A Nuffield Farming Scholarships Trust Report

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John Oldacre Foundation

Can you farm carbon?

Ben Hunt

November 2023

NUFFIELD UK

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A Nuffield (UK) Farming Scholarships Trust Report

Date of report: October/2023

"Leading positive change in agriculture. Inspiring passion and potential in people."

Title	Can you farm carbon?
Scholar	Ben Hunt
Sponsor	John Oldacre Foundation
Objectives of Study Tour	• Investigate nascent soil carbon markets (SCMs) overseas to understand how they are seemingly making a success of SCMs and overcoming challenges of greenwash. • Assess the potential for SCMs to financially stimulate farmers to adopt new carbon farming practices. • Provide guidance to farmers and the industry on the opportunities and risks of SCMs.
Countries Visited	Netherlands, Belgium, France, Denmark, USA, Canada, UK
Messages	• Farmers face increasing challenges and must spearhead internal transformation of the sector. • SCMs are not the transformative panacea I had envisioned. It is uncertain whether the offset SCM will be a suitable instrument for driving genuine climate impact, or agricultural transformation. It could play a modest future role if integrity and carbon pricing improve. • Offset SCMs face substantial challenges of 'greenwash', with additionality and permanence the biggest issues. • The risks of the offset SCM currently outweigh opportunities. • Farmers can mitigate risks by pursuing non-offset based SCMs, like insetting. • Policy, entrepreneur-led innovation (Regenpreneurship), new markets and social cooperatives are vital levers for transforming the agricultural sector.

EXECUTIVE SUMMARY

Can you farm carbon?

Farmers face increasing challenges, including rising costs, climate change and growing environmental regulations. Clearly, agriculture requires change, especially for farmers inside environmentally sensitive catchments. Is carbon farming the answer and, if so, how do we incentivise it?

The emerging soil carbon market (SCM) has generated much enthusiasm. Companies pay farmers to adopt practices that remove atmospheric carbon into the soil (carbon farming), offsetting companies' emissions. On one hand it seems like a win-win - increasing soil carbon could help farmers cope with future challenges by improving farm productivity, environmental performance and climate resilience while mitigating companies' emissions. On the other hand, it seems fraught with challenges around greenwash, with people often calling it the 'wild west'. Several projects in Europe and North America provided hope that these challenges could be addressed. I investigated how by interviewing a range of stakeholders involved in these overseas projects.

In reality, these projects weren't really addressing these challenges and exhibited issues regarding additionality and permanence. Most farmers had adopted all or most of the accredited carbon farming practices in the past, rather than adopting new practices, indicating minimal additional carbon storage. Substantially higher carbon pricing is likely needed to drive material change. Otherwise, companies gain credit for farmers' existing actions - a form of greenwashing that farmers risk getting embroiled in.

So, can you farm carbon? Yes, adopting carbon farming practices could demonstrably boost soil carbon with myriad benefits. But the scale of its potential climate impact remains debated. Therefore, climate change mitigation is currently best seen as a potential co-benefit, not the primary focus of carbon farming. Do SCMs hold the key to unlocking widescale adoption of carbon farming and associated advantages?

SCMs are nascent, they may play a modest future role if integrity and carbon pricing improve. Currently though, risks seem to outweigh opportunities for farmers. However, risks can be mitigated by pursuing non-offset carbon markets like insetting, which have fewer restrictions.

In summary, SMCs are not the panacea I once thought for agricultural transformation. But they may contribute future solutions alongside regulation, policy, entrepreneur-led innovation ('regenprenurship'), new markets and social cooperatives. Sustainable farming requires diverse solutions and co-ordinated efforts.

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Chapter 1 - Personal Introduction

Always rooted in agriculture, I grew up in South Dorset milking cows and grain carting under the influence of my grandfather, a dairy farmer, and my father, a livestock nutritionist. But with no family farm to succeed I went off to study a business degree at Loughborough University, then trained as an agronomist and took up various technical and commercial roles within agriculture. Always passionate about the environmental side of agronomy, I now work alongside farmers to improve drinking water quality by advising and incentivising farmers.

I am fascinated by the immense influence agriculture has on nearly all facets of society and the environment, for better or worse. Having witnessed agriculture's impact on water quality first-hand, I believe farming is arguably the most important industry in the world! My passion is to enable agriculture to evolve in a way that concurrently improves food production and addresses some of society's greatest challenges. I aspire to be part of driving positive change in this critical sector.

Chapter 2 - Background to my study subject

Agriculture faces challenges

Agricultural inflation currently sits at historically high levels (1), with nitrogen fertiliser prices rising over 320% to £870/tonne between Oct 2020-Oct 2022 (2)(appendix 2), hitting new records.

Recent climate records for both temperature and rainfall (3) (appendix 3a, 3b) are a clear signpost of what conditions may well be like under future climate change scenarios, more records are likely to continue to be broken (4). Agriculture is arguably the sector set to be most affected by climate change and the urgency to adapt to future climate change scenarios cannot be overstated (5).

For those farming inside environmentally sensitive catchment areas there's also the growing threat of regulation to protect the environment. This is well underway for some UK farmers, like those farming in the Poole Harbour catchment (6). For other UK farmers this may be just around the corner. For example, appendix 1 shows the catchment areas of two important underground drinking water aquifers in the south west of England, polluted with nitrate concentrations above the legal limits for drinking water (11.3mgN/L). Water has to undergo costly treatment or blending before it can be supplied to the public, and nitrate treatment at one of these sources alone would cost the billpayer an estimated £25m in capital outlay, plus large annual running costs (7). Unfortunately, these examples are representative of a UK-wide issue, predominantly arising from intensive agricultural activities. Studies show the future impact of farming on water quality could be exacerbated even further by climate change, if we don't change (8).

Given these challenges, particularly for farmers in environmentally sensitive catchments, I believe the agricultural sector must spearhead internal transformation. If it does not, external forces will likely impose unwanted changes instead.

Is carbon farming the answer? And if so, how do we incentivise it? There's been a lot of excitement about the soil carbon market (SCM), where companies pay farmers to employ carbon farming practices that remove atmospheric carbon into the soil (carbon farming), to offset companies' emissions. It seems like a win-win for everyone. Not only could increasing soil carbon help to mitigate climate change (9, 10, 11, 12), it could also improve the resilience and sustainability of farming by delivering other co-benefits (fig 1), helping farmers cope with the challenges just mentioned. However, these carbon farming practices are associated with costs (10) and we know a lack of incentives is a major barrier to their adoption (13). The emerging SCM has been hailed by some as having potential to deliver a paradigm shift that will accelerate climate change mitigation (14). On the other hand, it seemed fraught with challenges around greenwash, with some people calling it the 'wild west'. Do SCMs really hold the key to unlocking carbon farming, with the climate, production and environmental benefits that follow?

Chapter summary

This chapter outlined the imperative for change in agriculture as well as the obstacles inhibiting it. The next chapters will examine SCMs as one potential financial model to incentivise agricultural transformation.

Potential co-benefits of increasing soil organic matter
Increased adaptive capacity of soils, making them more resilient to climate change (15)
Yield resilience (16)
Improved food security (17)
Water infiltration and water holding capacity (18, 19)
Reduced flooding (20)
Lower Nitrogen inputs (21, 22)
Soil health (20) and below ground biodiversity (10, 23)
Resistance to drought and erosion (14)
Reduced water pollution, improved water quality (24, 25, 26)
Improved nutrient density of food (27)

Figure 1: Potential co-benefits of increasing soil organic matter

Chapter 3 - My study tour

Over the course of my Nuffield scholarship, I conducted research through travel in the following countries:

Country visited	Month & year of visit	Duration of visit	Notes
Netherlands	June 2022	1 week	Several European countries had early-stage carbon projects running so I went to visit a few and meet the different stakeholders involved. I also had the opportunity to travel with international scholars in the Netherlands and France that I met at the Nuffield CSC.
Belgium	June 2022	1 week	
France	June 2022, May 2023	2 weeks	
Denmark	September 2022	1 week	I was asked to speak at the international maize growers conference hosted in Denmark. I took the opportunity to visit a major carbon broker, farmers and a farmers' union/research institute.
US & Canada	September 2022	3 weeks	The US appeared to have the most activity happening with SCMs. I travelled with a US Nuffield scholar who is a conservation agronomist and therefore very well connected with stakeholders involved in these early-stage carbon programmes.
UK	March 2023 onwards	1-2 weeks	UK travel underwent a more targeted approach talking to key stakeholders.

Chapter 4 - Materials and methods

4.1 Materials

Key search terms such as 'carbon farming', 'regenerative farming' 'soil carbon', 'soil carbon markets' and 'soil organic matter' were used in an initial literature review to identify a research gap for this Nuffield Farming Scholarship.

Across several countries a range of different stakeholders were interviewed: farmers, carbon buyers, academics, carbon brokers, carbon market and policy experts, advocates, and sceptics of soil carbon markets (SCMs).

Countries where interviews were conducted:

- Netherlands
- Belgium
- France (Southern West France, Normandy)
- Denmark
- USA and Canada (IOWA, California, British Columbia)
- UK

4.2 Methods

4.2.1 Experimental procedure

The sample of respondents was largely determined by finding a few 'connectors' in each country who were willing to share their personal networks. This allowed for a range of perspectives to be captured across a variety of different stakeholders. Interviews were mostly speculative, with little prior knowledge of interviewees' experience and insight.

Stakeholder group	Interviewees
Agricultural industry body	7
Farm advisors	2
Farmers	16
Policy makers	3
Researchers	19
Food company	8
Corporate	15
Carbon broker	8
Total	78

Figure 2: Number and category of interviewees

4.2.2 Interviews

Interviews ranged from formal settings, in controlled environments with ample time allocation (e.g. a two-hour meeting in a boardroom) to quite informal settings in dynamic environments with uncertain and sometimes shorter than expected durations in a more conversational style (e.g. sat on

a combine with a farmer for 10 minutes in the thick of harvest). There were a lot of unexpected variables that made conducting the 'perfect' interview an experiment in itself. The interview process was adapted accordingly to quickly identify the respondents' main area of interest or specialist knowledge, and to focus on questions that related to that. In most cases this ensured maximum value from each interview, even if only a small sub-set of questions were discussed. Rarely did subjects address all questions (appendix 5), nor were identical subsets or sequences of questions used. However, interviewing extensively over the course of the scholarship enabled thorough collective coverage overall. Some interviews were conducted online where in-person meetings were not possible.

4.2.3 Survey

A survey comprising a mix of 21 quantitative and qualitative questions was completed by 93 UK farmers. The sample was selected by distributing the survey nationally through water company catchment advisors, Natural England, farmer membership organisations as well as social media. Sixty-four per cent of the 93 respondents confirmed they farmed inside a drinking water catchment, which aligns well with the aims of the study - to assess the potential of SCMs to incentivise the adoption of carbon farming practices, particularly in catchments where farmers face increased regulatory pressures to protect the environment.

4.2.4 Data analysis

While many interviews were recorded and transcribed via 'Otter', due to the dynamic nature of conducting Nuffield interviews, this was not always possible for practical reasons. However, in all cases interviews were summarised in writing and/or personal voice notes as soon as possible after completion to record the most salient points. These summary notes later underwent thematic analysis to pull out key themes and those themes are represented by the specific interviewees referenced in the report. Some interviewees are also referenced that provided unique information or viewpoints that progressed understanding or clarity of the topic.

Survey responses were captured and analysed by Aberystwyth University's subscription to 'Jisc' online surveys. Qualitative responses underwent thematic analysis to pull out key themes.

Chapter 5 – Findings

I embarked on my Nuffield research optimistic about Soil Carbon Market's (SCM) potential to catalyse agricultural transformation in the UK. However, these markets lacked momentum domestically and faced obstacles to growth. Were they the panacea I envisioned? To evaluate their viability, I examined successful overseas projects that were seemingly overcoming these challenges. By understanding their approaches abroad, I aimed to assess whether SCMs could gain traction in the UK and deliver intended benefits.

5.1 Opportunities

5.1.1 The size of the opportunity

Carbon programmes typically focused on entry level carbon farming practices like cover crops, zero/minimum tillage and application of organic manures, while some included more extreme practices like conversion to grassland. The amount for carbon sequestration modelled varied between programmes at 0.5-2.2tCO2/ha, the upper range allocated to more extreme measures like conversion to grassland. The carbon price ranged between £21-86/t, meaning farmers were earning wide-ranging revenues between £11-£95/ha depending on the model used to estimate carbon sequestration, the practices adopted by the farmer, and the carbon price paid by the buyer.

There appears to be some early-stage innovations that purport to increase the revenue potential from carbon credits per hectare. One is the use of artificial intelligence, to increase the accuracy of direct measurement whilst decreasing the cost (interviewee N2). This greater accuracy allegedly negates the need to apply the large discount factors that are currently required to compensate for the large degree of uncertainty in models, so that maximum possible carbon sequestration can be claimed per hectare. Concepts like 'fractionalisation' whereby carbon sellers sell smaller lots of carbon for a higher price, also purport to increase the revenue potential of carbon credits. Much like splitting a multi-pack of crisps and selling individual packets for a higher price. Several well-respected institutions are also predicting that the carbon credit demand and prices could increase significantly in the region of £40-£100/tonne between 2030-2050 (28, 29), which could increase the revenue potential for farmers who sell carbon credits.

In addition to the financial opportunity there could be other non-financial benefits, for example the climatic and environmental benefits associated with carbon farming could improve the perception of farmers by society.

Conclusions

While the financial reward of carbon credits might go some way to replacing dwindling Basic Payment Scheme (BPS), the cost of implementing carbon farming practices likely outweighs the value of the soil carbon credits. As a result, I mostly found pioneering 'front runner' farmers participating in the soil carbon programmes I visited, being paid for farming practices they were already doing. The level of reward seemed only sufficient to be attractive to those farmers, not to

mainstream intensive farmers who were unlikely to be led by the un-compelling short-term business case. This raised concerns - was the SCM merely rewarding existing behaviours without driving real change? As someone interested in incentivising change, it was a sobering possibility!
Just days into my first Nuffield trip, early findings punctured my optimism. I returned home questioning my project's relevance. For a time, I resisted the evidence but soon embraced objectivity, resolute to follow the insights wherever they led. My initial belief in the SCM as a silver bullet gave way to realism, could it even be a red herring? An open mind was required to investigate further. The emotional ups and downs of a Nuffield journey!

5.2 Challenges and risks

5.2.1 Greenwash

5.2.1.1 Additionality

For an activity to be 'additional', the sale of carbon credits must be pivotal to the decision to implement the change. If the activity would have happened anyway, without the sale of carbon credits, it is not additional and there would be no genuine benefit to the climate (30).
Much of what I saw overseas challenged my own understanding of additionality. It was the biggest area of contention I experienced between different stakeholders with huge variability in how additionality was defined.

Some carbon programmes rewarded 'front runner' farmers for what they were already doing without the requirement to implement new change. To manage this, some carbon programmes devised a 3-5 year 'look back period'. Other carbon programmes took the average farming practices for a region, then rewarded farmers for practices considered above that average baseline, regardless of whether practices were newly adopted or not. Other programmes defined additionality as anything farmers were doing that they weren't legislated to do.

These organisations justified rewarding existing practices on the basis of fairness, and to avoid perverse incentives for 'front runner' farmers to un-do past practices. However, interviewee X1 privately shared an alternative view – another motivation was capitalistic i.e. start-ups needed income, and at low carbon prices, the path of least resistance were pioneering farmers already engaged in carbon farming practices to whom even marginal rewards would be attractive. Some 'front runner' farmers actively sought out programmes with lax additionality rules, with no requirement to adopt new practices (fig 3). Were these farmers oblivious to additionality principles or ignoring them for profit? I wondered if corporate carbon buyers understood agriculture enough to recognise potential credibility gaps in their purchases. Arguably every party could benefit from these transactions, apart from the climate (fig 4). The government could even benefit, allowing private investment to substitute the dwindling 'Basic Payment Scheme'.

Figure 3: An example of one 'front runner' farm I visited in France that was selling soil carbon credits for practices they had already been doing prior to SCM enrolment. The farmer believed the carbon credits were being sold to an offsetter. The farmer had actively sought out a carbon programme with lax additionality rules that didn't require them to implement any new practices and had disregarded a stricter carbon program that required them to adopt at least one new practice to prove additionality. The farmer did not appear to share my concerns about additionality and seemed content being paid for practices they were already doing. *Source: author's own.*

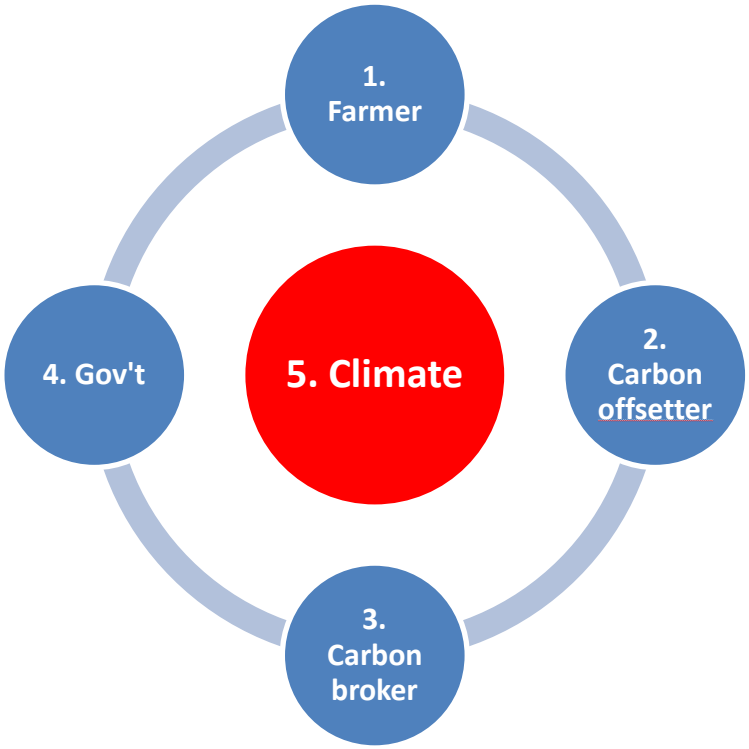


Figure 4: Infographic representing all parties involved in a carbon offsetting trade where there is no additional change incentivised by the sale of soil carbon credits. In such situations it became apparent that all stakeholders involved in the transaction could be winning (in blue), apart from the climate (in red).
1. Farmer - even small rewards could be attractive for farmers that don't need to do anything new.
2. Carbon offsetter - buying carbon offsets at a cheap price below the true cost of sequestering soil carbon
3. Carbon broker - market liquidity achieved quickly to generate income through commission on trades.
4. Government - The government could benefit by allowing the private voluntary offset carbon market to partly substitute the dwindling 'Basic Payment Scheme'
5. Climate - the climate is the only stakeholder in the transaction to lose out. The carbon buyer continues to pollute, claiming the carbon outcomes from pre-existing farming practices, supposedly cancelling out their own emissions, without having to pay the true price of incentivising new carbon farming practices. In reality, those carbon removals would have happened anyway without the sale of soil carbon credits.

Some of the stricter carbon programmes required farmers to implement at least one new practice to satisfy additionality requirements, even if that meant excluding 'front runner' farmers who were already implementing all the accredited carbon farming practices, a victim of their own success and a contentious issue among this progressive community of farmers (fig 5).
Even where farmers have capacity to adopt one or more new practices and be accepted onto one of these stricter carbon programmes, the reality is many will not be starting from a blank canvas and may have already adopted some practices in the past. Most carbon programmes seemed to overlook this and reward farmers for all practices, both new and old. Although accepted by most interviewees, this appears to challenge the concept of additionality. By the laws of nature, annual cropping systems of course have the potential to remove tonnes of atmospheric carbon into the soil each growing season, but the carbon farming practices that bake those tonnes of annual sequestration into the future, have already been implemented in the past. And where there are a mixture of new and old practices, one paper highlights the difficulty in quantifying the respective contributions of each individual practice towards the total annual carbon sequestration (10). These nuances further highlight agriculture's challenge of meeting the additionality requirements of soil carbon offsets.

Figure 5: Examples of progressive 'front runner' farmers I met in the US who expressed concerns about being excluded from the SCM on the grounds of additionality, because they had already implemented their carbon farming practices in the past - a contentious issue among this community of farmers. Despite some disgruntled views, the general consensus was this community of farmers was unlikely to consider un-doing (reversing) their past carbon farming practices in order to enrol in the SCM (perverse incentive). For them, the other benefits of carbon farming seemed to outweigh the relatively small income earned from the SCM. Of course, the risk of 'perverse incentives' leading to 'reversals' could become greater if the carbon price were to increase sufficiently enough. *Source: author's own.*

Although most carbon programmes seemed to have plans to add to their repertoire of accredited carbon farming practices in the future, most carbon programmes currently focused on just a few entry level carbon farming practices like zero/minimum tillage and cover crops. Survey results indicate these practices are already widely adopted by UK farmers, with 72% of surveyed farmers saying they've already adopted cover crops (fig 6), and 78% saying they've already adopted

minimum tillage practices (fig 7). This would suggest there is limited potential to demonstrate additionality with these carbon farming practices at a national level.

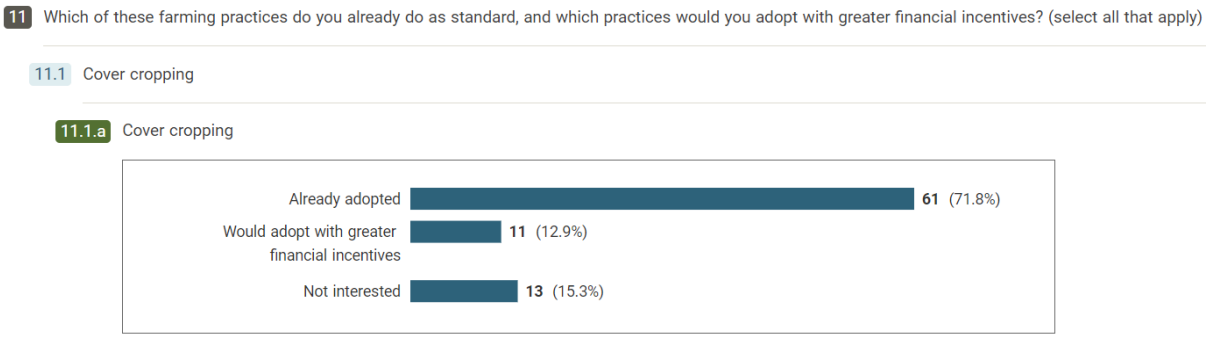


Figure 6: Results of survey question 11.3, from 93 UK farmers surveyed in April 2023

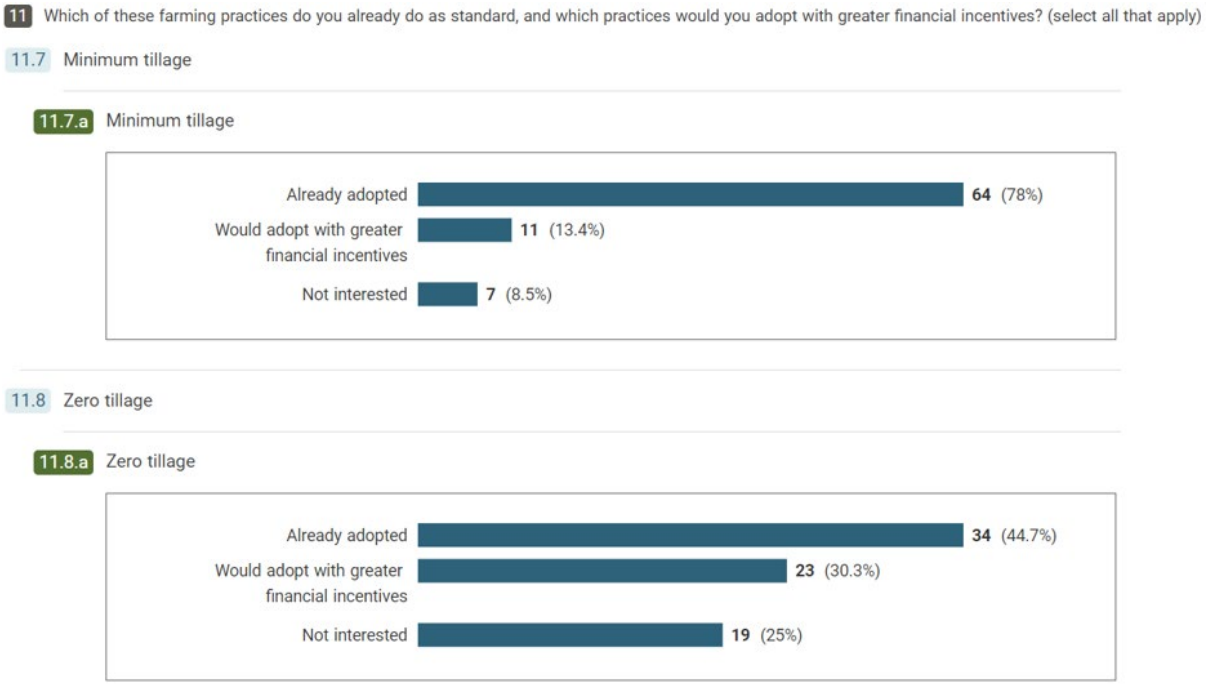


Figure 7: Results of survey question 11.7 and 11.8, from 93 UK farmers surveyed in April 2023

I visited a carbon project operating under the umbrella of the country's official emissions certification scheme, administered by a commercial organisation. Despite the scheme's stringent additionality rules, the project administrator (interviewee W) described how they had 'optimised' the paperwork to indicate participating farmers had not grown cover crops in the previous three years - when in reality, they had. This clearly demonstrated the potential for gaming the system. In theory, documentation should verify additionality, but in practice, buyers' funds did not enable additional carbon removal to offset their emissions - even if unknown to them.
Finally, some farmers planned to save soil carbon credits for higher future prices rather than sell immediately. This clashes with additionality, as current day emissions can't logically be offset by historical removal credits. As interviewee A2 analogised, unlike fine wine, older carbon credits would be less valuable than recently generated ones. Survey results suggest a general confusion surrounding the concept of additionality itself, with only 19% of surveyed farmers claiming to have a 'very good' or 'somewhat good' understanding of additionality (fig 8), and 79% of farmers 'wholly agreed' or somewhat agreed' to being confused by the carbon market (fig 9).

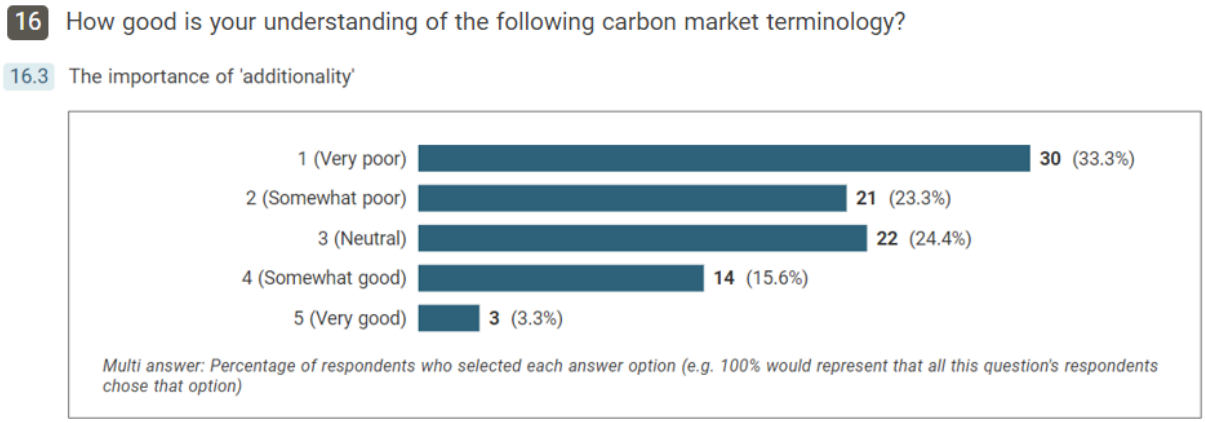


Figure 8: Results of survey question 16.3, from 93 UK farmers surveyed in April 2023

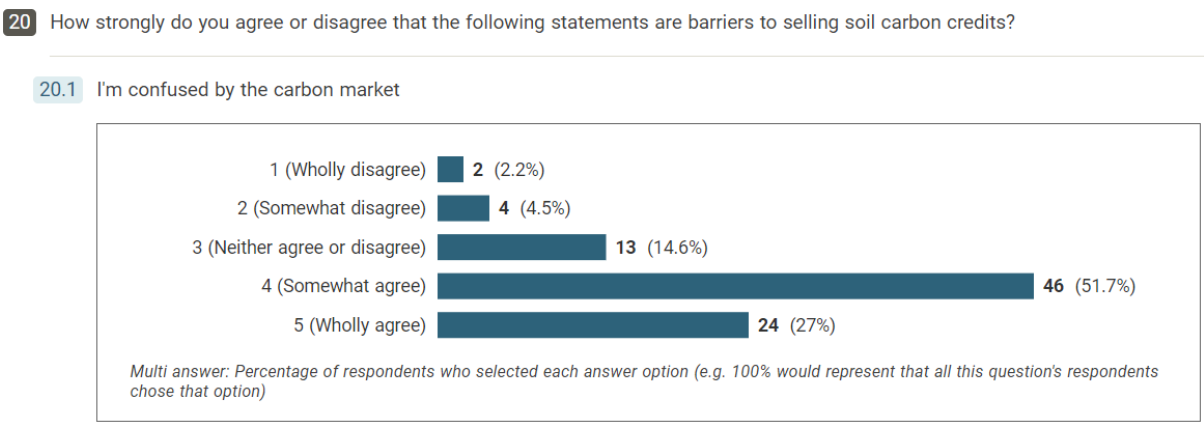


Figure 9: Results of survey question 20.1, from 93 UK farmers surveyed in April 2023

5.2.1.2 Permanence

At least for offsetters, they require sequestered carbon to be stored practically forever, which demands the carbon farming practices that led to those carbon removals to be maintained forever. There are clearly issues with being able to make such promises in agriculture:

- It reduces farmers' flexibility to change future management practices.
- Potential for tenanted or owned land to change hands in the future and farming practices to be discontinued.

Many of the carbon programmes attempt to deal with the issue of permanence by using a 'buffer pool' whereby they hold back a proportion of carbon credits sold to cover the risk that carbon removals could be reversed in the future. Even so, most agreements are quite short requiring farmers to maintain practices for 10 years or less.

My largely empty quest for answers on how to overcome the issue of permanence was met with an enlightening moment in the US when one project developer (interviewee F2) expressed their view that they simply weren't aware of any mechanisms in agriculture that could guarantee the permanence of removed carbon, that's the reason their carbon program solely focused on 'insets', not 'offsets', a point I'll expand on later.

5.2.2 Other risks/challenges

Risks/challenges		Description
Supply chain and agricultural sector emission	**Supply chain**	The analogy of Russian dolls (fig 10) helps to visualise how farmer's own emissions (represented by the inner doll) constitute the scope 3 emissions of food/beverage companies in the supply chain (outer dolls). If a farmer decides to sell carbon credits to offsetters outside the supply chain, it could potentially affect the ability of the supply chain to balance scope 3 emissions and reach net zero targets. At an individual farm level one way to mitigate this risk might be to only sell surplus carbon credits once the farm has reached net zero and below.
	Agricultural sector	The emissions of the sector (45.6mt CO2e/year) is currently estimated to outweigh the potential to sequester carbon in trees, hedges and soils combined (9mt CO2e/year) (appendix 4). Therefore, the sector would currently not be able to balance its own emissions even if it retained all its own carbon removals. Even if individual farms achieve net zero, there are likely to be others that can't, so overall does the sector even have any carbon removal credits to sell? To stand any chance of achieving net zero, the sector may need to retain every carbon removal credit possible. Greater leadership of this issue would help ensure the sector does not help other sectors achieve their net zero goals first, at the expense of its own.
Removal credits	**Removal vs reduction credits**	Given that the volume of sector emissions is reported to outweigh the potential to remove carbon from the atmosphere, there would appear to be a bigger opportunity to sell reduction credits than removal credits (interviewee C1 and R1). Reduction credits may also carry less risk in the context of permanence. Carbon removals carry a long-term liability to keep carbon permanently removed from the atmosphere into the soil, by maintaining carbon farming practices. Whereas with reduction credits, once reduced or avoided, those emissions have been avoided forever. Survey results indicate UK farmers have a poor understanding of the difference between reduction and removal credits (fig 11).
Unintended consequences	**Carbon as a single metric of sustainability**	According to interviewee L2, measuring carbon emissions per unit of production tends to favour intensive farming, whereas measuring it as an absolute value tends to favour regenerative farming. There may be a risk of unintended consequences by focusing on carbon as a single metric of sustainability depending on how it's measured.
	Perverse Incentives	If the carbon price increased to a sufficiently high-level, it could potentially incentivise 'front runner' farmers to un-do carbon farming practices, which would clearly be counter-productive to climate change mitigation.
	Delayed adoption of carbon farming practices	Due to the strict requirement for additionality with carbon offsets, some farmers may delay implementation of carbon farming practices that would have otherwise been implemented sooner, while they wait for greater confidence in the SCM or for the carbon price to increase. This would clearly be counter-productive to climate change mitigation and adaptation.
	Data	Interviewee W1 voiced concerns that carbon programmes are paying farmers a very small amount of money to capture their on-farm data, which is valuable when sold to large corporations to help measure their scope 3 emissions.

Figure 10: A full set of Russian dolls represents all the individual businesses in a food supply chain- from farmer, commodity buyer, processor, to retailer. With the farmers represented as the inner roll, their direct emissions make up the scope 3 emissions, a huge proportion (often >90%) of the total emissions of the food/beverage companies. *Source: Pixabay*.

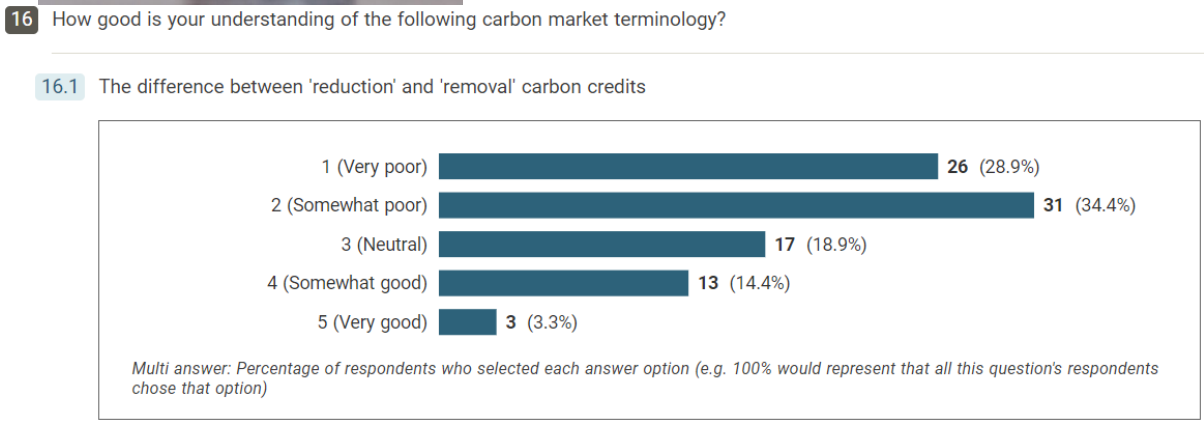


Figure 11: Results of survey question 16.1, from 93 UK farmers surveyed in April 2023.

Chapter summary

- I investigated overseas carbon projects that appeared to successfully implement SCMs and address credibility concerns around greenwashing.
- However, these projects still exhibited substantive issues related to demonstrating real additionality and permanence of carbon storage.
- Farmers require guidance on SCM participation, as their choices could reverberate across supply chains and the sector as a whole.
- Avoidance/reduction carbon credits may provide safer, greater opportunities than removal carbon credits.
- Reliance on carbon as the sole sustainability metric could bring unintended consequences.

Chapter 6 - Non-offset markets for carbon outcomes

According to one US expert (Interviewee B2), selling carbon credits to offsetters means farmers are essentially making a promise to permanently remove additional carbon from the atmosphere so that another entity can neutralise their own carbon emissions. As discussed, this presents challenges around additionality and permanence. Therefore, other private markets that encourage carbon farming for non-offsetting purposes could be preferable.

6.1 Insetting

According to Interviewee B2, in contrast to offsetting, insetting scope 3 emissions is more of a carbon accountancy exercise, where companies work with the farmers in their supply chain by incentivising them to reduce emissions or increase sequestration, and then tallying up the results in each year's carbon account for the products they manufacture from those specific farmers' crops. Therefore, the considerations of permanence and additionality is in service of producing "low carbon crops" rather than credits to offset emissions elsewhere. Under these circumstances additionality becomes less of an issue, since the aim of insetting is to keep farmers doing good practices they're already doing (to continue to produce low carbon crops) and incentivise other farmers to start adopting these practices (to convert from "conventional" to "low carbon" production). The very strict additionality and permanence requirements for offsets, are therefore less relevant for insetting.

Another advantage of insetting is that all parties in the supply chain benefit by their scope 3 emissions reducing, when a farmer reduces their net carbon emissions (fig 12). This potentially means that all parties could co-invest to share the cost of the farmer making that change. Whereas with offsetting only two parties benefit- the farmer and the single company buying the offsets (fig 13).

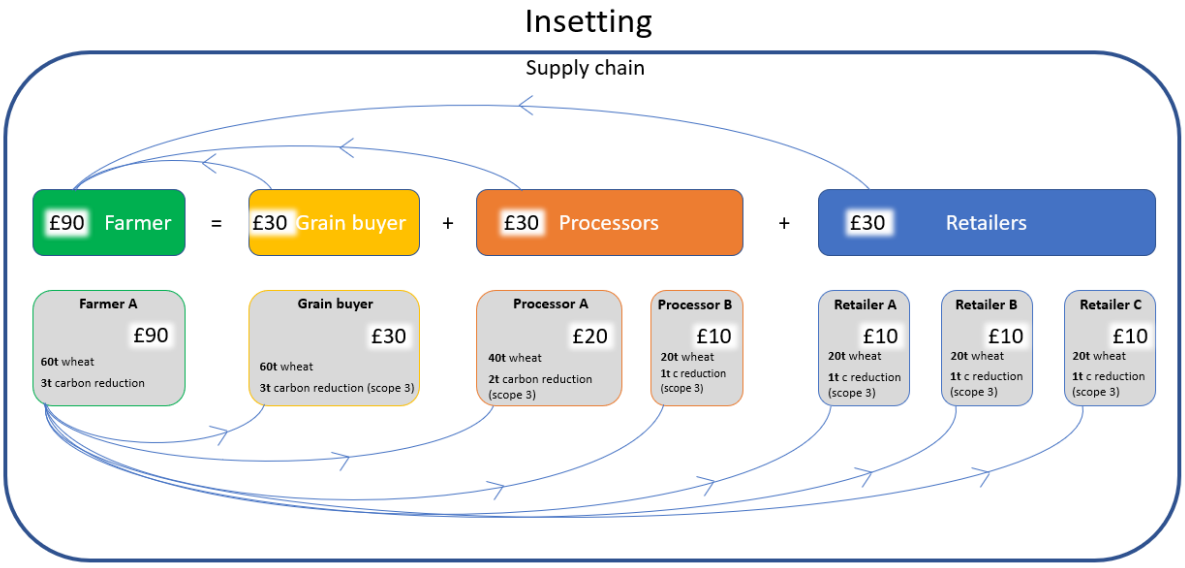


Figure 12: Insetting where all supply chain companies can co-claim net reductions in farmers' carbon emissions as scope 3 emission reductions. Cost sharing is also possible between supply chain companies.

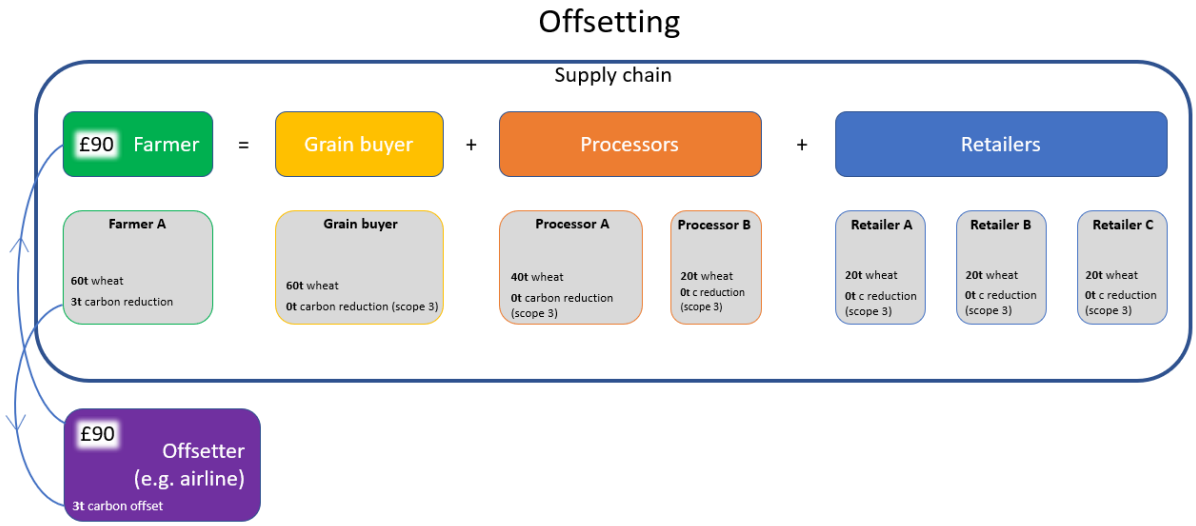


Figure 13: Offsetting where net reductions in farmers' carbon emissions are sold as carbon credits outside of the supply chain. Only two parties benefit, the farmer and the company buying the carbon credits as offsets.

Insetters generally view offsetters as a threat (interviewees Q and J2) because they could potentially compromise their supply chain's ability to reach net zero, by exporting carbon credits out of the supply chain. However, offsetters are willing to pay farmers for carbon farming practices, are insetters willing to do the same? In a supply chain where the consumer will not pay more, and companies all have the objective to maximise profits, it may be difficult to agree who's going to pay farmers to make changes. As one UK policy expert explained (interviewee Q2), there's a risk that progress towards net zero becomes a 'right to sell' rather than something the farmer can benefit from. If this were the case, it was described as being 'another form of extractive supply chain behaviour'. Interviewee Z2 also questioned whether farmers are really in the headspace for insetting after years of being (in their words) 'shafted' by their supply chains.

Despite the potential risks and drawbacks of selling offsets, the presence of offsetters could increase competition for farmers' carbon, offering farmers more selling power for carbon to counter extractive supply chain behaviour, and ensuring farmers capture some value for their efforts if supply chains aren't willing to pay. Offsetting could be viewed as a 'last resort'.

As Interviewees Q and I2 explained, in a supply chain that's struggling to find value, or agree who's going to pay farmers to make changes, offsetters could be seen as co-investors injecting new value into supply chains that wasn't there before. Although in theory offsetters and insetters could work in synergy in this way, according to one US expert (interviewee B2) the protocols required to manage such a complex mechanism whilst navigating the potential risks, do not currently exist. The head of a US based insetting program (interviewee F2) performed some quick calculations (fig 14) to show that in reality, food companies would only need to offer farmers a modest premium per unit of production to match the payments an offsetter would currently make for carbon credits, so this could be a simpler route for supply chains rather than managing complex relationships with offsetters. A compromise may be to work more closely with other external funders that don't compete for the same carbon outcomes, such as ELMS and water company catchment funding.

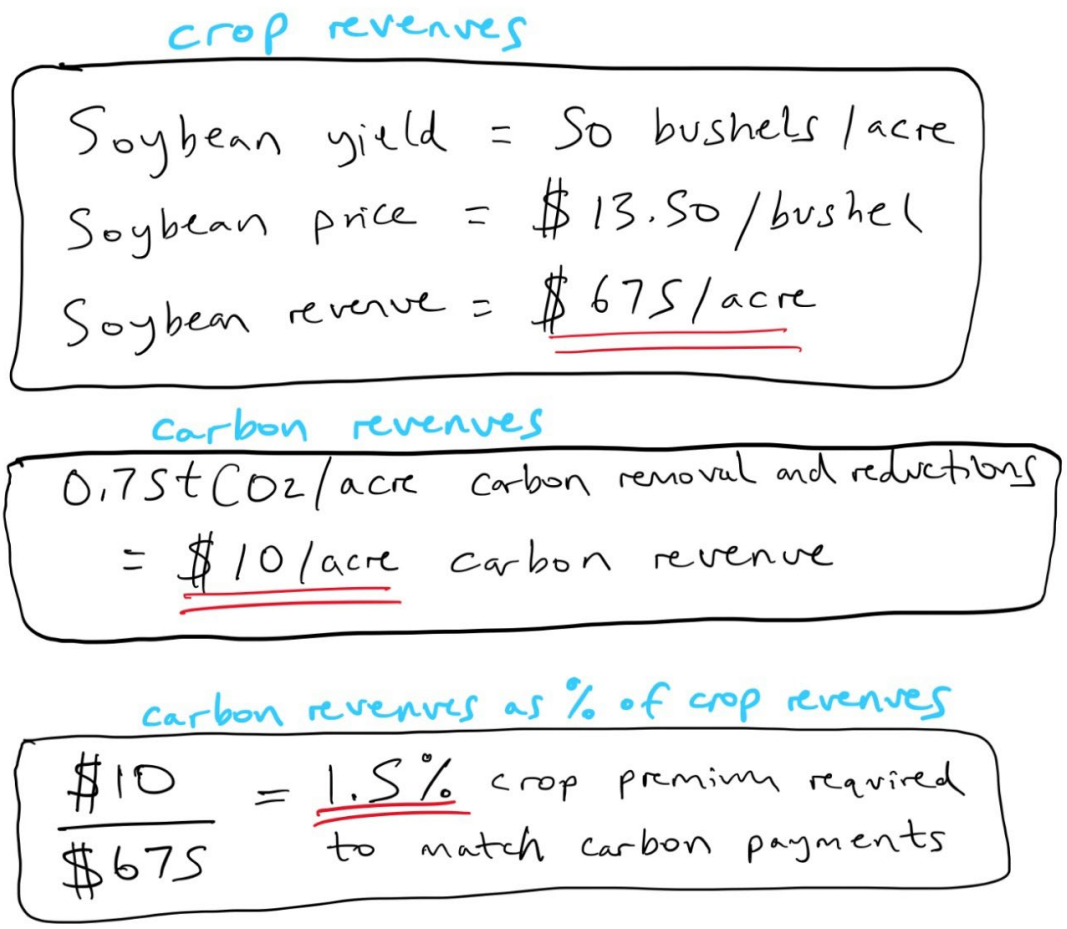


Figure 14: Calculations performed by interviewee F2 to show the crop premium required to equal the potential payments from the carbon offset market, in the US context. The purpose of the calculation was to aid a discussion about whether insetters were willing to pay for carbon outcomes or not. The interviewee aimed to show that a supply chain would not need to find much additional value to pay farmers, to equal the potential revenues farmers could earn by selling carbon credits into the offset SCM.

Surveyed farmers demonstrated a poor understanding of the difference between insetting and offsetting (fig 15). Given the potential significance of insetting and the interplay between insetting and offsetting, it would seem important for farmers to upskill their knowledge in this area.

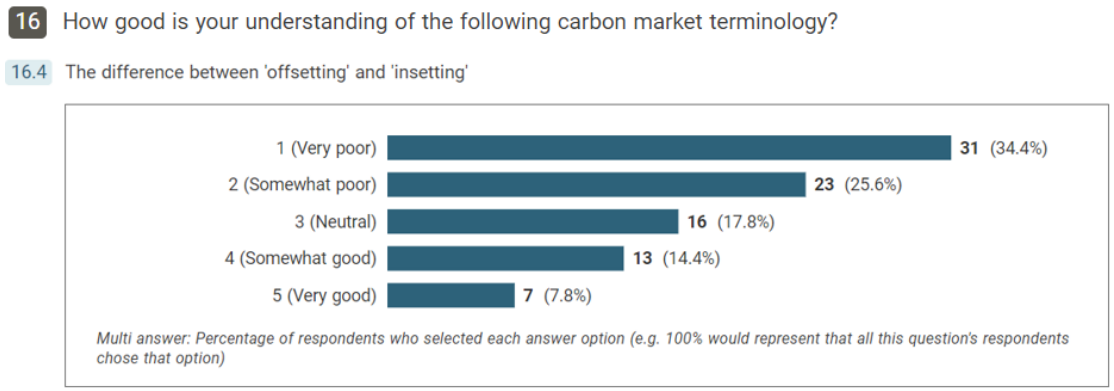


Figure 15: Results of survey question 16.4, from 93 UK farmers surveyed in April 2023

6.2 Other markets for non-offset based carbon outcomes

Case study 1 - Wind Park Krammer

The Dutch farmer organisation ZLTO has partnered with 15 farmers to develop a carbon farming project in association with the local windfarm called 'Wind park Krammer', operated by energy companies Zeeuwind and Deltawind. Part of Wind park Krammer's profits are put aside and paid to farmers per tonne of carbon sequestered into their soils through the implementation of different carbon farming practices. Projects like this are an important part of the energy operators' social agenda, connecting with local farmers and residents, helping to gain their support for windfarm planning permissions, by investing in the local environment. This is a good example of a non-offset based market for carbon outcomes with a local connection between the buyer and seller of the carbon, and co-benefits for the local people and environment. *Photos: top by kind permission of Interreg North Sea Region Programme; bottom, author's own.*

Case study 2 - Low carbon produce

An example of one US 'front runner' farmer who expressed injustice about potentially being excluded from enrolling in the offset SCM on the grounds of additionality, having already adopted the carbon farming practices accredited by carbon programmes, in the past. In relation to this issue, interviewee V1 favoured an alternative 'insetting' model, whereby farmers quantify their carbon emissions per bushel of grain. Similar to how other specifications for grain can affect price (specific weight, protein, moisture, admixture) they believe this metric could enable farmers to command a premium for low carbon crops, from those food companies trying to reduce the scope 3 emissions of their products. He argues this is a superior business model to the offset SCM, because in contrast it serves to reward 'front runner' farmers for their early efforts (as opposed to excluding them which could inadvertently create a perverse incentive to un-do old practices) whilst providing an incentive for late adopters to start producing low carbon crops. However, according to interviewee L2, focusing on carbon as a single metric of sustainability per unit of production like this, can have unintended consequences- it tends to favour the development of the most intensive forms of agriculture producing high yields, possibly at the expense of environmental performance elsewhere (e.g. poor water quality). Interviewee V1 counterargued that there is no trade off and 'regenerative' agriculture can have it both ways- high yields with low inputs (the best scenario for achieving low carbon grain), plus high environmental performance. *Photos: author's own.*

Chapter summary

- Alternative non-offset carbon markets like insetting circumvent some of the offsetting challenges:
    - Permanence and additionality are less relevant
    - All supply chain actors can share in the costs and benefits of emission reductions
- Insetters see offsetters as threats, but synergy is possible through co-investment. However, protocols don't yet exist to manage such a complex relationship.
- Insetters may favour partnerships with funders like water companies who don't compete for the same carbon outcomes.
- There's a risk that net zero becomes a 'right to sell' for farmers rather than a benefit.
- Offsetters may increase farmers' selling power, to combat extractive supply chain behaviour.

Chapter 7 - Other drivers of change

Given the observed limitations of SCMs to catalysing agricultural transformation, other potential drivers of change may have a more significant role to play:

7.1 Policy

7.1.1 Regulation

- Regulation and incentives to protect the environment, may need to be greater for farmers located in environmentally sensitive catchments to nudge farmers in the direction needed, at the pace that's required.
- Powerful food/beverage companies are pivotal to the transformation of the agricultural sector, through the process of insetting, but regulation may be required to ensure farmers are fairly treated, avoiding extractive supply chain behaviour.

7.1.2 Nitrogen (N) fertiliser tax

- In my own experience, many farmers demonstrate considerable inertia to reducing or experimenting with lower rates of N fertiliser. However, the 2020-22 320% surge in the price of N fertiliser has spurred more interest among farmers to innovate and find ways of reducing dependence on N.
- During this time, out of the 93 UK farmers surveyed, 28% of farmers said they kept N rates the same, 20% said they reduced N rates by <10% and 34% of farmers said they reduced N rates between 10-25% (fig 16). These surprisingly small reductions demonstrate the price inelasticity of N fertiliser, especially when the grain price is high like it was.
- Nonetheless, higher N pricing still proved more effective at encouraging N experimentation or reductions of N use, compared to the data/advice led approach I use as a farm advisor.
- Historically cheap N has enabled complacent, input-dependent farming. These experiences suggest a N tax could boost farmer innovation. However, the modest response to extreme price hikes indicates a N tax may need to be very substantial to impact behaviour.

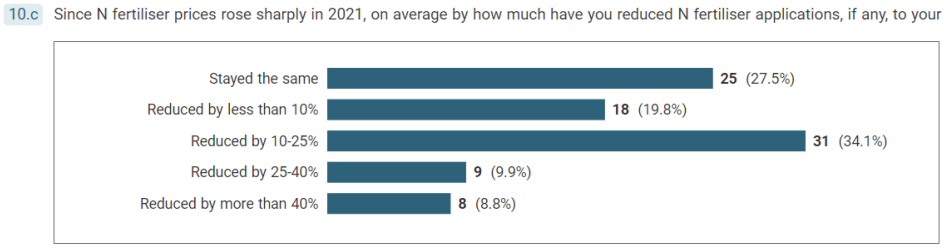


Figure 16: Results of survey question 10, from 93 UK farmers surveyed in April 2023

7.2 'Regenpreneurship'

- Surprisingly, my Nuffield research unearthed another promising driver of agricultural transformation - pioneering entrepreneurial farmers aka 'Regenpreneurs'. As showcased in several case studies 3-5, these innovators leveraged commercial enterprises as vehicles for delivering authentic regenerative change, to a level far greater than the SCM seems capable of. Having witnessed their impact first-hand, I now see tremendous potential in this entrepreneur-driven approach to catalyse reform. The impact of 'Regenpreneurs' could be

maximised by attracting and supporting them to operate land-based farming businesses specially in environmentally sensitive catchment areas where environmental gain is so desperately needed, for example those catchments highlighted in appendix 1.

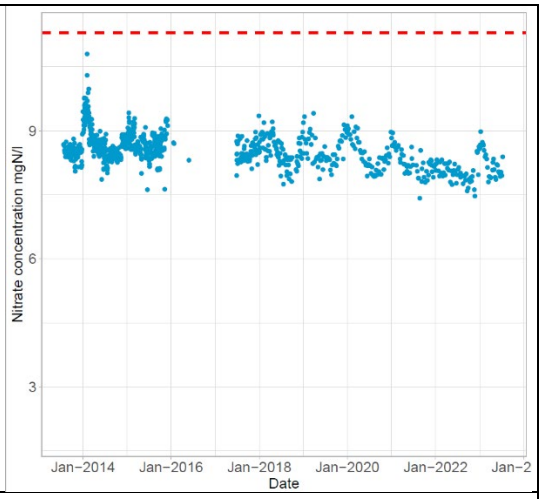
Case Study 3 - 'WilderLand'

This is Dutch entrepreneur Matthijs Westerwoudt who I met on my trip to the Netherlands. Matthijs is co-founder of 'Wilder Land', a young company paying farmers to plant in-field native wildflower strips, then harvesting and processing the biomass material into a range of premium herbal teas and healthy food & beverage products. Land regeneration is instilled in Wilder Lands' core business model, by creating persistent consumer demand for these regenerative products Wilder Land is using business as a vehicle for delivering improved biodiversity, water quality and carbon sequestration. This entrepreneur led innovation creates more enduring change, here biodiversity is supported by a market-led approach where customers and stakeholders are brought on the journey, increasing their buy-in, understanding and loyalty. Versus a conventional approach where governments and water companies essentially 'rent' conservation from farmers annually on a transactional basis - if payments dried up habitats may cease to exist. *Photo: author's own.*

Case study 4 - 'The Roaming Dairy'

Kingsclere estate was once a conventionally farmed arable estate in the UK. A partnership between estate owner Tim May, and new entrant dairy farmer Oliver Chedgey paved the way for Kingsclere to transition to a low input organic mixed arable/dairy farm. Having been an arable farm for many years, a lack of existing infrastructure was a barrier to the introduction of a 'normal' dairy, typically requiring tracks, fences, concrete, buildings and power. The concept of a mobile dairy overcame this problem, whereby a 450-cow dairy herd graze half of the estate area now planted with organic herbal leys, serviced by a complete mobile dairy milking system. Organic crops are grown on the other half of the estate. Every 3-4 years the arable and herbal ley areas of the farm switch over and the fertility built up by the herbal leys and livestock powers the next arable phase of the rotation. This system has achieved a huge transformation in land use, which insulates the estate against volatile input costs, climate change and regulatory threats. *Photo: author's own.*

Case study 5 - 'Hollis Mead Organic dairy'



In 2015 new entrant farmer Oliver Hemsley took over a conventional dairy farm located in an environmentally sensitive catchment in Dorset (UK), used to abstract public drinking water. The dairy was converted to organic status with a focus on farming alongside nature, and now produces a range of premium organic dairy products with direct sales to hotels, restaurants, online and through a network of local milk vending machines, allowing the business to capture maximum value from the retail price. The positive impact of this major land use change on the environment can be seen in the nitrate concentration of raw groundwater, which since the inception of Hollis Mead dairy, has been on a downward trend. The uniqueness of this example versus case studies 4 and 5, is this transformational business is targeted specifically in an environmentally sensitive catchment, where major change is really needed. *Photo: author's own. Graph by kind permission of Wessex Water.*

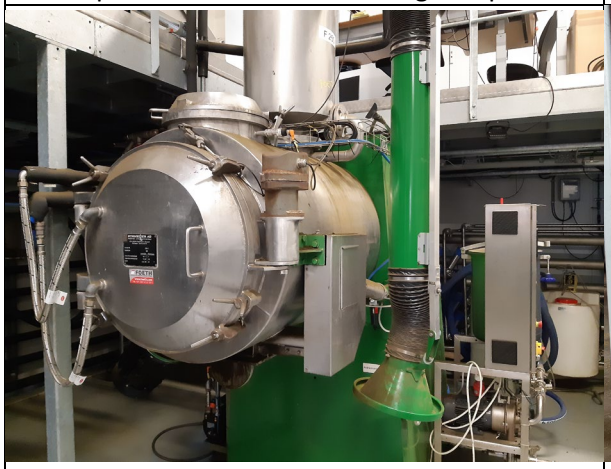
7.3 New markets

Overseas I saw examples of emerging markets that had the potential to facilitate regenerative land use change, such as in case study 6. Whilst the scale of these new markets may not be sufficient to catalyse agricultural change on a national scale, I saw how the production for these niche markets could be focused specifically in environmentally sensitive catchment areas, to provide environmental gain to where it is most needed (e.g. appendix 1).

Case study 6 - Grass biorefinery

Crude protein from different forage crops

Crude protein powder extracted from grass



Forage biorefinery equipment

Forage intake conveyor belt

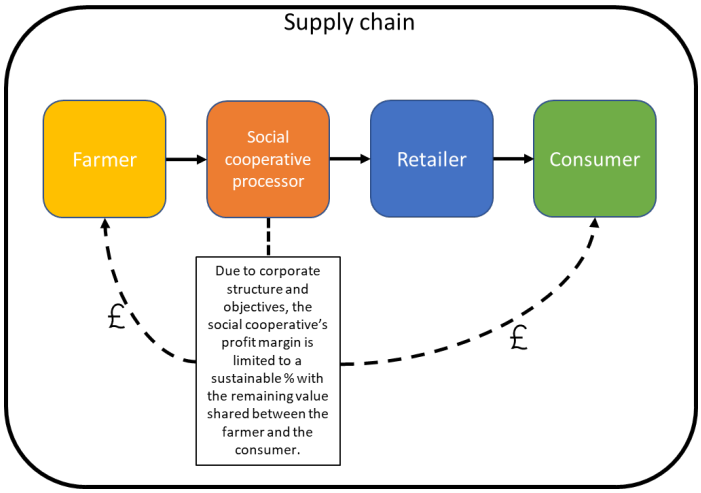
SEGES, an independent agricultural research and innovation organisation in Denmark was exploring the development of the grass biorefining industry, to extract home grown crude protein from forage crops, as an alternative protein source to imported soya. Owing to grass's potential for reducing nitrate leaching to water, forage production was being targeted on land adjacent to fjords to protect the water bodies from nitrate enrichment that arises from agricultural activities. *Photo: author's own.*

7.4 Social cooperatives

I saw examples of high-end consumer products being produced with very high environmental status, which were supporting regenerative land use change. This included some regenerative and organic farms selling under their own brand directly to consumers. Most of these products targeted a small niche of wealthy consumers. Whilst these products were very successful in their own right, they provided limited potential to change the agricultural landscape at scale. For example, if the premium price point of these products could only be afforded by the top 10% of wealthiest consumers, the production for these markets would also be limited to 10% of the farmed landscape, with the other 90% of land producing for the lower end of the market. Supply chains servicing this lower end of the market typically constitute consumers who aren't able or willing to pay more for food, and

companies operating the supply chain who all share the same objective, to maximise their own individual profits. In this supply chain model, it becomes difficult to see where value can be obtained to pay farmers to farm more 'environmentally'. Social cooperatives on the other hand, have a completely different set of corporate objectives and social drivers that allow additional value to be shared with both farmers and consumers. In France I saw a glimpse of how social cooperatives could support regenerative farming practices to happen at scale as opposed to remaining a niche way of producing, by making products affordable and accessible to the mass market (case study 7).

Case study 7- 'Ethiquable'



French social cooperative 'Ethiquable', owned by employees and founded by social entrepreneur Remi Roux, has a unique corporate structure and objective to pay a fair price to farmers in order to improve agroecology. Ethiquable import fairtrade commodities like cocoa to manufacture products like chocolate that are retailed through major supermarkets and achieve an annual turnover of around €70m. By limiting its profit margin to a sustainable percentage, Ethiquable is able to share additional value with both the farmer and the consumer. They can pay farmers a large premium over other household chocolate brands, facilitating agroecological farming practices. But this is no niche market targeting just the rich and ethically minded consumer. Ethiquable also share value with the consumer by selling at a price point accessible to the mass market consumer in mainstream supermarkets. This catalyses agroecology at scale, as opposed to it remaining just a niche way of producing, as appears to be the case for most other high-end, high environmental status products. *Photo: author's own*.

Chapter summary

- Given the limitations of SCMs, policy, entrepreneur-led innovation, new markets and social cooperatives could also be vital drivers of agricultural transformation.

Chapter 8 - Discussion

Experts widely agree that raising agricultural soils' organic matter through carbon farming practices offers multiple benefits (fig 1). These practices, which sequester atmospheric carbon, could provide farmers key advantages against mounting production and environmental challenges. Though there's a degree of consensus that in theory carbon farming could also play a role in climate change mitigation (9, 10, 11, 24, 31, 32, 14) the exact potential of this remains strongly debated, with some arguing that it is over-estimated (fig 17). Nonetheless, adopting carbon farming practices is understood to be generally advantageous irrespective of climate mitigation outcomes. Less understood is the suitability of the SCM as an instrument with which to drive this, and the associated risks of it, to farmers.

Reasons why the climate change mitigation potential of soils could be over-estimated
Long term field experiments show practical constraints to achieving estimates of soil carbon sequestration made by the 4 per 1000 initiative (34)
Social, economic and political barriers exist which may limit soils' technically achievable carbon sequestration potential (35)
Soil carbon decomposition could accelerate in a warming climate (36, 37, 38)
Some carbon sequestering practices may also increase soil nitrous oxide emissions (39)
Soil carbon saturation is often not taken into account in estimations (17)
One researcher in Europe (interviewee B1) challenged the availability of sufficient organic materials to increase soil carbon e.g. The climate benefit from baling and burning straw at power stations (thus displacing the use of fossil fuels), outweighed the climate benefit of returning those crop residues to the field where approx. 90% of this carbon input would be respired by soil microbes as CO2 back to the atmosphere.

Figure 17: Reasons why the climate change mitigation potential of soils may be over-estimated.

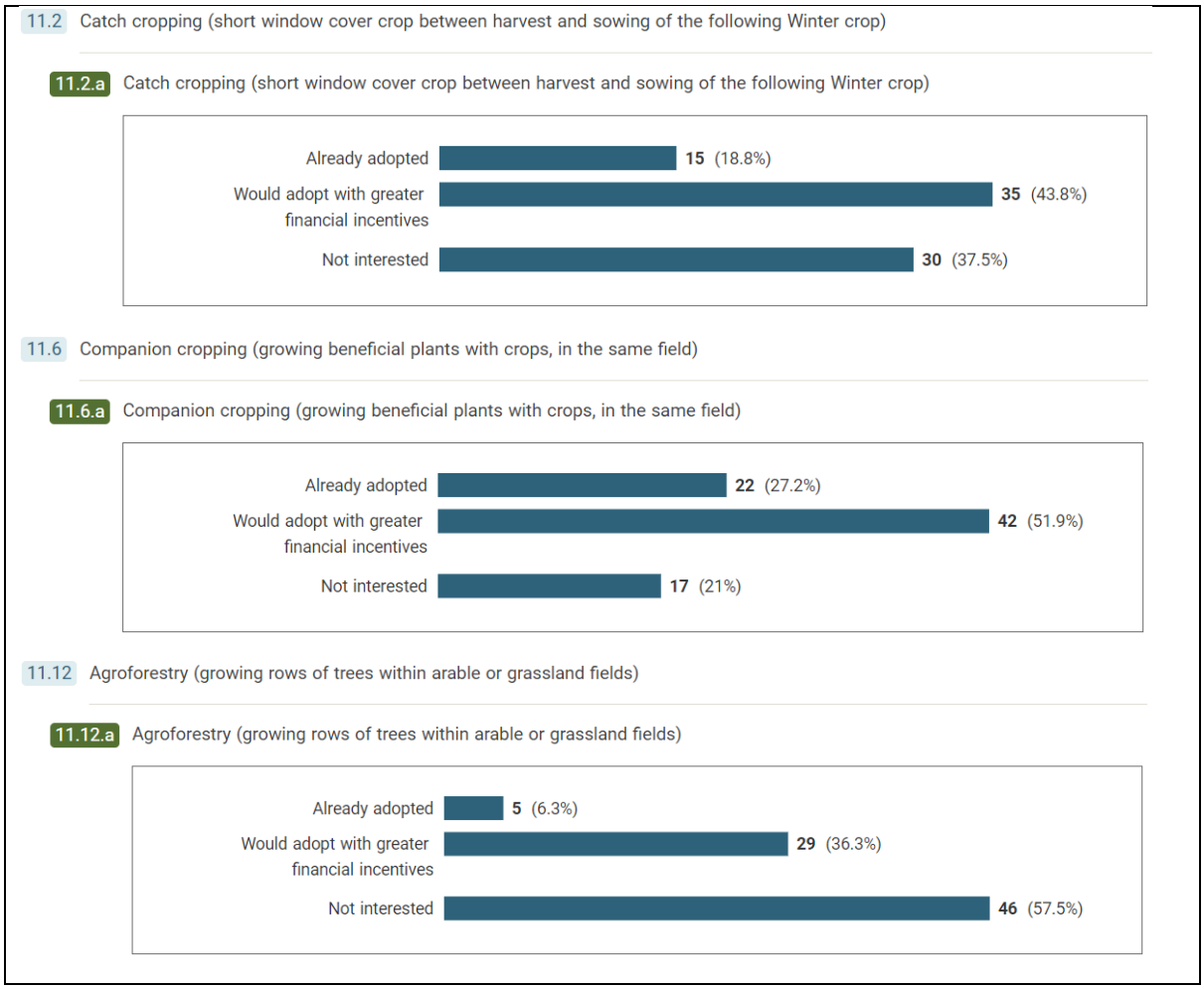
In theory the offset SCM sounds promising. If farmers could be sufficiently incentivised by offsetters to adopt new carbon farming practices, they could sequester additional carbon that would not have otherwise occurred. Those offsets would therefore genuinely compensate for their carbon emissions but could also be a force for good by delivering co-benefits and supporting food production, a distinct advantage over other nature based offsets like forestry (40). Despite the theoretical potential of SCMs to drive climate change mitigation with all these benefits that follow, my own findings would suggest they fall short of expectations.

Most of the farmers enrolled in carbon programmes seemed to be 'front runner' farmers, enlightened individuals already mindful of their soils and their impact on the environment. Unsurprising since practices that sequester soil carbon remain costlier than carbon credit rewards, even for the most entry level carbon farming practice like cover crops. Therefore, current low prices appear to be predominantly attracting pioneering "front runner" farmers who have already adopted practices, rather than driving new adoption. This conflicts with additionality principles. While some farmers may have coincidentally implemented practices around SCM enrolment, it's likely that other factors drove this decision, merely creating an illusion of incentive-driven additionality when in fact the changes may have been adopted anyway. Partial cost-contributions may appeal to committed pioneering farmers, but less to profit-focused conventional producers with greater potential for change. A self-perpetuating cycle may persist whereby low carbon prices inhibit additionality, and a

lack of additionality may keep carbon prices low for farmers, especially when they potentially face competition from more credible suppliers of other non-soil based offsets (41).

Additionality appears to be poorly addressed by existing carbon programmes, not conducive to a thriving offset market for soil carbon credits. Given the already high adoption levels of carbon farming practices like cover crops and minimum tillage by surveyed farmers in the UK (fig 6 & 7) additionality could improve if carbon programmes accredited fewer common practices, but ones that farmers would be interested in adopting if incentivised properly. According to surveyed farmers, these might include (fig 18):

- Catch cropping
- Companion cropping
- In-field biodiversity strips
- Agroforestry
- Hedgerows
- Elimination of fertiliser and pesticide use



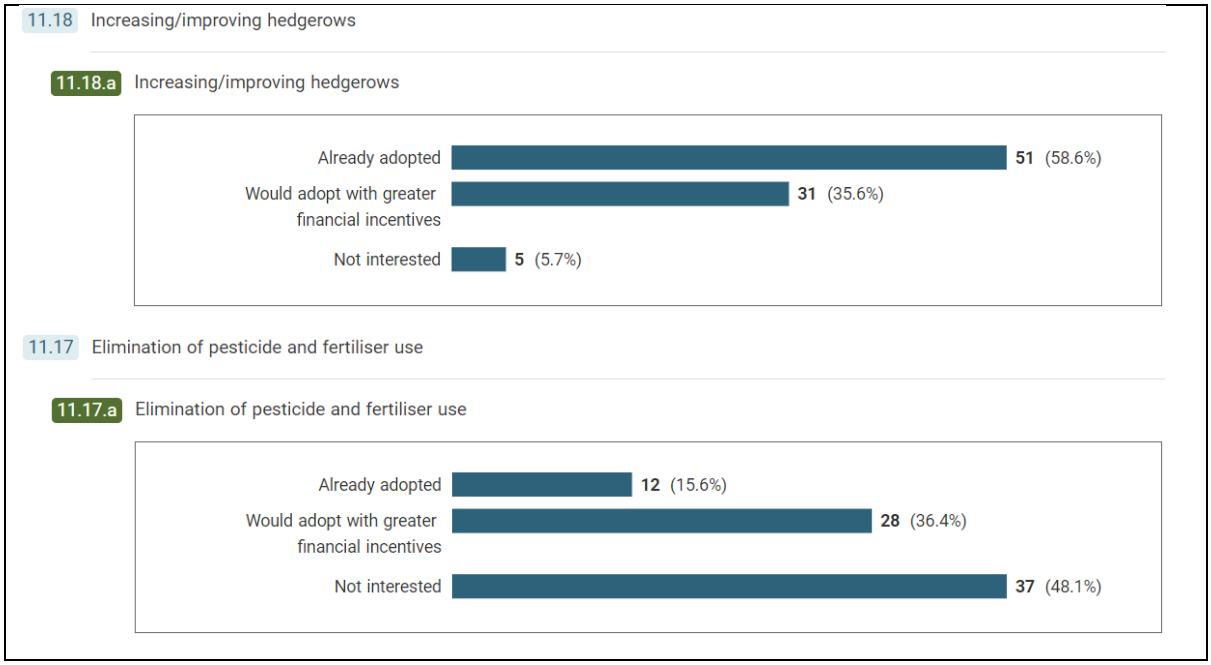


Figure 18: Results of survey question 11, from 93 UK farmers surveyed in April 2023

The findings of this report align with other recent sources, reporting that the carbon price needs to increase before the carbon market can drive genuine climate change mitigation (29) and without this, companies could be open to criticisms of greenwashing, claiming credits for emission reductions that would have been undertaken anyway. To avoid greenwashing, they explain the true price of removing atmospheric carbon into soils must be paid. Another recent paper reports that due to the issues of permanence and additionality, soil based carbon credits are unlikely to deliver the emission offset attributed to them and therefore their benefit for climate mitigation is uncertain (10).

Carbon brokers and other SCM advocates argue that narrowly fixating on additionality loses sight of the bigger picture - late adopters will follow rewarded 'front runners', accelerating reform. But the Oxford Offsetting Principles is quite clear that for carbon removal offsets to have a genuine climate impact, they need to be permanent and additional to what would have happened anyway (30). The brokers may have a vested interest in supporting their own point of view, because at low carbon prices the path of least resistance to generating soil carbon credits, is undoubtedly with 'front runner' farmers who've already embraced carbon farming practices. While avoiding punishing early adopters matters, offsets seem an improper mechanism. As pioneers often adopt practices for reasons unrelated to carbon credits, disseminating their insights could more effectively accelerate change than subsidising existing practices. Rather than dilute offset credibility, change may come quicker by spotlighting front runners' proven approaches to inspire others.

The SCM appears a complex, fragmented space filled with debate - characterised as an 'unarticulated patch of coexisting programmes with different rules, incentives, and penalties, rather than as a cohesive and transparent market where the same activity has the same implication across programmes' (42). Experts acknowledge private investment's importance but question if carbon offsets appropriately incentivise agricultural transformation (10). Potential exists if market integrity

and carbon pricing improve sufficiently, though impact may still be confined to minor changes on farm. High impact, costlier reforms needed in environmentally sensitive catchments seem unlikely to be driven by the SCM. As one eager for meaningful reform, I've found the SCM to be underwhelming and concerning regarding issues of credibility. Rather than a silver bullet, the SCM may play a modest future role, but likely not in catalysing large-scale climate change mitigation or agricultural change, at least for the moment. The SCM could represent one small piece of the puzzle in combination with other important drivers like policy, entrepreneur-led innovation (Regenpreneurship), new markets and social cooperatives.

The findings of this report align with a paper (10) which suggests alternative schemes, business models and labels could be researched and developed which encourage carbon farming, for non-offsetting carbon outcome purposes, such as insetting, and those described in case studies 1 and 2. A growing body of science even proposes water vapour as a more important driver of climate warming than carbon dioxide, accounting for as much as 60-70% of the greenhouse effect, versus only 25% for carbon dioxide. So private markets could be developed for non-carbon climate outcomes, for example farming activities that help to restore natural water cycles (43, 44).

So, can you farm carbon? Yes - soil carbon is fundamental to sustainable agriculture, and carbon farming practices offers potential gains. Experts widely agree increasing soil carbon is beneficial, and even small gains in soil carbon can have disproportionally large beneficial impacts on soil health and functioning for farmers (34). Along the way, carbon farming may contribute to climate mitigation and improve agriculture's societal perception (10). Yet some suggest viewing this as a co-benefit (17), not the primary aim, instead adaptation to climate change should be farmers' main focus (21, 34). As interviewee R2 noted, carbon farming provides a 'trojan horse' for instilling new thinking and understanding into farming, because to understand carbon sequestration requires the understanding of natural processes.

But are SCMs suitable for driving soil carbon sequestration? Likely not currently, in the case of carbon offset markets, though future potential exists if integrity and carbon pricing improve. More promise may reside in fledgling private markets for non-offset carbon outcomes like insetting. However, these require further development.

In summary, carbon farming merits adoption for its multiple benefits. But SCM suitability depends on the model - offset or non-offset. While immature, non-offset approaches appear better aligned to incentivise carbon farming practices. Yet many factors beyond SCMs are required to truly transform agriculture.

Chapter 9 – Conclusions

- The SCM is nascent, with substantial challenges around additionality and permanence to overcome if market integrity and carbon prices are to improve for farmers.
- The SCM may not be the transformative panacea I had envisioned. It is uncertain whether the offset SCM will be a suitable instrument for driving genuine climate change mitigation, or agricultural transformation. It could have a role to play in the future if the carbon price increases, even then its impact may be limited to small changes.
- Carbon farming benefits farmers and the environment, disseminating new knowledge and understanding into the farming sector. However, the potential of carbon farming to mitigate climate change is uncertain and strongly debated.
- Farmers should focus on climate change 'adaptation', as opposed to 'mitigation'.
- The risks of the offset SCM may currently outweigh the benefits. A major risk is farmers getting embroiled in 'greenwash' and damaging their own credibility.
- Farmers can mitigate risks by pursuing other private markets for non-offset based carbon outcomes, e.g. insetting within their supply chain, and other business models (case study 1).
- Policy, entrepreneur-led innovation (Regenpreneurship), new markets and social cooperatives could also be vital drivers of change in agriculture.

Chapter 10 - Recommendations

Audience	Recommendations
Farmers	• Spearhead internal transformation of the sector. Otherwise, external forces will likely impose unwanted changes instead. • Proceed with caution and consider the risks of SCMs. • Focus on climate change adaptation as opposed to mitigation. • Keep an eye on SCMs but keep expectations realistic, don't allow it to delay decision making. The challenges for farmers are clear enough to proceed in a direction. The risks of delaying action are bigger than the benefits. • Pursue non-offset based markets for soil carbon outcomes e.g. insetting.
Water companies	• Support the research and development of other private non-offset based markets for soil carbon outcomes. • Partner with food/beverage companies on insetting activities. There are opportunities to co-invest in reducing scope 3 emissions for mutually beneficial outcomes, without competing for the same carbon outcomes. • Attract, support, and incentivise 'regenpreneurs' to start land-based businesses specifically inside high-risk drinking water catchments. These individuals can create major change. • Support the development of new markets and social cooperatives that could catalyse regenerative land use change in catchments.
Government & Farming industry bodies	• Provide leadership to the farming sector to navigate SCMs, to avoid the potential pitfalls for supply chains, the sector and the climate. • Hold voluntary SCMs accountable, don't accept greenwash. • Regulate food/beverage companies to discourage extractive supply chain behaviour, so farmers receive fair value for produce and carbon outcomes. • Introduce greater regulation and incentives for farmers in environmentally sensitive catchments to nudge farmers in the direction needed, at the pace that's required. • Consider a very substantial N fertiliser tax to boost farmer innovation, as opposed to complacent, input-dependent farming. • Provide more incentives and support specifically to new entrant farming 'regenpreneurs'. • Support the development of new markets and social cooperatives that could catalyse regenerative land use change in agriculture.

Chapter 11 - After My Study Tour

My goals following the Nuffield scholarship include:

- Monitoring SCM developments to help guide the industry through this dynamic space.
- Fostering alternative non-offset SCMs by collaborating with the food supply chain on scope 3 emission insetting activities.
- Empowering ‘regenpreneurs’ to leverage commercial enterprises as vehicles for delivering authentic transformative change inside environmentally sensitive catchments. I've already participated in Defra's new entrant pilot scheme to explore support mechanisms for the next generation of farming entrepreneurs.

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Appendices

Appendix 1 - Examples of environmentally sensitive catchments where farmers could face an increasing threat of environmental regulation

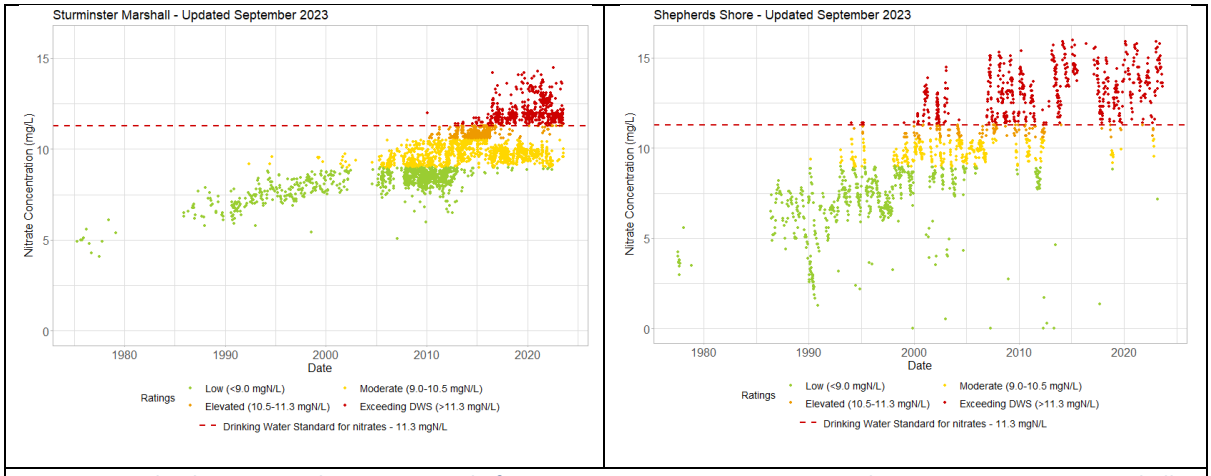

Fig 19: Graphs show a rising long term trend of nitrate concentrations in raw groundwater at Sturminster Marshall (left) and Shepherds Shore (right) public drinking water catchments (fig 20), in the Southwest of England. Source: Wessex Water

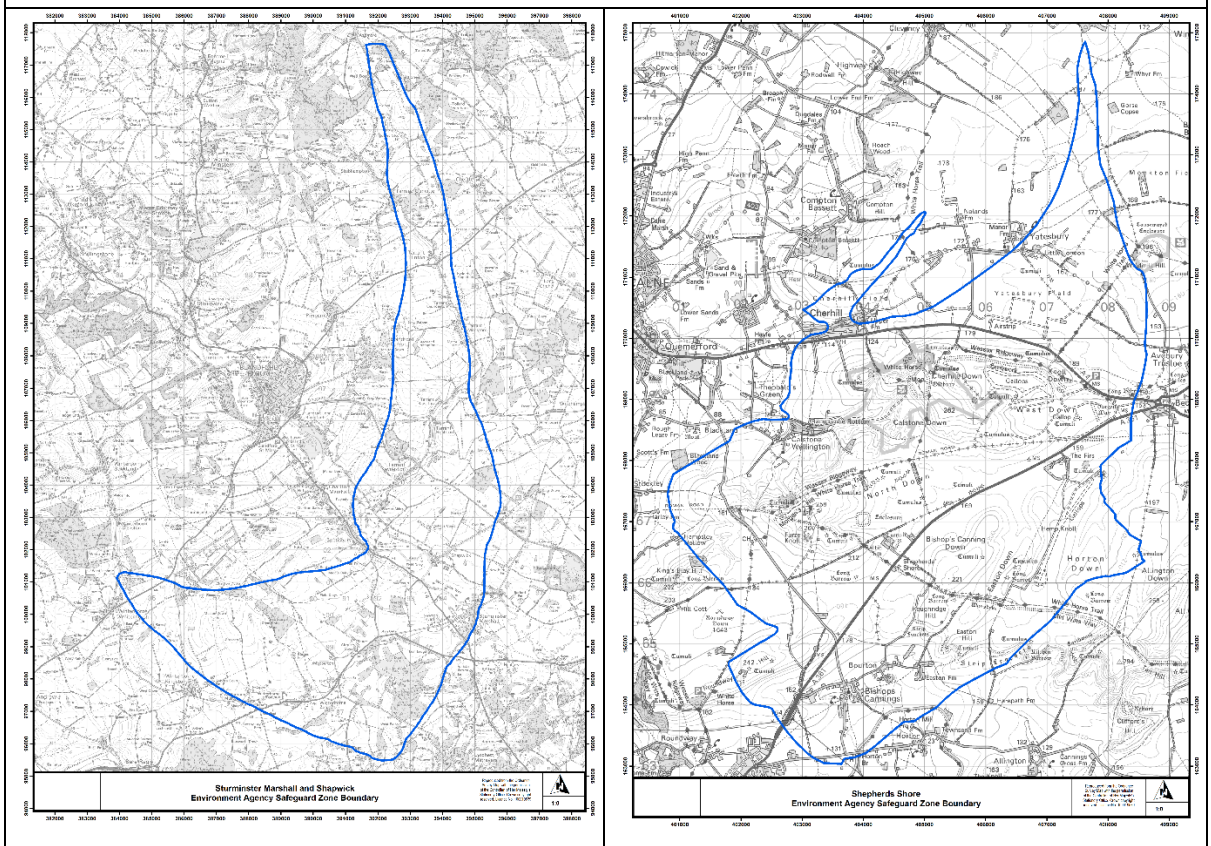

Figure 20: The Safeguard zones defining the Sturminster Marshall (left) and Shepherds Shore (right) public drinking water catchment areas. Nitrate pollution arising from intensive agriculture has negatively impacted raw drinking water quality, as seen in Fig 19. Source: Wessex Water

Appendix 2 - Price surge of nitrogen (N) fertiliser

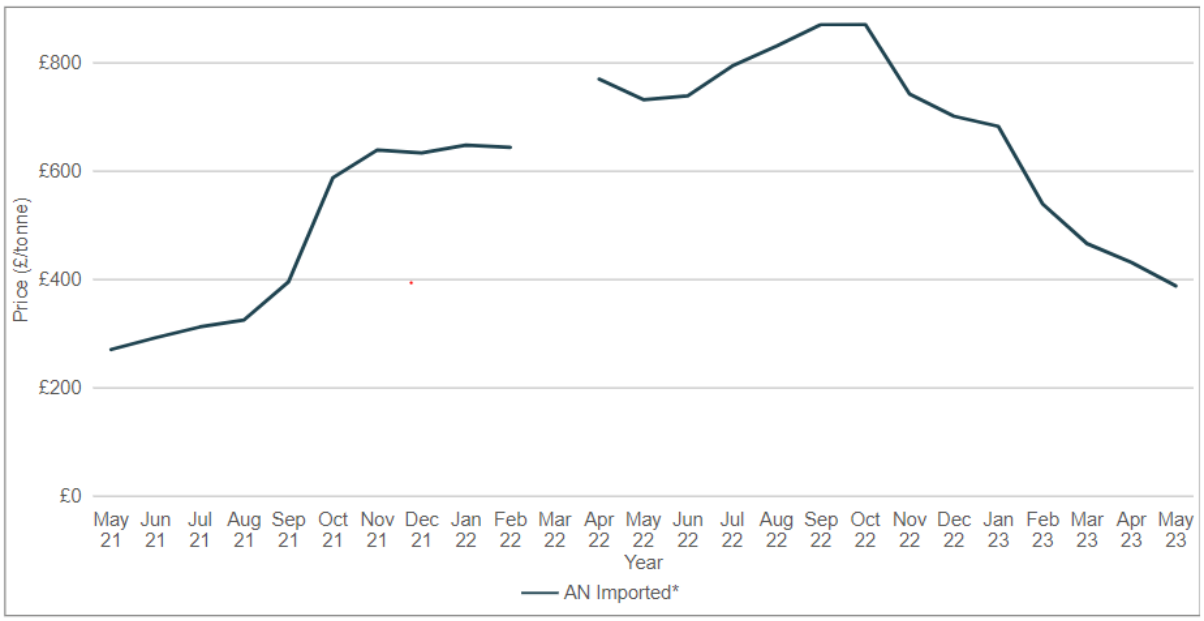

Figure 21: Price of imported Ammonium Nitrate fertiliser showing the price volatility between 2021-2023. Source: AHDB website

Appendix 3a - Evidence of climate warming

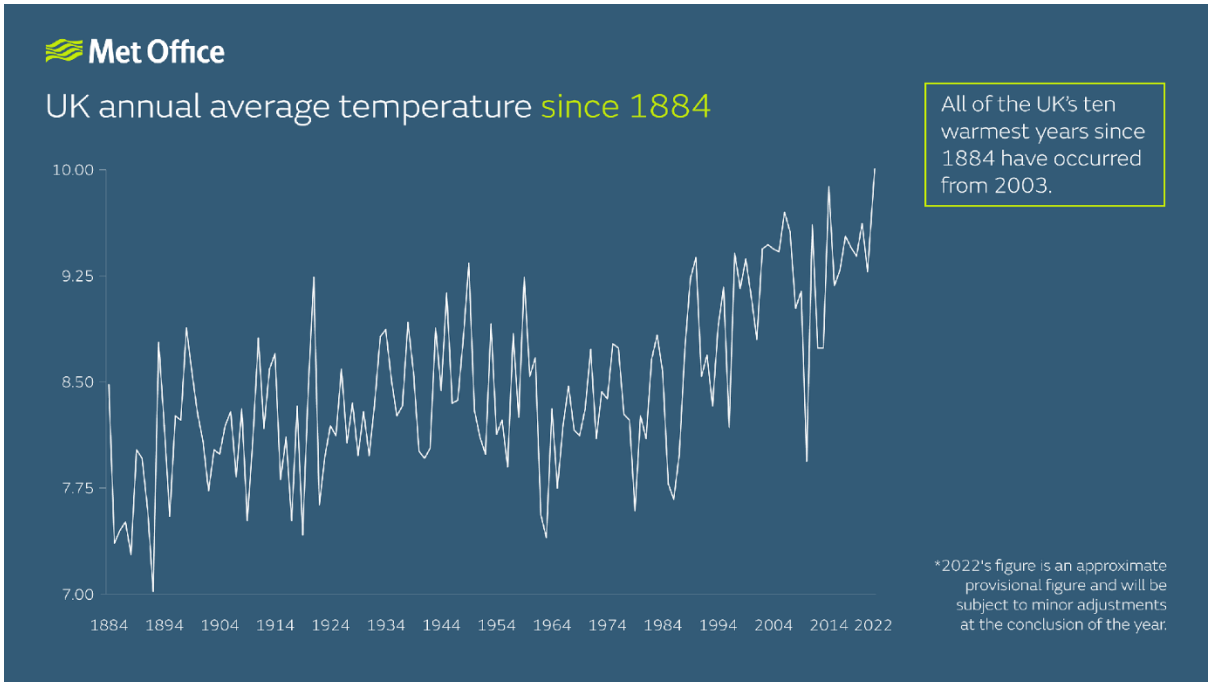

Figure 22: UK average annual temperature since 1884, showing 2022 as the warmest year on record for the UK. Source: Met Office website

Appendix 3b - Evidence of drought in the 2022 growing season

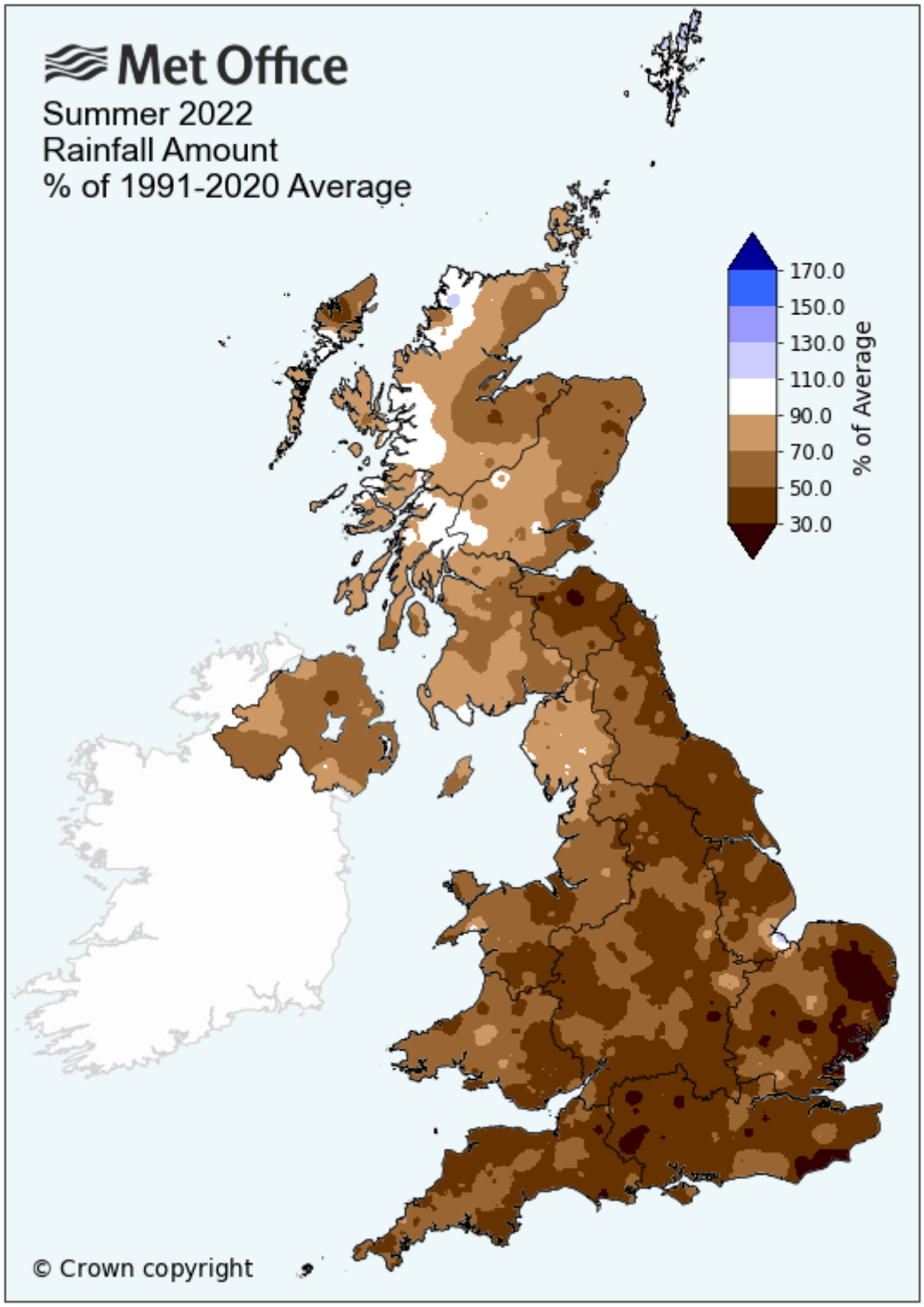

Figure 23: Showing % of annual rainfall in 2022 compared with the 1991-2020 average. Source: Met Office website

Appendix 4 - Agricultural sector GHG gas emissions and potential for carbon reductions/removals

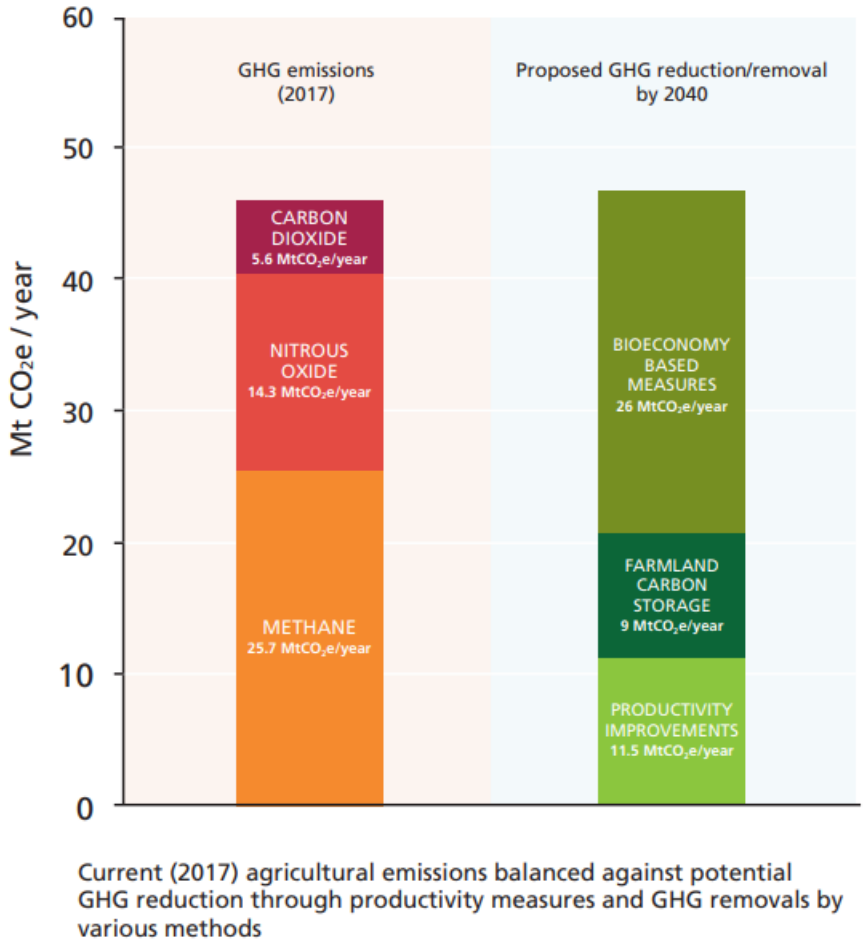

Figure 24: NFU's estimates of the agricultural sector's greenhouse gas emissions versus potential for reductions and removals. Source: NFU website

Appendix 5 - List of interview questions

NUFFIELD Farming Scholarships

John Oldacre Foundation

Themes for discussion with all stakeholders

As part of my Nuffield research, I recently carried out a literature review of soil carbon markets (SCM) which identified potential for SCM, but also several challenges to its implementation. The following questions seek to gain insight into your views on these issues, and how the challenges can be overcome.

1. **Additionality** (*i.e. the money from carbon credits should incentivise an action that wouldn't have happened without the carbon money*)
   - How much freedom should farmers have over when they sell their carbon?
   - Do you think financial incentives linked to carbon, are necessary for the adoption of regenerative farming practices?
   - To what extent do you think farmers might delay decisions about adopting regenerative practices, in order to participate in the carbon market and maximise returns from carbon?
   - To what extent could the additionality rules for entering carbon schemes create unintended consequences of 'front-runner' farmers reversing existing regenerative farming practices, in order to participate in the carbon market?

2. **Permanence** (*i.e. the requirement for soil sequestered carbon that is sold as a carbon credit, to remain locked away in the soil permanently*)
   - To what extent can agriculture meet the permanence requirements for carbon offsets?

3. **Insets vs offsets** (*i.e. an inset buyer would be a company inside the farmer's supply chain, like a biscuit maker who uses the farmer's grain to produce the end product, an offset buyer is a company outside the farmer's own supply chain, like an airline*)
   - What are the risks and benefits between selling offsets and insets from soil carbon?
   - Does rewarding farmers for GHG per tonne or litre of produce, incentivise regenerative farming or intensive farming, over the short and long term?
   - To what extent are offsets a risk to insetters, to what extent could they benefit the scope 3 work of insetters?
   - Will insetters be willing/able to pay for carbon insets? To what extent do offsets benefit the farmer by increasing competition for their carbon?
   - When it comes to commodity supply chains, how would you determine if there is a supply chain relationship between farmer and insetter?

4. **Net zero**
   - How do you feel about farms selling carbon to offsetters outside of the agricultural sector and direct supply chain? Does it present any risks?
   - What would be the consequences of a mandatory net zero target in the agriculture sector?
   - Should farmers sell carbon before they get to net zero?
   - Do you think it is important to differentiate between 'Net Zero' and 'Carbon Neutral' when considering the purchase of carbon credits?
   - Does how we measure carbon emissions on farm (e.g. carbon emissions intensity per unit of production vs absolute farm emissions) influence the risk of unintended consequences. I.e. could focusing on one metric and attaching incentivises to that actually encourage the most intensive form of Ag, instead of regenerative farming?

Ben Hunt - Nuffield Farming Scholarship 2022 – stakeholder interview questions

5. **Reduction/avoidance vs removal carbon credits** (*for example a reduction/avoidance credit could be generated by reducing/avoiding some N fertiliser use. Once this emission has been avoided, it's been permanently avoided forever. A removal credit could be generated by growing a cover crop which sequesters (removes) carbon from the atmosphere. Once removed, that carbon could be re-released to the atmosphere.*
   - Is there a difference in the risk profile for different types of carbon credits, and do farmers need to differentiate between them on this basis?

6. **Measuring and modelling**
   - Given the challenges of detecting small changes in soil carbon, how do you feel about farmers being incentivised for practices rather than outcomes?

7. **Carbon leakage** (*i.e. the unintended consequence that a reduction or removal of carbon emissions in one location, just increases the carbon emissions elsewhere*)
   - Can you foresee any negative unintended consequences of rewarding farmers for carbon positive practices/outcomes?

8. **Saturation point** (*i.e. the point at which soil carbon storage reaches equilibrium and stops increasing*)
   - What would happen when the soil is full of carbon? Does it concern you that soil carbon credits represent a theoretically finite market?
   - When saturation point is reached, how will farmers continue to offset their own emissions, in order to achieve net zero?

9. **Start-up costs** (*i.e. the initial cost of implementing a change in farming practice that stimulates soil carbon sequestration, as opposed to the ongoing revenue of carbon credits e.g. cost of cover crop seed, or the cost of taking some arable land out of production and introducing a rotational grass ley*)
   - Given that SCMs are a revenue stream for farmers, to what extent do SCM help farmers adopt a larger system change towards regenerative farming?
   - How can farmers pay for the start-up cost of implementing changes?

10. **Market uncertainty**
   - How can we provide more confidence, certainty and consistency to farmers and investors in SCM?
   - What role do you think the government should play?

11. **Size of the opportunity for farmers**
   - How much carbon is possible for a farmer to sell, including both sequestration and emission reductions?
   - What is the price of carbon now, and what is it projected to be in the future?

12. **General**
   - What are the perceived risks of participating in SCM?
   - What are the main barriers for farmers adopting regenerative farming practices?
   - To what extent is offsetting a force for good?

Appendix 6 - List of referenced Nuffield interviewees

Occupation	CEO	Manager	Manager	Manager	Manager
Organisation type	Carbon broker	Carbon broker	Commercial organisation	Carbon broker	Carbon broker
Country	UK	USA	France	USA	USA
Respondent code	N2	X1	W	A2	F2

Occupation	Manager	Managing Director	Farm adviser	Manager	Sustainability Manager
Organisation type	Research organisation	Research organisation	Agronomy	Carbon broker	Food company
Country	Denmark	UK	USA	USA	Belgium
Respondent code	C1	L2	W1	B2	Q

Occupation	Manager	Farmer	Researcher	Managing Director	CEO	Manager
Organisation type	Farming industry body	Farm	Research organisation	Corporate	Carbon broker	Farming industry body
Country	Netherlands	USA	Denmark	UK	USA	Netherlands
Respondent code	J	V1	B1	R2	R1	A

Occupation	Manager	Manager	Climate scientist	Sustainability manager	Farmer
Organisation type	Food company	Corporate	Agricultural industry body	Food company	Farm
Country	UK	UK	UK	UK	Netherlands
Respondent code	J2	Q2	Z2	I2	I

Figure 25: List of interviewees referenced in this report, their occupation, their type of organisation and the country.

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