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Fertile ground, complex matter: Plurality of farmers' attitudes towards green waste application as sustainable soil management

Maaike Happel MSc.[1] | Francesco Orsi PhD[1,2] | Thomas Hartmann PhD[3] | Martha Bakker PhD[1]

[1]Landscape Architecture and Spatial Planning Group, Wageningen University & Research, Wageningen, The Netherlands

[2]Department of Geography and Geospatial Sciences, Kansas State University, Manhattan, Kansas, USA

[3]Department of Spatial Planning, TU Dortmund University, Dortmund, Germany

Correspondence
Maaike K. Happel, MSc, Landscape Architecture and Spatial Planning Group, Postbus 47, 6700 AA, Wageningen University & Research, Wageningen, The Netherlands.
Email: Maaike.happel@wur.nl

Abstract

The adoption of sustainable soil management practices such as the use of green waste from road-side management and nature reserves is thwarted in practice by hesitance on the side of farmers. To foster the use of these practices, it is crucial to understand farmers' decision perspectives and attitudes towards them. Using Q-methodology, the perspectives of 12 dairy and arable farmers in The Netherlands were analysed. It was studied which barriers farmers perceive for green waste application (GWA), and whether perceptions of barriers are related to particular rationalities on the position of farmers within society. In Q-sorts and semistructured interviews, farmers ranked their degree of agreement on 41 statements about GWA, nutrient policy information, general beliefs on soil and farm management and circular agriculture, inspired by a cultural theory framework. Six decision perspectives were identified, globally agreeing on the benefits of GWA but challenged by rapidly changing regulations regarding nutrient management. Plurality in decision perspectives captured the need for trusted information, alongside differing views on responsibility and views on sustainable agriculture. Combining Q-methodology with cultural theory confirmed the need to include various notions of trust, power and responsibility in understanding complex decision-making perspectives within more sustainable soil management practices.

KEYWORDS
agriculture, cultural theory, decision-making behaviour, green waste application, Q-method, sustainable soil management

INTRODUCTION

Intensive agricultural practices depending on inorganic fertilisers and imported feed heavily impact global and local ecosystems and are among the key contributors to climate change (Tilman, 1999). Around 23% of total net anthropogenic emissions are induced by agriculture, forestry and other land use activities (2007–2016; IPCC, 2019). Soil biodiversity is decreased by intensive agriculture (Tsiafouli et al., 2015) and soil degradation, affecting around 80% of global agricultural land (Tilman, 1999). The accompanying loss of soil organic carbon can further reduce water retention capacity and general soil quality, which are needed for resilience in climate change adaptation, global food security and biodiversity (Pretty, 2008; Rhodes, 2017). To reduce the negative impact of agriculture, several countries are trying to stimulate a more sustainable use of agricultural resources. This can be achieved by more sustainable soil management but also by replacing (part of) the conventional inputs with waste from other activities (within or outside agriculture). For arable farming, this implies that part of the inorganic fertiliser is replaced by nutrient-holding green waste, harvested from roadsides, nature area maintenance or households. Not only would the application of green waste allow farmers to save on the use of artificial fertiliser, it would also help them raise soil organic matter, improve water retention capacity, foster carbon sequestration and prevent soil compaction (Liu et al., 2006).

In spite of several pilots of green waste application (GWA) with enthusiastic farmers, there is a general hesitance among the wider farmer community to adopt such practices (Aznar-Sánchez et al., 2020; Montaranella & Panagos, 2021). Earlier studied barriers to the adoption of organic matter as a soil conditioner include perceived economic inefficiency (Viaene et al., 2016), expected high production costs (Aznar-Sánchez et al., 2020), lack of information and knowledge on application techniques (Bijttebier et al., 2015), insecurity on crop protection and weeds (Hijbeek et al., 2018) and a lack of access to appropriate machinery, storage or advisory services (Montanarella & Panagos, 2021). On top of that, legislation regarding the environment and health prevents the use of contaminated waste, which is why in many countries, the use of household waste on agricultural soils is forbidden. Furthermore, social capital, namely, the 'shared knowledge, understandings, norms, rules and expectations about patterns of interactions that groups of individuals bring to a recurrent activity' (Ostrom, 2000, p. 176), is also known to have an influence on the uptake of more sustainable soil management practices (Rust et al., 2020).

Investigating these factors is particularly relevant in The Netherlands, a country characterised by very high agricultural productivity (van Grinsven et al., 2019), significant associated environmental problems and a labour structure involving a lot of contractual labour, which may have considerable impacts on social capital dynamics. In this context, the hesitation of farmers to make use of green waste could form a potential bottleneck in the transition to circular agriculture as propagated by the Ministry of Agriculture, Nature and Food in response to the persistent environmental problems (Scholten et al., 2018; Schouten, 2020) and therefore deserves further investigation.

Obviously, farmers are heterogeneous in their valuation of the potential benefits of GWA as well as in how much weight they give to the various drawbacks. Heterogeneity in farmers' attitudes towards changes in policy, climate change or the adoption of reintroduced (or new) agricultural practices has been extensively studied by many researchers (e.g., Bechini et al., 2015; Braito et al., 2020; Daxini et al., 2018; Prokopy et al., 2019). Often, such research enabled the categorisation of farmers into certain farmer typologies such as 'production maximisers' (Brodt et al., 2006, p. 94) or 'environmentalists' (Hyland et al., 2015, p. 323), which could then be used to simulate their spatial-dynamic behaviour using agent-based modelling (ABM; e.g., Huber et al., 2018; Valbuena et al., 2010). Such techniques are highly useful for simulating possible flywheel effects in the uptake of a practice or policy incentive (e.g., Groeneveld et al., 2019) and the role of certain policy-levers in stimulating or preventing such effects. Assessing the nature and heterogeneity of farmers' attitudes regarding GWA may also be helpful to better understand the potential of further adoption amongst the wider farmer population. It could tell us whether the large body of non-adopters is willing to adopt but simply waiting for more clarity and information or whether there are more fundamental reservations against the practice. Moreover, it could serve as input for an agent-based model, by which we could explore which incentives could trigger internal dynamics that push further adoption.

At the same time, an overly simple classification will not do justice to the complex decisions farmers are taking. Farmers generally have very profound knowledge about soil-crop-management-weather relations (even though many of them still feel it is insufficient) and understand that GWA has many potential implications for soils, crops, farm management and the environment. Often, they have a better overview than most policymakers and experts, who only have in-depth knowledge of one dimension of the practice. Reducing that wealth of knowledge into statements such as that the environmental-mindedness of a farmer will determine whether the practice will be adopted, would be a rough simplification. Assessment of perceptions is a complex matter, yet obtaining a thorough understanding of it may be an asset for developing policy mechanisms to enhance the adoption of sustainable soil management (Ingram et al., 2008). The objective of this article therefore is to provide insight in decision-making perspectives and attitudes of GWA as part of circular agricultural practices in The Netherlands. The research questions this article addresses are the following: Which barriers do farmers perceive for GWA? What are the differences between these perceptions? Are perceptions of barriers related to particular rationalities on the position of farmers within society?

By using a mixed-methods approach, the heterogeneity of farmers' perspectives can represent their individual context, from where their soil management decisions emerge. The goal is to connect similar perspectives in clusters whilst defining the differences between these perspectives. Therefore, the Q-methodology (Stephenson, 1953) was chosen for its ability to handle data that are qualitative in nature (i.e., attitudes) and yet to provide measures of association and clustering that are statistically robust (Ellis et al., 2007; McKeown & Thomas, 1988; Hermans et al., 2012). This article will first discuss the various elements and drivers to implement GWA, after which narratives to describe the diversity of decision-making perspectives are constructed based on the outcomes of the factor analysis and interpreted according to the grid/group theory.

ANALYTICAL FRAMEWORK

Attitudes

To characterise the various views and motivations of farmers towards GWA, the construct of *attitude* will be a guiding variable in this study and summarises the beliefs, thoughts, values and perceptions prior to a decision. Attitudinal and behavioural constructs have increasingly been included in agricultural adoption studies (Baumgart-Getz et al., 2012; Burton, 2004; Edwards-Jones, 2006; Wauters et al., 2010; Willock et al., 1999) and agent-based models (e.g., Schlüter et al., 2017; Smajgl et al., 2011), aiming to account for heterogeneity in complex decision-making. In agricultural adoption studies, attitudes are primarily operationalised from a social-psychological and behavioural approach. Within one of the frequently used theories in this field, the theory of planned behaviour (TPB), attitudes are defined as 'the degree to which performance of the behaviour is positively or negatively valued' (Ajzen, 1991, p. 188). Informed by behavioural beliefs, normative beliefs and control beliefs, attitudes along with subjective norms and perceived behavioural control form the intention towards a behaviour (Ajzen, 1991). Previously, empirical studies used the TPB to understand the decision-making behaviour of sustainable soil management practices (Bechini et al., 2015; Daxini et al., 2018; Hijbeek et al., 2018). Within adoption studies, economic operationalisations of attitude beyond a behavioural approach have been commonly used, for instance, by including risk variables, utility and uncertainty into a decision-making framework for the adoption of agricultural innovation, alongside farmers' perceptions and processes of learning (Ghadim & Pannell, 1999). Another economic operationalisation of attitude stems from the expected value theory (Fishbein, 1963; Fishbein & Ajzen, 1976), applied in a social-psychological study on the adoption of agricultural innovation (Wauters & Mathijs, 2013), where attitude was 'the farmer-oriented assessment of the relative advantage' of an innovation (Wauters & Mathijs, 2013, p. 55).

Cultural theory

The construction of perceptions can reflect 'rationalities' (Mamadouh, 1999, p. 400) as implemented in Mary Douglas' cultural theory and its adjacent grid/group theory (Douglas, 1978, 1982, 2007; Mamadouh, 1999). Rationalities, or cultural types, are described as 'viable combinations of social patterns and cultural patterns' (Mamadouh, 1999, p. 400).

In Figure 1, the four rationalities [1] are shown alongside the x- and y-axes. These represent the two dimensions of sociality: group or grid. On the Y-axis, the grid shows the inclination to regulations and control. The x-axis represents the group and shows the degree of community and belonging' (Mamadouh, 1999; Mars, 1982). To understand how individuals view their role within nature and society, four rationalities along the grid lines are distinguished: *fatalism* (1), *individualism* (2), *hierarchism* (3) and *egalitarianism* (4). In Figure 1, the four rationalities are summarised based on interpretations of Mamadouh (1999) and Bruce (2013). Understanding individuals' roles within nature and society touch upon decision-making on GWA. Decisions land users make will depend on both the condition of the soil and the natural resources available, as well as the effect GWA has on soil ecosystems and other connected ecosystems. Arguably, how agents are embedded in the social system affects their decisions regarding nature as an ecosystem: such dynamics have been considered in socioecological systems theories (Ostrom, 2009; Schlüter et al., 2017),

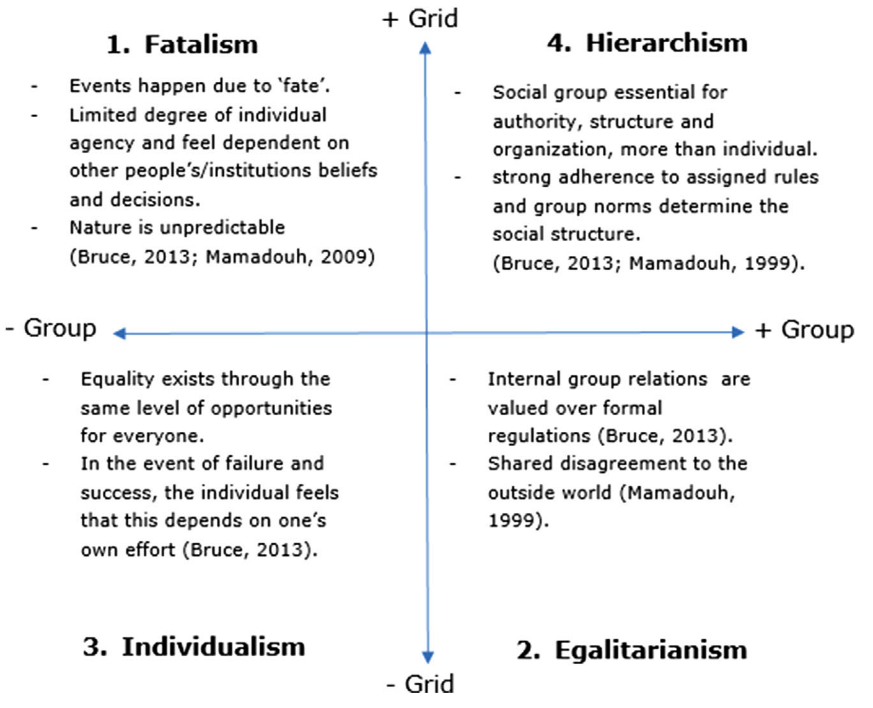

FIGURE 1 Four rationalities within grid and group theory. Adapted from: Thompson (2018), Bruce (2013) and Mamadouh (1999), having its origins in cultural theory (Douglas, 1978)

which are increasingly incorporated into ABM. Moreover, the grid/group divide and cultural theory may include social capital mechanisms of power and trust, which have been lacking in behavioural models of decision-making.

Review of barriers towards the adoption of GWA

Following Prokopy's framework for adoption drivers (Prokopy et al., 2008) Baumgart-Getz et al. (2012) conducted a meta-analysis of 46 adoption studies of best management practices to identify the many factors contributing to taking decisions. Table 1 summarises some of the key barriers to the adoption of agricultural practices, which we expect to be influential in the formation of decision-making perspectives for GWA. In summary, a diversity of endogenous and exogenous characteristics, beliefs and mechanisms will be studied to understand farmers' decision-making perspectives.

Farm typologies and family farming

A distinctive characteristic of Dutch agriculture is its extremely high productivity (van Grinsven et al., 2019). This is due to a number of geographical, technological and management factors. First, the physical context, encompassing a mostly flat terrain and deep soils with no stones, favoured mechanisation. Second, the country's water engineering tradition led to a very mendable

TABLE 1 Operationalisation and definition of barriers and drivers for adoption of green waste application (GWA) and circular agriculture, based on earlier literature reviews (Baumgart-Getz et al., 2012; Prokopy et al., 2008; Rust et al., 2020) of the statements per category

Barrier	Definition and assumption
Risk aversion	The extent to which farmers avoid risks with their decisions (Feder, 1980). Low risk aversion usually positively impacts GWA adoption (Baumgart-Getz et al., 2012)
Reflection and Learning	A variety in learning types exist. Learning phases can help to understand the role of the examination of previous behaviour, and its effect on adoption. In this way, beliefs and attitudes are organised through evaluation (O'Keefe, 1980). As the process of adoption is an adaptive and reflective process, learning is operationalised following an experiential learning approach (Kolb, 1984, 2001)
Access to Information, trust and quality of information	Continuous changes in knowledge, various degrees in information shortage or access to information are barriers to adoption of agricultural practices (Baumgart-Getz, 2012; Norris & Batie, 1987; Rodriguez, 2009). Trust and quality of information describe the perceived value and quality of information and enables to distinguish preferences in the selection process of information and sources of information
Subjective norms	Indicate on the one hand what the agent perceives others to think about or expect from oneself, and on the other hand whether this expectation influences the decision of the agent (Ajzen, 1991; Armitage & Conner, 1999b). As previous research on sustainable farming practices suggests, it is assumed that expectations and peer pressure play a significant role in adoption decisions (Daxini et al., 2018)
Knowledge on the soil and soil quality	The perceived knowledge on soil quality indicators and soil functions and knowledge on the relationship between applying GWA and improving such functions
Diffusion of Innovations	The model of *diffusion of innovations* (Rogers, 1976) was integrated to understand the effect of social peers on the timescale of adopting an agricultural practice or innovation. The diffusion of innovations model (Rogers, 1976) divides a group of adopters into five groups over time, each of which adopts at a different point in time, and may inspire the others: innovators, early adopters, early majority, late majority and laggards
Responsibility	Refers to the degree of compliance towards the positive or negative effect of one's agricultural decisions towards nature, others or future generations. Responsibility can include both environmental and social responsibility. Within farmers' attitudes regarding conservation practices, responsibility was included as an indicator of stewardship (Reimer et al., 2012)
Regulations	Laws and regulations regarding manure and fertilisers were among perceived barriers for the application of organic material in the behavioural survey among farmers in The Netherlands (Hijbeek et al., 2019). In the period of this research (2019–2021) a lot of changes and protests took place regarding the changes in EU and The Netherlands manure and nutrient laws. It was hypothesised that the key barriers for the application of soil organic matter would be related to the nutrient regulatory framework
Opinions on sustainability and circular agriculture	There is not yet a strong empirical foundation reflecting Dutch farmers' opinions specifically on circular agriculture. We expect the gaps between policy and practice as perceived around manure legislation, to be reflected in opinions on circular agriculture. Departing from the nitrogen debate among some groups of farmers in The Netherlands, the term circular agriculture may cause some opposition and misunderstanding

water system. Third, after the Second World War, large-scale land consolidation schemes further facilitated mechanisation, enabling even higher productivity on a per hectare and per farmer basis. Finally, high productivity is also favoured by inputs such as animal feed and artificial fertilsers, which are often imported from abroad (Smit, 2018), resulting in excess nutrients and associated environmental problems (e.g., nitrogen pollution). The oversupply induced by such high productivity, however, led to shrinking margins on most produce, urging farmers to seek ways to reap economies of scale. This eventually caused a strong decline in the number of farms and an increase in the size of the remaining farms (Bakker et al., 2015).

Despite the capital- and technology-intensive type of farming, the vast majority of Dutch farms can be considered family farms, namely, agricultural firms owned and run by one or more members of the same family (Contzen & Forney, 2017). According to Eurostat (2016), almost 90% of Dutch farms rely solely or considerably (i.e., 50% or more of the labour force) on family workers, slightly below the EU average but comparable to Spain and much higher than France. However, they make abundant use of contractors for such activities as harvesting and the spreading of manure and may have their income supplemented by members of the family working outside of agriculture. In 2013, for example, The Netherlands had a very high share of farm labour (28.1% of annual work units) provided by nonfamily regular workers, in line with other Central and Northern European countries but much higher than any Mediterranean country (except Spain), and one of the highest shares of farm labour (14.1%) provided by nonfamily nonregular workers, similar to Spain and Italy (Eurostat, 2021).

The unquestioned role of the family in Dutch farming arguably contributes to maintaining intrinsic values beyond economic profit (van Vliet et al., 2015), including the continuity of the farm (van Vliet, 2015), the maintenance of a certain identity (van der Ploeg, 2012; van Vliet et al., 2015) and the preservation of rural communities (van der Ploeg, 2012). The adoption of agricultural innovations may challenge this structure, although their effectiveness may be perceived as uncertain and the future of the farming enterprise may be threatened by the difficulty of finding an appointed successor (van Vliet et al., 2015). As of 2020, 59% of Dutch agricultural firms with a manager who was older than 55 years had no appointed successor (van Rossum, 2021). In general, farmers obtain most of their information on agricultural practices from colleagues and extension officers (e.g., the feed supplier). Peer pressure, however, has been reported by Westerink et al. (2021) as being a factor that may prevent the adoption of new practices, which may be considered as weird, dirty, messy or alternative by the majority.

METHODS

Research design: Q-methodology

To understand farmers' attitudes towards circular agricultural practices, data were collected by conducting a Q-sort survey. In the latter, respondents are asked to grade and rank a set of statements by sorting them in a so-called Q-sort (Figure 2; Brown, 1996; Davies & Hodge, 2007; Snel et al., 2019). This can best be described as a reversed triangle-shaped grid, whose cells depict agreement, disagreement or neutrality with respect to a given statement (Brown, 1996; Davies & Hodge, 2007; Snel et al., 2019). Using factor analysis on the Q-sorts, it is then possible to identify respondent typologies (the factors), that is, groups of respondents sharing similar views on the statements. The major strength of this method is that it allows to treat qualitative

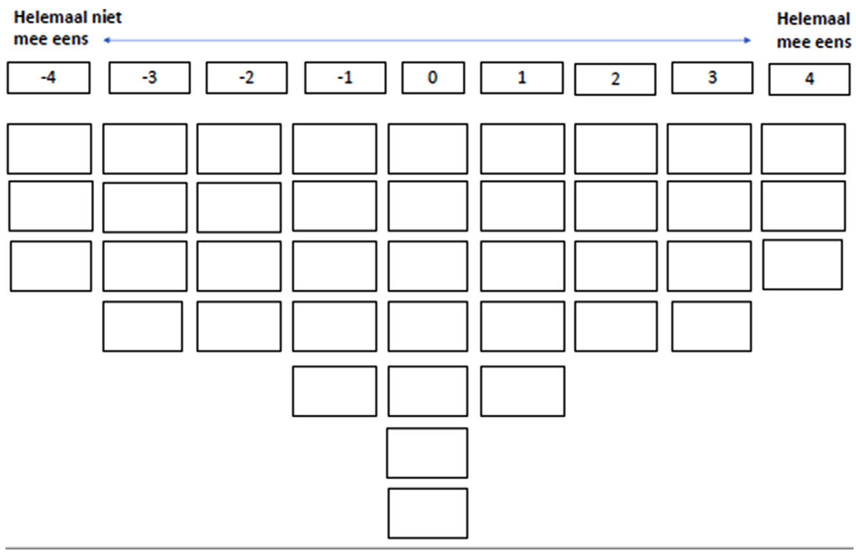

FIGURE 2 Nine point Q-sort as used during the interviews, ranging from '*completely disagree*' to '*completely agree*'. Adapted from van Exel & de Graaf (2008)

information through a quantitative technique requiring only a small sample of respondents to obtain statistically robust results.

In this research, a 9-step scale, ranging from −4 (*strongly disagree*) to +4 (*strongly agree*), and a set of 41 statements were utilised. First, an initial list was generated through a comprehensive literature review of studies on the adoption of sustainable agricultural practices (Baumgart-Getz, 2012; Edwards Jones, 2006; Knowler & Bradshaw, 2007; Prokopy et al., 2008) and organic matter adoption (Daxini et al., 2019; Hijbeek et al., 2018; Rust et al., 2020), as there is a lack of comprehensive studies, particularly on GWA or circular agricultural practices. This review also enabled the identification of categories of statements as summarised in Table 1. Then, the initial list of statements was further improved, in terms of both number and clarity, by conducting pilot interviews with fellow scholars and a stakeholder representing a local farm study group. The final list of statements is presented in the Appendix (Appendix Table A1).

Respondents and research area

Through purposive sampling, random selection and snowball sampling, five dairy farmers (one farm rearing young stock) and six arable farmers were selected (Bryman, 2016). Following the qualitative nature of the data collection and consistent with previous Q-studies (Watts & Stenner, 2005), we followed the recommended 3:1 ratio of statements and participants and determined that 12 participants were sufficient (Webler et al., 2009). The circumstance of interviewing during the Coronavirus disease (Covid-19) pandemic in March 2020 further induced to limit the number of participants. Most dairy farmers had between 150 and 170 milk cows, between 10 and 120 ha of land (total arable and grassland) in use and farmed on (mostly) dry sandy soils in the region of *Achterhoek* in the east of The Netherlands. Most were male (except one female dairy farmer), grew up on the family farm and were between 50 and 65 years old. This is consistent with the demography of Dutch farmers registered in the Agricultural Census of 2018 (Central Bureau for

Statistics, 2019). In 2018, more than half of the agricultural managers were above 55 years of age (CBS, 2019). Farmers' attitudes were elicited using the Q-sorts during in-person interviews, which were held in the period July–October 2020 in Achterhoek and included a set of demographic questions. Farmers were actively involved again in January 2021 through a short online survey and phone interviews to collect further information about adoption patterns.

Analysis and interpretation

Responses were analysed using Ken-Q software (Banasick, 2019) by performing a Varimax rotated factor analysis. As per the common procedure according to Q methodology, factor loadings, *z*-scores and distinguishing statements per factor were compared. Distinguishing statements refer to significant statements with $p < 0.05$ and $p < 0.01$, which characterised the key attitudes expressed per factor. *z*-scores and distinguishing statements were compared between and within factors (Appendix Table A1) to construct narratives that illustrate the attitudes of the farmer types (i.e., the factors), following guidelines by Webler et al. (2009), using a qualitative interpretation. In practice, this was done by first analysing each statement (row) and comparing the degree of agreement on it by different farmer types (columns) and then by assessing how different statements (rows) were agreed upon by the same farmer type (column). Special attention was given to those combined statements whose variance was higher than 0.5, showing a stronger disagreement among the factors, combined with distinguishing statements.

RESULTS

Basic output of factor analysis

The statistical analysis of Q-sorts resulted in six relevant factors, each representing a subset of farmers who share similar views on the statements presented in the questionnaire. The alignment between respondents (i.e., farmers) and factors is shown through factor loadings, which indicate the correlation between Q sorts and factors (Appendix Table A2). Farmers showing a significant correlation with the same factor can then be clustered together and assumed to belong to the same typology (factor). In this case, Farmers 2, 5 and 12 are strongly correlated with Factor 1; Farmers 6 and 7 with Factor 2; Farmers 1 and 11 with Factor 3; Farmers 3 and 8 with Factor 4; Farmers 4 and 10 with Factor 5; and Farmer 9 with Factor 6.

Decision-making perspectives based on distinguishing and remarkable statements

Below, we provide narratives for the six identified factors. Each factor represents a decision-making perspective based on distinguishing statements described through narratives. Factors will be referred to as decision-making perspectives hereafter. Observations include references to the statements, shown numerically in brackets. Please refer to Table A1 (Appendix) for all the *z*-scores, composite Q-sort values and statements.

TABLE 2 Distinguishing statements ($p < 0.05$) per factor

Factor	No.	Distinguishing statement	Cultural Theory: Grid or group	Barrier	Q-score
1	*No distinguishing statements*				
2	3	The rules and regulations should be clear before I change an agricultural practice	Grid	Risk aversion	−1
	14	Before I switch to a new technique, I make sure I know everything about it	Grid	Information and access	4
	37	The current form of conventional agriculture is not sustainable	Group	Opinions on sustainability and circular agriculture	3
	39*	Applying liquid manure and fertiliser is by far the most economic option	Grid	Knowledge (and economics)	−4
3	20*	I do not need permission or approval of my friends and neighbours in order to make agricultural decisions	Grid	Subjective norms	−4
4	29	It is much wiser to keep working with proven techniques instead of trying new things	Grid	Diffusion of innovations	−3
5	16	I completely trust my own experience and knowledge to value what works or not on my farm	Grid	Information and trust	3
	33	The government provides clear regulations regarding soil management	Grid	Regulations	−1
	38	Adjusting to climate change is only effective when all farmers in the local community do this together	Grid	Opinions on sustainability and circular agriculture	−4
6	2	At harvest failures due to extreme weather, the government should provide financial aid	Grid	Risk aversion	4
	17*	I am not going to apply organic matter on my soil if I do not know exactly what is inside	Grid	Information and trust	−4
	25	I know enough about the soil to make decisions on which soil amendment/fertilising strategy to adopt	None	Awareness: knowledge on the soil	3
	33*	The government provides clear regulations regarding soil management	Grid	Regulations	2
	40*	Investing in sustainable agricultural practices is investing in a healthy soil, to the benefit of the local community, my company and future generations	Group	Consequence: knowledge on benefits of more sustainable agricultural practices and GWA.	−3

Note: Q-score refers to the composite q-score of that factor.
Statements marked with '*' are $p < 0.01$.

Factor 1: Individual realist and productivist

Factor 1 did not include any distinguishing statements, so the narrative of this decision-making perspective is based on those statements that had divergent values, compared to the other factors. The key statements centre around the access, trust and clarity of information, and in particular, regulations regarding nutrient management (nitrogen placement space; statements 15, 3, 33). Moreover, finding information on a new technology through both formal institutions and the local community (11, 13) is expressed as difficult. Of all perspectives, the strongest disagreement is expressed in Statement 11 ('I always know exactly where to get the relevant information on new agricultural practices'). As for social learning on soil management, there is not a strong trust in the (soil) knowledge among the local community, given that farmers aligning with this factor strongly disagree with Statement 24: 'I discuss the soil management practices with my neighbours on a regular basis'. A low trust in regulations is expressed to the extent that inconsistent regulations could be a barrier to the adoption of GWA. The beliefs and motivations to adopt are strongly rooted in the belief that sustainable agriculture starts with a healthy soil and can provide environmental and socioeconomic benefits (40). However, adoption would not take place without the profit that manure and inorganic fertilisers seem to guarantee (39). Finally, these farmers expect responsibility in times of crisis and declining biodiversity mostly from governmental institutions (1, 32), and they tend to be late adopters (27, 28) rather than waiting to see whether neighbours or other social peers have success with the agricultural technique (27).

Factor 2: Entrepreneurial pioneer

Within the entrepreneurial pioneer perspective, strong confidence in one's knowledge of local soils (41) is expressed. The process of decision-making prior to adoption is informed by researching all relevant information (14, 17), of which the sources are relatively easily identified (11). As for broader agricultural training, Factor 2 perceives this to be a mix of self-taught training (6) and agricultural extension services (21), whilst opinions and permission from social peers were not seen as essential in the process of decision making (13, 18, 20, 27). Just like Factors 1, 2, 4 and 5, Factor 2 believes the current information on regulations from the government is unclear (33, 15) and not very trustworthy (15). Interestingly, the factor does not believe that official regulations are necessarily guiding (19). The environmental, social and economic benefits of sustainable soil management were perceived as a key element in Factor 2′s viewpoint (40). Financial profitability is a strong condition for the adoption of GWA (35), but surprisingly, manure and artificial fertiliser are not necessarily viewed as the most profitable option (39).

Factor 3: Social environmentalist

Farmers aligning with decision-making Perspective 3 showed some strong positions on knowledge sharing (13), which is perceived as very important, and subjective norms (20), with this factor being the only one to significantly disagree with the perceived unimportance of the opinions of social peers when it comes to decision-making (20, distinguishing statement). Like Factors 1, 2, 4 and 5, this type of farmer criticises the unclarity of nutrient regulations and policy (3, 15, 33), showing in fact the strongest disagreement of all factors in statement 33. Finally, this farmer type is the only one to support the assumption that only the collective effort of all farmers in a specific locality can achieve adequate climate adaptation (38).

Factor 4: Social pragmatist and experimental pioneer

The social pragmatist and experimental pioneer is characterised by a strong individual focus: that of a self-starter who knows where to find the right information and sympathises with learning by doing and experimentation (7, 11). Compared to the other factors, Factor 4 felt most confident in finding the right source for information prior to adoption. This 'experimental' attitude and openness to take risks is also reflected in the disagreement with statement 29: 'It is much wiser to keep working with proven techniques instead of trying new things' (29, distinguishing). In making decisions, farmers aligning with this factor do not seem to rely on advice from either extension services (21) or social peers (20). However, Factor 4 acknowledges the strong soil knowledge potential of the local community and, compared to other factors, is more open to discussing soil management practices with neighbours and colleagues (24), while nonetheless expecting the right example to be set by government (8). Although the farmers' responsibility for sustainable soil management and biodiversity as crucial (30, 32), this farmer type looks at circular agriculture in a pragmatic way (34).

Factor 5: Individual environmentalist

Farmers aligning with the decision-making perspective of the *individual environmentalist* mostly rely on their own experience and knowledge for learning (3), in combination with advice from extension agents (21), and knowledge exchange on soil matters with their local community. Yet these farmers are not necessarily late adopters, waiting to see if their peers were first to have success with an innovation (27). While they do not agree with the idea that it is a farmer's primary responsibility to take care of the landscape and the soil (30; just like Factor 6) and perceive conventional agriculture as sustainable (37), they do acknowledge that farmers are responsible for the decline in biodiversity (32). Finally, these farmers do not believe that a collective and simultaneous action by local farmers would contribute to adjusting to climate change (38).

Factor 6: Individual technologist

Factor 6 only represents the attitudes of one farmer. Characteristic of the sixth decision-making perspective is that the farmer does not need to know the specifics of the organic material before applying it (14, 17) but still prefers to adopt proven technology (29). While the farmer aligning with this factor feels confident about his/her knowledge of soil health and its influence on adoption decisions (25), he/she seems to not completely trust his/her own knowledge and experience when valuing what works on the farm (16) but has a strong trust in agricultural advisors (21). Clear regulations on soil management from the government (3) are expected, and yet Factor 6 is the only one disagreeing with statement 33 about the clarity of rules and regulations on soil management. Of all factors, Factor 6 also disagrees most with the social, economic and environmental benefits of sustainable soil management practices (40). The farmer aligning with this factor believes that it is not his/her main task to take care of the soil (30) and that he/she cannot be blamed for the loss of biodiversity (32). Finally, while the farmer feels that support from the local community in times of crisis is strong (31), he/she also greatly values the intervention of the government in such instances (2).

DISCUSSION

This research contributed to the understanding of sustainable soil management implementation as individual heterogeneity and plurality of drivers and attitudes were shown. Four remarkable findings emerged. First, perceived barriers to adopt GWA were embedded in six different decision-making perspectives. These distinctive perspectives showed that virtually all respondents (and factors for that matter) agreed on the primary lack of useful information regarding GWA and manure management in general. In particular, this mostly referred to a low degree of clear, steadfast and trustworthy regulations. Second, farmers are highly heterogeneous in terms of the perceived barriers and opportunities they associate with GWA and circular/sustainable agriculture in general. In particular, this was shown through attitudes regarding knowledge generation and differing interpretations of responsibility and sustainable agriculture. Third, farmers' perspectives can be internally contradictive: in particular, the responsibility of farmers in the overall decline in biodiversity and other environmental issues led to contradicting statements. We believe that this is the result of the very fierce debate in The Netherlands about the future of farming given the severe environmental problems. Our impression, based on the interviews and findings, is that farmers may believe that many farming practices are indeed not sustainable, but they also feel that they are now blamed and held responsible for everything, which makes them take a defensive stance towards responsibility. If this is indeed the case, we may conclude that the fierceness of the debate is contributing to a growing lack of trust between farmers on the one hand and policy-makers and the wider society on the other hand. In the case of empirical studies on GWA adoption and sustainable soil management practices, this calls for an increased integration of social capital factors, such as trust and power relations within knowledge and policy implementation, as such variables may identify the underlying dynamics of decreasing trust. Moreover, identifying various distinctive constructs classifying the nature of the relationships, interaction and context may clarify where, and between, whom misunderstandings occur. Fourth, regarding the methodological framework, perspectives (as constructed by dominant drivers and attitudes) are not necessarily connected to grid and group rationalities.

Barriers to GWA

Perceived barriers were associated with three categories of attitudes, which followed the analytical framework based on behavioural and socioeconomic theories (Ajzen, 1991; Armitage & Conner, 1999a; Kolb, 1984, 2001; Rogers, 1976) and previous research concerning the adoption of sustainable agricultural practices (Baumgart-Getz et al., 2012; Daxini et al., 2018; Hijbeek et al., 2018; Prokopy et al., 2008; Reimer et al., 2012).

1. Knowledge: learning, access to information and diffusion of innovations
2. Regulations
3. Opinions on sustainability and circular agriculture

Primarily, the trustworthiness of *regulations* (Category 2) is seen as a major obstacle in any kind of environmental decision-making. This category showed the strongest similarity across the decision-making perspectives, formed by opinions and attitudes, reflecting a shared frustration regarding the clarity and implementation of the current nutrient policy in The Netherlands. In addition, this attitude was reflected in shared agreement and disagreement with statements connected to Category 1: *knowledge: learning, access to information and diffusion of innovations*.

Almost all factors, except Factor 6 (*individual technologist)*, felt the rules were unclear, inconsistent, not applied to the farmer's reality and perceived governmental institutions to be lacking in giving the right example, while this was expected. The need for steadfastness and an expectation of the right example of the government confirmed previous studies, showing correlations of low institutional trust and a reduction in the adoption of sustainable agricultural practices (Hall, 2001; Prager & Posthumus, 2010; Rust et al., 2020). The perceived lack of steadfastness in information and regulations partially confirms earlier studies: Continuous changes in knowledge, various degrees of information shortage or access to information are barriers to the adoption of more sustainable agricultural practices (Baumgart-Getz, 2012; Norris & Batie, 1987; Rodriguez et al., 2009). Regardless, not all factors perceived as such lack a direct barrier to GWA, and this correlation should be researched further.

Differences between perceptions

Factor analysis made it possible to detect distinguishing statements reflecting perceived barriers, namely, characteristics constituting and identifying unique decision-making perspectives. Contrary to earlier research (Hartmann, 2012; Schwarz & Thompson, 1990), suggesting that specific rationalities distinguish social situations from one another, decision-making perspectives were not distinguished by either grid *or* group statements but rather by attitude categories expressing possible barriers. This aligns with earlier research, noting the difference in farmers' perceptions of access to and trust of information, as well as their reliance on social norms on sustainable soil management adoption (Arbuckle et al., 2015; Carlisle, 2016; Ingram et al., 2008; Rust et al., 2020) and Best Management Practices adoption (Liu et al., 2018). Access to, and trust in, information were perceived barriers to the adoption of GWA. However, previous research on farming typologies did not emphasise the variety in perceived access to information across the different decision-making perspectives; hence, more research is needed. A possible explanation for this variety is the differences in trust per source of information (i.e., technical or social; Daxini et al., 2019). Moreover, factors or decision-making perspectives varied in their opinion on the degree of trust in one's own experience and knowledge (Statement 16). This corresponds to perceived differences in self-efficacy or one's individual perceived capacity in changing a situation (Bandura et al., 1999; Burton, 2004; Wuepper & Sauer, 2016), further confirming studies showing the variability in perceived behavioural control on adoption decisions (Daxini et al., 2019). The factors differed in opinion on the quality and perceived benefits of the material and deliberating trade-offs in the economic profitability of changing to organic fertilisers. In sum, the plurality of trust in, and access to information, highlighted by grid/group distinctions, suggested the dependence on context and social group norms. At the same time, the self-efficacy of one's own knowledge and perceived ability to know where to source which information from, depends both on one's own learning experience and connection to one's social network.

Association between perceptions and rationalities

Our study revealed the importance of mechanisms of trust and power in shaping decision-making perspectives for GWA and circular agriculture. So far, these dimensions have been lacking in previous research on sustainable soil management adoption (Rust et al., 2020; Thorsoe et al., 2019). The results provided more empirical evidence on including social capital in soil management research (Rust et al., 2020). Informed by the analytical framework based on cultural theory and grid/group theory (Douglas, 1978, 1982, 2007; Mamadouh, 1999), power layers were shown, characterising and distinguishing decision-making perspectives. Among the statements referring to *opinions on sustainability and circular agriculture* (Category 3), remarkable differences within and between the decision-making perspectives were shown regarding perceptions of responsibility for biodiversity loss and climate change. Here, trust was particularly seen in the form of responsibility and perceived accountability. Overall, farmer responsibility for biodiversity was never completely agreed upon, although some emphasised a partial responsibility. Responsibility was perceived through various layers: individual versus collective responsibility and mutual perceptions of responsibilities through governmental institutions and farmers. This research went a step further than individual decision-making behaviour (Daxini et al., 2019; Hijbeek et al., 2018), as the grid and group dimension showed how individual agents position themselves in social and power structures and see their relation to natural resources and circumstances over which they may have influence.

The results of this study contribute to the increased importance of social capital within soil and agricultural management decisions as empirically shown before (e.g., Bartowski & Bartke, 2018; Pretty, 2003; Pretty & Buck, 2002; Rust et al., 2020). Pluralities between and within decision-making perspectives were distinguished primarily through constructs such as trust, social networks and social norms and responsibility. The plurality in the expression of responsibility and the importance of some social values as reflected within decision-making perspectives contribute to previous studies that emphasised the 'noneconomic' values of (family) farming through, for example, the contribution to future generations (Inwood et al., 2013; van der Ploeg, 2012; van Vliet et al., 2015), maintenance of rural community and a deep connection to one's farm and agricultural land (van der Ploeg, 2012). As previously addressed in this article, the changes that agricultural intensification brought about for the (labour) division and organisation of agricultural firms and rural regions may threaten the continuity of social relations, which is a key to maintaining social capital (Bourdieu, 1986; Riley et al., 2018). Social learning networks are shown to have a positive impact on the adoption of agricultural practices (Ramirez, 2013), where interactions based on experiential and social learning from peers and other trust-based relationships may foster the adoption of agricultural practices through processes of social diffusion (Ramirez, 2013). It is further assumed that such dynamics may decrease barriers related to uncertain outcomes as is often the case with soil conditioners such as GWA.

The results further confirmed the extent to which social norms are interpreted and to which degree interactions with other farmers are important (Bartowski & Bartke, 2018). To deepen the understanding and relevance of knowledge sharing and the role of trust in GWA, however, the degree of participation in social networks (Bartowski & Bartke, 2018) should be studied further (Rust et al., 2020). Another remarkable finding is that decision-making perspectives were not necessarily tied to one particular rationality per se, as in previous researches (Barry & Proops, 1999; Brodt et al., 2006), but rather showed combinations of more rationalities, highlighting a complex plurality to be found within the decision-making perspective. That decision-making perspectives are not bound to one rationality in particular is in contrast to earlier cultural theory predictions of the rationalities emerging in each social situation (Hartmann, 2012; Schwarz & Thompson, 1990). Compared to earlier rationality descriptions (Thompson & Wildavsky, 1986), each decision-making perspective acted out rationalities and views on the grid and the group, depending on their support of the different barriers and drivers. What our research further adds is the diverse 'layers' *within* one type of decision-making perspective and the overlapping, dynamic boundaries between the perspectives. Overlap between different farm typologies is not new, as was earlier shown in, for instance, the 'capitalist, entrepreneurial and peasant' mode of farming (van der Ploeg, 2012, p. 1) and the context-dependent 'farm development pathways' (Ingram et al., 2013, p. 267). Our research differs from van der Ploeg's approach, which is more structural and maintains the relation to the different means of production and the bond with consumers as a distinguishing feature of different modes of farming (van der Ploeg, 2012). Different from our approach, 'farm development pathways' addressed different phases in a farm's lifecycle and how different decisions may change accordingly (Ingram et al., 2013, p. 267).

Moreover, this result is partly in line with Liu et al. (2018), who acknowledged this diversity to be connected to a diversity in strategies and stages of adoption. The results have shown that rationalities are fluid and context-dependent, as each factor acted out elements from usually two rationalities, depending on the drivers and attitudes. The plurality of both farmers' typologies and rationalities within and among decision-making perspectives was in particular evident in the categories of *knowledge: learning, access to information and diffusion of innovations* (Category 1) and *opinions on sustainability and circular agriculture* (Category 3). For instance, the observed variations in combinations of self-taught, formal and rational informed knowledge confirm earlier conclusions to increase an organisation's competitive advantage through a *combination* of tacit and explicit knowledge (Jasimuddin et al., 2005). Moreover, the perceived influence of direct or indirect subjective norms that varied per decision-making perspective partly confirmed behavioural studies on sustainable soil management adoption, which showed the positive relation between social pressure and the adoption of sustainable soil management practices and GWA (Aznar- Sánchez et al., 2020; Baumgart-Getz et al., 2012; Daxini et al., 2018; Hijbeek et al., 2018, 2019).

This research follows earlier work, expressing the need for the increased empirical inclusion of perspectives, beliefs, (risk) attitudes and other behavioural attributes in the design of ABMs (Huber et al., 2018; Schlüter et al., 2017). Based on our findings, we argue that the plurality and overlapping nature of decision-making perspectives can enrich the development of ABM. This is in line with previous studies on ABM that showed the importance of accounting for interactions and combinations of major drivers, the plurality of barriers and the diversity of learning styles (Kremmydas et al., 2018; Zagaria et al., 2017).

Limitations

A key limitation of our approach is that it only captures a point in time, whereas the outcomes of GWA are uncertain and usually only visible after at least a few years. A longitudinal survey instead could have embraced the different stages of adoption as well as the behavioural feedback mechanisms towards the results of GWA. Such feedback mechanisms are increasingly advocated for in the SES modelling literature (Schlüter et al., 2017) and could certainly be explored further. Perhaps applying mixed methods studies based on factor analysis, such as Q-methodology, may lead the way to increased research acknowledging plurality in decision-making perspectives by adding ranked and temporal attributes to models. In that way, the adaptability to changes over time, and including differences in ranked considerations between attitudes, may improve their predictive strength. Such attributes, including uncertainty, were considered in Huber et al.'s (2018) framework for ABM in socioecological systems as part of farmers' 'decision-architecture' (Huber et al., 2018, p. 147).

CONCLUSION

This article has provided insights into the differences in attitudes and decision-making perspectives regarding GWA as part of more sustainable soil management practices and contributing to a transition to circular agriculture.

Six decision-making perspectives were identified alongside three design-induced main themes: knowledge and information, regulations and opinions on sustainability. The commonality in the need for clear and more steadfast regulations confirms a growing gap between agricultural policy and practical implementation. However, decision-making perspectives are distinguished from each other in terms of access to knowledge, trust in different sources of information and levels of perceived self-efficacy. For policy, research and communication, this confirms the need for methods and approaches that capture such individual diversity. In contrast to earlier studies, our results have shown that decision-making perspectives were rather a combination of one or two rationalities, determined by attitudes and possible barriers. This has further exemplified the fluidity and system boundedness of belief systems.

Combining the above insights shows the importance of including more social capital variables in studies on the adoption of sustainable soil management practices. It became evident that perceptions of institutional trust and social connectedness are important elements shaping attitudes towards GWA and could even 'make or break' the motivation for GWA. Policy implementation, research and modelling design can be enhanced by the inclusion of social capital variables, the increased use of mixed methods approaches and the utilisation of methods such as social network analysis. When combined with increased plurality and interaction between both drivers' and farmers' typologies, this can increase both institutional trust of communication, learning, implementation and regulatory schemes, on a 'grid' level, as well as through 'group' mechanisms, increasing social solidarity and social learning as social responsibility.

Even though cultural theory and Q-methodology could emphasise the importance of plurality and the mechanism of trust and power in adoption studies and modelling, the next level would be to turn this knowledge into the rules of an agent-based model that helps us investigate the impact of social capital factors on the way farmers manage their land over time. This research has shown the importance of acknowledging complexity and diversity within social-ecological systems research and modelling and has contributed to a fertile ground for further research and practice towards more sustainable soil management practices.

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CONFLICT OF INTEREST

All authors who contributed to this article declare to not have any affiliations, financial, political or personal interest in any of the firms, organisations or persons who contributed as participants (respondents) in this study.

ETHICS STATEMENT

All steps of data collection involving human participants in this study were conducted according to the 1964 Helsinki Declaration.

COVID-19

In light of the Covid-19 pandemic as ongoing during the time of the data collection, interviews took place according to the rules of the Dutch National Health Organisation, following up with the World Health Organisation (WHO) standards, as in place during July, August and September 2020. Face-to-face interviews only took place in the absence of any COVID-19-related symptoms, primarily outside, and maintained at least 1.5 m between the interviewer and respondent.

DATA AVAILABILITY STATEMENT

To protect the privacy of the study's participants, it was mutually agreed upon in an ethical declaration that all datasets (contact lists, interview audio, transcripts, Q-sorts and survey data) are to be deleted after (a) publication of this article and (b) publication of the corresponding author's PhD thesis. Data are not publicly available; anonymised data are available through the main author, after permission from the respondents, following ethical codes of conduct for qualitative research.

ORCID

Maaike Happel MSc. https://orcid.org/0000-0003-0927-6364

ENDNOTE

[1] Some explanations of Cultural Theory mention a fifth rationality, the Hermit, placed in the middle (Bruce, 2013). As the primary focus is more on how grid and group perceptions influence attitudes, we have chosen to limit our analysis to four rationalities.

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APPENDIX A

TABLE A1 *Z*-scores (*Z*) and composite Q-sort (*Q*) values per factor

Barrier	No	Statement	Cultural Theory: Grid or Group	1		2		3		4		5		6	
				Z	Q	Z	Q	Z	Q	Z	Q	Z	Q	Z	Q
Risk aversion	1	Farmers who go bankrupt can blame that on their own failure	None	−1.447	−4	0	0	−1.192	−3	−0.276	0	0.788	2	0	0
	2	At harvest failures due to extreme weather, the government should provide financial aid	Grid	−0.184	0	−1.35	−3	−0.419	−1	−0.551	−1	0.088	0	1.737	4
	3	The rules and regulations should be clear before I change an agricultural practice	Grid	1.618	4	−0.45	−1	1.263	3	0.825	1	1.533	4	0.869	2
	4	The risk to break the law (heavy metals, waste, manure), is preventing me from using organic residuals as a soil amendment	Grid	0.278	1	0.45	1	−0.772	−2	−0.554	−2	−1.663	−4	−1.303	−3
	5	I do not feel I am the person to be blamed after I have applied a new agricultural practice and it fails to be successful	Grid	−0.15	0	−0.45	−1	−1.119	−3	−0.275	0	−0.264	−1	0.869	2
Reflection and learning	6	I teach myself many things (I am an auto didact) in farming	None Low group	0.757	2	0.904	2	1.263	3	0.825	1	−0.306	−1	0.434	1
	7	Every farmer learns by trial and error	Grid	0.08	0	0.562	1	1.963	4	1.376	3	−0.218	0	0.434	1

(Continues)

TABLE A1 (Continued)

Barrier	No	Statement	Cultural Theory: Grid or Group	1		2		3		4		5		6	
				Z	Q	Z	Q	Z	Q	Z	Q	Z	Q	Z	Q
	8	The government and the direct environment are the ones who are supposed to give the right example	Grid and group	−0.151	0	−0.451	−1	−0.634	−2	1.655	4	1.27	3	−0.434	−1
	9	My direct community (family, friends, direct colleagues) taught me most knowledge and skills in farming	Group	0.378	1	−0.375	−1	0.772	2	−0.826	−3	0.13	0	−0.869	−2
	10	Farming is based on experience and intuition, not on information and data	Group	−0.402	−1	−1.091	−2	−1.263	−3	0.828	2	−0.481	−1	0	0
Information and access	11	I always know exactly where to get the relevant information on new agricultural practices	Both Low Grid	−1.202	−3	0.451	1	0.071	0	0.828	2	−0.7	−2	−0.869	−2
	12	I often receive up to date information from the government and extension services on new agricultural practices	Grid	−0.506	−1	0.451	1	0.281	1	−0.275	0	0.83	2	−0.869	−2

(Continues)

TABLE A1 (Continued)

Barrier	No	Statement	Cultural Theory: Grid or Group	1		2		3		4		5		6	
				Z	Q	Z	Q	Z	Q	Z	Q	Z	Q	Z	Q
	13	My direct community always provides one another with enough and up to date information on new agricultural techniques	Group	−1.249	−3	−0.529	−1	1.119	3	0.276	0	1.052	3	0	0
	14	Before I switch to a new technique, I make sure I know everything about it	Grid	0.737	1	1.807	4	0.353	2	−0.551	−2	0	0	−1.303	−3
Information and trust	15	The government does not provide any clear or trustworthy information at all regarding nitrogen and phosphate rules	Group (− grid)	2.157	4	1.014	2	1.473	3	0.282	1	1.927	4	0	0
	16	I completely trust my own experience and knowledge to value what works or not on my farm	Grid	−1.007	−2	−0.451	−1	−0.563	−1	0.28	1	1.399	3	−1.737	−4

(Continues)

TABLE A1 (Continued)

Barrier	No	Statement	Cultural Theory: Grid or Group	1		2		3		4		5		6	
				Z	Q	Z	Q	Z	Q	Z	Q	Z	Q	Z	Q
	17	I am not going to apply green waste on my soil if I do not know exactly what is inside.	Grid	1.115	3	0.98	2	0.348	1	1.099	3	1.052	2	−1.737* D	−4
	18	Only the agricultural knowledge of my direct social environment is trustworthy	Group	−1.032	−3	−0.716	−2	−0.071	−1	0.276	0	−1.14	−2	0.434	1
	19	As long as I comply to governmental regulations, I assume my decisions are right	Grid	−0.875	−2	−1.62	−4	0.21	0	0.554	1	−1.446	−3	0.434	1
Subjective norms	20	I do not need permission or approval of my friends and neighbours in order to make agricultural decisions	Grid	0.748	2	0.529	1	−1.963	−4	1.381	4	0.569	1	0	0
	21	I prefer to follow the advice that agricultural advisors give me, when making agricultural decisions	Grid	1.159	3	0.904	2	−0.629	−1	−1.378	−3	1.751	4	1.303	3

(Continues)

TABLE A1 (Continued)

Barrier	No	Statement	Cultural Theory: Grid or Group	1		2		3		4		5		6	
				Z	Q	Z	Q	Z	Q	Z	Q	Z	Q	Z	Q
	22	I will wait with applying more sustainable soil mangement practices until I have spoken to others that I know personally, having economic profit from it	Grid	−0.445	−1	−1.168	−3	−0.491	−1	−0.28	−1	−1.182	−3	−1.737	−4
	23	I consult my partner and those children (or other family members) working on the farm, prior to making an agricultural decision	Group Low group	1.42	3	1.244	3	1.754	4	0.83	2	0.264	1	1.737	4
	24	I discuss the soil management practices with my neighbours on a regular basis	Group	−0.951	−2	0.264	0	−0.91	−2	0.826	2	0.657	1	−0.434	−1
Awareness: knowledge on the soil and material	25	I know enough about the soil to make decisions on which soil amendment/fertilising strategy to adopt	None	−0.964	−2	0	0	−1.053	−2	−0.276	−1	−0.394	−1	1.303	3
	26	Within my local community, there is a solid knowledge on the soil life and functions	Group	0.104	0	0.451	1	0.353	1	1.376	3	0.481	1	1.303	3

(Continues)

TABLE A1 (Continued)

Barrier	No	Statement	Cultural Theory: Grid or Group	1 Z	1 Q	2 Z	2 Q	3 Z	3 Q	4 Z	4 Q	5 Z	5 Q	6 Z	6 Q
Diffusion of innovations	27	I only try out something new if I have seen it works well at the neighbours	Group	0.724	1	−1.091	−2	0.138	0	0.279	1	−1.27	−3	0.869	−2
	28	I am usually one of the first ones to try out a new agricultural technique	None	−1.755	−4	−0.639	−2	0.143	0	−1.929	−4	−0.876	−2	−0.434	−1
	29	It is much wiser to keep working with proven techniques instead of trying new things	Grid	−0.757	−1	0	0	0	0	−1.653 * D	−3	0.83	2	1.303	3
Responsibility	30	The most important task for the farmer is to maintain the landscape, including the soil	Group	0.432	1	1.355	3	0.281	1	1.38	3	−1.182	−3	−1.303	−3
	31	I can rely on my local community (family members, colleagues, neighbours) for support in times of harvest failures or other financial crises	Group	−0.217	0	1.091	3	1.544	4	−0.282	−1	0	0	−0.434	−1
	32	Farmers are not responsible for the decline of biodiversity	Grid	0.757	2	−0.187	0	0	0	−1.105	−3	−0.964	−2	0.434	1
Regulations	33	The government provides clear regulations regarding soil management	Grid	−1.835	−4	−1.543	−3	−1.963	−4	−1.931	−4	−0.569	−1	0.869	2

(Continues)

TABLE A1 (Continued)

Barrier	No	Statement	Cultural Theory: Grid or Group	1		2		3		4		5		6	
				Z	Q	Z	Q	Z	Q	Z	Q	Z	Q	Z	Q
Opinions on circular agriculture and sustain-ability	34	You cannot feed the world with circular agriculture	Group	0.275	0	0.375	0	0.276	1	1.381	4	−0.394	−1	0.869	2
	35	I cannot afford environmental friendly techniques if it will lower my income on a structural basis	Grid	0.998	2	1.543	4	0	−1	−0.55	−1	1.14	3	1.737	4
	36	I cannot afford innovation if I am not 99% sure on the success of the innovation	Grid	0.402	1	−1.432	−3	−1.263	−3	−0.279	−1	0.569	1	0	0
	37	The current form of conventional agriculture is not sustainable	Group	−0.278	−1	1.168	3	−1.754	−4	−0.555	−2	−1.751	−4	−0.434	−1
	38	Adjusting to climate change is only effective when all farmers in the local community do this together	Group	−0.331	−1	−0.264	0	1.053	2	−0.825	−2	−1.839	−4	0	0

(Continues)

TABLE A1 (Continued)

			Cultural Theory: Grid or	1		2		3		4		5		6	
Barrier	**No**	**Statement**	**Group**	**Z**	**Q**	**Z**	**Q**	**Z**	**Q**	**Z**	**Q**	**Z**	**Q**	**Z**	**Q**
Consequence: know-ledge on benefits of more sustainable agricultural practices and GWA	39	Applying liquid manure and fertiliser is by far the most economic option	Grid	1.401	3	−1.807	−4	0.91	2	−0.274	0	0.088	0	0.434	1
	40	Investing in sustainable agricultural practices is investing in a healthy soil, to the benefit of the local community, my company and future generations	Group	1.31	4	1.62	4	0.281	1	0.274	0	0.306	1	−1.303	−3
Awareness: knowledge on the soil	41	I know (close to) nothing on the soil properties of this area	Group	−1.31	−3	−1.543	−4	0.21	0	−2.206	−4	−0.088	0	−0.434	−1

TABLE A2 Factor loadings

Factor participants/Q-sorts	1	2	3	4	5	6
1	0.1136	0.2815	0.8734*	−0.1214	0.0616	0.0654
2	0.7456*	0.1396	0.1382	0.0604	0.3173	−0.2617
3	−0.0027	0.306	0.0237	0.7449*	−0.0338	−0.2742
4	0.2773	0.1844	0.0984	0.4361	0.613*	0.0767
5	0.6773*	0.2302	0.0129	0.2105	−0.0796	0.5599
6	0.2319	0.9258*	−0.0018	0.0514	0.0591	−0.0361
7	0.1529	0.8971*	0.1819	0.1471	0.1235	0.0077
8	0.1817	−0.0531	0.0964	0.7463*	0.1074	0.1847
9	−0.0538	−0.0627	0.0362	−0.0432	0.163	0.8978*
10	0.0776	0.0542	0.0148	−0.0419	0.8928*	0.1118
11	0.2094	−0.1009	0.8343*	0.3203	0.0205	−0.0234
12	0.779*	0.2037	0.2234	0.1123	0.0831	0.057

*indicates a significant correlation; $p < 0.05$.