed less cpis (see Dagevos and De Lauwere, 2021 for more details). In the quotes presented in Section 3.2, we refer to the farmers as cpi-high, cpi-medium and cpi-low farmers if they respectively addressed at least seven cpis, five or six cpis, or fewer than four cpis.

3.2. Behaviour of farmers who contribute to CA

3.2.1. Social norms and cooperation

Based on Raworth's first and third shift, we assumed that social norms and cooperation play a more important role in CA. We found some indications of this during the interviews[4]:

> 'I worked as a teacher at a school for secondary vocational education [.] Colleagues asked critical questions about the farm [her father's farm, ed.]' (cpi-high farmer 1)

However, we noticed during the interviews that it was more common for the farmers engaged in circular initiatives to be confronted with resistance from their environment. This made some of them more combative – they resisted the negative social norm – while others found it hard to deal with it, and it impeded them:

> 'It was difficult for my father to explain what I was doing at the football club. He meets a lot of conventional farmers over there [.] However, it is more difficult to explain it to my brother and his friends. They totally don't understand what I am doing [.] I find it hard to deal with.' (cpi-high farmer 1)

> 'Conventional farmers look at us differently. Some they think we are back-to-nature freaks. But we also organise excursions, and then farmers are surprised that we have a good turnover. Conventional farmers sometimes see us as a threat. They ask themselves "are we not doing well then?"' (cpi-high farmer 3)

We found that cooperation was important for all our interviewed farmers, regardless of whether they were engaged in a circular initiative or not:

> 'Cooperation is central at our farm. It is embedded in our concept.' (cpi-high farmer 4)

> 'Cooperation is very important; essential. You never have a good idea on your own. It does not matter either whose idea it was.' (cpi-low farmer 1)

However, it was striking that the farmers engaged in circular initiatives in particular expressed a strong drive to share their knowledge. This is a possible indication of their intrinsic motivation to propagate their way of farming, as indicated by one farmer:

> 'We want to show that it is possible. That drives us […]. People say that we are evangelical. And we like to share our knowledge indeed' (cpi-high farmer 5).

3.2.2. Values and motives to contribute to CA

Based on Raworth's second and fifth shift, we assumed that farmers engaged in circular initiatives are more intrinsically motivated and more motivated by social and environmental factors, and less motivated by economic values than other farmers, and that these farmers are more embedded in nature. One indication of intrinsic motivation, social and environmental values and embeddedness in nature was that – with the exception of the intensive livestock farmers – all interviewed farmers were rather critical about the current agricultural practices of increasing production and efficiency and lowering the cost price:

> 'Farms grew bigger and bigger by the use of chemical pesticides and fertilisers [.] I realised that it was not future proof. It went against my values as a farmer.' (cpi-high farmer 4)

> 'I wanted to do it differently because it has always surprised me that our food crops are treated with substances with skulls on the packaging. I wanted to show that it can be done differently. It is important that farmers produce healthy food [.]. Sustainability is important and the fulfilling of current needs should be set against the future needs. If you don't do that, like in the current agricultural practices, it is a dead end.' (cpi-high farmer 6)

> 'The conventional system is directed towards maximalisation. This has negative consequences for the health of humans, animals and our planet [.]; organic farming is a better system. It is a more natural way to produce food.' (cpi-high farmer 3)

> 'From the moment I knew that I could take over my father's farm, I knew that I wanted to do it differently. Changing from conventional to organic to biodynamic perfectly fitted this line.' (cpi-high farmer 6)

> 'You need to be a fool to start such an initiative and followers who are comparably crazy. People need to be prepared to work 80 h a day. I am one such big fool [.]. It is a kind of vocation. You have to preach the idea constantly.' (cpi-high farmer 7)

On the other hand, all the interviewed farmers were entrepreneurs, meaning they need to earn money as well. In that sense they are extrinsically motivated as well:

> 'We produce half of the concentrates ourselves. It is better if you can produce 100% of your own concentrate. It is also possible to produce milk without concentrate. In that case, cows produce about 5000 litres of milk. That does not fit in our business model yet [.] but I find farmers who do not use concentrate inspiring [.] maybe it will happen in the future, but you have to set priorities.' (cpi-high farmer 3)

Here we saw some differences between the farmers engaged in circular initiatives and the farmers with intensive livestock farms. Both groups are driven to do things differently (i.e. more sustainably), but in the first group, environmental and moral concerns seem to prevail, whereas in the other group, the business aspects seem to prevail.

> 'I could have earned more money as a conventional farmer, but I would not be as happy as I am now.' (cpi-high farmer 6)

> 'Our farm sometimes flourishes less because of our ideals and the time we spend sharing knowledge [.] we should not be ruined by our own success.' (cpi-high farmer 5)

> 'To what extent do we profit from CA? That is an important question. How much do we earn from it? What does the business model look like? It is nice, but you need to earn money as well.' (cpi-low farmer 2)

[4] Please note that the excerpts from the interviews quoted in Section 3.3 are not verbatim but paraphrased to improve readability.

Table 2
Some features of farmers participating in the survey.

	CA-low (n = 155)	CA-medium (n = 132)	CA-high (n = 142)
Relative number of CA-measures taken (mean (standard deviation))	0.5 (0.12)	0.7 (0.05)	0.9 (0.08)
Percentage of 380 farms which were not organic or biodynamic	37.6	32.9	29.5
Percentage of 38 organic farms	29.0	15.8	55.3
Percentage of 11 bio-dynamic farms	9.1	9.1	81.8
Percentage of 80 dairy farmers	36.3	40.0	23.8
Percentage of 133 arable farmers	30.1	30.8	39.1
Percentage of 79 pig farmers	46.8	29.1	24.1
Mean Age (standard deviation)	52.7 (9.9)	52.8 (10.1)	54.2 (10.2)
Percentage of farmers with higher vocational education or university	29.2 n = 147	32.5 n = 132	39.4 n = 137
Ha of owned land (mean (std))	40.7 (42.3) n = 144	50.4 (51.7) n = 118	64.4 (86.6) n = 135
Ha of owned land (median)	29.3	40.0	45.0
Ha of rented land (mean (std))	24.2 (42.0) n = 94	38.8 (111.5) n = 85	29.9 (44.0) n = 86
Ha of rented land (median)	10.0	16.0	15.0

3.2.3. Time-varying discount rates

Based on Raworth's fourth shift, we assumed that time-varying discount rates might a role play in a circular context. In the interviews, we found some indications that farmers engaged in circular initiatives were more concerned about the future (e.g. *'I realised that was not future proof.' (cpi-high farmer 4); 'Sustainability is important, and the fulfilling of current needs should be set against the future needs. If you don't do that, like in the current agricultural practices, it is a dead end.' (cpi-high farmer 6)*).

3.2.4. External conditions

As established in the introduction, external conditions can make the step from intention to action easier or more difficult. In the interviews, we asked what obstacles the farmers perceived. Besides the resistance of the environment that most of the interviewed farmers faced and the time they spent on finding and sharing knowledge (see 3.2.1), all farmers interviewed mentioned legislation as one of the main obstacles for their businesses. The farmers with circular initiatives complained that their farming systems did not fit the 'legislation for conventional farmers', as they called it:

> 'It takes a lot of time and costs a lot of money to comply with all the rules and administrative obligations […] It is deathly dull and very demotivating for someone who wants to start this kind of initiative.' (cpi-high farmer 2)

> 'Legislation makes it difficult. If you keep your sows on straw, you need an air washer because otherwise you do not comply with the rule of 85% reduction of ammonia emissions. It is strange [.] Animal welfare and reduction of ammonia emission cannot be combined. That makes it difficult.' (cpi-low farmer 2)

3.3. The surveyed farmers and their farms

3.3.1. Response

Of the 4584 farmers who received the survey, 429 sent back a completed questionnaire. Among them were 133 arable farmers, 80 dairy farmers, 79 pig farmers, 59 farmers with mixed arable and livestock farms, 43 farmers with multifunctional farms, 19 farmers engaged in initiatives that contribute to CA and 16 farmers from other sectors. In total, there were four poultry farmers, one farm with poultry and pigs, one farm with poultry, pigs and dairy cattle, four farms with pigs and dairy cattle, one fruit farm, one horticultural farm, one recreational farm, one experimental farm, one farm with animals for fattening (although it was not clear what kind of animals) and one horse farm. The total response on the survey was 9.4%. The response among farmers engaged in initiatives contributing to CA was 16.0%.

3.3.2. Some features of farmers participating in the survey

Table 2 shows some features of the CA-low, CA-medium and CA-high farmers. Most of the biodynamic and organic farmers participating in the survey were in the CA-high group, and most of the other farmers were in the CA-low group. However, because most farmers participating

Table 3
Predictors of attitude towards CA, intention to take (more) measures that contribute to CA and the relative number of CA-measures taken in the TPB model, and an extended TPB model on the basis of Structural Equation Modelling.

	B	z	95% confidence interval	B	z	95% confidence interval	B	z	95% confidence interval
	Intention			Attitude			Relative number of CA measures		
TPB model (RMSEA=0.168; CFI=0.866; SRMR=0.073; Overall R^2_{adj}=0.53)									
Intention							0.02	3.16 * *	0.01–0.03
Attitude	0.69	13.61 * **	0.59–0.79						
Injunctive social norms	0.18	3.02 * *	0.06–0.30						
Descriptive social norms	0.18	3.10 * *	0.07 − 0.29						
Perceived behavioural control	0.09	1.53	-0.03–0.21				0.04	3.56 * **	0.02–0.05
Behavioural beliefs				0.82	19.18 * **	0.74–0.91			
R^2_{adj}	0.51			0.46			0.07		
Extended TPB model (RMSEA=0.074; CFI=0.969; SRMR=0.024; Overall R^2_{adj}=0.73)									
Intention							0.02	3.29 * *	0.01–0.03
Attitude	0.51	7.81 * **	0.38–0.64						
Injunctive social norms	0.11	1.84(*)	-0.01–0.23						
Descriptive social norms	0.06	0.93	-0.06–0.17						
Perceived behavioural control	0.06	1.01	-0.06–0.18				0.03	2.73 * *	0.01–0.05
Subjective knowledge	-0.02	-0.52	-0.10–0.06				0.02	3.07 * *	0.01–0.03
Intrinsic motivation	0.18	2.88 * *	0.06–0.30	0.35	8.86 * **	0.27–0.43			
Extrinsic motivation	0.18	3.26 * *	0.08–0.30	0.10	2.49 *	0.02–0.18			
Perceived risk and uncertainty	-0.04	-0.91	-0.12–0.04	-0.22	-7.77 * **	-0.27—0.16			
Behavioural beliefs				0.33	6.91 * **	0.23–0.42			
R^2_{adj}	0.57			0.67			0.10		

* **p < 0.001; * *p < 0.01; *p < 0.05; (*)p < 0.10

Table 4
Descriptive statistics and Pearson correlations of constructs, *p < 0.05; * *p < 0.01; * **p < 0.001.

Constructs		Mean (sd)	1	2	3	4	5	6	7	8	9	10	11
1	Relative no. of measures	0.7 (0.2)	1										
2	Intention	4.1 (1.6)	.23 * **	1									
3	Attitude	3.9 (1.3)	.28 * **	.71 * **	1								
4	Injunctive social norms	3.9 (1.0)	.10 *	.45 * **	.44 * **	1							
5	Descriptive social norms	3.8 (1.2)	.19 * *	.49 * **	.50 * **	.51 * **	1						
6	Perceived behavioural control	3.6 (1.0)	.24 * **	.39 * **	.45 * **	.28 * **	.38 * **	1					
7	Subjective knowledge	4.1 (1.4)	.20 * **	.10 *	.14 * *	.06	.05	.24 * **	1				
8	Intrinsic motivation	4.3 (1.6)	.27 * **	.67 * **	.74 * **	.47 * **	.62 * **	.45 * **	.18 * *	1			
9	Extrinsic motivation	4.1 (1.3)	.11 *	.56 * **	.53 * **	.48 * **	.50 * **	.30 * **	.07	.68 * **	1		
10	Perceived risk and uncertainty	4.3 (1.5)	-0.19 * *	-0.36 * **	-0.50 * **	-0.18 * *	-0.27 * **	-0.31 * **	-0.10 *	-0.35 * **	-0.12 *	1	
11	Behavioural beliefs	4.2 (1.1)	.23 * *	.61 * **	.68 * **	.44 * **	.43 * **	.35 * **	.14 * *	.67 * **	.47 * **	-0.37 * **	1

in the survey did not have organic or biodynamic farms, these other farmers were still in the majority in the CA-high group (78.9% versus 14.8% organic and 6.3% biodynamic farmers). This also applied to the CA-medium group, of which 4.5% were organic farmers, 0.8% were biodynamic farmers, and 94.7% were other farmers; for the CA-low group, 7.1% were organic farmers, 0.7% were biodynamic farmers and 92.2% were other farmers. Looking at different sector shows that most dairy farmers were in the CA-low and CA-medium group, most pig farmers were in the CA-low group, and most arable farmers were in the CA-high group. The CA-high group also had the most farmers with a higher vocational education or university background. The CA-high farmers' farms also seem to be bigger than the farms of the CA-low and CA-medium farmers, although standard deviations were rather high.

3.4. Multivariate analysis - predictors of farmers' intention and attitude to participate in CA

Structural Equation modelling was applied to find out which constructs best predicted attitude, intention and the relative number of measures taken to contribute to CA. We started with the original TPB model with behavioural beliefs as predictors of attitude, attitude, social norms and perceived behavioural control as predictors of intention, and intention and perceived behavioural control as predictors of the relative number of measures taken. According to this model, attitude and injunctive and descriptive social norms are significant predictors of intention; intention and perceived behavioural control are significant predictors of the relative number of measures taken by farmers, and behavioural beliefs are significant predictors of attitude. The overall R^2_{adj} of this model is 0.53. TPB thus seems to be a useful model for understanding farmers' intentions to contribute to CA. However, following RMSAE, CFI and SRMR, this model has an insufficient fit with the data (RMSEA=0.168; CFI=0.866; SRMR=0.073;). An acceptable model fit was found by extending the TPB with the additional constructs perceived risk and uncertainty, intrinsic and extrinsic motivation and subjective knowledge (RMSEA=0.074; CFI=0.969 SRMR=0.024; overall R^2_{adj}=0.73). This model shows that behavioural beliefs, perceived risk and uncertainty, and intrinsic and extrinsic motivation are significant predictors of attitude, that attitude and intrinsic and extrinsic motivation are significant predictors of intention, and that intention, perceived behavioural control and subjective knowledge are significant predictors of the relative number of CA measures taken (Table 3). The model explains 57% of the variation in intention, 67% of the variation in attitude and 10% of the variation in relative number of measures taken. However, the new constructs in the extended TPB seem to interfere with the constructs in the original TPB as the constructs descriptive social norms are not significant in the extended TPB model and the construct injunctive social norm is not significant ($p < 0.10$ instead of $p < 0.01$). This seems to be caused by intrinsic and extrinsic motivation. If the extended model is executed without intrinsic and extrinsic motivation, all constructs that were significant in the original TPB model are significant again and perceived risk and uncertainty is a significant predictor of attitude and subjective knowledge is a significant predictor of the relative number of measures taken by the farmers. However, the model fit indices show an insufficient fit with the data again (RMSEA=0.142; CFI=0.890; SRMR=0.052; overall R^2_{adj}=0.60). If only intrinsic motivation is excluded from the model, $p < 0.10$ for descriptive and injunctive social norms. Model indices improve in that case but are still not sufficient yet (RMSEA=0.103; CFI=0.940; SRMR=0.033; overall R^2_{adj}=0.67). The extended TPB model with perceived risk and uncertainty, intrinsic and extrinsic motivation and subjective knowledge therefore seems to be a better model to predict farmers' intentions to take measures that contribute to CA than the original TPB model. Some basic descriptive statistics and correlations between the constructs are given in Table 4. The moderately strong correlations between most constructs shows that the extended TPB model was appropriate.

3.5. Univariate analysis: differences between CA-low, CA-medium and CA-high farmers

The univariate analysis and the separate propositions of the constructs are helpful for explaining what is behind the constructs in the statistical model.

3.5.1. Behavioural beliefs

CA-high farmers are more convinced than CA-low and CA-medium farmers that CA benefits animal welfare, animal health, plant health, the climate and societal appreciation, that CA increases work pleasure and that CA contributes to the reduction of antibiotics and pesticide use. CA-low farmers and CA-medium farmers are more convinced that CA affects farm results negatively (behavioural beliefs; Appendix I. C).

Appendix I

Mean scores and standard deviations of CA-low, CA-medium and CA-high farmers for all constructs and separate propositions on which the questionnaire was based; Cronbach's Alpha (CB) and results of the Kruskall-Wallis tests are mentioned as well; most propositions are measured on a 7 point scale, with 1 being the most negative answer and 7 being the most positive answer.

	CA-low farmers (n = 155)		CA-medium farmers (n = 132)		CA-high farmers (n = 142)		Kruskal-Wallis equality of populations rank test	
Constructs with separate propositions	Mean	Std.	Mean	Std.	Mean	Std.	Chi^2	P
A. Intention to take (more) measures to contribute to CA; CB= 0.96 *totally disagree - totally agree*	3.7[a]	1.7	4.0[a]	1.4	4.5[b]	1.6	20.36	0.0001
I am planning to take (more) measures that contribute to CA within the coming five years	3.8[a]	1.7	4.0[a]	1.5	4.6[b]	1.6	16.29	0.0003
I will take (more) measures that contribute to CA within the coming five years	3.6[a]	1.7	3.9[a]	1.5	4.5[b]	1.6	23.56	0.0001
B. Attitude: taking (more) measures to contribute to CA is. CB= 0.90	3.6[a]	1.3	3.8[a]	1.2	4.4[b]	1.3	26.13	0.0001
Totally unfeasible – very feasible	4.0[a]	1.6	4.1[a]	1.5	4.8[b]	1.6	22.05	0.0001
Totally unprofitable – very profitable	3.2[a]	1.4	3.6[b]	1.4	4.0[b]	1.5	16.07	0.0003
Very unfavourable – very favourable	3.4[a]	1.4	3.6[a]	1.3	4.1[b]	1.4	17.91	0.0001
Very unimportant – very important	3.8[a]	1.4	3.9[a]	1.4	4.7[b]	1.4	31.71	0.0001
C. Behavioural beliefs: circular agriculture. CB= 0.85 *very unlikely - very likely*	3.9[a]	1.1	4.0[a]	1.0	4.5[b]	1.1	21.76	0.0001
benefits animal welfare	3.3[a]	1.8	3.5[a]	1.7	4.2[b]	1.6	20.81	0.0001
affects the farm results negatively	4.7[b]	1.7	4.6[b]	1.6	4.1[a]	1.7	9.26	0.0098
benefits animal health	3.5[a]	1.8	3.7[a]	1.6	4.4[b]	1.6	22.12	0.0001
benefits plant health	4.1[a]	1.7	4.0[a]	1.6	4.7[b]	1.6	15.57	0.0004
increases work pleasure	3.7[a]	1.6	4.0[a]	1.6	4.4[b]	1.7	14.22	0.0008
contributes to the reduction of antibiotics use in livestock farming	3.0[a]	1.8	3.1[a]	1.7	4.0[b]	1.8	23.10	0.0001
contributes to the reduction of the use of pesticides	3.4[a]	1.7	3.6[a]	1.8	4.4[b]	1.8	21.93	0.0001
benefits the climate	4.3[a]	1.8	4.2[a]	1.8	4.8[b]	1.7	9.93	0.0070
benefits societal appreciation of agriculture	4.7[a]	1.8	4.6[a]	1.8	5.1[b]	1.6	8.22	0.0164
asks for more cooperation	5.1	1.4	5.0	1.4	5.2	1.3	1.04	0.5960
increases mutual dependency	5.1	1.5	4.9	1.6	4.8	1.5	5.07	0.0794
D. Injunctive social norms: which parties want you to take (more) measures to contribute to CA? CB= 0.83 *totally disagree - totally agree*	3.9	1.1	3.9	1.0	4.0	0.9	2.26	0.3227
Other farmers	2.8	1.3	2.9	1.4	3.1	1.4	3.86	0.1454
Other farmers I know well	2.8[a]	1.5	2.9[a]	1.4	3.4[b]	1.5	10.33	0.0076
Farmers interest organisations	3.9	1.4	4.0	1.5	3.9	1.5	0.51	0.7761
Citizens/ consumers	4.5	1.8	4.3	1.8	4.7	1.7	3.85	0.1459
Farm advisors (e.g. veterinarians, feed and seed suppliers, independent advisors)	3.2	1.4	3.3	1.4	3.4	1.4	1.26	0.5333
The government	6.0	1.3	5.9	1.5	5.8	1.5	1.72	0.4231
Buyers	3.9[a]	1.8	4.1[a]	1.7	4.4[b]	1.7	6.11	0.0472
accountants	3.7	1.6	3.5	1.6	3.7	1.5	1.76	0.4154
E. Descriptive social norms: to what extent do you think that other farmers contribute to CA? CB= 0.86 *Never - very often*	3.6[a]	1.1	3.8[b]	1.2	4.0[b]	1.1	11.81	0.0027
Other farmers	3.7	1.1	3.8	1.2	3.8	1.0	2.20	0.3331
Other farmers I know well	3.4[a]	1.3	3.8[b]	1.4	4.1[c]	1.3	18.98	0.0001
F. Perceived behavioural control: to be able to take (more) measures at my farm that contribute to CA. CB= 0.70 *totally disagree - totally agree*	3.3[a]	1.0	3.6[b]	1.0	3.8[b]	1.0	17.93	0.0001
I have sufficient knowledge	4.0[a]	1.5	4.5[b]	1.5	4.5[b]	1.5	12.05	0.0024
I have sufficient time	3.4	1.6	3.6	1.6	3.7	1.7	2.79	0.2475
I have sufficient money	2.9	1.8	2.9	1.6	3.3	1.8	4.29	0.1171
I have sufficient support from my near surroundings	3.6[a]	1.6	4.0[b]	1.5	4.1[b]	1.5	8.38	0.0151
I have sufficient land	3.3[a]	2.0	3.5[a]	2.0	4.3[b]	1.8	20.83	0.0001
I have too many animals	2.4	1.7	2.4	1.6	2.2	1.6	1.32	0.5180
The size of my farm is sufficient	3.8[a]	1.6	4.1[a]	1.7	4.5[b]	1.7	14.31	0.0008
G. Perceived risk and uncertainty* ; CB= 0.78 *totally disagree - totally agree*	4.7[c] (n = 152)	1.5	4.3[b] (n = 128)	1.4	3.9[a] (n = 142)	1.5	17.31	0.0002
I feel uncertain whether I will succeed to take (more) measures that contribute to CA at my farm within 5 years	4.4	1.9	3.8	1.8	3.9	1.7	5.20	0.0743
I have the feeling that it is quite risky if I take (more) measures that contribute to CA at my farm within 5 years	4.7[b]	1.7	4.5[b]	1.8	3.8[a]	1.8	16.29	0.0003
I have the feeling that I become too dependent of others if I start taking (more) measures that contribute to CA at my farm	4.8[c]	1.6	4.4[b]	1.7	4.0[a]	1.7	14.77	0.0006
H. Subjective knowledge; CB= 0.87 *totally agree - totally disagree*	3.8a	1.2	4.1[ab]	1.3	4.3[b]	1.5	8.69	0.013
I know a lot about CA	3.8[a]	1.4	4.1[a]	1.5	4.4[b]	1.7	9.88	0.0072
I feel very well informed about CA	3.7[a]	1.4	4.0[ab]	1.6	4.2[b]	1.8	7.49	0.0236
Compared to most other farmers, I know a lot about CA	3.9[a]	1.4	4.1[a]	1.4	4.5[b]	1.6	8.38	0.0151
I. Intrinsic motivation: what would motivate you to start taking (more) measures that contribute to CA? CB= 0.94 *totally disagree - totally agree*	3.9[a]	1.7	4.1[a]	1.5	4.8[b]	1.3	25.67	0.0001
Because I can contribute to something worthwile.	3.9[a]	1.8	4.1[a]	1.6	5.0[b]	1.4	28.66	0.0001
Because I think it is important.	3.9[a]	1.8	4.1[a]	1.6	4.9[b]	1.5	23.45	0.0001
Because I feel responsible for it.	4.0[a]	1.8	4.2[a]	1.6	4.8[b]	1.5	19.76	0.0001
Because I want to do something good.	3.8[a]	1.8	4.0[a]	1.6	4.7[b]	1.6	17.75	0.0001
J. Extrinsic motivation: what would motivate you to start taking (more) measures that contribute to CA? CB= 0.77 *totally disagree - totally agree*	4.0	1.5	4.0	1.3	4.3	1.1	1.89	0.3885
Because I am rewarded for it	4.5	2.0	4.5	1.9	4.6	1.9	0.17	0.9199
Because it is socially accepted.	3.7	1.7	3.9	1.6	4.1	1.5	2.02	0.3648
Because I want to be seen as a good agricultural entrepreneur	3.9	1.8	3.9	1.7	4.3	1.7	4.65	0.0980
Because it is expected of me.	3.7	1.7	3.8	1.7	4.0	1.6	3.18	0.2179

(*continued on next page*)

Appendix I (*continued*)

Constructs with separate propositions	CA-low farmers (n = 155) Mean	Std.	CA-medium farmers (n = 132) Mean	Std.	CA-high farmers (n = 142) Mean	Std.	Kruskal-Wallis equality of populations rank test Chi^2	P
K. Perceived obstacles* *: to what extent would the following possible aspects of CA withhold you to take (more) measures that contribute to CA? CB=N/A *Very certainly – certainly not*								
If I have to wait a year before I see the results	4.7	1.7	4.4	1.8	4.8	2.0	4.03	0.1331
If I have to wait 10 years before I see the results	4.0	2.1	3.9	2.0	4.2	2.0	1.44	0.4876
If it lasts until the next generation before I see the results	3.9	2.2	3.9	2.1	4.2	2.1	2.62	0.2698
If it is necessary to cooperate more	4.5	1.6	4.0	1.8	4.4	1.9	5.06	0.0796
If it makes me more dependent of others	4.1	1.9	3.8	1.7	4.0	1.9	1.38	0.5018
L. Prioritised goals of farmers; CB=N/A *Farmers were asked to divide 20 points over these 11 goals*								
Expansion	0.4	0.9	0.3	0.9	0.3	0.8	0.25	0.8820
Passing the land in a good condition to the next generation	1.9^{a}	1.9	2.5^{b}	2.0	2.7^{b}	2.2	10.97	0.0041
Work pleasure	4.2^{c}	1.9	3.9^{b}	2.1	3.5^{a}	2.5	18.66	0.0001
Maintain tradition	0.3	0.7	0.6	1.4	0.4	1.0	5.38	0.0678
Working with animals, plants and nature	2.2	1.9	2.1	1.9	2.1	1.9	0.11	0.9461
Being financially successful	3.4^{b}	2.6	2.6^{a}	2.7	2.4^{a}	2.3	14.82	0.0006
Taking good care of the environment, biodiversity and the surroundings	1.5^{a}	1.7	1.7^{a}	1.6	2.4^{b}	1.7	22.30	0.0001
Being a good employer	0.7	1.2	0.5	1.0	0.7	1.0	3.19	0.2030
Working with machinery and technology	0.8^{a}	1.3	0.9^{ab}	1.2	1.0^{b}	1.3	6.65	0.0360
Being independent/ autonomy	1.6	1.9	1.5	1.8	1.5	1.8	0.16	0.9217
Producing good and safe food	3.1	2.2	3.2	2.1	3.1	1.9	0.66	0.7188

[abc] different characters in a row indicate a significant difference

*because of an omission in the questionnaire, the farmers could also answer 'don't know/not applicable' in these questions (they could not in the others). These answers were included as missing values in the analysis

* * a high score for this construct means that an obstacle withholds a farmer to a lesser extent to take (more) measures that contribute to CA

Appendix II

Mean scores and standard deviations of organic, biodynamic and other farmers for all constructs; the propositions are measured on a 7 point scale with 1 being the most negative answer and 7 being the most positive answer.

	Farmers who do not have an organic or bio dynamic farm (n = 380) Mean	Std.	Organic farmers (n = 38) Mean	Std.	Bio dynamic farmers (n = 11) Mean	Std.	Kruskal-Wallis equality of populations rank test Chi^2	P
Intention	3.9^{a}	1.5	5.3^{b}	1.4	5.6^{b}	1.9	35.86	0.0001
Attitude	3.7^{a}	1.2	5.1^{b}	1.3	6.3^{c}	0.7	64.32	0.0001
Behavioural beliefs	4.0^{a}	1.0	5.2^{b}	1.0	6.2^{c}	0.6	66.17	0.0001
Injunctive social norms	3.9	1.1	4.0	0.8	4.1	0.8	0.81	0.6670
Descriptive social norms	3.7^{a}	1.1	4.2^{b}	1.1	4.5^{b}	1.0	10.68	0.0048
Perceived behavioural control	3.5^{a}	1.0	4.0^{b}	1.1	4.3^{b}	0.8	15.15	0.0005
Perceived risk and uncertainty*	4.5^{b} (n = 374)	1.4	3.2^{a} (n = 37)	1.3	2.5^{a} (n = 11)	1.5	37.16	0.0001
Subjective knowledge	4.0^{a}	1.3	3.9^{a}	1.8	2.2^{b}	1.7	11.26	0.0036
Intrinsic motivation	4.1^{a}	1.5	5.4^{b}	1.5	6.5^{c}	0.8	53.18	0.0001
Extrinsic motivation	4.1	1.3	4.1	1.3	4.9	1.0	3.873	0.1442

[abc] different characters in a row indicate a significant difference

*because of an omission in the questionnaire, the farmers could also answer 'don't know/not applicable' in these questions (they could not in the others). These answers were included as missing values in the analysis

3.5.2. Attitude, injunctive and descriptive social norms and perceived behavioural control

CA-high farmers have a more positive attitude towards CA than CA-medium and CA-low farmers. They think that taking measures that contribute to CA is feasible, favourable and important to a greater extent than the other farmers. CA-high and CA-medium farmers think that taking CA-measures is profitable to a greater extent. Looking at injunctive and descriptive norms revealed that mean scores for descriptive social norms were higher for CA-medium and CA-high farmers than for CA-low farmers. Farmers who take more measures that contribute to CA had higher scores for the proposition 'farmers I know well contribute to CA' (Appendix I. E). Mean scores for injunctive norms did not differ between CA-low, CA-medium and CA-high farmers, but looking at separate propositions of this construct revealed that CA-high farmers had higher scores for the propositions 'farmers I know well expect me to contribute to CA' and 'buyers expect me to contribute to CA' (Appendix I. D). Looking at perceived behavioural control revealed that CA-high farmers and CA-medium farmers had higher scores for perceived behavioural control than CA-low farmers. Having sufficient time and money are particularly important obstacles for the surveyed farmers in taking (more) measures that contribute to CA. None of the farmers seemed to think that they had too many animals to contribute to CA. However, CA-low farmers thought that they had enough knowledge and support from their surroundings to contribute to CA to a lesser extent than CA-medium and CA-high farmers, and CA-low and CA-medium farmers thought that they had sufficient land and a big enough farm to take (more) measures that contribute to CA to a lesser extent (Appendix I. F).

3.5.3. Perceived risk and uncertainty, subjective knowledge, intrinsic and extrinsic motivation and values

In the extended TPB model, perceived risk and uncertainty, intrinsic and extrinsic motivation, and subjective knowledge are included. CA-high farmers appeared to be less concerned than CA-medium and CA-

low farmers that it is risky to take (more) CA-measures, or that they risk becoming too dependent on others if they do so (perceived risk and uncertainty; Appendix I. G). Looking at subjective knowledge revealed that CA-high farmers perceived to have more knowledge about CA than CA-low farmers (Appendix I. I). Furthermore, CA-high farmers appeared more intrinsically motivated to contribute to CA than CA-medium and CA-low farmers (Appendix I. I). Scores for extrinsic motivation did not differ between the farmers (Appendix I. J). To learn more about the farmers' embeddedness in nature and why they were intrinsically or extrinsically motivated to contribute to CA, the surveyed farmers were asked to divide 20 points over 11 goals. CA-high and CA-medium farmers on average assigned more points to 'passing the land in a good condition to the next generation' than CA-low farmers and CA-high farmers assigned on average more points to 'taking good care of the environment, biodiversity and the surroundings' than the other farmers. On average, CA-low farmers assigned more points to 'work pleasure' and 'being financially successful' than CA-medium and CA-high farmers (Appendix I. L).

3.5.4. *Perceived obstacles and time-varying discount rates*

In the survey, we looked at possible obstacles for the participating farmers through perceived behavioural control (see 3.5.2) and the perceived obstacles mentioned in Appendix I.K. The possibility that the surveyed farmers have to wait one year, ten years or until the next generation before they see the results of the measures they take to contribute to CA, but it does not prevent them to do so (time-varying discount rates; Appendix I. K). The same is true of the possibility that more cooperation is needed. More mutual dependency also exists between parties involved in CA (last two propositions of perceived obstacles; Appendix I. K). On the other hand, CA-low farmers had higher scores for the proposition 'CA makes me too dependent of others' than the other farmers and CA-medium farmers had higher scores for this proposition than CA-high farmers (proposition 3 of perceived risk and uncertainty, Appendix I. G).

4. Discussion

4.1. *Behavioural factors influencing Dutch farmers' decision making in circular agriculture*

This paper focused on behavioural factors and external conditions that play a role in the transition towards CA. We hypothesised, based on Raworth's five shifts (2017), that social norms and cooperation are more important as farmers are more engaged in CA, that farmers who contribute to CA are more intrinsically motivated and are motivated more by social and environmental and less by economic values, and that farmers who are more engaged in CA are less affected by time-varying discount rates. The study confirmed part of this hypothesis. Of the behavioural factors that we assumed to be important in CA, injunctive and – from the original TPB model – descriptive social norms (what others expect and do) and intrinsic motivation seem to play a particularly important role. However, we did not find indications that cooperation was more important in CA or that farmers engaged in CA were less sensitive to time-varying discount rates.

Dessart et al. (2019) mentioned different examples of descriptive and injunctive social norms positively affecting farmers' adoption of sustainable practices in their review paper (see 1.2.1). Differences regarding intrinsic motivation and values found between CA-high farmers and other farmers in the survey and in the findings of the in-depth interviews correspond with findings of other authors who compared behavioural factors of organic and other farmers. Examples are more ideological motivations (Canavari et al., 2008), more often following an eco-centric approach towards agri-environmental issues (Kings and Ilbery, 2012), showing more environmentally orientated behaviours (Kings and Ilbery, 2012; Power et al., 2013; Dessart et al., 2019). In our survey, we did not compare organic or biodynamic farmers with other farmers; this was not the goal of our study. However, most of the organic and biodynamic farmers participating in the survey were in the CA-high group, and univariate analyses aimed at finding the differences between organic, biodynamic and other farmers pointed to similar conclusions as found when comparing CA-low, CA-medium and CA-high farmers (Appendix II).

We also hypothesised that farmers who are more engaged in CA, have a more positive attitude towards and more positive beliefs about CA, perceive more control and less risk and uncertainty about CA and think that they have more knowledge about CA than farmers who are less engaged in CA. Our study confirmed this. Perceived risk and uncertainty and beliefs appeared to predict attitude, attitude appeared to predict intention and intention and subjective knowledge appeared to predict the relative number of CA-measures taken. The importance of attitude, group norm, perceived behavioural control, risk perception and knowledge is mentioned in many other studies concerning behavioural change of farmers in different agricultural sectors (Staats et al., 2011; Power et al., 2013; Lokhorst et al., 2014; Sok et al., 2016; van Dijk et al., 2016; de Lauwere et al., 2020; Yanakittkul and Aungvaravong, 2020).

4.2. *External conditions*

The starting point of our study was that the intention to change behaviour depends on behavioural factors as well as external conditions that influence the step from intention to action (see introduction). Therefore, we also hypothesised that external conditions play a role in the transition towards CA.

In the in-depth interviews, knowledge, resistance from the environment and unsuitable legislation were the barriers mentioned most often. The interviewed farmers who attempted to contribute to CA by taking measures like closing nutrient cycles on farm level, not importing concentrate from abroad anymore and not keeping more animals than could be fed from the own land were eager to share their knowledge – some of them even called themselves evangelical. The importance of knowledge in agricultural practices is emphasised by different authors (Meijer et al., 2015; European Commission, 2019; Siebrecht, 2020). However, it is questionable whether farmers who do not feel addressed by CA want to hear about or are sensitive to this knowledge, or as one of our interviewed farmers said: '*Most people only read what they want to read without looking what is really written.*' (cpi-low farmer 5). Siebrecht (2020) mentions that some of the debates about sustainable agriculture can be understood as "personal criticism, or an attack, on conventional agriculture" and that this can lead to situations where farmers can become defensive. This was also mentioned by some of the interviewed farmers (see 3.2.1). They also mentioned the resistance that they experienced from the environment. This is also found by Läpple and Kelley (2013) in the context of organic farming. In our interviews, it appeared that some of the farmers confronted with it were hampered by it, while it made others more combative. In that sense, we may speak of a negative social norm for farmers engaged in circular initiatives, and the ability to resist that seems to be important. Unsuitable legislation was another complaint among the interviewed farmers. They stated that their initiatives did not fit in with legislation designed for conventional farming. This caused a lot of trouble. Hoes et al. (2020) also mention that farmers engaged in CA sometimes kept their initiatives small on purpose – on a hobby level – in order to prevent them from being confronted with this unsuitable legislation and the administrative burden it entails.

In the survey, propositions were included (in the perceived behavioural control construct) about having enough time, money and knowledge, having a suitable barn and farm size and having sufficient support from the near surroundings. All surveyed farmers perceived having enough time and money as an obstacle. CA-low farmers in particular perceived knowledge and having enough support from the near surroundings as an obstacle, and both CA-low and CA-medium farmers perceived not having sufficient land and a suitable farm size

as obstacles.

Complex and overlapping regulations and the lack of governmental support, lack of knowledge and information, lack of social support and economic factors also are mentioned by other authors (Lewandowski, 2016; Tura et al., 2019). These authors do not write specifically about circular agriculture but about circular businesses in general. Lewandowski (2016) distinguishes the so-called 'PEST-factors' for the adoption of circular businesses, referring to Political, Economic, Social and Technological factors. Tura et al. (2019) also mention these factors, in addition to institutional, informational, supply chain-related and organisational barriers that can hamper the development of circular business models.

4.3. Implications of the study

The aim of our study was to get a better understanding of behavioural factors and external conditions that influence Dutch farmers' decision making in the transition towards CA. These can be important for policymakers as well as for other advisors who influence farmers' decision making regarding CA (see introduction). According to Greiner et al. (2009), the design of conservation policies and programmes at the regional level ought to be guided by a better understanding of the motivations and risk attitudes of farmers so incentives can be tailored and bundled for maximum effectiveness and efficiency; the authors state that "If a high rate of adoption of conservation practices is critical to achieving region-scale improvements in environmental condition, incentives need to appeal to the range of motivational profiles and risk perceptions of farmers, which may vary between industries and regions". Our study showed that attitude, intrinsic and extrinsic motivation, injunctive norms, behavioural beliefs and perceived risk and uncertainty and subjective knowledge seem to be particularly important behavioural factors in CA.

A behaviour change method that may prove suitable for influencing motivations and beliefs – and thus attitude – is persuasive communication (Kok et al., 2015; Muranko et al., 2018). This means guiding individuals and environmental agents towards the adoption of ideas, attitudes or actions by using arguments or other means (Kok et al., 2015). Framing context is a powerful and well-established persuasive technique (Jackson, 2005, p.67; Raworth, 2017; p. 109) and is helpful to encourage widespread (unsubsidised) uptake of environmental management practices (Mills et al., 2018).

In our study, subjective knowledge appeared to be a significant predictor of the relative number of CA measures taken. According to Lam et al. (2017) education is a very strong method for increasing internal motivation. Siebrecht (2020) mentions that different formats and methods of knowledge communication are necessary for the implementation of sustainable agriculture, and that new knowledge and how it is brought to farmers has to be adapted to individual situations. Providing information can also be useful for decreasing farmers' perception of risk and uncertainty. For example, Trujillo-Barrera et al. (2016) found that it is important to provide farmers with more content knowledge about the risk and uncertainty of an investment if the perceived financial risk is a barrier to the adoption of sustainable practices.

According to our interviews, still a lot of resistance seems to exist in the case of CA. This is to be expected because, according to the Stages of Change model (SoC) or Transtheoretical model (TTM) of Prochaska et al. (2015), behaviour change comes in stages. The model assumes five stages of motivation and readiness for change making: (1) pre-contemplation, (2) contemplation, (3) preparation, (4) action and (5) maintenance. Individuals in different stages of the behaviour change process need different interventions (Ludden and Hekkert, 2014). In the pre-contemplation and contemplation stage, people are not aware of the need to change and are not yet ready to change. In these stages, interventions should be directed towards raising awareness, probably in a general publicly available intervention rather than a personal one, because people will not be motivated to start changing their behaviour yet (Niedderer et al., 2014).

For farmers already engaged in circular initiatives, interventions aiming at raising awareness and motivation are not necessary, but interventions enabling them to maintain and manage their circular initiative can be helpful, for example, by regulation that fits their special way of farming or less bureaucratic procedures concerning certification (Canavari et al., 2008). According to Läpple and Kelly (2013), policy incentives in terms of support payments are not sufficient to increase the size of the organic sector, since social and technical barriers seem to outweigh financial incentives. However, once these obstacles are overcome, economic incentives seem to be important. This was also mentioned by several interviewed farmers engaged in circular initiatives.

4.4. Limitations

In our study, we applied the original TPB model and an extended TPB model to explore the behavioural factors important in the transition towards CA. According to the original TPB, behavioural beliefs predict attitude, injunctive and descriptive social norms predict intention, and intention and perceived behavioural control predict the relative number of measures taken by the farmers. However, model fit indices of this model showed an insufficient fit with the data. Extending the model with perceived risk and uncertainty, intrinsic and extrinsic motivation and subjective knowledge substantially improved these model indices. Accordingly, perceived risk and uncertainty and subjective knowledge did not interfere with the other factors in the model. These two factors thus seem to be valuable additions in our model. Intrinsic and (to a lesser extent) extrinsic motivation (see 3.4) seem to interfere with social norms. A possible explanation for this is that descriptive and injunctive norms are about what important others do and what they expect (Nolan et al., 2008), and are therefore important for guiding one's own behaviour (Schultz et al., 2007; Keizer et al., 2008). Intrinsic and extrinsic motivation also are related to what people find important and value (Greiner and Gregg, 2011). More research is necessary to get a better understanding of the relationship between intrinsic and extrinsic motivation and social norms.

In our study, we applied a mixed method approach. The in-depth interviews were helpful to get a better understanding of what motivated the surveyed farmers' answers. However, the in-depth interviews mainly included 'special farms'. For example, four farmers had biodynamic farms, one farmer had an organic farm, three farmers said to fulfil the conditions for organic or biodynamic farming but did not want to certify, and one other farmer applied special technology to reduce greenhouse gasses. Comparatively, most surveyed farmers (380 of 429) were farmers who did not have an organic or biodynamic farm and contributed to CA to varying degrees (referred to as CA-high, CA-medium and CA-low farmers). As such, it is important to be careful when comparing the results of the interviews and the survey. On the other hand, comparing organic, biodynamic and other farmers in the survey instead of CA-low, CA-medium and CA-high farmers gave results that pointed to similar conclusions (Appendix II). The in-depth interviews were also important for gaining further insight into the external conditions that play a role in the transition towards CA, and they illustrate how intrinsically motivated farmers engaged in CA can be.

5. Conclusions

In this paper, we have shown that attitude, intrinsic and extrinsic motivation, injunctive norms, behavioural beliefs and perceived risk and uncertainty, and subjective knowledge are important behavioural factors that influence farmers' decision making in the transition towards CA. We also saw that CA-high farmers are triggered more by social and environmental values, which can be expected if farmers are more intrinsically motivated (Muranko et al., 2018).

The insights presented in this paper can be helpful for targeted interventions aimed at stimulating farmers to undertake actions that contribute to CA. Persuasive communication can be helpful to influence motivations and beliefs, and thus attitude (Kok et al., 2015). Framing directed towards increasing pro-environmental and social values and education can be helpful for increasing intrinsic motivation (Jackson, 2005; Mills et al., 2016; Raworth, 2017; Lam et al., 2017), economic incentives can be helpful to increase extrinsic motivation; and providing information can be useful for decreasing farmers' perceptions of risk and uncertainty (Trujillo-Barrera et al., 2016; Kok et al., 2015), and increasing farmers' knowledge, provided the way information is offered is adapted to individual situations (Siebrecht, 2020).

We do not expect that social pressure will be helpful at this stage of the transition towards CA, as many conventional farmers still seem to resist CA. As such, interventions to stimulate the adoption of CA measures should be directed at first raising awareness among those farmers who are negative about CA.

The intention to change behaviour depends on behavioural factors as well as external conditions that influence the step from intention to action (Wilson and Dowlatabadi, 2007; Ellis-Iversen et al., 2010; Niederer et al., 2014; Meijer et al., 2015). Finding ways to overcome internal barriers (i.e. a lack of intrinsic motivation, negative attitudes, beliefs and perceptions) and external barriers (i.e. legislation, lack of knowledge and negative social pressure) is necessary to enable the transition towards CA.

Declaration of interests

None.

Acknowledgements

This research is part of the Knowledge Based programme 'Towards a circular and climate neutral society' funded by the Dutch Ministry of Agriculture, Nature and Food Quality and carried out by Wageningen University and Research. We would like to thank all the farmers who participated in this research by giving an interview or finishing the survey. We would also like to thank our colleagues Siet Sijtsema, Jamal Roskam and Tom Kisters for their useful comments on earlier drafts of this paper.

Appendix

See Appendix I and Appendix II.

References

Ajzen, I., 1991. The theory of planned behavior. Organ. Behav. Hum. Decis. Process. 50, 179–211. https://doi.org/10.1016/0749-5978(91)90020-T.

Arora, N.K., 2018. Agricultural and food security. Environ. Sustain. 1, 217–219. https://doi.org/10.1007/s42398-018-00032-2.

Bijttebier, J., Ruysschaert, G., Hijbeek, R., Werner, M., Pronk, A.A., Zavattaro, L., Bechini, L., Grignani, C., Ten Berge, H., Marchand, F., Wauters, E., 2018. Adoption of non-inversion tillage across Europe: Use of a behavioural approach in understanding decision making of farmers. Land Use Policy 78, 460–471. https://doi.org/10.1016/j.landusepol.2018.05.044.

Bruijnis, M., Hogeveen, H., Garforth, C., Stassen, E., 2016. Dairy farmers' attitudes and intentions towards improving dairy cow foot health. Livest. Sci. 155, 103–113. https://doi.org/10.1016/j.livsci.2013.04.005.

Canavari, M., Lombardi, P., Cantore, N., 2008. Factors explaining farmers' behaviours and intentions about agricultural methods and production. Organic vs. conventional comparison. 16th IFOAM Organic World Congress, Modena, Italy, June 16–20, 2008. ⟨https://orgprints.org/id/eprint/12577/1/12577.pdf⟩.

Dagevos, H., De Lauwere, C., 2021. Circular business models and circular agriculture: perceptions and practices of Dutch farmers. Sustainability 13, 1282. https://doi.org/10.3390/su13031282.

Deci, E.L., Ryan, R.M., 2012. In: Van Lange, P.A.M., Kruglanski, A.W., Higgings, E.T. (Eds.), Self-determination theory. In Handbook of Theories of Social Psychology, 2011. Sage, Thousand Oaks, CA, USA, pp. 416–436. https://doi.org/10.4135/9781446249215.n21.

Defrancesco, E., Gatto, P., Runge, F., Trestini, S., 2008. Factors affecting farmers' participation in agri-environmental measures: a Northern Italian perspective. J. Agric. Econ. 59 (1), 114–131. https://doi.org/10.1111/j.1477-9552.2007.00134.x.

Dessart, F.J., Barreiro-Hurlé, J., van Bavel, R., 2019. Behavioural factors affecting the adoption of sustainable farming practices: a policy-oriented review. Eur. Rev. Agric. Econ. 46 (3), 417–471. https://doi.org/10.1093/erae/jbz019.

Edwards-Jones, G., 2006. Modelling farmer decision making: concepts, progress and challenges. Anim. Sci. 82, 783–790. https://doi.org/10.1017/ASC2006112.

Ellis-Iversen, J., Cook, A.J.C., Watson, E., Nielen, M., Larkin, L., Wooldridge, M., Hogeveen, H., 2010. Perceptions, circumstances and motivators that influence implementation of zoonotic control programs on cattle farms. Prev. Vet. Med. 93, 276–285. https://doi.org/10.1016/j.prevetmed.2009.11.005.

Erisman, J.W., Verhoeven, F., 2020. Integraal op weg naar Kringlooplandbouw 2030: Een Voorstel voor Kritische Prestatie Indicatoren Systematiek (An Integral Way towards Circular Agriculture). Louis Bolk Institute, Bunnik, The Netherlands. ⟨https://www.louisbolk.nl/sites/default/files/publication/pdf/integraal-op-weg-naar-kringlooplandbouw-2030.pdf⟩.

European Commission, 2019. Building stronger agricultural knowledge and innovation systems (AKIS) to foster advice, knowledge and innovation in agriculture and rural areas; ⟨https://ec.europa.eu/info/sites/default/files/food-farming-fisheries/key_policies/documents/building-stronger-akis_en.pdf⟩.

Fishbein, M., Ajzen, I., 2010. Predicting and Changing Behavior: the Reasoned Action Approach. Psychology Press, New York.

Flynn, L.R., Goldsmith, R.E., 1999. A short, reliable measure of subjective knowledge. J. Bus. Res. 46 (1), 57–66. https://doi.org/10.1016/S0148-2963(98)00057-5.

Fresco, L.O., Geerling-Eiff, F., Hoes, A.C., Van Wassenaer, L., Poppe, K.J., Van der Vorst, J.G.A.J., 2021. Sustainable food systems: do agricultural economists have a role? jbab026 Eur. Rev. Agric. Econ.. https://doi.org/10.1093/erae/jbab026.

Garforth, C., 2015. Livestock keepers' reasons for doing and not doing things which governments, vets and scientist would like them to do. Zoonos. Pub. Health 62 ((suppl.1), 29–38. https://doi.org/10.1111/zph.12189.

Gilbert, W., Rushton, J., 2018. Incentive perception in livestock disease control. J. Agric. Econ. 69 (1), 243–261. https://doi.org/10.1111/1477-9552.12168.

Greiner, R., Gregg, D., 2011. Farmers' intrinsic motivations, barriers to the adoption of conservation practises and effectiveness of policy instruments: empirical evidence from Northern Australia. Land Use Policy 28 (1), 257–265. https://doi.org/10.1016/j.landusepol.2010.06.006.

Greiner, R., Patterson, L., Miller, O., 2009. Motivations, risk perceptions and adoption of conservation practices by farmers. Agric. Syst. 99 (2–3), 86–104. https://doi.org/10.1016/j.agsy.2008.10.003.

Hair, J.F., Anderson, R.E., Tatham, R.L., Black, W.C., 1998. Multivariate Fata Analysis, Fifth ed. Prentice-Hall International, Inc, New jersey.

Herzfeld, T., Jongeneel, R.A., 2012. Why do farmers behave as they do? Understanding compliance with rural, agricultural, and food attribute standards. Land. Use Pol. 29 (1), 250–260. https://doi.org/10.1016/j.landusepol.2011.06.014.

Hoes, A.-C., Slegers, M., Savelkouls, C., Beldman, A., Lakner, D., Puister-Jansen, L., 2020. Toekomstige Voedselproductie: Een Portret van Pionierende Boeren die Bijdragen aan Kringlooplandbouw in Nederland (Future Food Production: A Portrait of Pioneering Farmers who Contribute to Circular Agriculture in the Netherlands). Wageningen Economic Research, Wageningen, The Netherlands, p. 2020. ⟨https://edepot.wur.nl/519070⟩.

Hollander, A., Temme, E.H. M., Zijp, M., 2016. The environmental sustainability of the Dutch diet. Background report to 'What is on our plate? Safe, healthy and sustainable diets in the Netherlands. RIVM Report 2016–0198. ⟨https://doi.org/10.13140/RG.2.2.23632.92162⟩.

Jackson, T., 2005. Motivating Sustainable Consumption. A Review of Evidence on Consumer Behaviour and Behavioural change. A report to the Sustainable Development Research Network. Centre for Environmental Strategy, University of Surrey, Surrey.

Jones, P.J., Marier, E.A., Tranter, R.B., Wu, G., Watson, E., Teale, C.J., 2015. Factors affecting dairy farmers' attitudes towards antimicrobial medicine usage in cattle in England. Prev. Vet. Med. 121 (1–2), 30–40. https://doi.org/10.1016/j.prevetmed.2015.05.010.

Keizer, K., Lindenberg, M., Steg, L., 2008. The spreading of disorder. Science 322, 1681–1685. https://doi.org/10.1126/science.1161405.

Kings, D., Ilbery, B., 2012. Farmers' attitudes towards organic and conventional agriculture: a behavioural perspective. In: M. Reed (Ed.), Organic Food and Agriculture – new trends and developments in the social sciences. ⟨https://doi.org/10.5772/27572⟩.

Kok, G., Gottlieb, N.H., Peters, G.Y., Dolan Mullen, P., Parcel, G.S., Ruiter, R.A.C., Fernández, M.E., Markham, C., Bartolomew, L.K., 2015. A taxonomy on behaviour change methods: an intervention mapping approach. Health Psychol. Rev. 10 (3), 297–312. https://doi.org/10.1080/17437199.2015.1077155.

Kunreuther, H., Novemsky, N., Kahneman, D., 2001. Making low probabilities useful. J. Risk Uncertain. 103–120. https://doi.org/10.1023/A:1011111601406.

Lam, T.J.G.M., Jansen, J., Wessels, R.J., 2017. The RESET Mindset Model applied on decreasing antibiotic usage in dairy cattle in the Netherlands. Ir. Vet. J. 70–75. https://doi.org/10.1186/s13620-017-0085-x.

Läpple, D., Kelley, H., 2013. Understanding the uptake of organic farming: accounting for heterogeneities among Irish farmers. Ecol. Econ. 88, 11–19. https://doi.org/10.1016/j.ecolecon.2012.12.025.

de Lauwere, C., van Asseldonk, M., Bergevoet, R., Bondt, N., 2020. Understanding decision-making of farmers with regard to participation in a dairy health programme. Livest. Sci. 239. https://doi.org/10.1016/j.livsci.2020.104061.

Lewandowski, M., 2016. Designing the business models for circular economy – towards the conceptual framework. Sustainability 8, 43. https://doi.org/10.3390/su8010043.

LNV, 2018. Agriculture, nature and food: valuable and connected. Dutch ministry of Agriculture, Nature and Food Quality, Den Haag.
LNV, 2019. Agenda to realize a circular agriculture (uitvoeringsagenda). Dutch ministry of Agriculture, Nature and Food Quality, Den Haag.
Lokhorst, A.M., Hoon, C., le Rutte, R., de Snoo, R., 2014. There is an I in nature: the crucial role of the self in nature conservation. Land Use Policy 39, 121–126. https://doi.org/10.1016/j.landusepol.2014.03.005.
Ludden, G.D.S., Hekkert, P., 2014. Design for healthy behavior. Design interventions and stages of change. 9th International Conference on Design and Emotion, Bogota, Colombia.
Meijer, S.S., Catacutan, D., Ajayi, O.C., Sileshi, G.W., Nieuwenhuis, M., 2015. The role of knowledge, attitudes and perceptions in the uptake of agricultural and agroforestry innovations among smallholder farmers in sub-Saharan Africa. Int. J. Agric. Sustain. 13 (1), 40–54. https://doi.org/10.1080/14735903.2014.912493.
Mills, J., Gaskell, P., Ingram, J., Dwyer, J., Reed, M., Short, C., 2016. Engaging farmers in environmental management through a better understanding of behaviour. Agric. Hum. Values 1–17. https://doi.org/10.1007/s10460-016-9705-4.
Mills, J., Gaskell, P., Ingram, J., Chaplin, S., 2018. Understanding farmers' motivations for providing unsubsidised environmental benefits. Land Use Policy 76, 697–707. https://doi.org/10.1016/j.landusepol.2018.02.053.
Muranko, Z., Andrews, D., Newton, E.J., Chaer, I., Proudman, P., 2018. The pro-circular change model (P-CCM): proposing a framework facilitating behavioural change towards a circular economy. Resour. Conserv. Recycl. 135, 132–140. https://doi.org/10.1016/j.resconrec.2017.12.017.
Niedderer, K., Cain, R., Clune, S., Lockton, D., Ludden, G., Mackrill, J., Morris, A., 2014. Creating Sustainable Innovation through Design for Behaviour Change. Full Project Report. ⟨https://www.researchgate.net/profile/Kristina_Niedderer/publication/271702914_Creating_Sustainable_Innovation_through_Design_for_Behaviour_Change_Full_Report/links/54cf98700cf298d656646e6c/Creating-Sustainable-Innovation-through-Design-for-Behaviour-Change-Full-Report.pdf?origin=publication_detail⟩.
Nolan, J.M., Schultz, P.W., Cialdini, R.B., Goldstein, N.J., Griskevicius, V., 2008. Normative social influence is underdetected. Personal. Soc. Psychol. Bull. 34 (7), 913–923. https://doi.org/10.1177/0146167208316691.
Ogurtsov, V.A., Van Asseldonk, M.P.A.M., Huirne, R.B.M., 2008. Assessing and modelling catastrophic risk perceptions and attitudes in agriculture: a review. Wagening. J. Life Sci. NJAS 56 (1/2), 39–58. https://doi.org/10.1016/S1573-5214(08)80016-4.
Pollitt, M.G., Shaorshadze, I., 2013. The role of behavioural economics in energy and climate policy. In: Fouquet, R. (Ed.), Handbook on Energy and Climate Change. Edward Elger, Cheltenham, UK, Northampton, MA, USA, pp. 523–546.
Power, E.F., Kelley, D.L., Stout, J.C., 2013. Impacts of organic and conventional dairy farmer attitude, behaviour and knowledge on farm biodiversity in Ireland. J. Nat. Conserv. 21, 272–278. https://doi.org/10.1016/j.jnc.2013.02.002.
Prochaska, J.O., Redding, C.A., Evers, K.E., 2015. The transtheoretical model and stages of change. In: Glanz, K., Rimer, B.K., Viswanath, K. (Eds.), Health behavior: Theory, research, and practice. Jossey-Bass, San Francisco, CA, pp. 125–148.
Raworth, Kate, 2017. Doughnut Economics. Seven ways to think like a 21st-century economist. Random House, UK.
Razali, N.M., Bee Wah, Y., 2011. Power comparisons of Shapiro-Wilk, Kolmogorov-Smirnov, Lilliefors and Anderson-Darling Tests. J. Stat. Model. Anal. 2 (1), 21–33.
Ritchie, H., Roser, M., 2020. Environmental impacts of food production. Published online at OurWorldInData.org. ⟨https://ourworldindata.org/environmental-impacts-of-food⟩.
Schermelleh-Engel, K., Moosbrugger, H., Müller, H., 2003. Evaluation the fit of structural equation models: tests of significance and descriptive goodness-of-fit measures. Methods Psychol. Res. 8 (2), 23–74.
Schultz, P.W., Nolan, J.M., Cialdini, R.B., Goldstein, N.J., Griskevicius, V., 2007. The constructive, destructive, and reconstructive power of social norms. Psychol. Sci. 18, 429–434. https://doi.org/10.1111/j.1467-9280.2007.01917.x.
Senger, I., Borges, J.A.R., Macchado, J.A.M.D., 2017. Using the theory of planned behavior to understand the intention of small farmers in diversifying their agricultural production. J. Rural St. 49, 32–40. https://doi.org/10.1016/j.jrurstud.2016.10.006.
Siebrecht, N., 2020. Sustainable agriculture and its implementation gap – overcoming obstacles to implementation. Sustainability 12 (9), 3853. https://doi.org/10.3390/su12093853.
Sok, J., Hogeveen, H., Elbers, A.R.W., Oude Lansink, A.G.J.M., 2016. Using farmers' attitude and social pressures to design voluntary Bluetongue vaccination strategies. Prev. Vet. Med. 133, 114–119. https://doi.org/10.1016/j.prevetmed.2016.09.016.
Staats, H., Jansen, L., Thøgersen, J., 2011. Greening the greenhouse grower. A behavioral analysis of a sector-initiated system to reduce the environmental load of green houses. J. Environ. Manag. 92, 2461–2469. https://doi.org/10.1016/j.jenvman.2011.05.007.
Sumberg, J., Giller, K.E., 2022. What is 'conventional agriculture'? Glob. Food Secur. 32, 100617 https://doi.org/10.1016/j.gfs.2022.100617.
Tavakol, M., Dennick, R., 2011. Making sense of Cronbach's alpha. Int. J. Med. Educ. 2, 53. https://doi.org/10.5116/ijme.4dfb.8dfd.
Termeer, K., 2019. Het bewerkstelligen van een transitie naar kringlooplandbouw. Briefing transitie naar kringlooplandbouw. Notitie opgesteld op verzoek van de Tweede Kamer Commissie LNV. Wageningen University & Research, Wageningen. ⟨https://edepot.wur.nl/500675⟩.
Trujillo-Barrera, A., Pennings, J.M.E., Hofenk, D., 2016. Understanding producers' motives for adopting sustainable practices: the role of expected rewards, risk perception and risk tolerance. Eur. Rev. Agric. Econ. 43 (3), 359–382. https://doi.org/10.1093/erae/jbv038.
Tura, N., Hanski, J., Ahola, T., StråS, M., Piiparinen, S., Valkokari, P., 2019. Unlocking circular business: a framework of barriers and drivers. J. Clean. Prod. 212 (1), 90–98. https://doi.org/10.1016/j.jclepro.2018.11.202.
van Dijk, W.F.A., Lokhorst, A.M., Berendse, F., De Snoo, G.R., 2016. Factors underlying farmers' intentions to perform unsubsidised agri-environmental measures. Land Use Policy 59, 207–2016.
van Eijk, F., 2015. Barriers & Drivers towards a circular economy. Literature Review. A-140315-R-Final. ⟨https://www.circulairondernemen.nl/uploads/e00e8643951aef8adde612123e824493.pdf⟩.
Wilson, C., Dowlatabadi, H., 2007. Models of decision making and residential energy use. Annu. Rev. Environ. Resour. 32, 169–203. https://doi.org/10.1146/annurev.energy.32.053006.141137.
Yanakittkul, P., Aungvaravong, C., 2020. A model of farmers intentions towards organic farming: a case study on rice farming in Thailand. Heliyon 6 (1), e03039. https://doi.org/10.1016/j.heliyon.2019.e03039.