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The role of information in shaping the emerging agricultural soil carbon market

Lisette Phelan[a], Pippa J. Chapman[a], Guy Ziv[a]

a School of Geography, University of Leeds, Leeds, LS2 9JT

Abstract

The agricultural soil carbon market that has emerged in recent years is widely regarded as a promising opportunity for farmers in the Global North and South, enabling them to generate carbon credits and derive a source of income from the adoption of alternative land management practices which contribute to climate change mitigation by increasing soil carbon sequestration and/or reducing soil-derived greenhouse gas emissions. This paper takes the UK as a case study region and explores farmers' willingness to engage with a dynamic and evolving market, based on their access to information; confidence in carbon developers' and investors' positive market sentiment; and expectations as regards the growth and development trajectory of the market. Data for this study was collected through key informant interviews with 24 farmers across England. Results suggest farmers are reluctant to engage with the market as discourse has become polarised, with the amplification of certain positions and perspectives making it difficult to decode and evaluate the messaging received. This paper generates important insights as regards incentivising farmers' market participation by highlighting how information is shaping the market; the extent to which a polarised discourse is undermining farmers' willingness to engage with the market; and how policymakers and practitioners could 'unlock' the potential of the market by enhancing the availability of, access to, and exchange of credible, context-appropriate market-related information. This will ensure farmers can make informed decisions as regards the market and reduce the likelihood that an avoidable information void stymies long-term market growth and development.

Introduction

Soils equate to the largest carbon pool and most persistent terrestrial sink for atmospheric carbon (Lal et al., 2021; Scharlemann et al., 2014). Land use change and intensification of farming practices have resulted in soils being severely depleted in carbon and created a large soil carbon debt of approximately 40–90 Pg carbon (Smith, 2008). Carbon sequestration in agricultural soils, realised through a variety of land management practices that increase soil carbon stocks and/or reduce direct soil greenhouse gas (GHG) emissions, is widely regarded as a key natural climate solution (Bossio et al., 2020); a nature-based solution to climate change (Seddon et al., 2021); a global-scale climate change mitigation strategy (Amelung et al., 2020; Goglio et al., 2015) and a greenhouse gas removal technology (Smith et al., 2020; Sykes et al., 2020).

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Global initiatives such as the 'Soil carbon 4 per mille' (Minasny et al., 2017) have underscored the important contribution that carbon sequestration in agricultural soils can make to realising the goals of the United Nations Framework Convention on Climate Change (UNFCCC) Paris Agreement and driving a transition at the level of the global economy towards Net Zero (Costa Jr. et al., 2022). These initiatives have paved the way for the emergence of an agricultural soil carbon market (hereafter referred to as the carbon market) in the Global North and South (Alexander et al., 2015; Lee et al., 2015).

There have been growing calls for policymakers and practitioners to improve the effectiveness of communication and the credibility, salience and legitimacy of information available to farmers regarding the role that soils can play as carbon sources or sinks, depending on the agricultural land management practices adopted (Abbas et al., 2020; Lal et al., 2021). Currently, so-called 'frontrunner' farmers are adopting practices to manage SOC stocks and, importantly, derive associated co-benefits, despite lacking in-depth scientific knowledge about sustainable soil management (Mattila et al., 2022) and having only limited knowledge regarding the long-term impact of these practices on productivity (e.g., increased risk of yield decline) and production costs (e.g. higher input costs; potential for reduced input use and costs, due to improved soil health), and, thus, profitability at a whole farm system level (Skaalsveen, Ingram and Urquhart, 2020; Paustian et al., 2019; Dumbrell, et al., 2016). The scientific community has committed to developing a global soil information system and decision support frameworks - drawing on published meta-analysis data from long-term field experiments rather than process-based models - to provide insights into the impact of different agricultural management practices on crop yields, SOC and nitrogen surpluses (i.e., the difference between nitrogen inputs into and outputs from a farming system) (Paustian et al., 2019; Jandl et al., 2014). Moreover, it will shed light on the unexpected outcomes of practices and synergies and trade-offs among sustainability indicators that are often analysed separately (Young, Ros and de Vries, 2020). It is envisaged this soil information system will incentivise farmers' adoption of practices that optimise carbon storage by enhancing the level of information available regarding in-situ measurement, modelling, and remote sensing-based approaches to evaluating the condition of a soil and monitoring changes in soil carbon stocks and/or reductions in soil-derived GHG emissions (Costa Jr. et al., 2020; Smith et al., 2020; Minasny et al., 2017).

Although scientific research is driven by the idea that findings as regards SOC dynamics should be interpreted and translated into actionable information and advice that enables farmers to make informed management decisions that positively impact the capacity of soil to sequester and store carbon (Paul et al., 2023; Mattila et al., 2022; Lal, 2021; Stockmann et al., 2013), the scientific community has, to date, largely failed to engage farmers as information co-creators (Mattila et al., 2022). In doing so, it has underestimated the extent to which involving potential knowledge users and stakeholders from the 'practice sector' (e.g., policymakers, lawyers, agronomists, landowners, and farmers) in different stages of the research process can increase the practical relevance and usability of the research outcomes' (Thorsøe et al., 2023, p.14; Stockmann et al., 2013). In 'largely ignor[ing]' farmers' values, identities, views, knowledge, and capacity to adopt alternative land management practices (Amin et al., 2020, p.6); information environments (Ingram et al., 2016) and knowledge networks (Rust et al., 2022); and the fact that they may be 'selectively engaging with information that reinforces their pre-existing beliefs' (Colvin et al., 2018), the scientific community has missed an opportunity to 'update' farmers' 'skillset[s]' for managing soil carbon (Mattila et al., 2022, p.2). This is noteworthy given that, beyond the frontrunner farmers who are adopting practices and experimenting with the use of carbon calculators and could be early entrants to the carbon market (Phelan, Chapman and Ziv, 2023), it is imperative the scientific community engages and provides advice, support and information to 'harder to reach' farmers. These latter farmers are currently 'left out of the conversation [regarding the growth and development of the market], including in research' (Buck and Palumbo-Compton, 2022, p. 60) and are, thus, also at 'risk of being left behind' by agri-environmental schemes and ecosystem services markets that are instead being shaped by political and corporate interests (Hurley et al., 2022, p.2).

The emergence of a global carbon market has been framed as a positive development (Schilling et al., 2023; Bossio et al., 2020; Vermeulen et al., 2019). Yet, the scientific community is at risk of undermining its commitment to 'allow[ing] the hope rather than the calamity of Pandora's box to prevail' in discourse and narratives related to practices that can be adopted to manage SOC stocks (Jungkunst et al., 2022). A paucity of studies has documented farmers' access to information regarding the costs and (co-)benefits associated with adopting practices that promote soil carbon sequestration and/or reduce soil-derived GHG emissions (Skaalsveen, Ingram and Urquhart, 2020; Mills et al., 2020). This research has contributed to inspiring, justifying, and legitimising sustainable soil management (Krzywoszynska, 2019). Studies have not, however, explored farmers' ability to access information relating to (i) carbon calculators and understanding of monitoring, reporting and verification (MRV) of carbon sequestered and/or GHG emissions reduced; (ii) the rules of engagement in the market and the implications of carbon contracts as regards additionality and permanence (i.e., stability) of carbon sequestered; and (iii) the risks associated with participation in a dynamic, evolving market characterised by uncertainty. Moreover, studies have not considered whether actual or perceived polarisation of the GHG emissions reduction discourse (Simmonds, Maye, and Ingram, 2024) may be undermining the growth and development of the market, despite studies suggesting that carbon market stakeholders are failing to carefully select communication frames; deliver information through non-partisan, trusted messengers; and go beyond strategic messaging towards building support for climate change policies (Badullovich, 2023; Colvin et al., 2018). Taking the UK as a case study of a region where the carbon market is dynamic and evolving, this paper explores the hypothesis that farmers' willingness to engage with the market is contingent on their access to market-related information (i.e., information related to MRV, carbon contracts, and the risks associated with participation in carbon projects) and their perception of the carbon market-related discourse as polarised; confidence in positive sentiment regarding the market; and expectations as regards the growth and development trajectory of the market.

Methodology

2.1 Sampling strategy and study area

Data for this study were collected through in-depth, semi-structured, key informant interviews with a total of 24 farmers across England between May and July 2022. The majority of the farmers (21 individuals) were recruited through a purposive and convenience sampling strategy. These farmers had previously indicated their interest in participating in a follow-up interview while completing a self-administered online questionnaire relating to their willingness and capacity to adopt practices that could increase soil carbon stocks and/or reduce soil-derived GHG emissions and engage with the carbon market (Phelan et al, 2023). Three additional farmers were recruited, towards the end of the data collection period, through a snowball sampling approach; these individuals expressed an interest in participating after learning about the study from those who had already participated in the interviews.

2.2 Contents and structure of the key informant interviews

The key informant interview protocol developed for this study consisted of 13 open-ended questions related to farmers' ability to access information regarding (i) soil carbon sequestration and emissions reduction practices; (ii) approaches to quantifying and verifying soil carbon capture and/or reduced GHG emissions; and (iii) the emerging UK carbon market. Moreover, the questions explored (iv) farmers' engagement with soil carbon-related knowledge exchange actors (e.g., academics, private sector stakeholders and government agencies; (v) views of carbon sequestration-related concepts (e.g., such as permanence, additionality, and leakage); (vi) preferences regarding carbon credit buyers; and (vii) perceptions of the benefits derived from participation in the market.

2.3 Data collection procedure

The key informant interview protocol was pilot-tested with six farmers to ensure that it would facilitate the collection of relevant data. Farmers were asked for feedback on the protocol, ranging from their opinion regarding the contents of the protocol; the clarity of the wording of the questions; and the time required to provide answers to each question. Data collected during the pilot-testing phase of the study was used to improve the framing of questions but was omitted from the final sample. The interviews with farmers recruited to participate in the study took between 40-90 minutes and were conducted by phone call, Zoom, and Microsoft Team.

2.4 Data management and analysis process

The key informant interviews were audio recorded using a Dictaphone and the recordings were transcribed, with the transcripts uploaded to the qualitative data analysis software package, NVivo, and content analysis performed on the data. An inductive content analysis approach was taken to analyse the data, with open codes determined and assigned to transcript excerpts. These codes were combined to form sub-concepts, -categories and -themes and, subsequently, organised into overarching concepts, categories and themes that facilitated insight into the topics discussed and underscored where there was consensus among farmers, as well as where opinions diverged. Key quotes (ad verbatim) that illustrated farmers' convergent and divergent opinions were also identified.

3. Results

3.1 Demographic characteristics of farmers sampled

The demographic characteristics of 21 of the 24 farmers who participated in the key informant interviews are presented in Table 1. The demographic data indicate these respondents were predominantly male; aged between 45-64 years; had more than 11 years of farming experience; and owned the land on which they were engaging in agricultural production. Demographic data and data on land management practices were not collected for the remaining three farmers who subsequently requested to be part of the study.

Table 1: Demographic characteristics of farmers sampled (n=21)

		n	**%**
Gender	Male	16	76
	Female	5	24
Age	45-54 years	8	38
	55-64 years	6	29
	35-44 years	4	19
	65 years and over	3	14

Education	Bachelor's degree		7	33
	Master's degree		5	23
	Not completed any formal training		5	24
	Engaged in ongoing technical/vocational training		2	10
	Doctorate		2	10
Farming experience	More than 30 years		11	52
	21-30 years		4	19
	11-20 years		4	19
	6-10 years		2	10
Source of income	Earning sole source of income from farming		10	48
	Earning income from farming, but also off-farm activities		9	43
	Earning income by managing a farm on behalf of a company		1	5
	Not earning an income from farming		1	5
Land tenancy situation	Own land		19	90
	Land rented under a short-term agreement		3	14
	Land rented under a long-term agreement		2	10
	Share farm (arable) land		1	5
Farm size (ha)	0-100		6	28
	101-200		5	24
	201-500		5	24
	501-1000		4	19
	More than 1000		1	5
Type of farm	Arable production		11	52
	Mixed crop-livestock production		5	24
	Livestock production	Lowland grazing livestock production	3	14
		LFA grazing livestock production	2	10

3.2 Farmers' access to information regarding the emerging carbon market

Farmers obtained information regarding the carbon market from a wide range of sources, including traditional print media and/or online media (e.g., newsletters distributed via email; social media networks; and online webinars organised by carbon developers, non-governmental organisations, and farmer groups). Although several farmers felt that there was "almost too much information out there", the majority of farmers did not believe they were in a position to make an informed decision about engaging with the carbon market as there were "so many unknowns". Farmers explained that identifying information that was useful and tailored to their interests and needs was challenging, as was discerning the credibility of different sources of information:

> "It's quite difficult; distilling the really important stuff and the science from the noise and the excitement is quite tricky at the moment." (Farmer 1)

Farmers who were already participating in the carbon market (n=6) observed that the information landscape was changing, with market-related information increasingly disseminated via social media. Noting that there was "still a lot to be said for that magazine, that's just sat on the desk, that you flick through [to find information]", these farmers indicated that they regarded private and public sector and civil society actors' approaches to disseminating information as somewhat ineffective. They explained that a large segment of the UK farming population, namely, older farmers - 35% of principal farmers and holders were aged 65 years or older in 2023 (DEFRA, 2023) – were being left out of market-related discourse and at risk of left behind in the transition towards Net Zero, due to their (in)ability to access online information and make decisions regarding the merits of participating in the market and reliance on face-to-face interaction with advisers and farmer peers who were risk-averse, sceptical of, and/or had limited knowledge regarding the market. Online webinars held by academics, non-governmental organisations, and charities, such as the Soil Association, and online platforms, such as Farmers Weekly Interactive, were identified as important sources of information related to the market. However, although the topics of these webinars were regarded as relevant and interesting, the information provided was described as being "way over the pay grade of knowledge" of the average farmer in the UK (i.e., information provided was difficult to understand). In failing to take "a layman's approach" to discussing the market and recognise the significance of "speaking the same language" as their audience, carbon developers were "making it [the market] massively complicated" and discouraging farmers' participation in the market:

> "I think when you sit down and talk to a farmer about additionality and everything else […] you've got some people who really get it, and other people who just don't […] I mean, it's complex, but it's not complicated. We've got to demystify all this terminology." (Farmer 2)

Farmers who were participating in the carbon market cited online peer-to-peer knowledge exchange as having positively impacted their ability "to make contact and discuss what we're doing and help each other out" in deciding, for example, which practices to adopt to sequester soil carbon and/or reduce GHG emissions and, more broadly, 'make sense' of the opportunities associated with market participation. However, they conceded that social media networks, such as X (formerly known as Twitter), could be "a bit of a dangerous place to get your information" if a farmer did not have a means of ascertaining the quality of information. Potential new entrants to the market, they explained, needed to recognise that although important lessons could be drawn from "see[ing] someone else's mistakes and [not] spend[ing] money making your own", information exchanged on social media networks was not always relevant to the UK farming context. Farmers also observed a tendency among some peers who were active on social media to "har[k] on about how awesome their system is", boasting that they were "doing this amazing stuff [adopting practices]" while failing to appreciate that their behaviour might lead to those who did not find it as easy to engage with information regarding the market feeling "disheartened" and discouraged to participate:

> "It's about delivering messages […] without preaching because it's so easy […] to put people off if they feel they're being sort of berated for not being good enough." (Farmer 3)

Noting that the discourse as regards the carbon market was being shaped by those who were "very good at speaking out" about their journeys towards achieving Net Zero status, farmers who were already participating in the market asserted that online information exchange should be underpinned a willingness among farmers to be "collaborative and […] supportive and really hel[p] each other". Committed to ensuring that "the conversations going on between farmers are positive", farmers observed that it was imperative that those who were vocal on social media networks, but not necessarily providing relevant or useful information, recognise that peer farmers were simply trying to learn from others' experience. Information exchange should, therefore, not lead to farmers feeling alienated and discouraged from engaging with the market:

> "Polarisation [of opinions in social media networks] […] switches a lot of people off. It's a real shame that we have identity agriculture out there at the moment because it's not helpful […] there's a lot of farmers who think, this [engaging with the carbon market] is definitely not for me." (Farmer 2)

> "I think people need to come together more […] we need to inspire and stimulate people to get them involved and to get them interested in it [the carbon market] and to use people like me to show it can be done and we can, you know, be a more profitable business and we're healing the planet at the same time." (Farmer 4)

Unlike the minority of farmers (n=6) who were participating in the carbon market, farmers who were not yet doing so stated that they (n=18) were "too busy farming to attend meetings and workshops and spend a great deal of time on social media". Relying on online and face-to-face peer-to-peer knowledge exchange and interaction with farm advisors and agronomists to make sense of the market, they were confused and overwhelmed by the "absolute barrage of different perspectives" and found it difficult to navigate the information landscape and distinguish between useful information, misinformation, and disinformation.

Many farmers described feeling as if they were "go[ing] down a rabbit hole" in trying to understand terms used in market-related discourse, such as additionality, permanence, and leakage, and, more broadly, finding answers to questions they had regarding the risks and opportunities and costs and benefits associated with participation in the carbon market.

3.3 Farmers' perceptions of the carbon market as an opportunity or a risk

Farmers described the term 'carbon' as "buzzing around". They observed that discourse about the emerging carbon market reflected the fact that, whereas "10 years ago there might have been quite a lot of opposition […] disagreement about climate change from the farming community", this was no longer the case; instead, it was widely accepted that farmers had a key role to play in mitigating climate change and achieving the UK's ambition of Net Zero by 2030. However, farmers noted, the trading and/or sale of carbon credits was a topic of intense discussion among the farming community as the carbon market had quickly become a "Wild West" - "a relatively new space […] [that had] inevitably filled up with cowboys and pirates wanting to make a quick buck":

> "Maybe it's just a reflection of where the market is at the moment, but it does feel as if there's, you know […] lots of investors from markets super excited, lots of cash, saying, I want to buy from you guys […] the market needs to settle down." (Farmer 6)

> "There's a lot of salesmen out there who are trying to sell you something [carbon schemes]. They sound bullish, confident, and assured and you're inclined to believe them, aren't you?" (Farmer 5)

Critical of the "sales pitch" given by carbon developers that was "so strong that individuals are finding themselves signing up to things that they don't really understand […] seeing it [market participation] as easy money", farmers observed that not only was there no regulation of the market, there was "zero guidance […] on soil carbon other than how to improve it". Although a minority of farmers thought that they could benefit from further information regarding "not very complicated, not very high tech" practices that could sequester carbon in soils and/or reduce soil-derived GHG emissions and the interaction effects between different practices, the majority of farmers did not think that they lacked information related to the costs and benefits associated with practices. Having already adopted a range of practices (Table 2), they were prepared to adopt additional practices.

Table 2: Practices adopted by farmers for whom demographic data was collected (n=21)

	n	%
Cover crops	17	81
Incorporation of organic amendments into soils	16	76
No/low/minimal/conservation tillage	15	71

Management of field margins	13	62
Introducing leys in crop rotations	12	57
Low intensity/rotational/mob grazing	9	43
Incorporation of a mix of legumes and herbs into grasslands	7	33
Agroforestry	4	19

Perceiving the UK farming community as being asked to bear more risk than investors from the public and/or private sector, farmers who were not yet engaging with the carbon market asserted they were wary, in the absence of 'trustworthy' market-related information, of signing up to carbon contracts that equated to "a lot of hoodwinking" and might "cause problems down the line", for example, if regulatory standards for the market were developed:

> "Farmers are taking the risk […] the buyer doesn't, the buyer is just making a commitment to buy some carbon, and it's up to the farmer to be able to deliver that consistently." (Farmer 6)

> "A 20 or 30-year agreement is effectively a generational agreement, at this stage something where there is still so much in flux, it seems unwise…you wouldn't do that with a mobile phone, so why would you do it with something that's so unmeasured as soil carbon sequestration." (Farmer 7)

As early adopters of practices, many farmers were unsure whether they would be eligible to participate in carbon schemes. Furthermore, they were unsure whether they could benefit from participation in the market as they did not know how to proceed as regards determining a soil carbon stocks baseline and did not feel in a position to measure, report, and verify (MRV) subsequent changes in soil carbon stocks nor how far their soils were from reaching carbon saturation:

> "On average, I've got just under six per cent organic matter on average across all the farm and without really knowing if I am pretty close to peak, or what the capacity of my soils is […] it will be hard for me to gain carbon credits because my understanding is carbon credits mostly come through demonstrating change." (Farmer 6)

Reflecting on carbon calculators that were available and could facilitate MRV of soil carbon stocks, farmers asserted that calculators were only "as good as the data that goes into them". Although they recognised the accuracy of the results of using a given calculator hinged on "how many data points you get […] across your farm", farmers expressed their frustration that the same data entered into different calculators failed to produce identical results. The significant level of divergence in carbon assessments and the need to harmonise carbon accounting tools used in the UK has been recognised by Defra, which commissioned a report in 2022 that concluded, although 'currently no consistent approach [is] taken to assessing carbon removals or emissions from soils, vegetation and land use change by calculators […] calculators are all able to provide the farmer with a robust baseline understanding of emissions and can facilitate the start, and ongoing development, of a decarbonisation process' (DEFRA, 2024a). Farmers were also critical of the fact that, while calculators considered woody biomass carbon, they did not take into consideration carbon sequestered in soils:

> "We want to identify how much carbon we actually have on the farm and how much we're sequestering […] but there is confusion, you come up with different answers and different results as to how much carbon you've got on the farm […] there's masses of uncertainty as to which is the best calculator to use." (Farmer 8)

> "It's something that we're conscious of, that we're probably not showing the whole farm scenario without the soil carbon bit in there. But then there's the whole argument about, when, how, and how often do you sample? I think originally, they [carbon developers] thought, well, let's just not worry with that because that opens up a whole new can of worms." (Farmer 9)

Despite recognising "somebody has to be first into these things", farmers – who were not yet engaging with the carbon market – indicated they thought their peers had "unrealistic expectations" as regards their potential to earn an additional source of income from the trade and/or direct sale of carbon credits. They observed, "the cart has been put before the horse in many ways; if we're going for Net Zero agriculture by 2030, well, first of all, we're going to have to have a lot simpler way of measuring it". Moreover, they noted, their peers "could be facing a bit of a wake-up call when they actually start doing some measurements" as required by carbon contracts, due to their reliance on carbon calculators that might, in the future, be "exposed as not being at all accurate". Asserting there was a need to instil greater confidence among the UK farming community in the science underpinning the carbon calculators, farmers called for MRV procedures to be standardised to reduce the level of risk that might be incurred in engaging with the market:

> "I think the risk element will stop people engaging fully [with the market] right now. I'm going to be the second mouse that gets the cheese here rather than being the innovator […] I'm going to be the laggard, I'm afraid and sort of follow and just see what happens." (Farmer 5)

Farmers who were already engaging with the carbon market recognised that their peers, who were not yet doing so, had reasons to be concerned about MRV. Admitting they were "the forward-thinking ones […] the ones that have got their eyes open, are seeing the opportunities and are getting themselves ready or are trying to [implement MRV]", they recognised the imperative to serve as positive role models and encourage their peers to engage with the market. Cognisant of the fact that the growth and development trajectory of the carbon market hinged on it being "farmer-led", farmers were aware that being "evangelical" (i.e., having strong beliefs and trying to persuade others to have the same beliefs) about what they were doing and failing to acknowledge the risks associated with MRV was likely to undermine their peers' confidence in the market. Consequently, they did not hesitate to acknowledge that they were also trying to figure out the market and investors' expectations:

> "I think it's, it's all very much a learning curve for everybody, isn't it? We have just started, last year we made the first tentative steps towards carbon accounting on the farm." (Farmer 7)

> "All we're trying to do now is understand what to measure, what to record and what to verify to prove that carbon is carbon […] [and ensure] not only just the carbon integrity up into the market but also the social, environmental integrity of credits." (Farmer 11)

Asked to consider why, beyond the obvious challenges of navigating the complex information landscape and implementing MRV, their peers might not yet have engaged with the carbon market, farmers mused that the discourse related to the market had been polarised by those who had rendered the discourse "carbon-centric". Motivated to adopt practices from a soil health rather than soil carbon perspective, several farmers posited that their peers were tired of "seeing carbon tunnel vision". They remarked that, if public and private sector and civil society actors' objective was to encourage them to "build up [soil] carbon content through certain actions", it would make more sense to invoke soil health rather than soil carbon in discussions related to the carbon market as this was a concept that likely to resonate to a greater extent with farmers:

> "I think we need to be carbon-focused, but I think [we also] need to look at the big picture […] everybody can strive to do the best to reduce carbon emissions and to store more carbon on the farm and I think every farm can probably do better." (Farmer 8)

> "The focus is always on soil carbon for markets, but actually, if you improve your soil carbon you improve your productivity […] we need to stack those multiple benefits together to see that it isn't just about one output, it's about why you're doing this to make your business, long term, more sustainable." (Farmer 12)

Observing that "nobody quite knows what the future holds", farmers indicated that they felt "pessimistic [in the] short term, [and] optimistic [in the] long term" about the emerging carbon market. Albeit hopeful that the science underpinning carbon calculators would be improved, and the integrity of carbon credits would be enhanced in the long term, farmers took the view that the growth and development trajectory of the market would not positively impact farmers in the short term; rather, there would be "a hell of a lot of losers". Farmers thought that the market "risk[ed] frustrating quite a lot of farmers" as carbon schemes required historical soil management records and the establishment of baselines against which changes in soil carbon stocks could be measured and were, therefore, more likely to reward "those who ha[d] been [doing] the most damage to soils" than "those who ha[d] been running a different system and ha[d] been providing natural capital benefits". Farmers were concerned that the unregulated development of the carbon market – as there was neither regulation of information nor regulation by information - would have "the net effect of putting people off for good". Convinced that there would be "some big casualties" and asserting that many farmers would "feel hard done by" the development of the market, they questioned how the market could be turned into a more level playing field so that it would benefit all farmers:

> "What's available to me when actually I'm already providing a service effectively through the changes that I've made over the last 20 years […] if others are going to get rewarded for change to a degraded system, how can we make it fair?" (Farmer 6)

3.4 Farmers' perceptions of public and private sector and civil society actors' leadership in shaping the growth and development trajectory of the carbon market

Alluding to the lack of guidance from public and private sector actors and civil society actors, farmers indicated that they were disappointed that civil society actors who they expected and trusted to give advice and advocate for them in discussions relating to the format of the market. In particular, farmers thought that the National Farmers Union (NFU) did not appear to have formed a strong opinion on the market and how it could be adapted to benefit the UK farming community. They were also frustrated by private sector actors in the agri-food sector who were reliant on but not supportive of farmers taking action as regards sequestering carbon in the soil and/or reducing soil-derived GHG emissions:

> "We still have an [agri-food] industry that campaigns against change and is campaigning with the language of 'we're going to fight this' [transition towards Net Zero by 2030]. Rather than, 'we're going to lead this and we're going to help the industry get through it'." (Farmer 12)

> "[Farmers] feel quite isolated, we're always the butt of a problem […] we would be a lot more open to taking some risks, which we're not at the moment, and feeling a lot more secure [if we were supported] […] we all need to start having more dialogue, I think." (Farmer 2)

In contrast, farm advisors and agronomists were perceived as guiding farmers in understanding the carbon market, translating information available into actionable advice such as which practices to adopt to sequester carbon and/or reduce soil-derived GHG emissions. A minority of farmers reported that they had taken initial steps to establish a soil carbon stocks baseline in response to encouragement from farm advisors and agronomists who they regarded as being knowledgeable about MRV, of increases in soil carbon stocks and/or reductions in soil-derived GHG emissions. However, although they were advising farmers to ready themselves for participation in the market in the future, farm advisors and agronomists were not yet suggesting that farmers engage with carbon schemes and, in some cases, actively discouraging farmers from doing so, as they did not consider the information available sufficient and/or appropriate to facilitate farmers' informed decision-making:

> "I think if we can sort of get on the rung now [by adopting practices] we will be better placed when things become mandatory if we started on the sort of voluntary basis. I've no interest at the moment in trading carbon […] the agent who helps us has very strongly advised us against getting onboard with any sort of carbon trading at the moment." (Farmer 7)

Although the minority of farmers who were already engaging with the carbon market observed that "one doesn't wait for the perfect system, you just have to crack on and do it", the majority of farmers indicated that they were unwilling to engage with the market until there was "a proper system [in place] […] that people can trust" to directly sell and/or trade carbon credits. Farmers were optimistic that, as it was "a very new market", carbon was "quite low priced" and there was "pent-up demand [for carbon credits] […] [from] various industries wanting to buy the carbon on offer", the carbon price would rise. However, questioning the extent to which this future price would be in line with their expectations, farmers asserted that they wanted greater clarity from private sector actors regarding the likely growth and development trajectory of the market. Several farmers were concerned that if information was provided by government agencies only, it would reflect "political bias"; farmers were in favour of the development of the market being industry-led as they expected it would be "more beneficial". Noting that "each farmer is different, each farm is different […] each farmer is looking for something different in the library of information", farmers stated that they required answers from private sector actors to a range of questions:

> "It's all very frustrating…no one knows who to turn to. Who are these people that want to bank [roll] us? Who are these people that want to potentially pay us? Who is monitoring it? There are so many questions we don't know the answer to yet." (Farmer 13)

> "We talk about selling carbon […] and they may have a price, we may have a price. How on earth do you get to a [common, agreed-upon] price?" (Farmer 14)

Regarding the carbon market as "having done farmers very few favours" and, simultaneously, being "of great benefit to a few", farmers attributed the limited benefits derived by farmers to the fact that the market development was being driven by "certain people" who were not necessarily "well-intentioned" and/or "represent the views and the best interests of farmers". Highlighting the wealth of relevant context-specific knowledge held by farmers, farm advisors and agronomists that could be leveraged in developing the market, they observed:

> "For the right schemes to be developed then farmers and the people who are working in the countryside need to be listened to […] these people have some excellent ideas and through practical experience are able to say what needs to be done." (Farmer 16)

In the absence of a policy framework, farmers noted, there was "a huge gap" between those impacted by and those shaping the growth and development trajectory of the carbon market, with the market skewed in favour of private sector actors. Observing that there was "a lot of interest and everybody now wants to be able to demonstrate carbon credentials", farmers indicated that they hoped that the UK government would recognise the need to draw up regulations and standards to safeguard the integrity of carbon credits:

> "There is a lot of uncertainty around carbon credits and whether it's an opportunity, it's been sold by some as an opportunity, but it's a very, very risky thing to get involved with at this moment in time because of the levels of uncertainty around it." (Farmer 8)

> "The whole thing [carbon market] is just riddled with controversy and I think the only way it's ever going to get sorted out is for the government to start helping us to define some standards, some fixed points that everybody has to adhere to […] then we can begin to move forward."
> (Farmer 15)

Farmers also voiced their concerns that the emergence of the carbon market was likely to adversely impact the UK food system, by taking land out of production and reducing the extent to which farming was "a viable vocational livelihood". They asserted that the market was perceived by farmers as "contentious" as it was paving the way for government-led farm support, agri-environmental support to be progressively reduced and the private sector stepped in to provide financial support:

> "I just feel like we're such an industry that's so used to handouts, that then we're just moving from one type of handout to another type of handout." (Farmer 2)

Moreover, they took the view that unless there was greater ambition and leadership in the agricultural sector in the future, it would take too long to get to Net Zero as farmers would continue to be "dependent on artificial fertiliser". Rather than reduce the use of fertiliser – which was "the hard bit" – farmers explained, some of their peers were likely to "fudge the results" generated by carbon calculators if it enabled them to show that they were Net Zero. Observing that "to actually get there to see real change on farms […] [would] take a lot longer", farmers noted that it would be particularly challenging to convince their peers to participate in the market if they were "farming conventionally […] [and were] net polluters themselves" or were ideologically opposed to soil carbon being commodified by public and private sector actors:

> "There're a lot of farmers who are very sceptical about the whole thing [carbon market] […] they don't think it's right that people should carry on polluting as they are and then just pay it off somewhere else […] they have been very successful in their businesses and don't see any reason to change." (Farmer 17)

> "We want full transparency […] we're a little bit particular who we sell to, we wouldn't want to be involved in greenwashing; it's got to be a company that's trying to improve itself and their practices in as much as they can and then they can offset with us". (Farmer 18)

4. Discussion

The following section discusses the results in line with the objective of this paper which was to explore farmers' willingness to engage with the emerging UK carbon market based on their access to information; confidence in carbon developers' and investors' positive sentiment regarding the market; and expectations as regards the growth and development trajectory of the market.

4.1 Influence of access to information on farmers' willingness to engage with the carbon market

Access to information can be considered to play a key role in determining farmers' perceptions of and willingness to engage with the carbon market. The results of this study suggest the information landscape related to the carbon market is a dynamic, complex, and contested space that is continuously being redefined by the 'drip feeding' of information by public and private sector and civil society actors who are directly and indirectly supporting the growth and development of the market. This finding is in line with Blum (2020) who argues that the carbon market is contested due to the role that private sector actors, in particular, are playing in shaping the market and polarised due to the disconnect that has emerged between private sector actors and public sector and civil society actors. The data underscore the fact that promoting the growth and development of the market and avoiding the alternative scenario, whereby the market 'becom[es] obsolete or worse, a threat to effective climate change mitigation' (Kreibich and Hermwille, 2021, p. 953), hinges on private and public sector and civil society actors recognising and responding to the tension between their different perspectives as stakeholders. There is an imperative for stakeholders to work towards identifying common value positions and, by extension, compromise positions (Tholen, 2022; Kreibich and Hermwille, 2021; Blum, 2020). In the absence of such compromise positions, polarisation will continue to undermine the broad support base required for an effective and enduring soil carbon policy that motivates farmers to adopt practices that contribute to soil carbon sequestration (Buck and Palumbo-Compton, 2022). In a political environment where soil carbon sequestration continues to be characterised as 'a risky investment, given the scientific knowledge base' (Buck and Palumbo-Compton, 2022, p. 60), there is a role for all knowledge exchange actors 'with a voice in this emerging discourse to consider the implications of how their research and viewpoints are communicated' (Colvin et al., 2018, p. 31).

The results of this study suggest academics are not currently perceived by farmers as playing a central role in shaping the information environment beyond hosting and/or participating in online webinars. Given that 'science underlies both policy and corporate interest' (Buck and Palumbo-Compton, 2022), it is important that academics – from soil scientists to social scientists - 'repositio[n] themselves to access resources and audiences' (Buck and Palumbo-Compton, 2022) and more proactively guide the discourse on agricultural soil carbon sequestration. By taking a more visible position in debates and knowledge exchange activities, avoiding the use of complex jargon, and authoring a plain-language 'Farmers' Guide to the Carbon Market', academics could enhance the effectiveness of policy messages aimed at farmers and contribute to ensuring that policymakers and other knowledge exchange actors engage in two-way communication and relationship-building with the farming community (Badullovich, 2023; Rose et al., 2019). Moreover, they can address a concern - voiced more than two decades ago by Bouma (2001, p. 874) - namely, that 'the poor use of soil science expertise in society's dealings with modern environmental and land-use issues articulated by nonspecialists who relentlessly advance their own, often politically motivated, ideas, leav[es] little room for specialists, such as soil scientists, who would be quite capable of raising both the level and the yield of such discussions'. Currently, there are questions about whether farmers who were early adopters of practices should receive retrospective compensation based on historic carbon sequestration; their demonstrated commitment to maintaining higher-than-peer-average soil carbon stocks; or carbon stocks that are high relative to a favourable reference state and compensate for future climate change-driven SOC losses, taking into account soil type, climatic conditions, and land use (Ziv, Orman and Reed, 2023; Phelan, Chapman and Ziv, 2023; Riggers et al., 2021). There are also questions about whether farmers should be allowed to bundle and stack soil carbon with other co-benefits (e.g., improved wildlife habitat, enhanced water quality, reduced flood risk) and whether blending and stacking of funding from other public or private sector sources (e.g., government farming subsidies) should be permitted in ecosystem service markets (Black et al., 2022; Thompson et al., 2022). Related to stacking, there are questions about how additionality should be conceptualised and operationalised by carbon market stakeholders; unlike temporal stacking, contemporaneous stacking (i.e., stacking that occurs during the same period) renders it difficult to determine whether a funding stream is additional or non-additional and constitutes a source of revenue that enables a farmer to justify incurring the costs associated with establishing a carbon project (Brammer and Bennett, 2022; Vegh and Murray, 2020).

The data from this study indicate farmers are not currently interested in engaging with the market schemes – despite recognising its development could potentially benefit them in the long term – as they regard the information landscape as being shaped by carbon developers who have a not-very-hidden agenda of wanting to incentivise their participation in specific carbon schemes. These carbon developers, according to farmers, are benefitting from perpetuating rather than addressing information and power asymmetries characterising the carbon market. The extent to which information and power asymmetries in the carbon market risk undermining farmers' ability to negotiate carbon scheme contracts has been documented by DeFries et al. (2022) and Lee (2017). Increasing farmers' access to information serves to reduce farmers' exposure to adverse selection and moral hazard (Paul et al., 2023; Alexander et al. 2015) and the likelihood that they will be perversely incentivised to take advantage of the market and derive benefits from lowering their soil carbon stock baselines, for example, by tilling, which would enable the sequestration of a greater amount of 'additional' carbon relative to peers over the duration of a carbon contract (Strong and Barbato, 2023; Oldfield et al., 2022b). The findings of this study do not support the views of Rust et al. (2022), namely, that farmers have 'had enough of 'traditional experts'' (e.g., farm advisors and agronomists) in the context of decision-making related to sustainable soil management. On the contrary, these actors are increasingly serving as 'sense makers' in an information landscape where offline peer-to-peer knowledge exchange is limited and online information exchange is viewed as polarised, co-opted and shaped by farmers who have stronger views than others in favour of, or against, engagement with the carbon market. As Ingram and Maye (2020) note, the ongoing digital transformation of agricultural knowledge has brought 'new demands, relations and tensions to agricultural decision-making' and a 'reliance on technical experts and […] technology'; it has forced farmers to move 'beyond individual experiential knowledge' towards data-driven decision-making. In an era of data-driven smart farming, farm advisors and agronomists are playing an important role as knowledge brokers shaping farmers' decision-making processes; their synthesis of knowledge related to land management practices, calculators and the carbon market is perceived as context-specific, credible, and legitimate (Thomas et al., 2020; Eastwood et al., 2019).

As the carbon market is evolving rapidly, there is an imperative to ensure farm advisors and agronomists have access to formal training about the carbon market and are in a position to answer farmers' questions and assess and allay their fears regarding the risks associated with participation in carbon schemes. The results of this study suggest farmers' willingness hinges on these stakeholders creating an enabling environment that allows farmers to fact-check the validity of statements about the benefits derived from participation in carbon schemes and access balanced information, for example, regarding the implications of signing carbon contracts that have intergenerational implications as regards approaches to land management. Currently, there is no independent, codified, and validated knowledge base providing impartial and relevant evidence to inform farmers' decision-making; instead, farm advisors and agronomists act within a framework shaped by the economic objectives of supply chain actors and, moreover, provide 'a very heterogenous range of advice, the quality of which is practically impossible to control' (Dhiab, Labarthe and Laurent, 2020, p. 9). The results of this study suggest there is a need to improve information flow and address the level of misinformation that farmers face, as well as their misinterpretation of information, for example, regarding the risk of being 'locked-in' to carbon contracts; the accuracy of soil carbon calculators; and the use of buffers that provide insurance in cases of force majeure (e.g., extreme weather events). Farmers would benefit from the integration of information regarding the carbon market into existing agricultural training programs (Cammarata et al., 2020). Moreover, they would benefit from information, tailored to their needs and context, provided by advisers and intermediaries who are qualified to provide advice related to soil carbon management, soil sampling and analysis, and the carbon market based on their completion of accredited courses grounded in agreed upon syllabuses (Knierim and Ingram, 2024; Reijneveld et al., 2023). These courses could be similar in format to the existing BASIS courses, focused on pesticides and fertiliser management, and be 'monitored, discussed, updated and modified by committees that comprise representatives from farmer organisations (e.g. NFU), authorities (DEFRA), [independent agronomist] advisor organisations (AICC)' (Knierim and Ingram, 2024). There is an imperative to improve the quality of advisory services available to farmers in the complex and highly fragmented agricultural advisory landscape in the UK (Knierim and Ingram, 2024; Pappa and Koutsouris, 2024; Dhiab, Labarthe and Laurent, 2020).

4.2 The type of information that could enhance farmers' willingness to participate in carbon schemes and the challenge that policymakers and practitioners face in disseminating information

Enhancing farmers' access to information regarding alternative land management practices is often regarded as key to incentivising farmers' participation in carbon schemes (Ingram et al., 2014; Kragt et al., 2014). Although farmers may face challenges in accessing relevant, credible information regarding the benefits, co-benefits, costs and impacts on production and yields of practices (Strong and Barbato, 2023; Niles and Han, 2022; Kragt, Dumbrell, and Blackmore, 2017), the results of this study suggest information dissemination strategies which focus on enhancing farmers' access to information regarding practices that sequester soil carbon may be ineffective as regards incentivising participation in carbon schemes. Access to information about practices did not appear to constitute a barrier to farmers' adoption of practices in this study; indeed, the majority of farmers had adopted a range of practices and were willing to adopt additional practices. However, they were hesitant and/or not interested in participating in carbon schemes and engaging with the carbon market due to the perceived challenges faced in accessing information related to MRV, carbon contracts, and the risks associated with the market. The data support the findings of Buck and Palumbo-Compton (2022), namely, farmers' scepticism regarding the carbon market cannot simply be addressed by increasing their access to information. Incentivising farmers' engagement with the market necessitates tailoring information to farmers' needs (e.g., traditional media as well as social media) and interests (e.g., clarification as regards market demands for additionality and permanence of carbon sequestered; carbon calculators and MRV protocols, and carbon prices and policies). There is an imperative for stakeholders to reduce the extent to which uncertainty gives rise to speculation and leads to risk-averse behaviour; for example, farmers are currently unsure about the carbon sequestration potential and income generation opportunities associated with practices adopted. Empirical data generated through long-term experiments and space-for-time substitution sites are key to testing and benchmarking models used to interpolate and infer how different combinations of land use, climate, soil type and management practice interact to impact carbon stocks (Jordan et al., 2022; Smith et al., 2019) and enhancing farmers' understanding of how SOC dynamics are affected over time by alternative land management practices, such as cover crops, ley-arable rotations and hedgerow establishment (Biffi et al, 2022; Drexler, Gensior and Don, 2021; McClelland et al., 2020).

With regard to the polarisation of the discourse relating to the carbon market, policymakers and practitioners face a major challenge in incentivising farmers' engagement with the market as perceptions regarding the shortcomings of the market and risks associated with carbon schemes may already be entrenched. This is in line with Colvin et al. (2020, p. 27) who observe 'once a topic becomes politically polarized […] attitudes are likely to be influenced not by the substantive detail of the top, but instead by where their political ideology is seen to be "pro" or "anti"'. The data from this study suggest there is a continuum from pro- to anti-carbon market along which farmers are positioning themselves as regards their interest in participating in carbon schemes; the majority of farmers support the growth and development of the market and recognise the direct sale and/or trade of carbon credits could constitute an additional source of income in the future. However, the findings of this study underscore the extent to which farmers' engagement with peers via online social media – in particular, X (formerly Twitter) – should not be disregarded by policymakers and practitioners seeking to enhance farmers' willingness to engage with the market. Farmers' willingness to engage with the market may be indicative of the fact that, in navigating the information landscape related to the market, they are knowingly and, in some cases, unknowingly, 'selectively engag[ing] with information that reinforces [their] pre-existing beliefs' (Colvin et al., 2020, p. 27). As Rust et al. (2022) note, farmers' knowledge networks and 'social media farmer influencers' could also play an important role in enhancing access to information and opening up new communication channels that appeal to and reach 'the modern farmer', as well as challenging misinformation regarding the carbon market. So-called 'frontrunner farmers' could also play an important role in enhancing peers' confidence and ability to participate effectively in carbon schemes and, by extension, the market, by sharing experiential knowledge (Cammarata et al., 2024; Phelan, Chapman and Ziv, 2023). The findings of this study suggest there is an imperative for public and private sector and civil society actors to amplify the voices of farmers who are cognisant of the fact that a broader population of farmers conceptualise participation in carbon schemes as exposing them to unknown and unforeseeable risks and facilitating greenwashing by public and/or private sector investors. By sharing insights into the learning curve associated with participation in the market – positive experiences, but equally, their negative experiences - these frontrunner farmers can contribute to challenging entrenched positions in debates and peer-to-peer knowledge exchange via social media that are detrimental to inspiring confidence in the market and supporting its growth and development. However, this necessitates creating integrated farmers' knowledge networks that incorporate 'social media farmer influencers' who may provide 'tangible evidence of the benefits of new management practices and technologies' and, therefore, be 'perceived as more credible and trustworthy' than traditional farm advisory service providers (Rust et al., 2022, p. 38) and frontrunner farmers into the broader agricultural knowledge and information system in the UK (Knierim and Ingram, 2024). As social media is playing an increasingly important role in stimulating individual and collective learning through knowledge exchange and production (Prost, Gross, and Prost, 2022; Phillips, McEntee, and Klerkx, 2021), farmers who are not yet literate in using social media could potentially benefit from training. Conversely, farmer influencers communicating 'symbols of good farming' and presenting a 'nuanced picture of the everyday activities of farming' (Riley and Robertson, 2021, p.445) could benefit from training on responsible social media use. This would increase the likelihood of the online discourse being balanced and not dominated by the views of a minority either in favour or against carbon sequestration and engagement with the carbon market. Moreover, it would shift the discourse from a polarising focus on 'good' and 'bad' practices' to addressing 'cultural resistance to changes associated with rethinking farm practices' (Riley and Robertson, 2021, p.438), with farmers already engaging with the market in a position to challenge misinformed discourse and, thereby, support a transition towards more sustainable modes of agricultural production. Currently, 'few agricultural knowledge and services networks have sustainable soil management as their primary concern' (Krzywoszynska et al., 2023, p. 8), however, peer-to-peer exchange of relevant knowledge could also be facilitated by the establishment of "living laboratories" premised on a 'new knowledge culture […] [that] engage[s] farmers to become their own researchers, observers and decision-makers […] rather than expecting them to follow the standard, linear technology transfer model, which invariably is top-down' (Rust et al., 2022, p. 41). These living laboratories could, through adequate, long-term institutional support, be supported to evolve into "lighthouses" to promote joint learning between farmers, government agencies, academics, private sector (e.g., carbon developers, agri-food industry, and investors) and civil society actors regarding the contributions that sustainable soil management can make to ecosystem services as envisaged by the EU Soil Mission (Bouma, 2022; Rust et al., 2022).

4.3 Farmers' confidence in carbon developers' and investors' positive sentiment regarding the emerging carbon market

The results of this study suggest farmers are currently only cautiously optimistic and are somewhat sceptical about the emergence of the carbon market. They regard carbon developers as overconfident, relative to farm advisors and agronomists, in their assessment of the income generation potential opportunities associated with carbon schemes and question private investors' motivation for supporting the emergence of the carbon market. Although investment by public and private sector actors in soil carbon credits is still limited due to questions over the additionality and permanence of carbon sequestered and/or GHG emissions reduced; and the equivalency of carbon credits generated (Oldfield et al., 2022b; Costa Jr. et al., 2020; Vermeulen et al., 2019), carbon trading and offsetting have long been framed in terms of 'rogue traders […] trying to make a quick buck' (Böhm and Dabhi, 2009, p. 14), with 'gold rush, Wild West, and cowboy metaphors' used to describe the level of risk inherent to any carbon market (Asplund, 2011, p. 2). Farmers are concerned that they are being encouraged to engage with a carbon market equating to a 'Wild West'. Although McLaren et al. (2023) and Henderson et al. (2022) have documented general scepticism around the carbon market, farmers' scepticism and the reasons for their scepticism - alluded to by Brockett et al. (2019) and Fleming et al. (2019) - have to date been somewhat lost in the broader discourse relating to this market; its emergence has been framed as a largely positive development by public and private sector and civil society actors. The findings of this study support Strong and Barbato's (2023) view that farmers do not want to engage with the carbon market against a backdrop of price and policy uncertainty and a lack of rules and regulations governing the functioning of the market. In this context, the development of a minimum standard for soil carbon schemes, such as that proposed by the 'UK Farm Soil Carbon Code' (UKFSCC) project (Phelan, Chapman and Ziv, 2024; Black et al., 2022), and broader standards for ecosystem markets being developed by the British Standards Institute (BSI), such as the 'BSI Flex 701' which outlines overarching principles and requirements for the design and operation of high-integrity nature schemes (BSI, 2024), can be expected to enhance farmers' confidence in and ability to compare different MRV approaches and reduce their exposure to unnecessary financial risks by safeguarding the integrity of carbon credits generated. The European Council and Parliament have agreed upon a voluntary Carbon Removal Certification Framework (CRCF) to regulate permanent carbon removals, carbon farming and carbon storage in products (European Council, 2024a; European Council, 2024b; European Council, 2022). This framework has been modelled on a low carbon standard and labelling scheme existing in France, known as 'Label Bas Carbone' (Bamière et al., 2021) and, as it explicitly refers to soil emission reductions, goes beyond regulations previously proposed by the European Commission (European Council, 2024a). However, farmers currently still lack clarity and information about the regulatory framework and, specifically, how the minimum certification criteria 'QU.A.L.ITY' (i.e., Quantification, Additionality and baselines, Long-term storage, and Sustainability) should be interpreted in the context of ensuring high-quality removals from climate-friendly soil management (Cammarata et al., 2024; McDonald et al., 2023).

Farmers are particularly sceptical about the science underpinning carbon calculators, recognising their ability to meet carbon contract conditions hinges on the existence of a standardised MRV protocol that ensures the accuracy of measurements and safeguards the credibility and integrity of carbon credits. MRV currently constitutes a challenge for farmers due to the costs involved and the uncertainties resulting from the different approaches to estimating and measuring SOC (Oldfield et al., 2022a; Keenor et al., 2021). The data in this study support the views of Black et al. (2022) and Mercer and Burke (2023) who argue the development of an accurate and well-designed MRV protocol is key to not just inspiring confidence among public and private sector actors in the market but, also, the broader farming community. To date, calls for a standardised approach to MRV have stemmed from recognition that private sector investment in the voluntary carbon market hinges on carbon offsets being generated by farmers' adoption of practices resulting in 'genuine climate abatement' by 'correspond[ing] to a real increase in SOC sequestration for the nominated 'permanence' period and represents a fungible unit (t CO_2-e) for offset markets' (Henry et al., 2023, p. 10). The results of this study also support the findings of Costa Jr. et al. (2020) who posit the design of a standardised, low-cost, fit-for-purpose approach to MRV is, equally, key to incentivising farmers' engagement with the market. In the absence of an accurate and well-designed MRV protocol, farmers' participation in carbon projects will continue to be undermined by a lack of confidence in 'the expected relationship between practice change and soil carbon stocks in various climates and soil types' (Henry et al., 2023, p. 29). In this context, the development of minimum standards regulating methods and protocols according to which changes in soil carbon are measured will ensure the generation of robust scientific evidence that farmers' investments in soil carbon sequestration practices deliver the intended public goods benefits and do not have unwanted effects, while also reassuring private investors about the integrity of carbon credits generated (Reed et al., 2022).

4.4 Farmers' expectations as regards the growth and development trajectory of the market

The results of the study indicate farmers recognise the voluntary carbon market will become mature and stabilise over time; indeed, the data suggest they are accepting of the fact that the market currently constitutes 'a necessary sandbox for innovation […] a mechanism to bridge the divide between current challenges and a GHG conscious economy of the future […] [that] should be reimagined […] rather than [an] instrument[t] to be overly-disparaged, or abandoned' (Miltenberger et al., 2021, p. 2).

As Michaelowa et al. (2019) observe, enhancing the transparency of additionality determination, baseline setting, third-party validation and verification procedures facilitates scrutiny and improvement of carbon market mechanisms. The results of this study suggest farmers expect the market to become transparent over time and, consequently, also more effective and efficient, as new information emerges regarding carbon calculators and carbon contracts, as regards additionality and permanence expectations, and a standardised MRV protocol is developed and implemented by all market participants. Given interaction between farmers, carbon developers and public and private sector investors is currently defined by a lack of trust, the data generated by this study support the view that enhancing access to information and promoting information exchange relating to MRV - for example, through the development of minimum standards for soil carbon schemes and ecosystem markets (Phelan, Chapman and Ziv, 2024; Black et al., 2022; Reed et al., 2022) - will be key to reducing price dispersion and the transaction costs currently associated with participation in the market (Fabregas et al., 2019; Michaelowa et al., 2019). The digitalisation of agriculture and increased reliance on technologies such as blockchain may, in the future, play a key role in further reducing information asymmetry in the carbon market (Ehlers et al., 2021) and enhancing the traceability of information and the reliability of information flow in carbon emission trading and/or direct sale (Pan et al., 2019). The data underscore the imperative for public sector actors and civil society actors to fulfil their socio-moral obligation to regulate the market (Shamir, 2008) but, equally importantly, reduce information asymmetry and enhance trust by encouraging private sector investors to voluntarily disclose information related to their carbon performance (Borghei, 2021; Velte et al., 2020).

5. Conclusion

This paper, which takes the emerging UK carbon market as a case study, generates important insights for policymakers and practitioners globally by underscoring farmers are currently reluctant to engage with the market as they find it difficult to decode and evaluate the quality, objectivity, utility, and integrity of messaging received regarding the market and the risks associated with participation in carbon schemes due to the polarisation of offline- and online market-related discourse. In the UK, an information void has led to the positions and perspectives of carbon developers and a minority of farmers – who are risk-taking or risk-neutral and in favour of and/or already engaging with the carbon market – being amplified; it has also resulted in the majority of farmers, who are risk-averse, feeling alienated by market-related discourse and private sector actors' information dissemination strategies and sceptical about the benefits derived from participation in carbon schemes and, by extension, engagement with the market. This paper underscores the urgent imperative for policymakers and practitioners globally to regulate the market and enhance the availability of, access to, and exchange of credible, context-appropriate market-related information through traditional media and social media; farm advisory services; as well as peer-to-peer knowledge exchange networks (e.g., living laboratory and lighthouse farms). By providing information and supporting knowledge exchange related, in particular, to ongoing efforts to develop a standardised MRV protocol, as well as minimum standards for soil carbon schemes and ecosystem markets that will safeguard the integrity of carbon credits, policymakers and practitioners can ensure farmers are in a position to make informed decisions as regards engaging with the market. In addition to enhancing farmers' confidence in carbon developers' and investors' positive sentiment regarding the market, this information provision and knowledge exchange will also ensure the information void which currently exists does not stymie the long-term growth and development trajectory of the market.

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