Regenerating soils for climate and farmers

AgriCaptureCO_2

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Position paper: A European Regenerative Agriculture scheme

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Executive summary

The AgriCaptureCO2 project seeks to make it easier and more profitable for farmers to adopt regenerative farming practices. We bring together pioneering farmers, agronomists, soil scientists, public bodies, and technology experts working in 6 pilot sites across Europe and Africa to co-develop a suite of valuable services powered by satellite data. At the same time, we are developing and promoting a European Regenerative Agriculture Community to facilitate engagement and knowledge transfer.

The purpose of this document was to gather information regarding the use of Earth Observation (EO) within agricultural practice, and to assess the feasibility of incorporating it into environmental Standards, both on the level of existing Standards and more theoretically with regards to a possible European Standard. The literature of EO and regenerative agriculture, respectively, was reviewed and assessed as to the current and past research that has been undertaken. It was concluded that whilst EO has been successful in situations such as trend mapping and long-term climate change measurements, there is a clear gap in communication between the research undertaken and the farm level, particularly amongst organisations with lesser and moderate EO maturity. In addition to this, the regenerative literature established that with the burgeoning global population, and the ever-demanding requirement for food, global agriculture needs to shift towards more sustainable practices to support both environmental and food systems.

Interviews were conducted with a variety of stakeholder groups within environmental certification to establish the feasibility of including EO within Standards and a cultural shift towards regenerative agriculture. The intention of this is to close the communication gap between the research and farm-level action. The conclusion was that EO within environmental Standards is not currently feasible to implement, due to high accumulative cost from a range of avenues involved, highly technical skill requirements, and the incapacity of EO to deliver actionable results in its current format. Regenerative agriculture was concluded to be a requirement by all stakeholders involved to support the food and farming systems and allow for global population expansion, as well as mitigation of climate effects and harmonised food production. However, stakeholders agree that whilst there are many benefits involved in adopting regenerative principles, there are also major challenges that need to be addressed through assurance systems.

Overall, this project has concluded that further research is required to further delve into whether EO can be integrated into assurance schemes to support producers with their agricultural practices. In its current capacity, there are barriers for implementation, however a breakdown of the cost involved from the data collection, right through to the on-farm audit, would provide more transparency for its use and implementation requirements. Also, processes for evolution of Standards place a significant burden of proof for innovations to demonstrate their value, which is in all perspective a long-term endeavour. It was also discovered that whilst there was a general agreement for including regenerative practices in environmental Standards, the challenges to producers should be considered including whether making 'Essential' Control Points would be beneficial to producers given all farms are different.

List of abbreviations

CB	Certification Bodies
EO	Earth Observation
GHG	Greenhouse Gas
IFOAM	International Federation of Organic Agriculture Movements
LAI	Leaf Area Index
VI	Vegetation Index
LEAF	Linking Environment And Farming
EOV	Ecological Outcome Verification
ROA	Regenerative Organic Alliance
SFI	Sustainable Farming Incentive
AGW	A Greener World
LANCEP	Landscape And Nature Conservation And Enhancement Plan
SOM	Soil Organic Matter
PA	Precision Agriculture
UAV	Unmanned Aerial Vehicle

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1 Methodologies

Throughout this report, there are two sections:

- Section 1 is comprised of a literature review regarding the use and implementation of Earth Observation (EO). Moreover, section 1 also examines a range of regenerative Standards, looking at the five core principles of regenerative agriculture as well as analysing whether EO is included as part of assurance schemes.
- Section 2 is an accumulation of stakeholder responses to pre-determined questions regarding the use of EO and regenerative agricultural principles in certification schemes and on-farms. The stakeholder groups interviewed included producers, CBs, Standard setters, and a drone pilot.

Within each section there is an introduction, results, discussion, and conclusion. In addition to this, there is a synthesis which links both sections together and highlights the primary findings discussed throughout. The interview schedule including the questions asked to all stakeholder groups (producers, CBs, Standard setters, and a drone pilot) can be viewed in the Appendices at the end of this report. A full list of all cited sources used can also be seen in the References section. In turn, we present a synthesis of results from both sections and a discussion of consequences for use of EO in existing environmental Standards and the potential for a European regenerative agriculture Standard.

The purpose of this report is to evaluate and understand the feasibility of including EO in environmental Standards, considering all stakeholders as well as advancements and the future of the agricultural systems. A blended approach of qualitative and quantitative data was used for the research. The qualitative data was gathered through a literature review about EO, using Google Scholar and Elsevier, which looked at the different types of EO at a global scale. As Regenerative farming was deemed to be the future of agricultural systems, a framework, and the comparison of 11 environmental Standards comparison against the 5 core principles of regenerative agriculture was presented. These frameworks were found through the Google search engine. The literature reviews were conducted independently of each other, by separate members of the team to prevent feasibility bias towards or against the implementation of EO. The results of this and common themes, found within both sets of reviews, were presented, and discussed in relation to agricultural systems and socio-economic factors.

To understand feasibility of EO in current systems, stakeholder interviews were conducted to gather industry opinion of EO implementation on farm. Stakeholders were categorised as producers, Certification Bodies (CBs), Standard setters, and a drone pilot. These were identified as important demographics as they will be directly affected by the inclusion of EO into environmental Standards and certification systems. The drone pilot was included to gain a technological perspective regarding the aspects such as uptake and barrier for implementation that have been witnessed.

Individuals for the stakeholder groups were selected through requesting involvement via the LEAF network. There was no formal screening method to ensure a broad range of demographics. Overall, there were five producers, two CBs, two Standard setters and one drone pilot. Interviews were then conducted between December 2022 and January 2023 via Microsoft Teams. The interviews ranged in length from 20 minutes to 1 hour 30 minutes

depending on the level of detail provided by the interviewee. All interviews were conducted on days convenient to all parties during the working week.

The questions for each demographic group followed similar themes, which were identified from the literature reviews and the Standard comparisons. The questions did vary slightly depending on the specific industry sections. Within the producer interview group, LEAF Marque certified businesses were asked questions relating to the LEAF Marque Standard, whereas non-certified businesses were asked about the certification sector. The questions were split into questions regarding EO and questions surrounding regenerative agriculture. The interview schedule including the questions asked can be seen in the Appendices (Chapter 14).

The meetings were recorded, and the transcripts were downloaded and reviewed to identify the themes that were mentioned. Each answer to the set of questions, EO and regenerative agriculture, were reviewed by the research member who wrote the respective literature review. This removed a source of bias or comparison between the uses of EO and its implementation in agriculture.

These themes were then totalled and added to an excel spreadsheet, from which graphs were created to visually present the findings. The results were presented in the report and discussed, drawing comparisons across demographic groups.

2 Introduction: Section 1

Section 1 considers the use of EO technology in agriculture and how it is currently used for data collection and research in the literature. It explores the use of EO in both food and environmental Standards and provides suggestion for both incorporation and improvements to utilise EO on a global scale. Further to this, regenerative agriculture is also a predominant theme throughout, including the use, and implementation on a global scale.

At present, the global food system releases around 25% of annual anthropogenic greenhouse gas (GHG) emissions, resulting in approximately one-third of terrestrial acidification and is also accountable for a significant amount of global surface water eutrophication (Poore & Nemecek, 2018). Continuing with current, intensive agricultural practices such as using synthetic pesticides, artificial fertilisers, hydrocarbons (fossil fuels), and producing more than 1.3 billion tonnes of food waste per year (United Nations, 2020), will result in the surpassing of the planet's carrying capacity (Campbell, B.M. et al, 2017). Ensuring the continuation of global food security is, therefore, a major challenge for humanity, and has been recognised to be significantly important by policies such as the Paris Climate Agreement (United Nations, 2015), the EU Circular Economy Action Plan (European Commission, 2015), and the Common Agricultural Policy (European Commission, 2020).

The challenges facing global food security have, according to Schreefel et al. (2020), led to new ideas for sustainable farming – one of those being regenerative agriculture. Unlike other concepts that relate to sustainable agriculture (e.g., agroecology, conservation farming, organic farming, ecological intensification, and carbon farming, amongst others) (EASC,2022), the concept of regenerative agriculture was developed in the 1970s and is still gaining international interest and recognition. Regenerative agriculture is "both an attitude/approach and a suite of practices that restores and maintains soil health and fertility, supports biodiversity, protects watersheds, and improves ecological and economic resilience" (White, 2020). Malik and Verma (2014) also describe regenerative agriculture to be "a dynamically advanced modified technique involving the use of organic methods", whilst others such as Elevitch et al. (2019) argue that regenerative agriculture has the capacity to build resiliency and self-renewal, to increase water percolation and retention, contribute to soil health, to enhance, and conserve biodiversity, and sequester carbon. In addition to this, AgriCapture (2022) themselves, further noted that regenerative agriculture should be considered a mindset approach incorporating generation as well as regeneration; that it is not just about minimising the impacts of production but also ensuring that the environment is restored and revitalised.

The growing desire of farmers and consumers to move towards more sustainable farming has led to the rise of environmental and regenerative agriculture certification systems (Elevitch, Mazaroli, & Ragone, 2019), and within those systems include Standards, frameworks, and reports. The development of such tools has provided the opportunity to globally re-consider the design and implementation of agricultural systems that not only maximise productivity, but also improve ecosystems and provide socio-economic benefits (Elevitch, Mazaroli, & Ragone, 2019). The range of Standards, frameworks, and reports examined within this research extends from the USA to Europe, all of which include up-to-date best practice management tools to achieve on-farm sustainability.

3 Literature Review

3.1 Earth Observation (EO)

Earth observation (EO) was first used in agriculture in the 1960's and has since seen large technological development in a variety of applications. The main two applications of EO in agriculture are rooted in the use of satellite images and the use of Unmanned Aerial Vehicles (UAV's) via drone technology (Kovalev & Testoyedov, 2020), though various combinations exist and are complemented with a new array of sensors placed in soils, mounted on machinery, etc. Across the globe, EO has been used to assist with the development of Precision Agriculture (PA) and the sustainable intensification of farming practices (Negula, Badea, Moise, & Poenaru, 2017), producing "more with less". This paper will review the literature found on the different uses of EO and how it can be improved for further advancements within Agriculture.

3.2 Yield estimations

Global population has risen by 2 billion people since 1998 (United Nations, 2022), causing increased pressure on global resources; productive optimisation and efficient resource management is required, whilst increasing output of yield (Liaghat & Balasundram, 2010) (Houborg & McCabe, 2016). There is a heavy focus within the literature on the ability of EO to predict yields, which suggests that EO can provide affordable solutions to the increasing demand (Castilo-Vilamor, et al., 2021). EO has been developed to identify yield-limiting factors within field e.g., poor germination rates, and in specific global regions, which allows for selective treatments and applications to be made. The identification of underperforming plants has been proven to be 80% accurate (Castilo-Vilamor, et al., 2021) and provides farmers with actionable data sources from which spot treatments can be made, which is more financially and environmentally sustainable for both the farmer and the environment.

In-field variability has been measured at each phenological stage on growth using the Leaf Area Index (LAI) and the Vegetation Index (VI), which allow increased precision management to combat irregularities at each growth stage (Segarra, Araus, & Kefauver, 2022). The use of LAI in EO has also been used to identify different species in fields, which opens the possibility for intercropping and spot weed treatments (Lobell & Asner, 2003). More in-depth plant factors have also been proven to assist with yield estimations. The use of UAV's has increased the data collection capabilities and can now measure the Nitrogen content of specific plants, as well as an average land area (Veroustraete, 2016). Measuring in-field variability is key to increasing efficiencies as it will reduce the 'blanket' approach management techniques, therefore reducing over-applications and environmental leaching.

The inclusion of yield estimating models should be used in conjunction with local land knowledge, to be used as a mitigation strategy to reduce food security issues. Yield estimations were replicated in Sub Saharan Africa as a method of supporting regional and international food security assessments. It was noted that the model did not account for management, natural effects and socioeconomical factors, and so cannot be used to address such issues. It was also noted that further studies should include soil moisture

and solar radiation for improved forecasts late into the growing season (Lee, et al., 2022). Kogan et al. (2013) noted that winter forecasted wheat yields required multiple models to increase the accuracy, as on an individual level, each model over- or under- estimated the yield. This suggests there is not yet a singular model that can understand all the influencing factors to provide an accurate estimate.

As Lee et al. (2002) noted in Sub Saharan Africa, food production in arid/semi-arid countries is greatly impacted by irregular climate and political instability, which often results in unrest due to lack of food and high poverty rates (Qadar, et al, 2021). EO can begin to mitigate the issues of food security by providing warning in cases of low yields and being able to identify and estimate cropping areas, crop status, and health and yield forecasts. Pest monitoring in these areas has been noted as being extremely useful when mitigating reduced yields (Qadar, et al., 2021), as 20-40% of global food production is lost to pest and disease, equating to $220bn. (Qadar, et al., 2021). Lowering this statistic would dramatically improve global food production efficiencies, and significantly reduce the threat to food security. Pati et al. (2002) discussed the benefits of pest and disease forecasting, and how a reduction in inputs that would be required by using prevention, rather that problem solving techniques. For water management in high-value crops, the management techniques that are used in PA irrigation allow micro applications across the farm, and within the field to address water level variability. Methods such as this provide huge increases in water efficiency and therefore reduction in volumes used and energy required (Patil, Maru, Shashindhara, Shanwad, & Fang-guan, 2002).

The literature strongly suggests that improved yield predications and climate trends occur with introducing meteorological data to PA (Choudhary, John Shi, Kupriyanov, & Signh Boori, 2022). High spatial and temporal data allows both climate and yield trends to be predicted, and hence informed decisions regarding tolerant cropping rotations.

One method to show the crop/climate relationship is through yield estimation modelling which uses data to simulate expected harvests. Management techniques are added to the data set, as well as the temperature at each growth stage. This then allows a yield estimate that considers the surrounding climate (Santos, Proenca, & Canavarro, 2022), which is also suggested by Gumma et al (2019) who state that rainfall patterns are necessary to assist cropping predications and assessments.

The capability of the Sentinel images allows field history construction and the building of bio-physical crop profiles, adding scientific and commercial value to the images – allowing further extrapolation of datasets for Precision farming methods (Thenkabail, 2010). Measuring LAI allows farmers and growers to assess and analyse each growth stage of the plant, monitoring the productivity from germination through to harvest (Campos-Taberner, et al., 2015). This data is invaluable due to its ability to identify areas of inefficiency and highlight unproductive areas of land. Digitalisation and algorithm use allows cropping records and models to be kept, maintained, and referred to in future years. Collection of this data is a useful tool for future practices and allows easy record keeping for farmers on large acreage. It reduces the likelihood of large monocultures due to poor record keeping and rotation planning, therefore maintaining a healthy biodiversity of the surrounding environment and soil structure, with different root structures being introduced and permeating the soil; cropping changes will also reduce the chance of large pest or disease build up, therefore reducing chemical need (Sharp, et al., 2021).

3.3 Water monitoring

Droughts have significant impact on crop health and output, and can clearly be seen in Skakun et al (The Use of Satellie Data for Agriculture Drought Risk Quantification in Ukraine, 2015) study which notes that the Ukraine Wheat Market made a loss of $19 million due to the lack of rainfall. As mentioned earlier, PA irrigation techniques are the most efficient method to combat this, supported by Dalezios et al (2019) who suggests that improved water management will increase yields due to better soil structure and increased vegetation cover.

The correlation between evapotranspiration and photosynthesis can be mapped using EO and shows details such as changes in grain yield and plant biomass in relation to water use. The graphs generated from this dataset provides farmers with actionable insights into their own water consumption and the subsequent yield effects (Palacios-Velez, Palacios, Rodriguez, & Palacios, 2010). This will prove any crop pressures felt by water reduction as well as an understanding as to the production system requirement (Vanino, Nino, Michele, Bolognesi, & Pulighe, 2015). Once this is understood, efforts can be made to increase efficiencies and reduce water usage, as agriculture uses 70% of the global fresh water supplies (Petropoulos, Srivastava, Piles, & Pearson, 2018). There is an ever-increasing risk to global water supplies due to population growth and demand, making a water crisis the 3rd highest impact risk (Petropoulos, Srivastava, Piles, & Pearson, 2018). Further research is required to improve efficiencies in data collection and how this can be applied in the most useful method.

The use of UAV's in water monitoring has been extremely useful as they have a high spatial and temporal resolution. Methods using data related to chlorophyll properties have been noted to be the most accurate in understanding water stress (Gago, et al., 2015). Technological advancements in cell distinction using UAV's will be a huge step forward in long term breed improvement (Gago, et al., 2015). Increased accuracies have also been noted in river basin monitoring, which has proven to be 98.4% accurate for basins in the Mediterranean (Alexandridis , Zalidis , & Silleos, 2008). Methods such as these are key for food production in these areas and are highly repeatable globally.

Historical data was used to establish drought trends, which are moving towards 'moderate', showing that there is a wetness increase. It was most noted that the GDP of Sri Lanka declined sharply during the years of the most severe drought, suggesting that agriculture has a direct correlation with the economic health of the country. An introduction of drought-tolerant crops and changes to cropping patterns can be made from the EO (Alahacoon, Edirishinghe, & Ranagalage, 2021) which will reduce the extent of the effect that climate conditions have on food production.

3.4 Technological advancements

There is a need for technological advancements in the ability of EO to capture a greater temporal and spatial scale (Safar, Charvat, Mildorf, Crehan , & Kolitzus, 2022). An increased amount of data will improve reliability, allowing more informed decisions to be made at ground-level. This will have positive ecological and environmental benefits, from reduced inputs, but also vegetation ground cover assessments and species population

monitoring. Data such as this allows records of germination success and weed cover, identifying issues for future crop planning (Safar, Charvat, Mildorf, Crehan , & Kolitzus, 2022). The use of UAV's has reduced the cost of EO data gathering, however they have a much lower flying altitude required, which results in an increased image resolution but are more time dependent due to the increased fly time at such low heights (Gago, et al., 2015).

It has been noted however, that despite the advancements that have been made with EO, there is a gap in the availability to the end user. Researchers are the only current stakeholders who can interpret EO data and so a bridging of the knowledge and data sets is required to progress regenerative agriculture and distribute its potential globally. The data needs to be translated by an algorithm into actionable points that can be implemented by the farmer (Schiavon, Taramelli, Tomato, & Pierangeli, 2021).

The framework for data collection by satellites can be extended and scaled, allowing it to be transferred to any global region for observation broadening its application and the accessibility for all productive types. Dense data collection can then be made which will understand vegetation density and health, which could be transferred into assessing biome health globally.

3.5 Climate change

Climate change was only mentioned a few times in the literature surround EO and agriculture; it was noted that EO could be mobilised for disaster prevention, and to some degree for disaster management as shown by the Copernicus Emergency Management Service. Policy change is required to work in conjunction with EO data to assess climate effects and their reduction (Kansakar & Hossain, 2016), and improve the systems surrounding developing countries, often the most effective stakeholders. The inclusion of carbon sequestration in agricultural activities is a new revenue avenue, however it is a slow process and noted that total additional storage in global croplands in small compared to the rate of emissions. The restoration of 418 million ha could achieve 75-90% of sequestration goals, although this needs to be done in conjunction with carbon reduction plans to have a significant effect (Padarian, Budiman, Alex, & Peter, 2022).

Satellite images were able to capture changes in crop phenology over 16 years on a large scale. The study provides information on the five major crops and their responses to climate change. This data can be used to make informed decisions about cropping patterns, for yield prediction and resilient development techniques. Evidence suggests there is more temperature sensitivity at planting than harvesting dates, with advances and delays in growth as a response to climate shown across the year. As climate of the growing season climate, the phenological stages of the crops will also adapt, as may the input requirement (Yang, et al., 2020). Rising temperatures in India have shown to have negative effects on food production, with higher rainfalls unable to mitigate the effects (Praveen & Sharma, 2020). Climate change simulations shows how integrated farming systems are due to rise to mitigate any climate effects through different income avenues (Seo, 2010).

Climate change and biodiversity loss are deeply connected problems that are a global challenge (Forsius, Kujala, Minunno, Homberg, & Leikola , 2021). Forsius et al (2021) suggests the potential to become carbon neutral through mitigating greenhouse gas emissions and significantly reducing the cropping of forestry. Forest and biodiversity protection can be monitored by EO techniques and will therefore impact sequestration abilities. Whilst green vegetation is increasing globally using EO, it is unclear how to measure these effects on carbon sequestration levels (Zhang, Song, & Band, 2019). Zhang et al (2019) noted that the increase in 'greening' was due to cropland and other non-forest habitats; tropical forests negatively impacted the global trend due to their decline. Cropland carbon sinks are low compared to forest ability therefore there is a global decrease in carbon sink capacity. Despite this, Namyanga (2002) estimated biomass and carbon data from EO is still feasible with studies producing baseline data from carbon stocks in Serowe, Africa. The ability for EO to measure carbon sink capacity provides invaluable data to measure trends over time to meet sequestration targets.

3.6 Aquaculture

There is a need for detailed statistics on aquaculture for sustainable natural resource management. It sources a major food group, and advanced mapping of the aquaculture sector is necessary to meeting the rising fish demand and secure its sustainable intensification, whilst maintaining natural ecosystems of the coast lines. There is no consistent data collection and without Standardisation, it is difficult to compare across data sets. Whilst the literature is on pond-based systems, as this is the largest share of aquaculture that enters the food chain, there is the potential to transfer data collection to offshore fishing. More advanced EO will be required to detect cages and fishing nets. This will reduce food security issues from improved resource usage and reduce climate effects from poor resource management in fisheries (Ottinger, Clauss, & Kuenzer). From this, there is also huge potential for ocean modelling forecasts, which will improve fishing ground efficiency and sustainable fishing practices - with EO saving salmon and albacore fishing $500,000 a year (Kansakar & Hossain, 2016).

3.7 Environmental degradation

Land degradation for agricultural purposes has been measured using EO. Areas in China have surveyed and assessed improvements in methods that can be implemented nationally, using 'Hyper sensing' technology (both spatial and temporal data sets simultaneously) (Onojeghuo, Blackburn, Huang, Kindred, & Huang, 2018). Similarly, swidden (land that has been converted from habitat to agricultural use) land in Brazil has been monitored as to its regenerative value after abandonment by the farmer. There is a limit to the temporal richness of this dataset but holds great promise for the future to enable better management techniques in these farming styles and in the future of the land (Dutriex, Jakovac, Latifah, & Kooistra, 2016).

3.8 Barriers of EO and why it is not used in Standards

Whilst becoming more readily available, there are technological and economic barriers with EO as it can be cost and time intensive to gain a reliable dataset (Forsius, Kujala, Minunno, Homberg, & Leikola , 2021). The use of UAV's has provided less expensive images than are traditionally used from aerial sources, however they are an enormous time investment due to the low flying height used and still carry significant costs. Further technological advancements are required to increase the spatial and temporal scales which will increase usage efficiency and reduced cost; though there is potential for combining UAV and satellite data to this end. This is noted in carbon sequestration concerns; the measure for carbon sinks requires a large temporal scale and is an extremely complex issue and very computing-resource heavy, and indeed is difficult to measure by technologies that do not have (accurate) direct readings of soil properties.

There is a data extrapolation barrier (Forsius, Kujala, Minunno, Homberg, & Leikola , 2021) as EO data is not understandable on a consumer level, therefore making it difficult to replicated to farmers in a coherent and actionable fashion. Bridging the gap between researchers and reports, on national and global scales, will improve the communication of datasets and cascade into farm level, and subsequently implemented on the ground (Whitcraft, et al., 2019). Until this, it is unfeasible to add EO data to agricultural Standards, as the friction of data gathering, and actionable implementation techniques is too great at present.

3.9 Further study and uses in future Standards

There was little mention of grasslands monitoring in the literature, which is vitally important when considering, not only its uses in agriculture, but the marginal land areas which have great environmental potential. A study in Switzerland showed differentiation between mowing and grazing areas, with biomass production being measured (Stumpf, et al., 2020). Vegetation pattern data was collected, which shows species variation and production intensity. This requires further replicated studies to be used in areas globally (Hank, et al., 2018). The creation of a data sharing platform and improved data resource management would open a much wider community to the uses of EO and allow and encourage its global usage, as more stakeholders become aware of its abilities.

A noticeable improvement that is required is the ability for EO to be applied to small scale farms. EO is significantly easier and cheaper on homogenous crops and large-scale farming, whereas 12% of global farming is in small holdings (Hank, et al., 2018). Breaking through this barrier would open avenues for more stakeholders to get involved with EO and apply it to their farming methods.

EO has the potential for inclusion in agricultural Standards, but only once it is accessible to all farmers on an affordable and basic level, e.g., by mobile or through recognisable formats by service providers, otherwise there will be little engagement if there is too much friction and input required.

4 Results: Section 1

Whilst many of the Standards, frameworks, and reports examined throughout this research correlated with the five core AgriCapture Principles for regenerative farming, there were also some major differences between them (Table 1). Scoring highly for the majority of Principles was the Regenerative Organic Alliance (ROA) Standard, as well as A Greener World (AGW), Regenagri, and SAI Platform. Others such as LEAF Marque, the Soil Association (Farming and Growing), Ecological Outcome Verification (EOV), and Food Alliance. They had similar outcomes to the principles and included some regenerative requirements, however, only partially matched. Those that scored poorly due to a lack of detail and information regarding regenerative practices included the Global Farm Metric, the Carbon Neutral International Standard, European Parliament (Carbon Farming), and the Sustainable Farming Incentive (SFI).

It should be noted that whilst the latter scored poorly against the Principles, each Standard, framework, and report examined within this research contained highly useful and important information about sustainable farming.

Reviewing whether each Standard, framework, or report contained the current inclusion of, and engagement with, carbon sequestration through EO was a core objective of Section 1. Whilst carbon sequestration was covered in terms of the practices used on-farm, the research concluded that, overall, there was no explicit reference to EO in each Standard, framework, or report. As a result, this investigation cannot report on any particular risks or barriers to the implementation of EO in analysing carbon sequestration from a certification system perspective. This does not suggest there are any risks associated with the use of EO, it just clarifies that there was no direct evidence found, and that further research is required.

In contrast to this, the partners at AgriCapture investigated which Control Points within the LEAF Marque Standard have the opportunity to use EO to verify evidence as part of an audit process. This can be seen from Table 2 which outlines the various Control Points from the Soil Management and Fertility section and the Landscape and Nature Conservation section of the v16.0 LEAF Marque Standard. It is clear to see that report generation and optimal soil sampling are considered the primary features that could support the remote verification of LEAF Marque Control Point requirements. Other verification features identified include crop type product, cover crop identification product, tillage type identification product, and land cover map (UK), amongst others.

Table 1: The Standards, frameworks, and reports reviewed against the five core AgriCapture Principles for regenerative farming. A no match, partial match, and full match system was used to compare and contrast.

5 Core Principles	No match	Partial match	Full match
Keep the soil surface covered as much as possible	- A Greener World (AGW) - Ecological Outcome Verification (EOV) - European Parliament (Carbon Farming) - Leading Harvest - Carbon Neutral International Standard - Global Farm Metric	- LEAF Marque - Regenagri - Soil Association (Farming and Growing) - Sustainable Farming Incentive (SFI)	- Regenerative Organic Alliance (ROA) - SAI Platform - Food Alliance
Limit the amount of physical and chemical disturbance of the soil	- Ecological Outcome Verification (EOV) - European Parliament (Carbon Farming) - Carbon Neutral International Standard - Global Farm Metric - Sustainable Farming Incentive (SFI)	- LEAF Marque - SAI Platform - Leading Harvest - Soil Association (Farming and Growing) - Food Alliance	- Regenerative Organic Alliance (ROA) - A Greener World (AGW) - Regenagri
Combine a wide diversity of plants to increase soil biodiversity	- Ecological Outcome Verification (EOV) - Carbon Neutral International Standard - Global Farm Metric - Sustainable Farming Incentive (SFI)	- LEAF Marque - Regenagri - Soil Association (Farming and Growing) - Food Alliance	- Regenerative Organic Alliance (ROA) - A Greener World (AGW) - European Parliament (Carbon Farming) - SAI Platform - Leading Harvest
Keep living roots in the soil for as much of the year as possible	- LEAF Marque - Regenerative Organic Alliance (ROA) - Regenagri - Ecological Outcome Verification (EOV) - European Parliament (Carbon Farming) - Leading Harvest - Carbon Neutral International Standard - Global Farm Metric - Soil Association (Farming and Growing) - Sustainable Farming Incentive (SFI) - Food Alliance	- A Greener World (AGW) - SAI Platform	No explicit reference found.
Integrate grazing livestock into the system	- SAI Platform - Leading Harvest - Carbon Neutral International Standard - Global Farm Metric - Sustainable Farming Incentive (SFI)	- LEAF Marque - Ecological Outcome Verification (EOV) - European Parliament (Carbon Farming) - Food Alliance	- Regenerative Organic Alliance (ROA) - A Greener World (AGW) - Regenagri - Soil Association (Farming and Growing)
Earth Observation (EO)	All	No explicit reference found.	No explicit reference found.

Table 2: LEAF Marque Control Points that support AgriCapture remote verification.

LEAF Marque Control Point requirement	AgriCapture product/service that support remote verification of LEAF Marque Control Point requirements
2.2: Measures are taken to conserve and build up soil organic matter. Soil Management Plan (see 2.1) states measures to conserve and build up soil organic matter. Measures include incorporation of crop residues and efficient use of other organic materials where available and appropriate	- Crop residue cover product - Report generation
2.2: Measures are taken to conserve and build up soil organic matter. If soil organic matter is being measured, LEAF Sustainable Farming Review Question Soil Organic Matter % (SM.SD.01) has been completed with appropriate figures.	- Optimal soil sampling service - Parcel based estimation of SOC/SOM - Report generation
2.14: Soil health is measured. Business identifies and implements an appropriate sampling strategy	- Optimal soil sampling service
2.8: All cultivations and field operations are recorded. Field operation records by crop type or by field Checking field records can be very onerous on large farms with small fields so grouping may occur and is acceptable	- Crop type product - Cover crop identification product - Tillage type identification product - Report generation
8.1: There is a documented Landscape and Nature Conservation Audit (including map). Landscape and Nature Conservation Audit includes map(s) with reference to the following key environmental features: • areas and sites on farm with any statutory landscape designation • lakes, ponds and watercourses	- Land cover map (UK) - Wetland map (Copernicus land monitoring service) - Forestry and small woody features map (Copernicus land monitoring service) - Individual trees, bushes and hedgerows product

• semi-natural habitats (e.g. moorland, wetlands, lowland heath, species-rich grassland, carbon sinks etc.) • linear features (e.g. hedges, fence lines, verges, field margins, walls, ditches) • public rights of way • archaeological or historical sites • land on which other important species are found • areas that are grazed • lists of any important species recorded in the area • traditional buildings • fire breaks that help protect crops and habitats **8.7:** There is an implemented Landscape and Nature Conservation and Enhancement Plan. The implementation of the Plan is reviewed at least annually, recording achievements and progress towards all targets, and used to inform updates to the Plan. Standard 8.7 (*see below*) **8.11:** In-field trees and trees in boundaries and hedgerows are retained. Hedgerows and trees are present as recorded in the Landscape and Nature Conservation Audit (see 8.1)	- Report generation
8.7: Traditional field boundaries, environmental/landscape features and other natural habitats are retained. Field boundaries, environmental/landscape features and other natural habitats have not been removed and maps and plans show no intention to remove them. Standard 8.1 (*see above*) Standard 8.11 (*see above*)	- Time series of optical imagery - Historical time series of crop type data products - Historical time series of individual trees, bushes, and hedgerows products - Report generation

5 Discussion: Section 1

5.1 Strengths and weaknesses of Standards

Principle 1: keep the soil surface covered as much as possible

As stated, the ROA Standard scored the most highly for all five AgriCapture Principles for regenerative farming. The first Principle, which aims to keep the soil surface covered as much as possible, was a key requirement within the Standard, and included a scoring system of bronze, silver, and gold. A full match was given to this Standard as the verification stated that farming operations must 'maintain year-round vegetative cover on between 25, 50, 75, and 100% of all cultivated land'. Included in the gold requirement was the need to 'utilise at least one nitrogen fixing cover crop (i.e., legumes) in each full crop rotation'. This suggests that the ROA Standard has gone above and beyond to implement regenerative agricultural practices, as cover cropping – particularly legumes – improves soil structure (Deepdale Farm, 2021) and adds essential nutrients to the soil (Vanheems, 2017).

A further Framework that has shown to include the requirements for Principle 1 is SAI Platform. The Land and Soil section emphasised that to promote healthy soils for high levels of microbial activity, soil organic matter (SOM) and to form good soil structure, 'keeping the soil covered with plant material as much as possible' is necessary, as well as ensuring that plant material is present on a 'year-round' basis. Thus, as a result, a full match was given.

The Food Alliance Standards, (Crop Sustainability and Livestock Sustainability) also scored highly as there were requirements that fully matched those of Principle 1. For example, the Soil and Water Conservation section highlighted that producers must reduce erosion and protect soils by 'optimising plant cover throughout the year'. Both Standards further stated ways to achieve this, including the establishment of 'permanent vegetative cover in orchards and vineyards, by using pastures, rangeland, and rotational grazing, and by selecting tillage technologies that minimise degradation of soil quality'. Again, like those previously discussed, a full match was given.

Those that did not correlate to Principle 1 should also be noted. AGW, EOV, European Parliament (Carbon Farming), Leading Harvest, the Carbon Neutral International Standard, and the Global Farm Metric all lacked the requirement for ensuring the year-round availability of soil cover.

Principle 2: limit the amount of physical and chemical disturbance of the soil

Similar to Principle 1, the ROA Standard scored highly (fully matched) for Principle 2: limit the amount of physical and chemical disturbance of the soil. The scoring system of bronze, silver, and gold stated that businesses must reduce soil disturbance 'as much as possible', and that only, when necessary, should disturbance occur (e.g., when incorporating crop residues and/or green manures, to control weeds, to prepare seed bed/planting, to develop drainage, and to break up compacted soil). In addition, the Standard also noted that 'operation shall adopt a no-till system where soil disturbance only occurs at the time of planting'. Also noting that tillage operations should be reduced, includes AGW and Regenagri Standards. Ensuring businesses are implementing a no-till approach will not

only help to rebuild soil aggregates, enabling long-term productivity (USDA, n.d.) but also, it is essential for keeping carbon in the ground, preventing the release of GHG emissions (Bertrand, 2022).

Partially matching the requirements for Principle 2 includes the LEAF Marque Standard. Although not directly a 'regenerative' Standard, the Control Point stated that 'control strategies to reduce possible risks to soil health' are necessary to include within the Soil Management Plan. In addition to this, businesses must note any 'targets to improve and maintain biological, physical, and chemical attributes of soil health'. Whilst not directly referring to the Principle, the Standard does consider the effect farming operations have on soil health and fertility. Similarly, the SAI Platform framework refers to 'reducing soil disturbance' by 'retaining, building and restoring soil health' – again, resulting in a partial match.

Those that did not correlate to Principle 2 should also be noted. EOV, European Parliament (Carbon Farming), the Carbon Neutral International Standard, the Global Farm Metric, and the SFI all lacked the requirement to limit the physical and chemical disturbance of the soil.

Principle 3: combine a wide diversity of plants to increase soil biodiversity

Combining a wide diversity of plants to increase soil biodiversity was referenced in a range of both Standards and reports. AGW, for example, fully matched with Principle 3 as the Standard noted that 'cover crops or green manures must be used to prevent erosion', as well as stating that businesses should use 'leguminous cover crops' as they 'increase productivity by providing an organic source of nitrogen'. Such requirements conform to research carried out in recent years that also emphasised the utilisation of cover crops. Not only do they improve the recycling of nutrients, but due to greater root biomass, diverse plant communities have also demonstrated to accumulate soil carbon, however, further studies are needed to fully support such claims (Isbell, et al., 2017).

A further Framework that has shown to include the requirements for Principle 3 is the ROA. The Practice Description section emphasised that crop rotations are needed, and depending on the system (e.g., bronze, silver, and gold), there should be at minimum between three and seven rotations per area. Included in the gold system, the Standard also stated that at least one nitrogen-fixing cover crop should be implemented. As a result of demonstrating high-level research, a full match was given to this Standard.

Partially matching the requirements for Principle 3 includes the LEAF Marque Standard. Businesses are required to include reference to a 'selection of varieties relevant to production systems and long-term sustainability'. Whilst 'selection of varieties' is mentioned, the Standard only partially matches as the research concludes a lack of information and detail required in comparison to those previously discussed. Similarly, only partially matching is the Food Alliance Standards. Although Food Alliance is not a regenerative Standard, there is reference for producers to 'conserve and recycle nutrients by converting organic wastes into productive uses and by seeking ways to generate nutrients on the operation through such methods as cover cropping'.

Those that did not correlate to Principle 3 should also be noted. EOV, the Carbon Neutral International Standard, the Global Farm Metric, and the SFI all lacked the requirement to combine a wide diversity of plants to increase soil biodiversity.

Principle 4: keep living roots in the soil for as much of the year as possible

It was concluded in the research that there were no full matches for Principle 4 in any Standard, framework, or report. Despite this, in the Land Use and Cropping section, AGW noted that 'the foundation of the fertility system must be generated via activities such as…deep rooted perennials ('living roots')'. Similarly, the SAI Platform framework emphasised that 'good land and soil management is important to ensure a farm's continued profitability and to protect long-term soil sustainability: practices include: … and perennial plants with deep root systems'. Whilst there is no reference to how long roots should be present in the soil, both Standards and frameworks consider the importance root systems have in improving soil structure and reducing soil erosion.

Those that did not correlate to Principle 4 should also be noted. LEAF Marque, ROA, Regenagri, EOV, European Parliament (Carbon Farming), Leading Harvest, the Carbon Neutral International Standard, the Global Farm Metric, Soil Association (Farming and Growing), the SFI and Food Alliance all lacked the requirement to keep living roots in the soil for as much of the year as possible.

Principle 5: integrate grazing livestock into the system

Similar to Principles 1,2 and 3, the ROA fully matched the requirements of Principle 5. The principle, which aims to ensure businesses integrate grazing livestock into the system, was a key requirement in the Standard. The scoring system of bronze silver and gold stated that farming operations should 'practice intensive grazing in which animals are used in high concentrations for brief periods of time'. The Standard further highlights the importance of considering the environment when carrying out such practices and stated that 'sensitive areas' should not be 'grazed in times of the year when it could have a negative impact on the ecosystem or on local wildlife'. Ensuring that grazing is undertaken in a sustainable manner suggests that the ROA Standard has considered not only the economic benefits of integrating grazing but also that environmental protection is achieved.

Another Standard that has shown to include the requirements for Principle 5 is AGW. The Livestock section emphasised that ruminants hold an important role as they convert forage to protein, and also produce manure which provides and improves soil fertility. Similarly, the Regenagri Standard argued that 'a rotational grazing management plan should be in place for as much of the year as possible'. As a result of the requirements, both Standards were given a full match.

Partially matching the requirements for Principle 5 includes the LEAF Marque Standard. The Control Point requiring an Integrated Landscape and Nature Conservation and Enhancement Plan (LANCEP), stated that businesses must 'reference opportunities to create or enhance temporal changes in habitat provision (e.g., through rotation and/or grazing)'. Similarly, the European Parliament (Carbon Farming) report refers to grazing as an important tool for carbon sequestration. Not only this, but the report ensures environmental factors are accounted for, including the benefits grazing has on soil health and water management, all of which are noted as crucial in research conducted by (Sekaran, et al., 2021).

Those that did not correlate to Principle 5 should also be noted. SAI Platform, Leading Harvest, the Carbon Neutral International Standard, the Global Farm Metric, and the SFI all lacked the requirement to integrate grazing livestock into the system.

5.2 Use of Earth Observation (EO) for existing standards

According to an executive summary published in 2022 by GOV.UK, Earth Observation (EO), particularly from satellites, 'is a fundamental source of location data used by society'. It provides important information about the planet at both a frequency and coverage that is not possible from any other source. EO is continuously gaining recognition and is used by a range of businesses across the UK, particularly mature users, i.e., organisations with longstanding use of the tool (e.g., Ministry of Defence, Rural Payments Agency, and the Met Office). In recent years, these organisations have invested significantly in developing their in-house capabilities and are, therefore, well positioned to take advantage of future market developments.

At present, current, and evolving demand for commercial high-resolution EO data accounts for 30% of the use cases. The 30%, however, does not include many of the emerging cases where users are considered to have the lowest levels of maturity. Such cases include agricultural systems, land management schemes, achieving Net Zero, national climate reporting, and sustainable finance. It was discovered that these organisations have limited capacity to invest in considering the opportunities EO has to offer. Albeit there is a general belief that EO has a strong place in supporting emerging cases and policy areas such as those discussed, but potential EO solutions are yet to be explored (GOV.UK, 2022). The research did note the challenges and barriers to developing EO maturity, and subsequent progression of EO in the UK market.

Amongst the four universal challenges GOV.UK (2022) highlights, one of the primary barriers to implementation found within the research is the high data cost of EO. The cost of the technology prevented the majority of stakeholders from adopting it. This could apply even to free and open Copernicus data as users would still require to develop capacities and physical/online tools to access/process data. Similar to their research, it was concluded in this investigation that no regenerative Standard discussed the use, benefits, or risks of implementation of EO. Many of the Standards, frameworks, and reports were derived from small, non-profit organisations. Therefore, a suggestion as to their lack of investment in EO and advancing technologies could be attributed and limited to their financial capacity. A further suggestion could be due to a lack of knowledge and understanding of this technology and available tools. The GOV.UK (2022) research found that whilst EO is continuing to gain the interest of UK businesses, there is a misunderstanding regarding the potential such technologies have in monitoring both climatic and environmental risks, particularly of carbon sequestration.

Other barriers to developing EO maturity within the UK include understanding the tool and platform capability. Currently, there little evidence on the capabilities EO has with new data systems unknown or misinterpreted by end users. Gauging technological possibilities is a further barrier to adoption. There is limited awareness of maturing technological developments in the wider EO sector that might improve the integration of EO into the

broader UK public sector. Similarly, establishing a case for investment was considered a major challenge.

It is important to note that whilst there were a range of barriers, the opportunities, and recommendations for the UK public sector to consider the value of EO were discussed at length. According to GOV.UK (2022), the implementation of EO reduced barriers to the use of openly available data for UK public sector bodies. Where data services have been established, there are opportunities for continued evolution and Standardisation of services across a range of organisations and opportunities to gain increased value. As a result, this could include simplified access to a number of data sources as well as value-added data products. This would encourage the enhancement of growth and diversification skills, as well as promote greater use of data, reduce overheads from duplicate services, and finally, ensure maximum value for money.

Further to this, there is continued demand in the UK public sector for very high-resolution commercial EO data with several pilots showing successful results. Broader engagement with this data across UK public sectors is likely to increase the efficiency in existing EO cases, and new insights to inform emerging cases. However, market understanding, licensing considerations and availability of in-house skills limit this from progressing. Therefore, GOV.UK (2022) suggests that the public sector should consider mechanisms to ensure awareness of the opportunities EO holds in providing the UK public sector with accessible data.

The final opportunity noted by GOV.UK (2022) is that improving the exchange of expertise and insights across the UK public sector enhances knowledge sharing and collaboration and further encourages greater uptake of data amongst organisations with a lesser and moderate EO maturity. This could include those organisations previously discussed such as the agricultural systems, land management schemes, Net Zero, national climate reporting, and sustainable finance.

6 Conclusion: Section 1

Overall, the research for Section 1 has shown that regenerative Standards, frameworks, and reports differ greatly in their requirements. Of those examined, it was clear that only a few, such as the ROA, AGW, and Regenagri, corresponded to the five core AgriCapture Principles for regenerative farming, whilst the majority demonstrated to have a no match. That aside, it should be mentioned that all Standards, frameworks, and reports reviewed included an array of varying regenerative practices, different from the requirements of AgriCapture.

As stated, agroforestry, reduced or no tillage, retaining crop residues, and the inclusion of perennial crops in crop rotation were just some of the additional Control Points stated – all of which are increasingly important for carbon sequestration in a changing climate. With climate change one of the most significant challenges facing the 21st Century, the continuation of intensive agricultural practices will eventually be detrimental to not only the environment but also to global food security. Therefore, this research has indicated that restoring and maintaining soil fertility through regenerative agricultural practices is immensely important. Further to this, it has also been highlighted that in order to achieve this on a global scale, more regenerative/environmental Standards are required to guide farmers in ensuring up-to-date best practice operations are carried out to achieve on-farm sustainability. After all, there is a rising demand for food to be produced in a more sustainable and responsible way.

Our research found that there was a lack of discussion about the use and implementation of EO. Whilst many mature UK business users continue to adopt the technologies, there still appears to be a general lack of understanding, particularly among organisations with low levels of maturity. Of the barriers to implementation, varying cost of data, understanding the tool and platform capabilities, gauging technological possibilities, and establishing a case for investment were the primary findings from the GOV.UK (2022) report. However, as EO continues to gain interest amongst the UK public services, the opportunities for adoption have been discussed. Those highlighted in the report include continued evolution and Standardisation of services, access to investment case for commercial EO to meet current and emerging policy requirements, and sharing knowledge and collaboration between organisations, which subsequently, encourages uptake of data amongst lesser and moderate EO maturity organisations.

7 Introduction: Section 2

Section 2 analyses feedback from a range of stakeholders including producers, CBs, and Standard setters on the use and implementation of EO and regenerative agriculture in food and farming sustainability Standards. Structured interviews were the primary method used to collect responses as they allowed to gather rich information which could be compared to draw upon more detailed conclusions. Each interview schedule, including the questions asked, can be seen in the Appendices (Chapter 14).

8 Results: Section 2

8.1 Survey results regarding implementation of EO within food and farming Standards

Producers

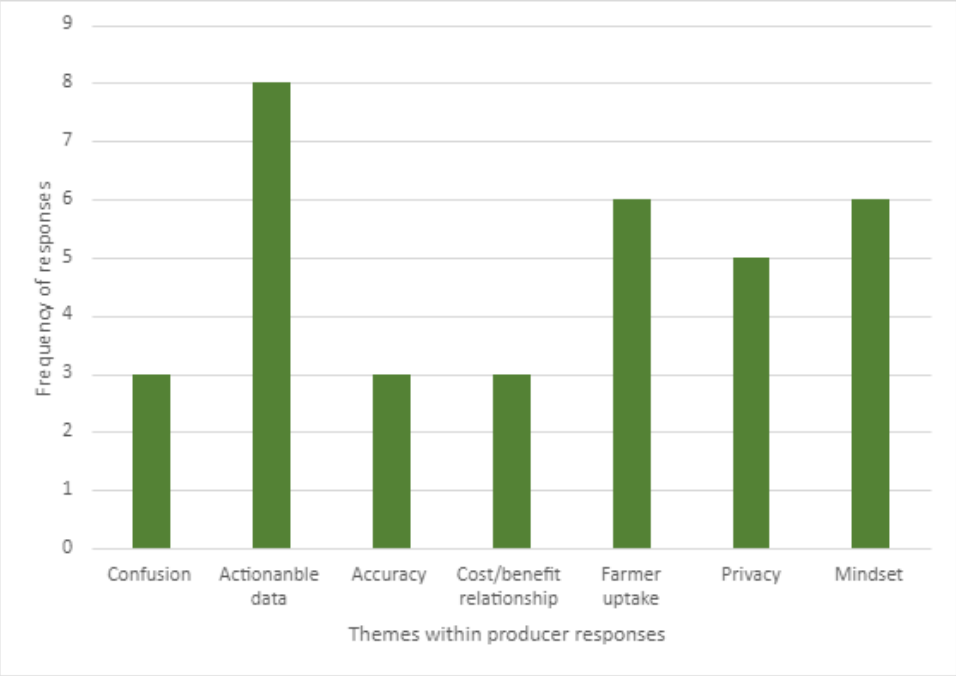

Figure 1: Themes identified from Producer responses to 'Do you think there are any challenges to implementing EO (Earth Observation) within farming practices?'

Figure 1 shows the themes that were identified from producer responses to 'Do you think there are any challenges to implementing EO within farming practices?'. There was a range of themes found from the answers given; the most common was actionable data collection, mentioned 8 times. The second two most common answers were farmer uptake of technology and mindset effects, both mentioned 6 times. Privacy issues were mentioned 5 times, with confusion as to what EO is, data accuracy, cost/benefit relationship all mentioned 3 times.

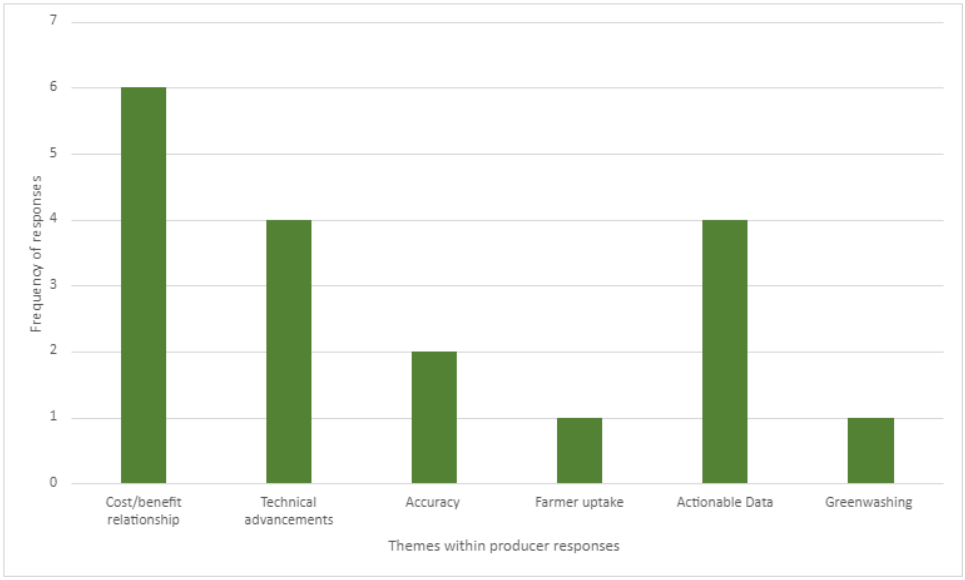

Figure 2: Themes identified from producer responses to 'What do you think the future of EO looks like?'

Figure 2 shows a range of responses from the producers interviewed. In regards to what the future of EO looks like, the most common theme discussed by producers was the cost/benefit relationship, which was mentioned 6 times. The technical advancement of EO was mentioned 4 times by producers, as was collection of actionable data. Data accuracy was raised as a concern which was mentioned twice within the interviews. Farmer uptake was discussed as a barrier, as well as greenwashing effects of use EO.

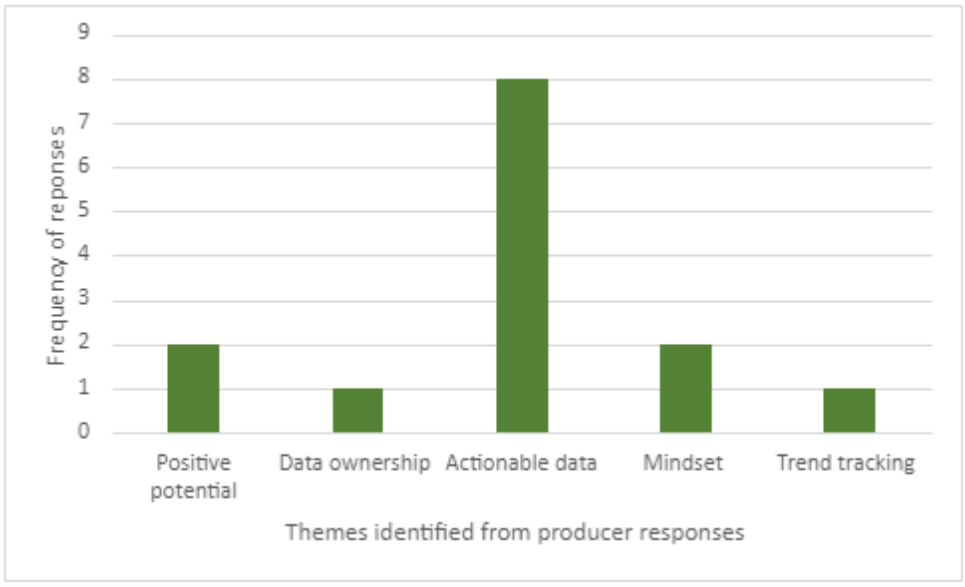

Figure 3: Themes identified from producer responses to 'Do you think there are benefits to using EO?'

Figure 3 shows the range of theme responses that occurred in response to considering the benefits of EO. Actionable data stood out a common theme that was mentioned 8 times during the interviews. Mindset was again mentioned as an important theme, as well as the potential for positive results, data ownership and tracking trends.

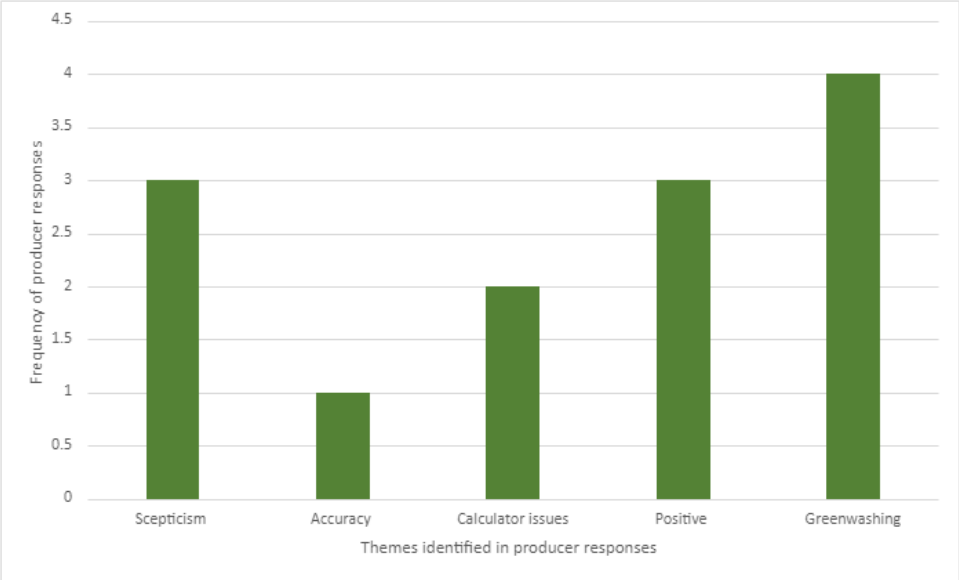

Figure 4: Themes identified from producer responses to 'What is your opinion on carbon credits?'

Figure 4 shows the range of responses to the use of carbon credits. When asked their opinions, the most common themes that producers responded with were skepticism, mentioned 3 times, and greenwashing which was mentioned 4 times. There were concerns surrounding carbon calculator, mentioned twice, with data accuracy issues mentioned once. Positive results from carbon credits were highlighted 3 times during the interviews.

Certification Bodies

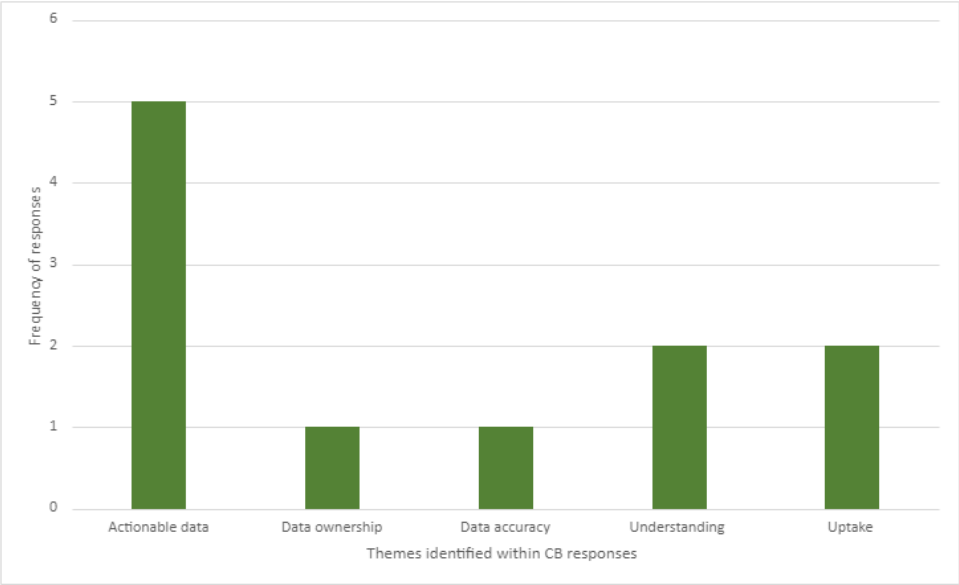

Figure 5: Themes identified from Certification Body responses to 'Do you think there are any challenges with the auditing of EO?

Figure 5 shows the frequency of themes from CBs in response to discussing the challenges of auditing EO. The most common answer was the question of actionable data being produced from EO, which was mentioned 5 times. Understanding of the data was mentioned twice, with concerns about farmer uptake being mentioned twice. Data accuracy and ownership were also raised once during the interviews.

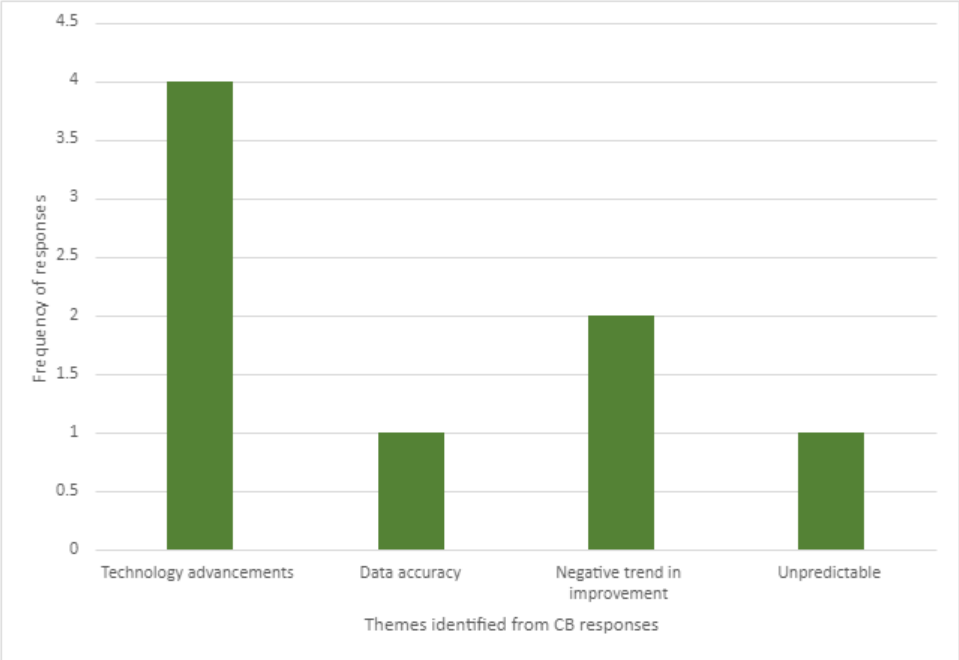

Figure 6: Themes identified from Certification Body responses to 'If implemented, what are the future challenges of auditing EO?

Figure 6 shows responses from CBs about the future challenges of auditing EO. A strong theme that was named 4 times was the speed at which technology advances and how this would create auditing issues. Negative trends in improvement were mentioned twice in reference to over focus on EO rather than improvement of practice. Unpredictable nature of changes in EO and data accuracy issues were also raised as concerns once each.

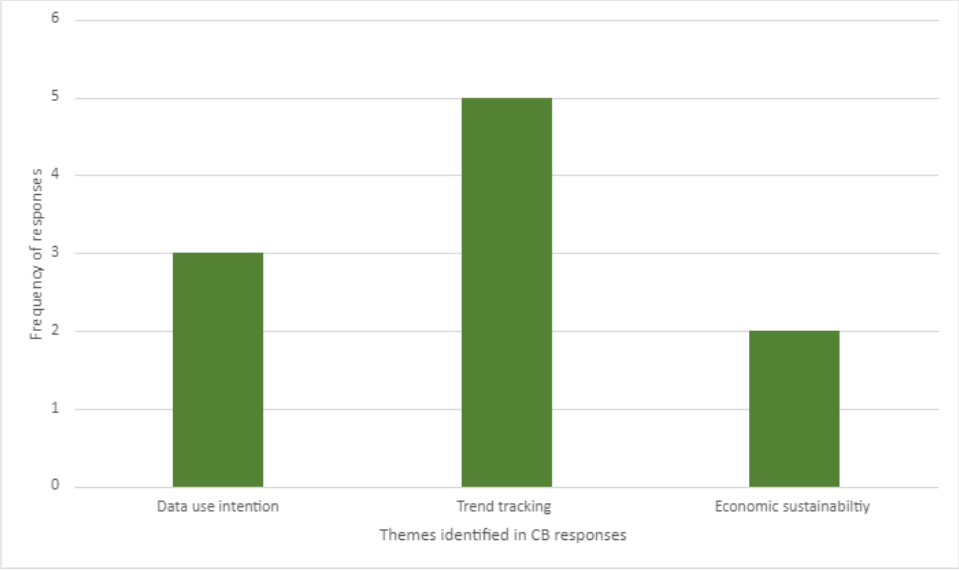

Figure 7: Themes identified from Certification Body responses to 'Do you think there are benefits to EO?'

Figure 7 collates the data collected from the CB responses to being questioned about the benefits of EO. The most common theme was the ability to track trends, both in farm practices and crop establishment, and in wider uses such as biodiversity trends. This was mentioned 5 times. Data use intention was a necessary benefit to show the purpose of the

data collection, to use it in the most successful way. Economic sustainability was also suggested as a potential benefit, through aspects of a cost/benefit reward scheme.

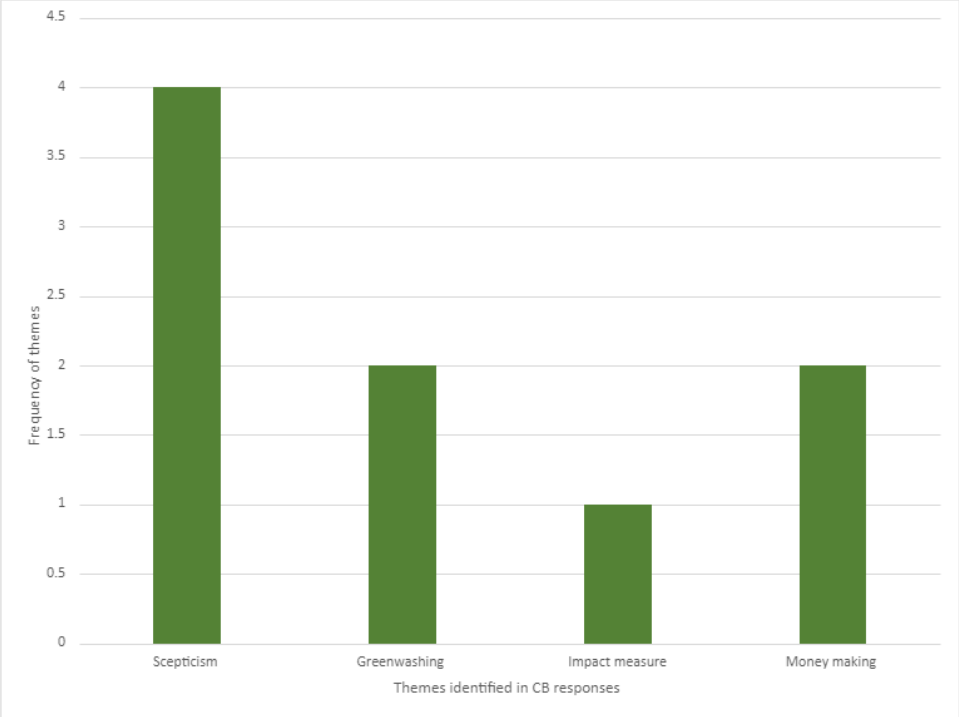

Figure 8: Themes identified from Certification Body responses to 'From an auditing perspective, what is your opinion on the use of carbon credits?'

Figure 8 portrays the themes identified from responses to the use of carbon credits from an auditing perspective. The standout theme from the interviews was scepticism surrounding the market, which also came from a lack of understanding what was involved. Greenwashing was mentioned twice, as well as the idea that the market was digressing into a money-making scheme. A lack of true impact measure was mentioned once.

Standard setters

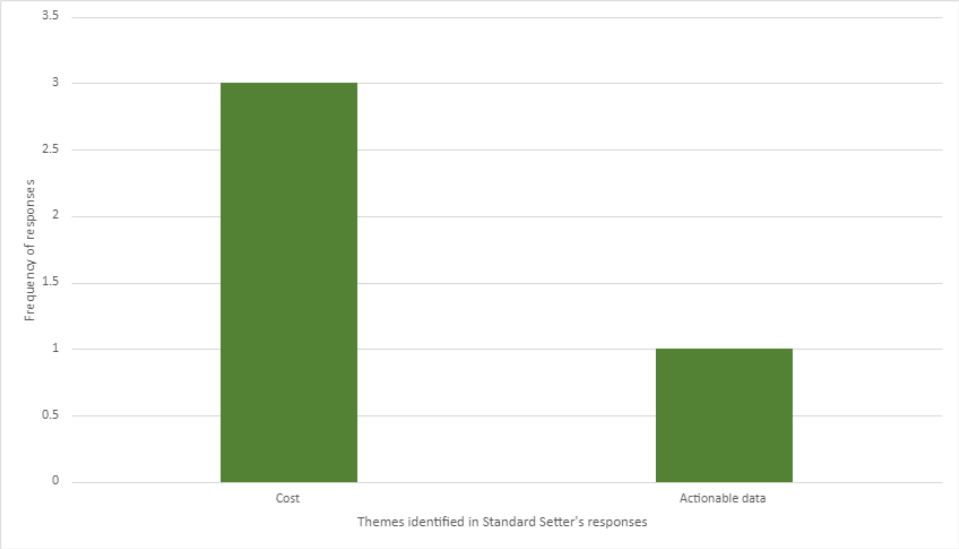

Figure 9: Themes identified from Standard setter's responses to 'What do you perceive to be the challenges related to the inclusion of EO within environmental Standards?'

Figure 9 shows Standard setter's opinions to the greatest challenges for the implementation of EO in environmental Standards. Cost was a significant factor in the conversations; when considering the demographic group size of two cost being mentioned three times shows the weighting of this as a challenge. The collection of actionable data was also a theme that was mentioned once.

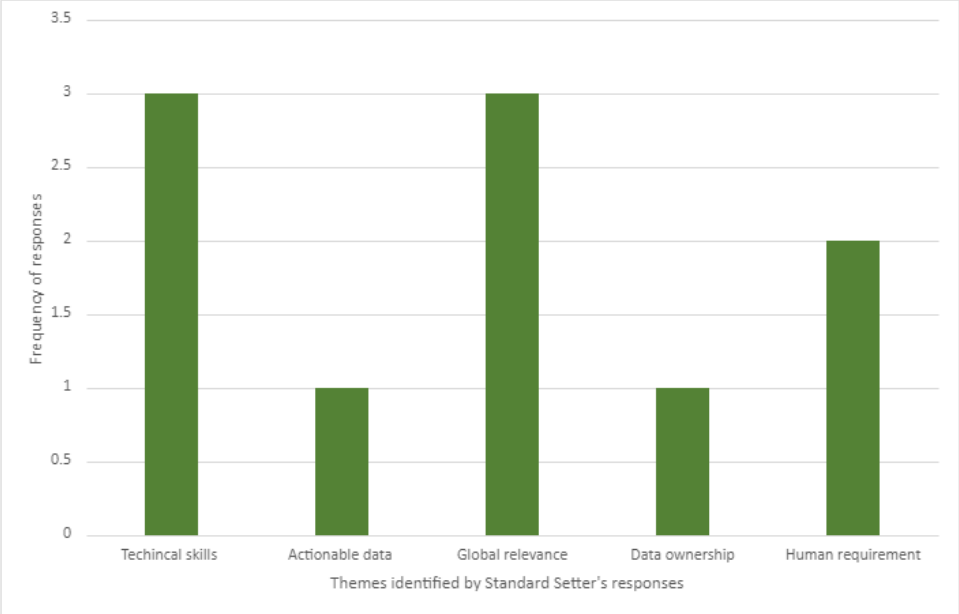

Figure 10: Themes identified from Standard setters in response to 'Do you think EO will be included in future versions of environmental Standards?'

Figure 10 shows responses from Standard setter's on future versions of environmental Standards and the inclusion of EO. Technical skills and global relevance were two leading themes were there was concern about EO, both being mentioned 3 times each. Human

requirement in EO would also take a different approach in terms of auditing, which was mentioned twice.

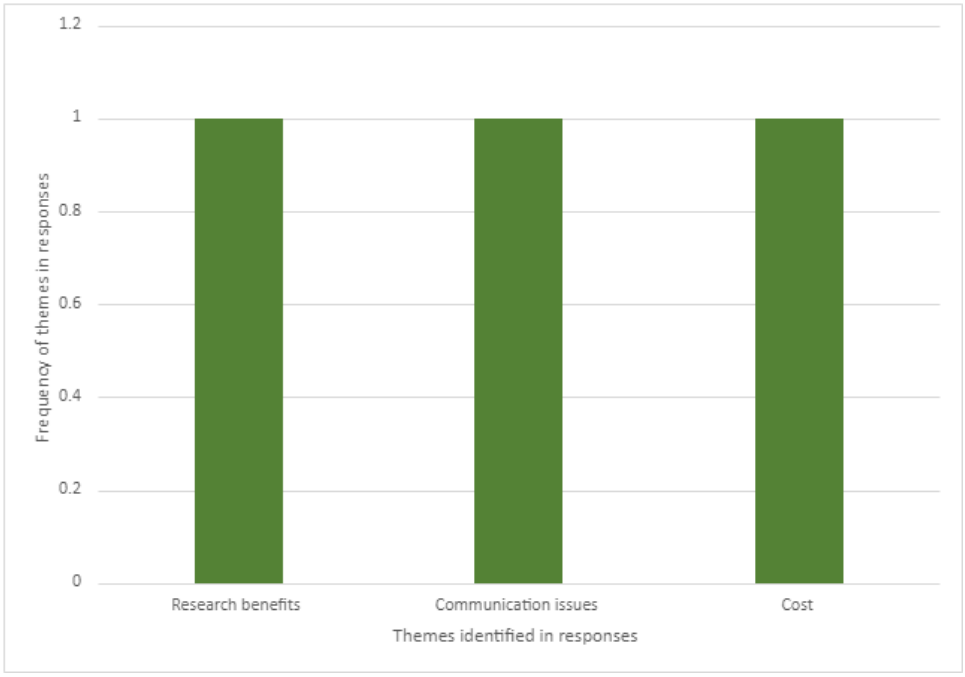

Figure 11: Themes identified by Standard setters in response to 'Do you think there are benefits to using EO?'

Figure 11 shows the results from Standard setters in response to being questioned about the benefits of using EO. Research benefits, communication issues and cost were all identified in equal amounts in response to this question.

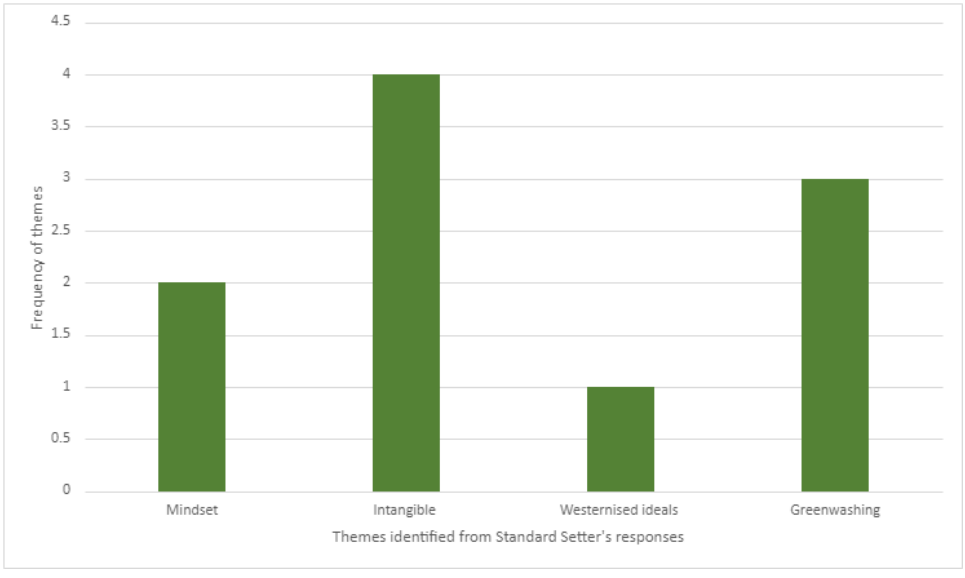

Figure 12: Themes identified by Standard setters in response to 'What is your opinion on carbon credits, and do you think it has a place within environmental Standards?

Figure 12 show Standard setters opinions on carbon credits and their place in environmental Standards. Intangibility was the most common theme, mentioned 4 times,

with greenwashing being found 3 times in the interviews. Mindset was mentioned twice, and westernised ideals was mentioned once.

Drone pilot

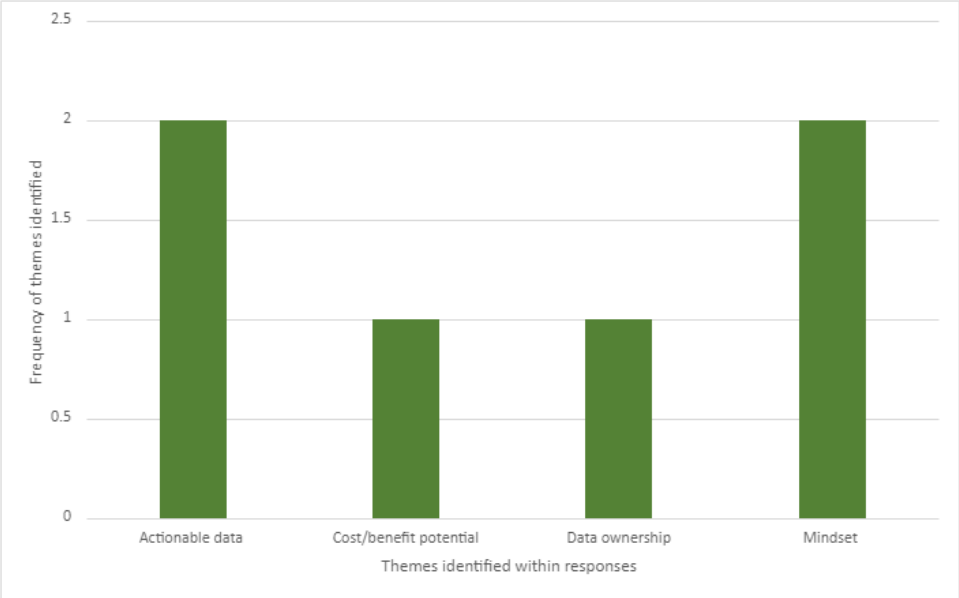

Figure 13: Themes identified by a Drone Pilot in response to 'From a technological and data point of view, do you think there are any challenges to implementing EO within farming practices?'

Figure 13 shows results from interviews with a Drone Pilot, on challenges of implementing EO within farming practices from a technological point of view. Actionable data and farmer mindset were both mentioned twice, with cost/benefit potential and data ownership both being mentioned just once.

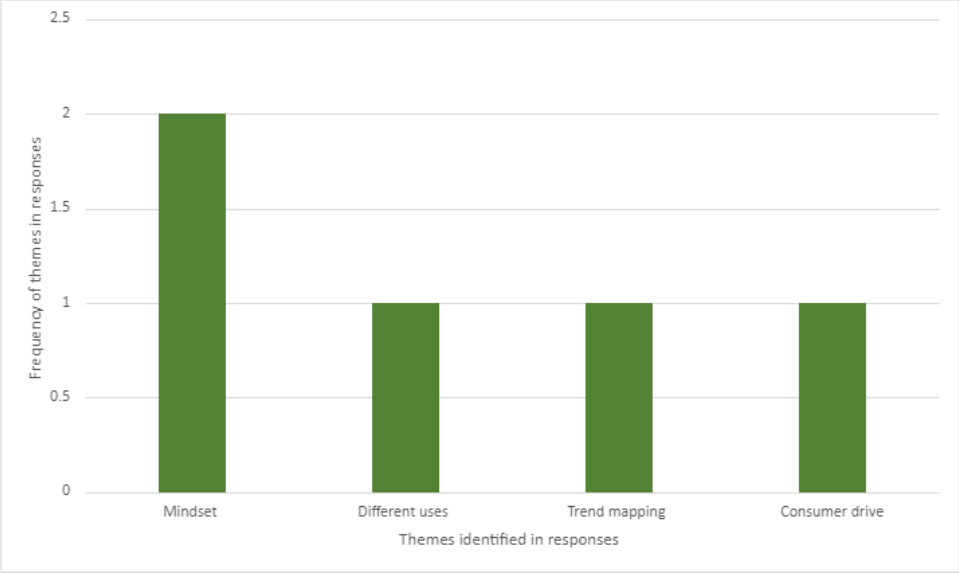

Figure 14: Themes identified from a Drone Pilot in response to 'What do you think the future of EO looks like from a tech point of view?'

Figure 14 shows responses to the future of EO from a technological viewpoint. Mindset was identified as the most common response, being mentioned 2 times, with different uses, trend mapping and a consumer drive all being mentioned once.

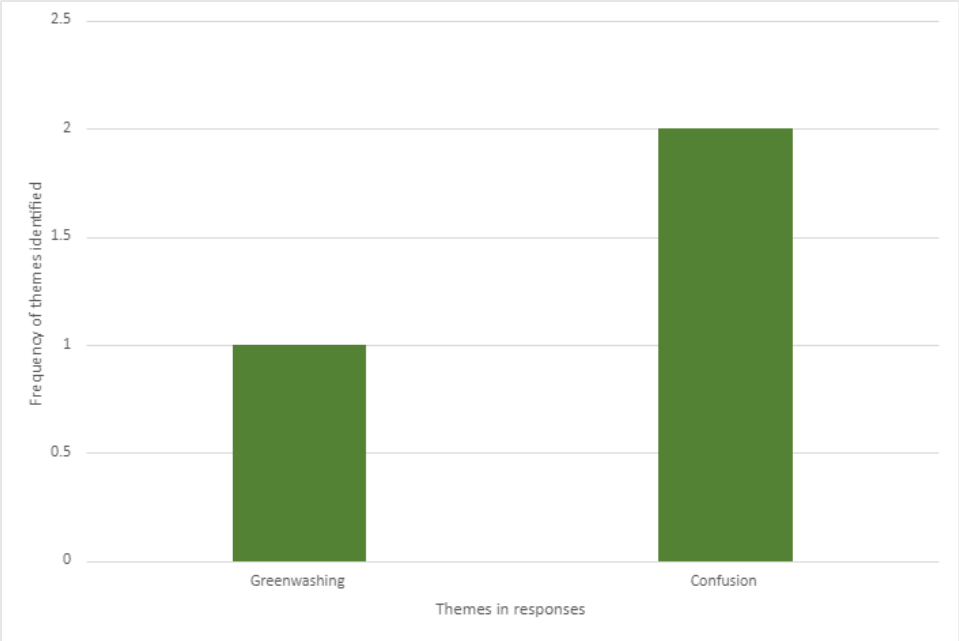

Figure 15: Themes identified by a Drone Pilot in response to 'What are your opinion of carbon credits?'

Figure 15 shows responses to opinions on carbon credits by a Drone Pilot. Confusion was a common theme that arose twice from the interview as well as Green Washing being mentioned once.

8.1 Survey results regarding implementation of regenerative agriculture within Standards

Producers

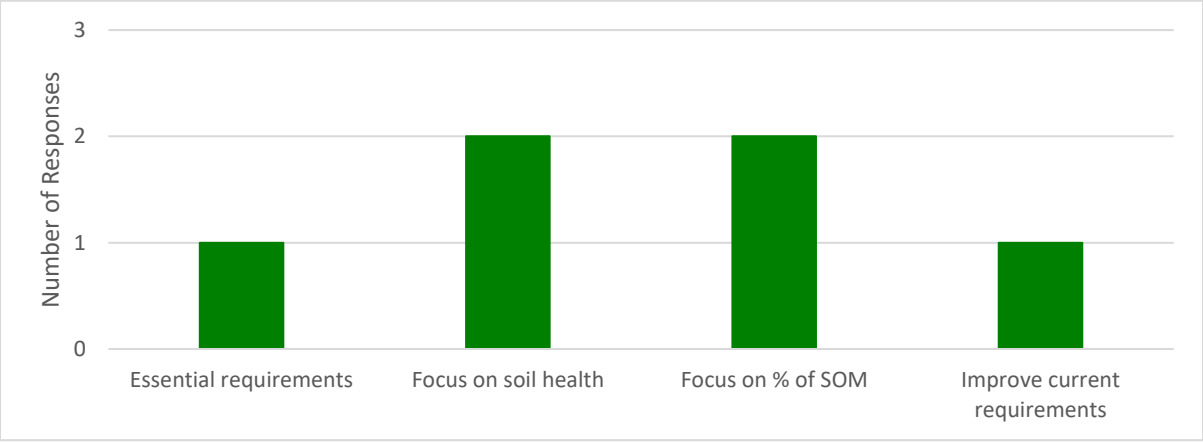

Figure 16: Producer responses to the question 'Do you think the LEAF Marque Standard could improve its requirements for regenerative practices?'

Figure 16 presents the producer responses to question 'Do you think the LEAF Marque Standard could improve its requirements for regenerative practices? If yes, what would you like to see in future Standards?' The figure shows that a greater focus on soil is required for the future development of the LEAF Marque Standard. For example, 2 responses suggested that Control Points should emphasise the importance of soil health. Similarly, 2 responses noted that requirements for the % of Soil Organic Matter (SOM) should be strengthened. Other themes discovered include the need for more essential requirements and improvements to current requirements.

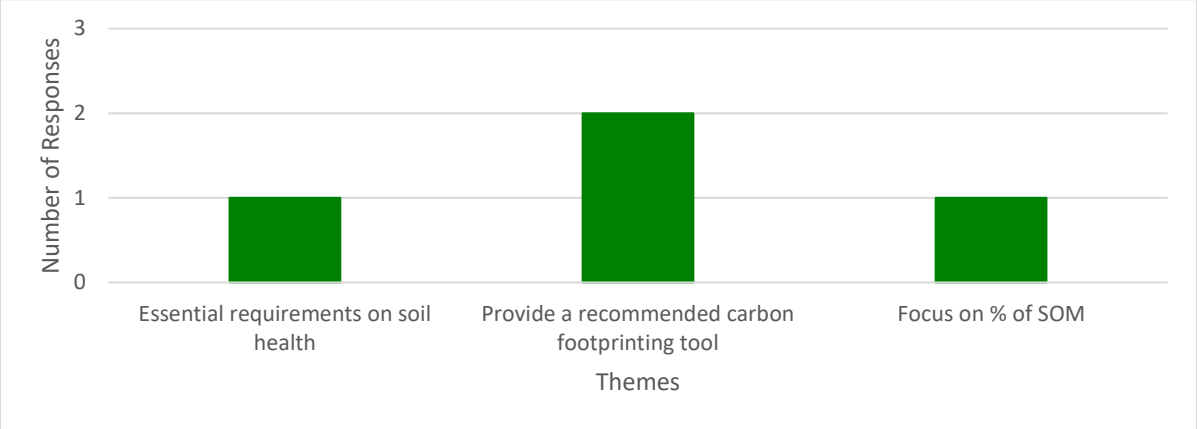

Figure 17: Common themes relating to 'How could the LEAF Marque Standard improve its Control Points on measuring carbon?'

Figure 17 displays the producer responses to question 'How could the LEAF Marque Standard improve its Control Points on measuring carbon?' The figure shows that there is a greater preference for LEAF to provide a recommended carbon footprinting tool to measure carbon emissions, as noted by 2 responses. Other themes discovered include the need for more essential requirements on soil health and an improved focus on the % of SOM.

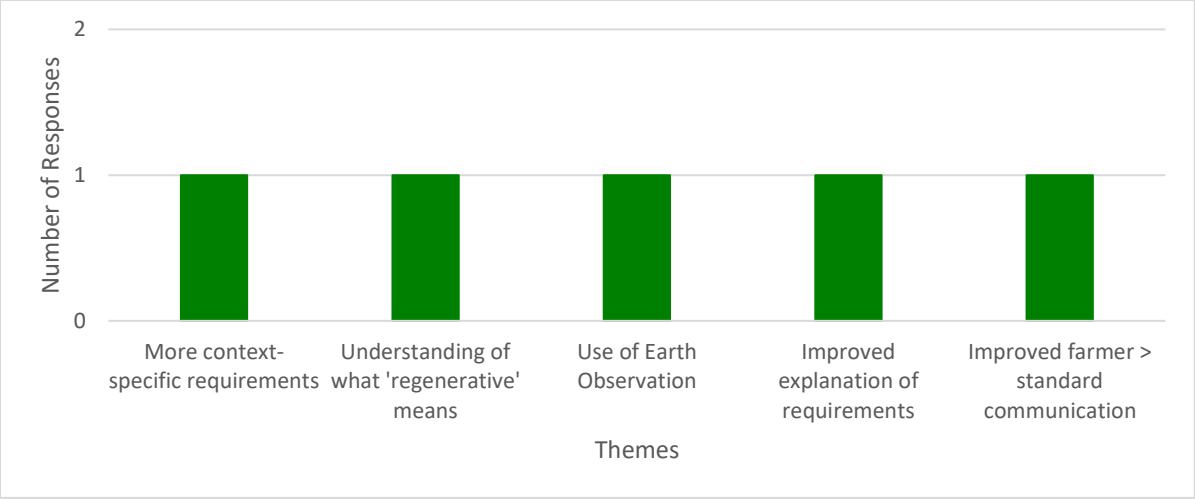

Figure 18: Common themes relating to 'Do you think Standards could improve their requirements for regenerative practices? If yes, what would you like to see in future Standards?'

Figure 18 shows the producer responses to question 'Do you think Standards could improve their requirements for regenerative practices? If yes, what would you like to see in future Standards?' The figure illustrates a range of themes including more context-specific requirements, understanding the term 'regenerative', use of EO, improved explanation of requirements, and improved communication between producers and Standard setters.

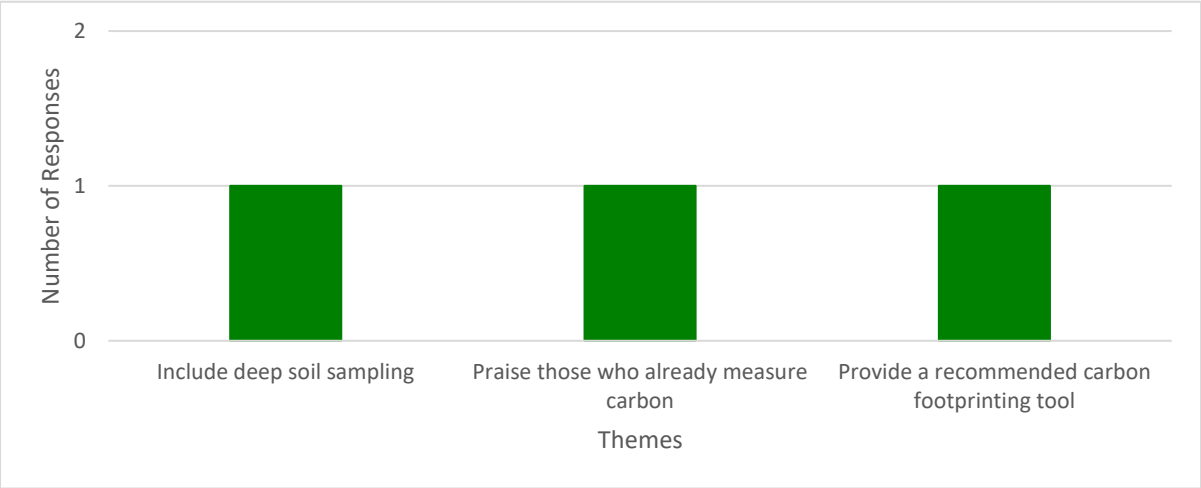

Figure 19: Common themes relating to 'How could Standards improve their Control Points for measuring carbon?'

Figure 19 presents the producer responses to question 'How could Standards improve their Control Points for measuring carbon?' The figure demonstrates that 1 response suggests there is a need to consider the sample depth during soil sampling. Similarly, 1 response notes that Standards should praise those who continue to measure carbon, as well as provide a recommended carbon footprinting tool.

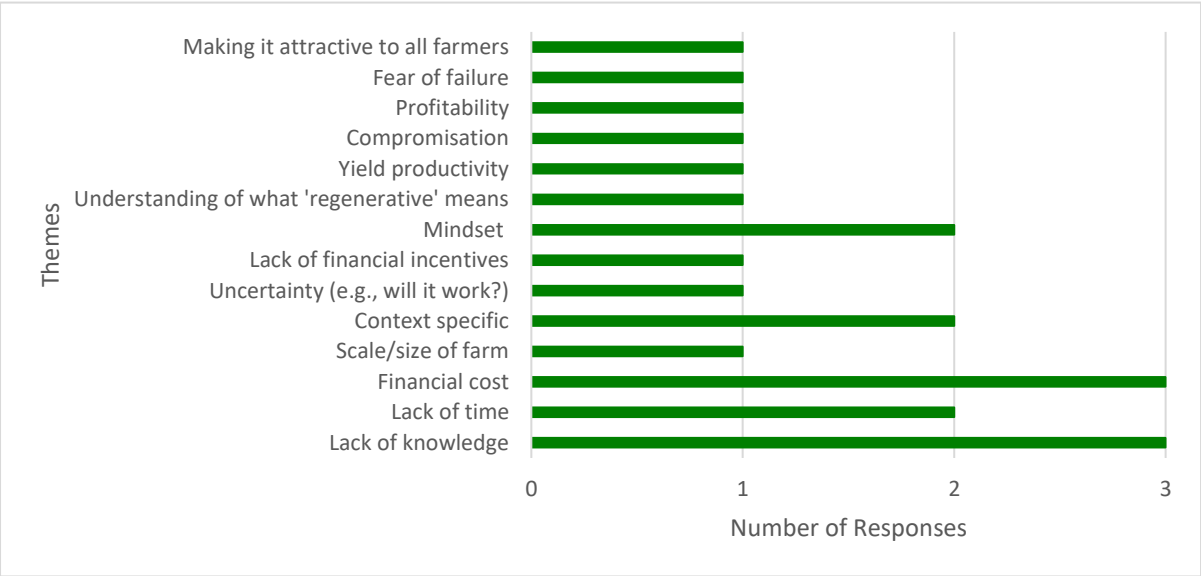

Figure 20: Common themes relating to 'Do you think there are any challenges to implementing regenerative principles within farming practices?'

Figure 20 displays the producer responses to question 'Do you think there are any challenges to implementing regenerative principles within farming practices?' The figure shows that 3 responses implied a lack of knowledge being the primary challenge for the implementation of regenerative practices. Similarly, 3 responses also noted financial cost to be a limitation. Other challenges identified include making it attractive to all farmers, fear of failure, profitability, mindset, yield productivity, compromising, understanding the term 'regenerative', lack of financial incentives, scale/size of the farm, uncertainty, lack of time, and the context of the farm.

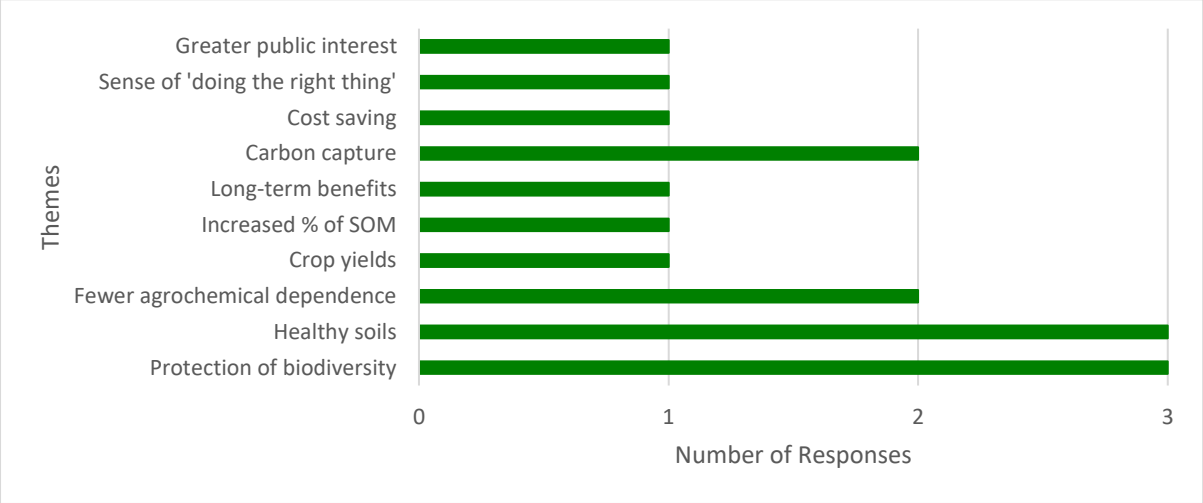

Figure 21: Common themes relating to 'What are the benefits and opportunities within regenerative agriculture?'

Figure 21 shows the producer responses to question 'What are the benefits and opportunities within regenerative agriculture?' The figure demonstrates that 3 responses emphasised that the protection of biodiversity is a significant benefit of regenerative principles. Likewise, 3 responses also noted improvements in soil health. Other benefits identified include greater public interest, a sense of 'doing the right thing', cost savings, carbon capture, long-term benefits, increased % of SOM, enhanced crop yields, and fewer dependence on agrochemicals.

Certification Bodies

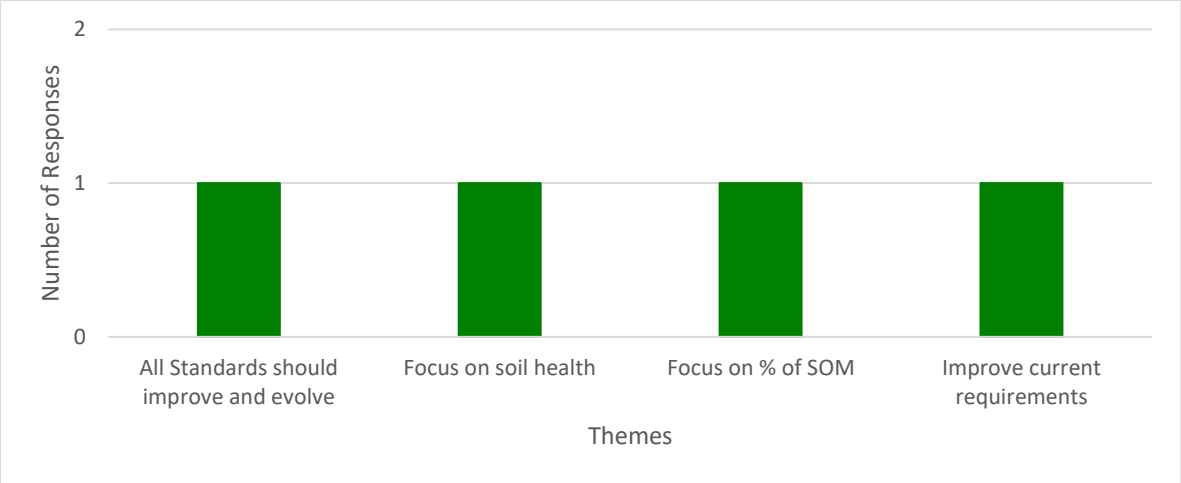

Figure 22: Common themes relating to 'Do you think the LEAF Marque Standard could improve its requirements for regenerative practices? If yes, what would you like to see in future Standards?'

Figure 22 presents the CB responses to question 'Do you think the LEAF Marque Standard could improve its requirements for regenerative practices? If yes, what would you like to see in future Standards?' The figure shows that 1 response suggests that all Standards should evolve to improve Control Points. In addition, a greater focus on soil is required for the future development of the LEAF Marque Standard. For example, 2 responses suggested that Control Points should emphasise the importance of soil health. Likewise, 2 responses noted that requirements for the % of SOM should be strengthened. Other themes identified include improvements to current requirements.

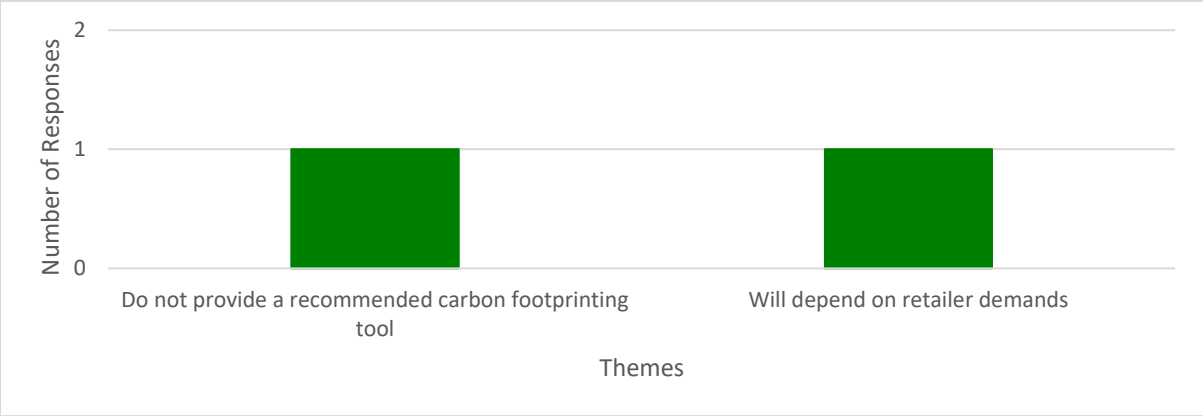

Figure 23: Common themes relating to 'How could the LEAF Marque Standard improve its Control Points on measuring carbon?'

Figure 23 shows the CB responses to question 'How could the LEAF Marque Standard improve its Control Points on measuring carbon?' The figure identifies that a recommended carbon footprinting tool should not be provided, as noted by the 1 response. Other themes discovered include the response that improvements will depend on retailer demands.

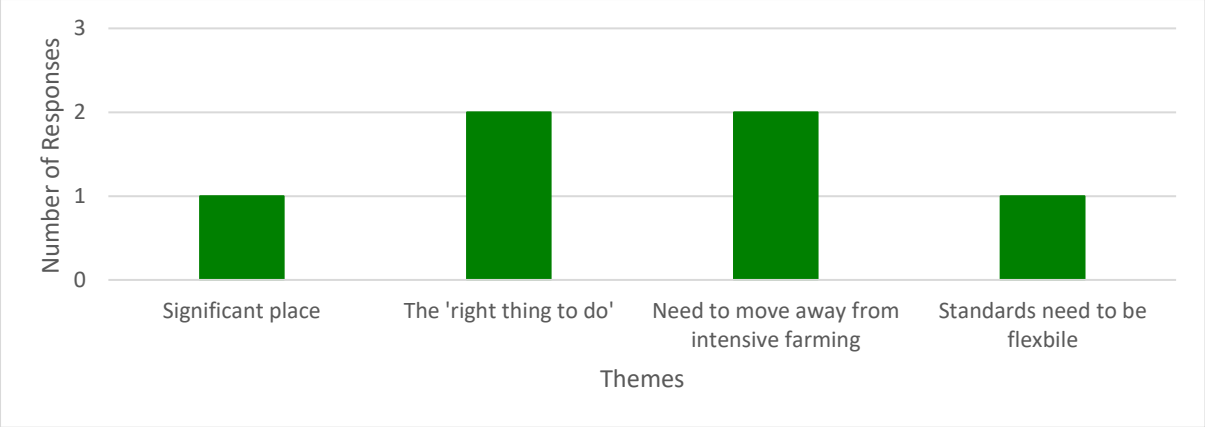

Figure 24: Common themes relating to 'What place does regenerative agriculture have in global food and farming systems?'

Figure 24 displays the CB responses to question 'What place does regenerative agriculture have in global food and farming systems?' The figure shows that 1 response suggests that regenerative principles have a significant place in the global food and farming system, and 2 responses note it being the 'right thing to do'. Similarly, 2 responses emphasise the need to move away from intensive practices. Other themes identified include that Standards need to be flexible with their Control Points.

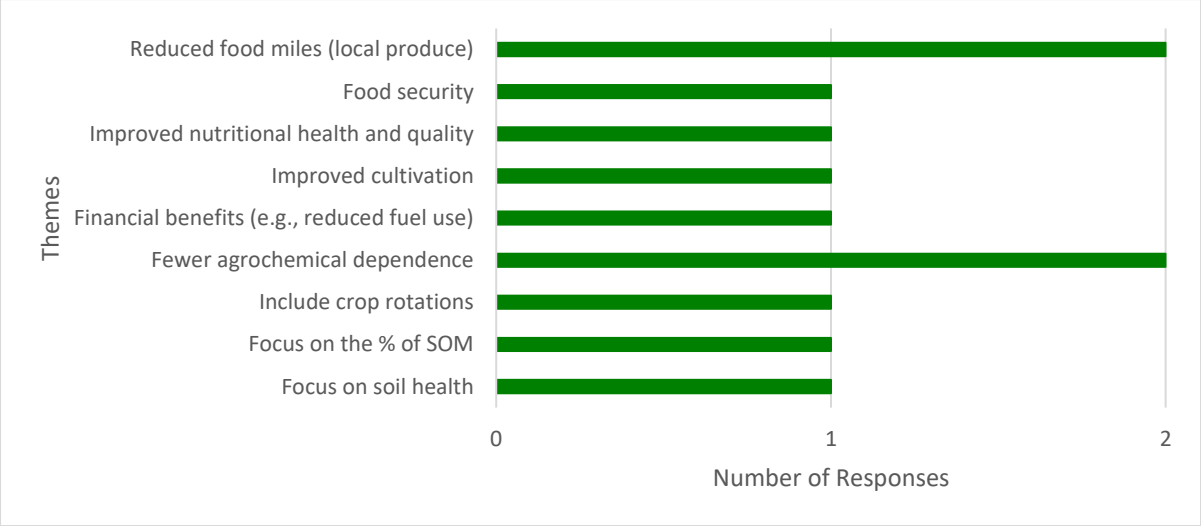

Figure 25: Common themes relating to 'Are there benefits and opportunities within regenerative agriculture?'

Figure 25 presents the CB responses to question 'Are there benefits and opportunities within regenerative agriculture?' The figure shows that 2 responses indicated fewer agrochemical dependence as being a benefit of regenerative agriculture. Likewise, 2 responses noted the reduction to food miles and the subsequent purchase of local produce. Other benefits identified include improved food security as well as nutritional health and quality, improved cultivation, financial benefits such as reduced fuel use, inclusion of crop rotations, a greater focus on the % of SOM, and also to soil health.

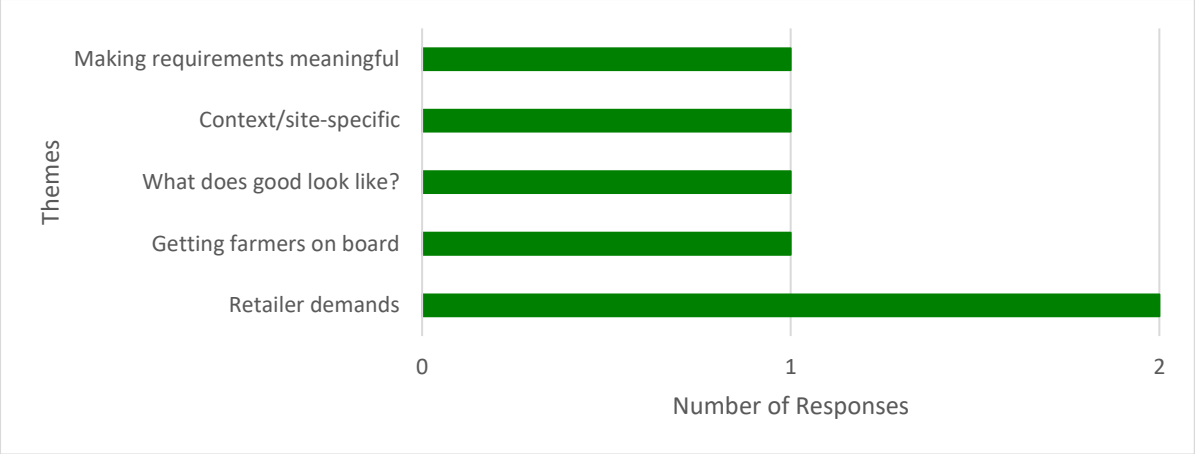

Figure 26: Common themes relating to 'Are there challenges with auditing regenerative agriculture?'

Figure 26 presents the CB responses to question 'Are there challenges with auditing regenerative agriculture?' The figure highlights that retailer demands are the primary challenge to auditing regenerative principles, as noted by the 3 responses. Other challenges identified include making the requirements meaningful, considering context/site-specific, getting farmers on board, and what does good look like?

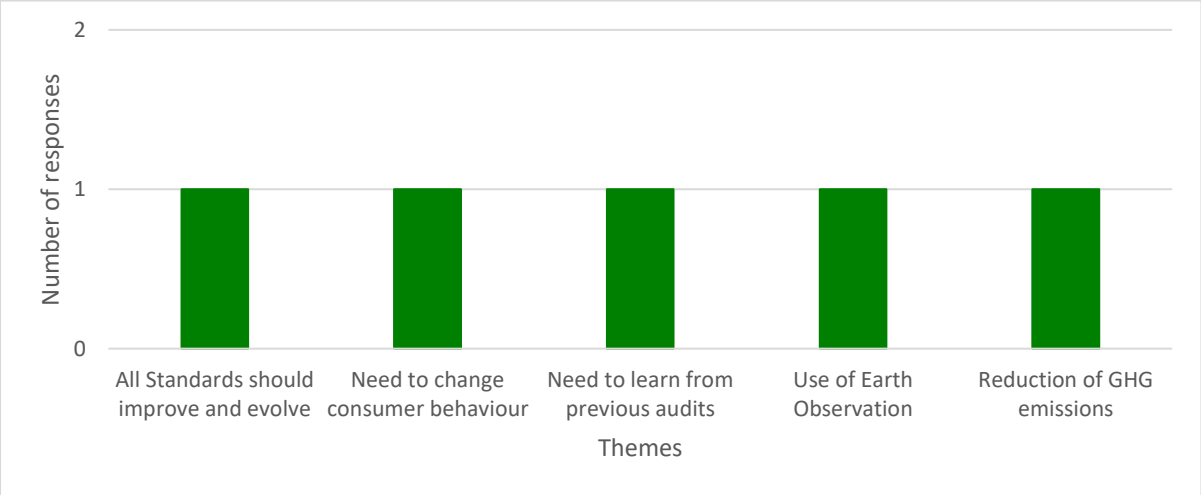

Figure 27: A yes or no response to 'Do you think there is a need for more regenerative practice Control Points within environmental Standards?'

Figure 27 displays the CB responses to 'Do you think Standards could improve their requirements for regenerative practices? If yes, what would you like to see in future Standards?' The figure shows a range of responses from participants including the need for Standards to change consumer behaviour, learn from previous audits, use of EO, and reduce GHG emissions. One response also notes that all Standards should improve and evolve.

Standard setters

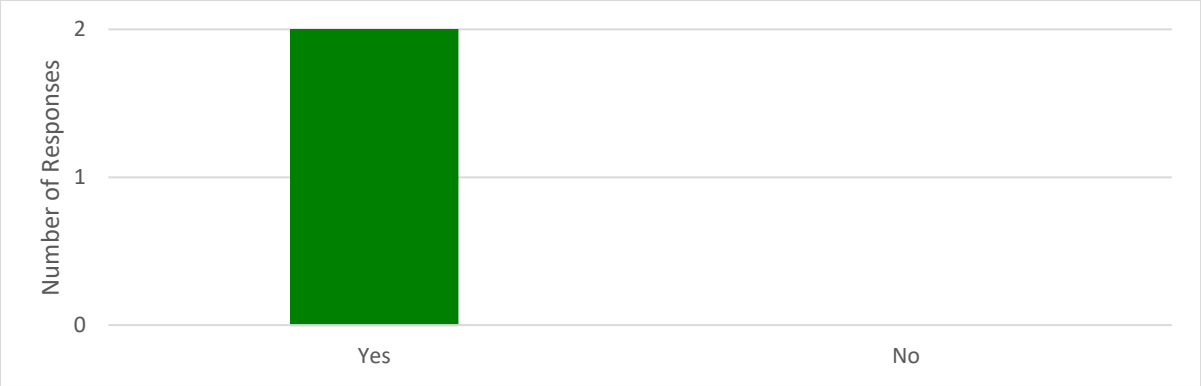

Figure 28: Common themes relating to 'Do you think there are any challenges to implementing regenerative principles within environmental Standards'

Figure 28 displays the Standard setter responses to question 'Do you think there is a need for more regenerative practice Control Points within environmental Standards?' The figure shows that both participants suggested that there is a need to include more regenerative practice Control Points within environmental Standards.

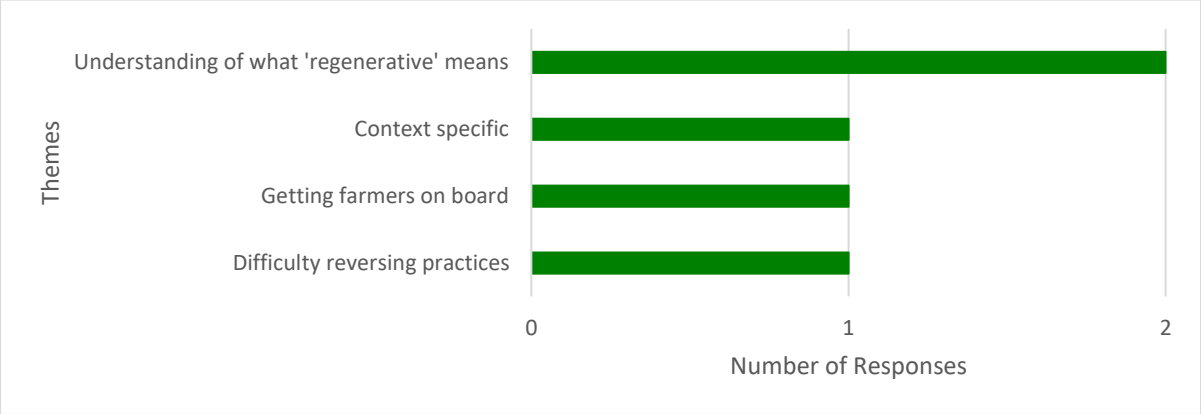

Figure 29:29 Common themes relating to 'Do you think Standards could improve their requirements for regenerative practices? If yes, what would you like to see in future Standards?'

Figure 29 shows the Standard setter responses to question 'Do you think there are any challenges to implementing regenerative principles within environmental Standards?' The figure demonstrates that both participants suggest understanding what the term 'regenerative' means to be a significant challenge. Other challenges identified include context/site-specific, getting farmers on board, and a difficulty in reversing intensive farming practices.

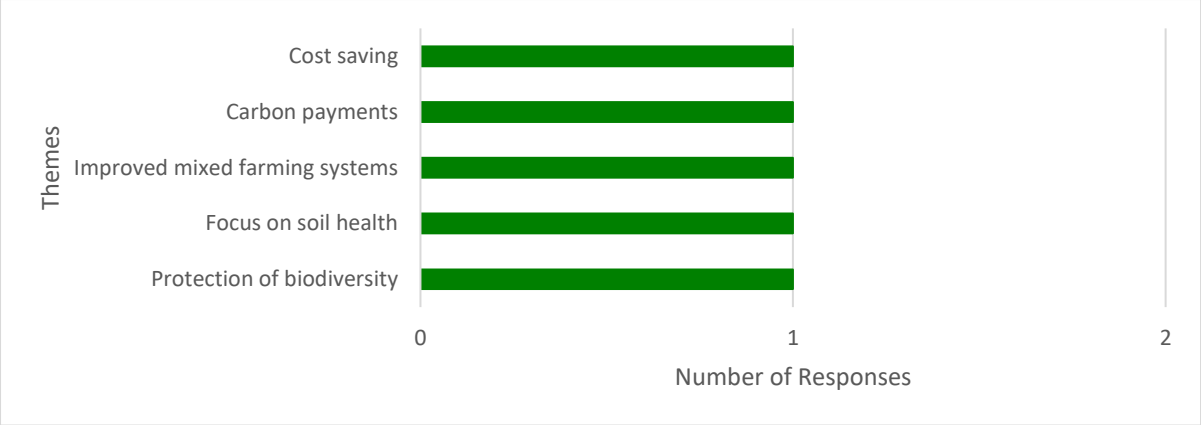

Figure 30: Common themes relating to 'What are the benefits and opportunities within regenerative agriculture?'

Figure 30 presents the Standard setter responses to question 'What are the benefits and opportunities within regenerative agriculture?' The figure shows that both participants emphasise cost savings, carbon payments, improvement in mixed farming operations, a greater focus on soil health, and the protection of biodiversity as some of the key benefits to a regenerative system.

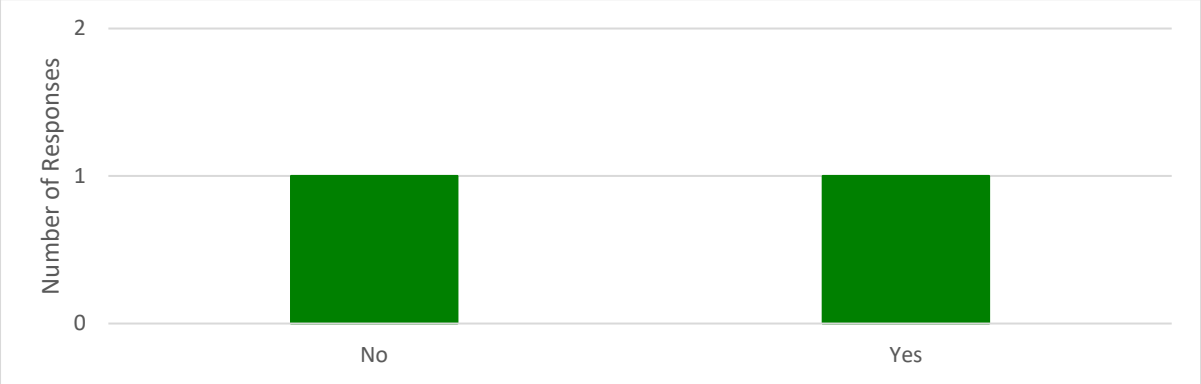

Figure 301: A yes or no response to 'Do you think there is potential for Standards to align with other carbon schemes to work towards shared aims?'

Figure 31 displays the Standard setter responses to question 'Do you think there is potential for Standards to align with other carbon schemes to work towards shared aims?' The figure shows that one participant suggests there is no potential, whilst the other participant notes there is potential to work with other carbon schemes.

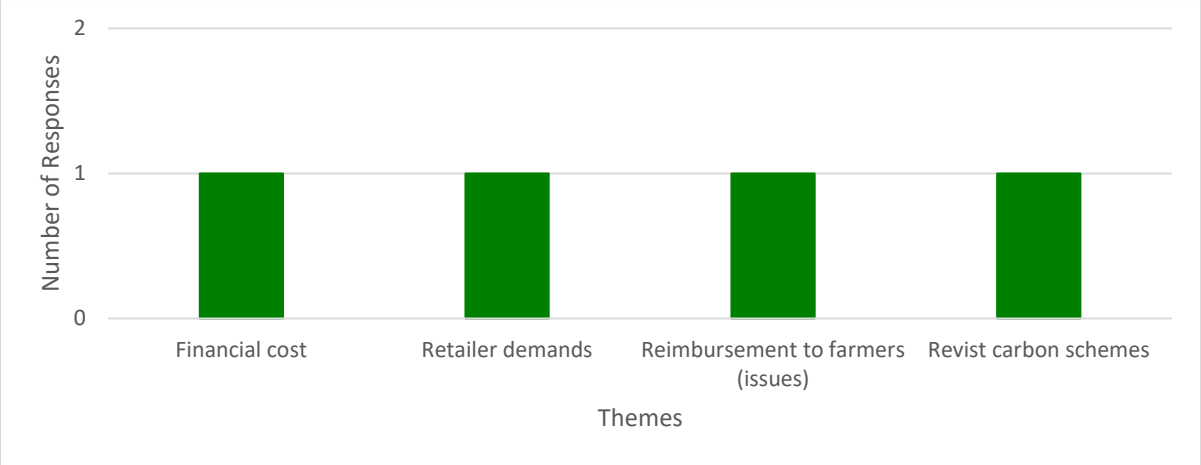

Figure 312: Common themes relating to 'Do you think there is potential for Standards to align with other carbon schemes to work towards shared aims?

Figure 32 shows the Standard setter responses to question 'Do you think there is potential for Standards to align with other carbon schemes to work towards shared aims?' The figure illustrates that the participants suggest financial cost to be a factor that may limit the possibility of working with other carbon schemes. Other themes identified include the dependence on retailer demands, a reimbursement to farmers, and the requirement to revisit carbon schemes.

Drone pilot

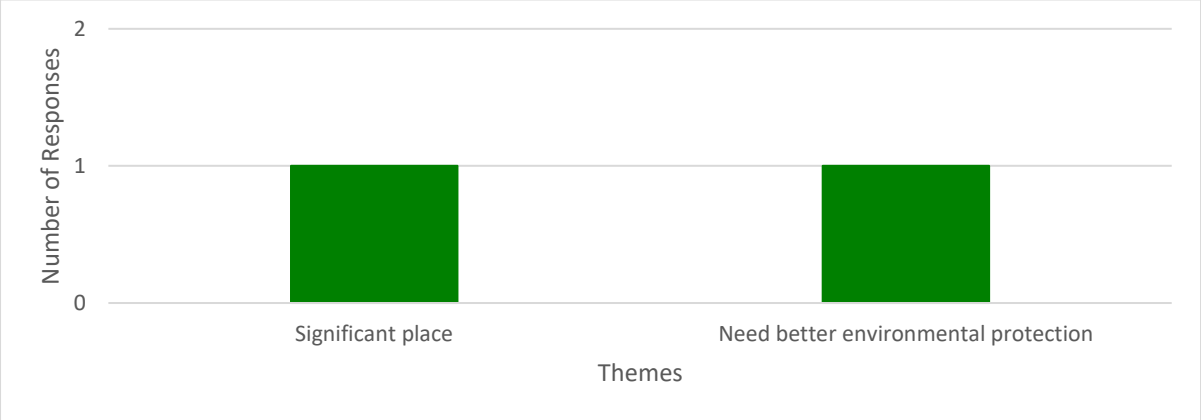

Figure 32: Common themes relating to 'What place does regenerative agriculture have in global food and farming systems?'

Figure 33 displays the Drone pilot's response to question 'What place does regenerative agriculture have in global food and farming systems?' The figure shows that the participant emphasised that regenerative principles have a significant place in farming as there is a need for better environmental protection.

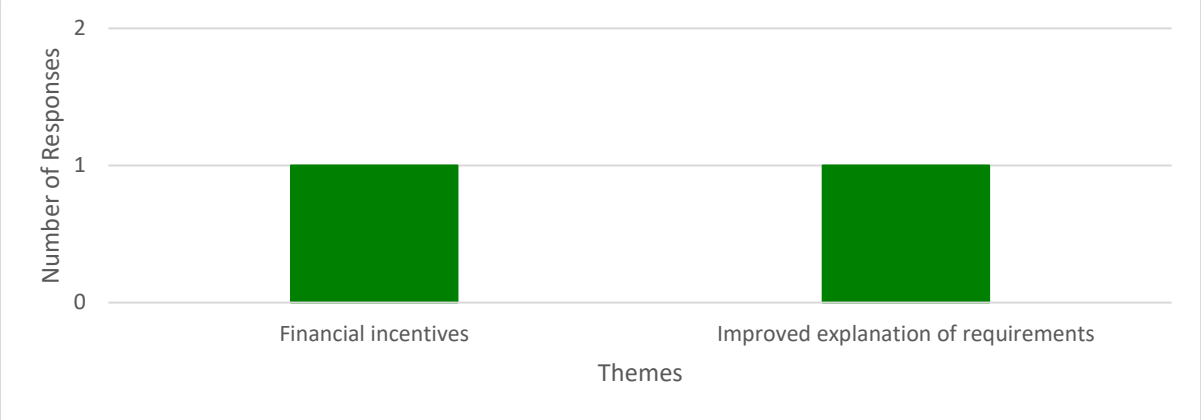

Figure 33: Common themes relating to 'Do you think that environmental Standards could improve their requirements for regenerative practices? If yes, what would you like to see in future Standards?'

Figure 34 presents the Drone pilot's response to question 'Do you think that environmental Standards could improve their requirements for regenerative practices? If yes, what would you like to see in future Standards?' The figure shows that the participant highlighted that financial incentives should be given to producers to encourage the implementation of regenerative principles. Other themes mentioned include the need to improve the explanation of requirements.

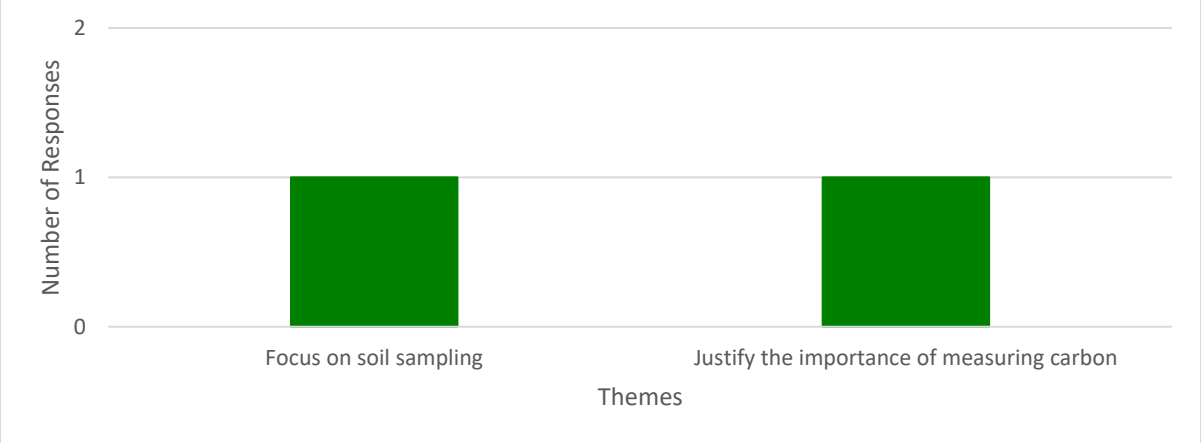

Figure 34: Common themes relating to 'How could Standards improve their Control Points for measuring carbon?'

Figure 35 shows the Drone pilot's response to question 'How could Standards improve their Control Points for measuring carbon?' The figure demonstrates that the participant suggested a greater focus on soil sampling is required. Other themes noted include the need to justify the importance of measuring carbon.

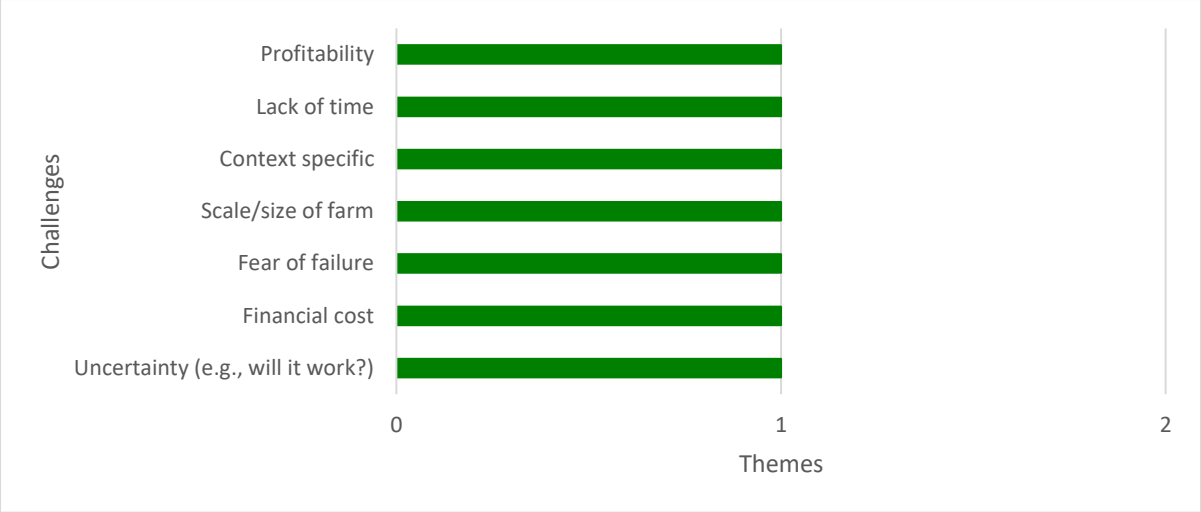

Figure 35 Common themes relating to 'Do you think there are any challenges to implementing regenerative principles within farming practices?'

Figure 36 presents the Drone pilot's response to question 'Do you think there are any challenges to implementing regenerative principles within farming practices?' The figure shows that participant highlighted a range of challenges including the profitability for farmers, a lack of time, context/site-specific, the scale/size of the farm, fear of failure, the financial cost to implementation, and the uncertainty of whether regenerative agriculture would suit the type of farm.

9 Discussion: Section 2

This section highlights some of the common themes each stakeholder group noted during the interview process for the implementation of EO and regenerative agriculture within food and farming Standards. For structural purposes, this section separates the themes by each stakeholder and includes producers, CBs, Standard setters, and the drone pilot.

9.1 Discussion regarding implementation of EO within food and farming Standards

Producers

Mindset has been identified as the most common theme in the Producer interview group and has been shown as a factor in Figure 1, 2 and 3. A progressive mindset is one that is open to new challenges and unique perspectives and so the data suggests that a lack of this approach will be a considerable barrier for uptake of new practices. It was mentioned with regards to both the future of EO and the challenges that it will and currently faces; from this it can be inferred that mindset will consistently be an issue in the use of EO. Within the interviews, it was mentioned that farmers are quick to disregard practices that do not produce tangible results, which leads on to the issue surrounding actionable data collection.

As a stakeholder group, farmers are focused on tangible change, which is needed to be a deliverable of EO for increased uptake. Figure 1,2 and 3 all show the requirement for EO to provide actionable data, whether that is through future developments or to address current issues, as there is a wider concern that EO does not provide financial benefits through the collection of actionable data. This risk is poor incentivisation for uptake as few farmers will engage with the technology, and even less will continue to use the product if no value is added to their operation, identified as cost/benefit relationship in Figure 2. It was identified in the literature as the communication gap between researchers and farm level prevents useful data being collection and fed down to the farm level. Accurate data collection was also raised as an issue (Figure 2), as Producers have already known inconsistencies to have arisen with current methods of EO.

Data ownership and privacy issues was brought to attention in Figure 3, with concerns regarding data sharing and privacy invasion. This was mentioned five times by the stakeholder groups, showing considerable concern amongst interviewees.

EO is considered an abstract concept as there was confusion about what EO is and the practices covered (Figure 1). Friction from the lack of understanding, combined with mindset issues as set out previously, are enough for a large number of Producers to reject EO altogether. Leading on from this, there is a knowledge gap between user and non-users and a perceived inability to close or reduce the gap.

Greenwashing was a theme in both Figures 2 and 4. It was linked in Figure 2 to the concept false action, when no action results from the data collected on farm, but a perceived action is in effect because steps have been taken to collect the data. Further greenwashing was mentioned surrounding carbon credits, and effects on the consumer. There is an increasing

risk in carbon credits becoming a purely commodity-based market, and there was a large amount of scepticism from Producers as to the carbon credit market due to a perceived lack of understanding.

Certification Bodies

CBs found clear themes when discussing auditing using EO. Figure 5 shows a concern with the purpose of EO data collection and how this is translated to the farm context, leading onto a concern with the technical ability to audit substantial amounts of data. CBs suggested that EO focus can be too abstract and can lose focus on the intent of the data, which increases the difficulties when auditing due to a broad range of views. CBs also mentioned during the discussion of Figure 5 that EO may not apply to all farming contexts and therefore will be needed to cover a vast range of scopes and practices, loosing focus on the details.

Accuracy was a theme identified in Figure 5 and 6 by auditors. There is a credibility risk for audited data and concerns were raised surrounding this issue. There was also discussion around the issues of rapid technological advancement (Figure 6), as this would results in changes in method and make long-term data collection inconsistent. To further this, there was suggest that technology advancements could result in negative effects, with producers becoming too focused on data collection for specific farming parameters, rather than looking for future developments on practices.

CBs identified the greatest benefit from EO was the intention of the data collection (Figure 7), which is correlates to data insights and trend tracking. Purposeful data provides value in agricultural practices to supply oversight and tangible evidence of change. Whilst agriculture needs evidence of positive trends, it is important that the inclusion of EO is economically viable, and it was suggested for increased up take, there was a practice/reward system that tracks changes and good practice in exchange for monetary value.

Figure 8 portrays the amount of scepticism within CB's regarding the use of carbon credits. This is mirrored in the themes found by the producers regarding greenwashing and a lack of understanding of the market. It was thought that the carbon market is becoming a purely money-making schemes and a strong feeling regarding consumers buying power being influenced by greenwashing using carbon credits.

Standard setters

Concern was expressed at including EO in environmental Standards due to cost (Figure 9). There was a consistent feeling that by making EO mandatory, Standards risk discriminating against low socio-economic groups, and removing a substantial portion of their customer base, making their own business financially unviable. As was previously discussed, EO is not applicable to every farming system, therefore there is a cultural issue of forcing westernised ideals and practices onto a global population.

Consistent with other demographics, Standard setters voiced their concerns about actionable data (Figure 9). The consistency of this theme across all interviewees strongly implies the knowledge and understanding gap that separates users and non-EO users. Again, data ownership and privacy has been mentioned consistently, which is a cultural reflection of the 21st Century.

Technical skills and breadth of technical knowledge was a strong theme in Figure 10. The breadth of knowledge needed to write Standard parameters is extensive and therefore a challenge for those looking to include it. The feasibility of such a venture would require careful consideration.

Intangibility of the carbon credit market was commonly mentioned by Standard setters (Figure 12), suggesting a lack of understanding. This was further supported by an idea that carbon credits encourage focus on the wrong aspects of both agriculture: too much focus on carbon, and the way the market is structured: too much focus on commodity exchange. Greenwashing, consistent with other demographics, was again said to be a negative factor in carbon credits.

An alternative view was the connection carbon credits creates, between the consumer and the supply chain, and the potential for adapting the mindset of both the consumer and the producer into considering their purchasing and producing power in the mitigation of climate effects and personal carbon footprints. Research benefits were also suggested to be a benefit to EO by measuring climate change and tracking trends (Figure 11).

Drone pilot

To gain a round view of the EO stakeholders, a Drone Pilot was interviewed to understand application of the technology. Challenges identified followed a similar course to the other demographics groups, with mindset and actionable data being the two leading themes (Figure 13), closely followed by the cost/benefit relationship. It was noted that mindset presented a considerable barrier to the uptake of technology by farmers, crossing over with the opinions of the producers. Another crossover was the quick disregard that has been witnessed of farmers discarding products due to increased friction that reduces their understanding and usage of the tool, or if the tool does not produce tangible results, or financial benefits. It is interesting the consistency of these barriers and that it has been shown across the chain.

The done pilot identified changes in mindset as being the future of EO (Figure 14). It was stated that progressive and technologically driven farmers are already involved in EO and those with more friction towards the process, employ the second generation to feedback the actions required.

It was made clear that EO applies to a variety of circumstances, often being used in water and construction companies with trend mapping being used for environmental monitoring. There is an increasing drive from the consumer for greater transparency in the supply chain. Data ownership was mentioned as a tricky barrier to navigate with certain customers (Figure 13), as there is a great deal of privacy desired in certain practices.

As with the other demographic groups, confusion was consistent surrounding carbon credits (Figure 15). A lack of understanding of the market was clear and the concern of it becoming solely a commodity base market was apparent. There was also mention of the consistent theme of greenwashing that carbon credits bring with it and the potential for poor practice off-set being a constant factor.

9.2 Discussion regarding implementation of regenerative agriculture within food and farming Standards

Producers

As shown in Figure 16, a common theme discussed by producers is the need to enhance requirements for soil health. Of the interviews, there was a total of two responses that suggested all environmental Standards should include strengthened requirements regarding the protection and enhancement of soils. It should be noted that several of those participants also highlighted that there should be an improved focus on increasing the % of SOM on farm. The responses obtained are particularly interesting given the current challenges producers are facing with food production. According to the FAO (FAO, 2005) healthy soils are 'the foundation of the food system' and are prerequisites for robust crop production and a sustainable future for farming. Soil is also a crucial component in mitigating the risks from climate change, and the results from Figure 16 suggest producers have an understanding of those risks, thus protecting soils is at the forefront of their actions.

In terms of measuring carbon, a theme noted throughout is the need for environmental Standards to provide a recommendation for a specific, and accurate carbon footprinting tool, as noted in Figures 17 and 19. It became apparent that during the interviews, producers felt a lack of guidance was a clear factor influencing their ability to measure carbon and other GHG emissions on farm. Of the responses, three producers suggested environmental Standards should provide guidance on the most suitable, and ISO-accredited tool to use. The tool should be independent and context/site-specific. From a LEAF perspective, the carbon footprinting tool should also be globally relevant, as this is a primary factor limiting the ability of LEAF, and LEAF Marque, to provide a single, recommended tool to use. Moving forward, and with the continued advancements in technology, providing a recommended tool could be implemented into environmental Standards, particularly given the concerns surrounding the global increase of GHG emissions, and the subsequent effects these gases have on both the climate and food production.

When asked about the challenges of implementing regenerative practices on farm, producers noted a range of answers, as shown in Figure 20. Of those discussed, a lack of knowledge regarding why and how producers should adopt and amend their current practices was a common theme highlighted. Producers can be a catalyst for change, and this research has shown that environmental Standards should provide additional advice on the importance regenerative practices have within the agricultural industry. In addition to this, financial cost of implementation was another challenge identified. It was clear throughout the interviews that producers felt converting their conventional farm to include more regenerative principles would be too expensive. However, research conducted by LaCanne and Lundgren (2018) discovered that farms with regenerative practices were 78% more profitable than conventional farms as a result of two primary factors: a reduction in input costs and end markets. Other themes discovered include mindset approach and context/site-specific. Producers believe a greater amount of knowledge and education is required to gain a full understanding of the potential benefits regenerative

practices may have on their farm. This was discussed by examining neighbouring fields in order to encourage the uptake of such practices.

Whilst there were various challenges to the implementation of regenerative practices discussed by producers, the benefits of uptake were also noted. The protection of the environment, specifically of biodiversity within and out of the soil was emphasised as a significant advantage, as shown in Figure 21. As the global population continues to rise, a greater amount of land will need to be utilised for agricultural production. In recent years, farmland biodiversity has been under significant threat with reductions in the presence of wildlife as a consequence of intensive, and conventional practices (Gov.Wales, n.d.) However, on-farm biodiversity is critical for ecosystem productivity and function, and this research has discovered that producers recognise the importance regenerative principles have on protecting and restoring flora and fauna. Further to this, another theme identified is the importance regenerative principles have on improving soil health. As previously discussed, producers believe a greater focus is required for environmental Standards to incorporate further requirements regarding soil management and fertility. It should also be highlighted that a reduction in the dependence of agrochemicals was mentioned as a benefit by two responses, as is the potential for more carbon capture and sequestration.

Certification Bodies

CBs were the second group of stakeholders interviewed as part of Section 2 for this research project. As part of improving the requirements for regenerative principles in environmental Standards, CBs noted a greater focus on soil health was required, as shown in Figures 22 and 27. Included within that, one response also highlighted the need to strengthen Control Points surrounding the % of SOM. Participants emphasised the significance SOM has in improving the soil's capacity to store and supply essential nutrients, allowing soils to cope and recover from the change in weather events. In fact, research by LaCanne and Lundgren (2018) found that the increase in SOM within their research increased the diversity of insects found in the soil. Further to this, it has become apparent that due to the close working relationship, CBs are aware of the significance a producer's role has in maintaining soil health and fertility to support the increasing demand for global food production.

In contrast to the producers' response, CBs suggested that environmental Standards should not provide a single recommended carbon footprinting tool to measure carbon, as shown in Figure 23. Participants noted that continued research and development are needed to support the implementation of each tool for Standards to ensure farmers are accurately measuring carbon emissions. Further to this, one response also discussed the global utilisation of the tools, including whether the technology needed to measure carbon is accessible worldwide. Despite this, CBs also noted that retailer demands will encourage the uptake of carbon footprinting tools, and so would depend on their obligations.

When asked about whether regenerative agriculture has a place in global food and farming systems, one participant noted that it holds a significant place, implying that it is the 'right thing to do' with the current concerns surrounding soil degradation and the subsequent loss of productivity, as shown in Figure 24. The Green Revolution was discussed as a cause for the overuse of agrochemical applications and the start of intensive farming, from which both participants agreed regenerative practices would allow producers to move away from the increased dependence. However, to encourage the uptake of principles, CBs

emphasised that environmental Standards should be flexible in their requirements as whether practices would be suitable is dependent on the context of the farm. This is a theme also highlighted by producers in their interviews.

Throughout the interview, CBs discussed the range of benefits associated with the uptake of regenerative principles, as noted in Figure 25. A major theme highlighted is the reduced reliance on agrochemical applications, as previously discussed. Both participants agreed that producers would be able to minimise their utilisation of fertilisers, and pesticides on farm. However, whilst conventional farms generally experience higher yields (LaCanne & Lundgren, 2018) producers could benefit financially because of decreasing expenditure on fuel and chemical inputs. Other themes communicated include fewer food miles, and the change in consumer behaviour though there is no research supporting this statement so cannot comment on whether this is verifiable.

Another question asked was whether CBs believe there are challenges with auditing regenerative principles. A reoccurring theme throughout the answers continues to be the dependence on retailer demands, as agreed by both participants in Figure 26. This suggests that retailers have a particularly powerful and crucial role in the food and farming system, and in this case, with how CBs are able to audit regenerative practices. Other themes discussed include the difficulties associated with different farm contexts. Again, this has been highlighted by producers as a specifically important challenge, with participants noting that a greater amount of education is needed to support producers in the uptake of regenerative agriculture. In addition, CBs also suggested that financial incentives may encourage producers and would be crucial to incorporate into environmental Standards.

Standard setters

Another crucial stakeholder group as part of this research were Standard setters. When asked whether there is a need to implement more regenerative practices within environmental Standards, both participants agreed as noted in Figure 28. Despite this, a range of challenges were mentioned including how 'regenerative' farming is defined, and whether the concept is fully understood by producers (Figure 29). In fact, due to regenerative agriculture being used interchangeably with concepts such as agroecology and conservational agriculture, research has found that the term is often challenging to define (Gov.Wales, n.d.); (Schreefel, Schulte, de Boer , Pas Schrijver, & van Zanten, 2020). Thus, both participants noted that a greater amount of guidance is required by Standard setters in order to support producers in implementing regenerative principles on their farm. In addition to this, another reoccurring theme also noted by participants is that Standards should consider the site-specific requirements of each farm, and that it would not be appropriate to include 'Essential' requirements for producers to adhere to.

Whilst there were various challenges associated with implementing regenerative principles within environmental Standards, the benefits were also discussed in detail as shown in Figure 30. Many of the themes highlighted coincide with those noted by producers and CBs. For example, improvements to the environment, particularly to biodiversity, was an important point raised by both participants during the interview. Not only this but emphasis on soil health was incorporated into the discussions and how improvements could allow for a combination of environmental benefits as well as a guaranteed income stream from carbon capture and storage. For example, according to research by Schreefel

(2020), not only did regenerative agriculture enhance soil biodiversity, but the principles also improved soil carbon sequestration. In addition to this, both participants emphasised the importance of incorporating the five core principles on farm: do not disturb the soil, keep the soil surface covered, keep living roots in the soil, grow a diverse range of crops, and integrate grazing into the system (Groundswell, 2022).

As shown in Figures 31 and 32, there was a contradiction between participants regarding whether there is potential for environmental Standards to work with carbon schemes on sharing aims. A similar theme throughout this research has been that it would depend on retailer demands, as noted by one participant. Other themes mentioned include the financial challenges associated with collaboration and the potential requirement to reimburse producers for their commitment towards carbon capture and storage.

Drone pilot

The final stakeholder interviewed for this research was a drone pilot, who has a good understanding of the technological advancements required for not only the implementation of EO but also for regenerative agriculture. Whilst the questions asked differed slightly from the previous groups, the themes throughout remained the same. Regarding whether there is a place for regenerative principles within food and farming Standards, the participant agreed that there is, noting that farming must move away from conventional practices towards more sustainable, and environmentally friendly alternatives such as regenerative principles. In fact, 'better environmental protection' was mentioned as a response to this question. It is clear to see that damage and loss within agriculture can be assessed through the use of drone technology.

When asked whether environmental Standards should improve the requirements for regenerative practices, the participant agreed, however, noted to encourage the uptake of principles, Standards must provide financial incentives, as shown in Figure 34. Converting to more environmentally friendly practices would result in losses on farm, particularly towards crop yields, as also found in research by LaCanne and Lundgren (2018). On the other hand, the long-term benefits associated with transitioning were also highlighted including improved soil health and enhanced on-farm biodiversity. A further point raised was that producers should be offered additional guidance, particularly towards what Standards require of them. It was noted that the language used in environmental Standards is often challenging and could be made more user-friendly, which, would increase the likelihood of uptake from producers.

In terms of measuring carbon, the participant highlighted that a greater focus on soil sampling should be raised within environmental Standards, and includes justifying why measuring carbon is important, as shown in Figure 35. It has become apparent throughout this research that there is currently a lack of information regarding why carbon is important and what producers could gain from capturing and storing carbon. This could be a potential area for improvement for the future development of Standards, particularly as carbon is becoming a more prevalent issue within society and policy.

As noted in Figure 36, there were various challenges mentioned associated with the implementation of regenerative agriculture. Profitability and the financial cost of transitioning was discussed as a primary challenge for producers globally. Further to this, time limitations were also highlighted, and as producers are having to adapt to changes

in both the climate and environment, these issues could become more of a concern. As a result of these challenges, the drone pilot also noted that producers feel a lack of certainty and fear of failure, which are preventing them from carrying out regenerative approaches. Other themes noted include the size and scale of farms and that each farm is different, and that what regenerative practices work on one farm may not work as well on the other.

10 Conclusion: Section 2

The results from the interviews suggest that there are a considerable number of issues surrounding further uptake and implementation of EO in agricultural certification. The opinions from Standard setters and CBs indicate there are significant challenges that present a large cost barrier, such as acquiring the technical knowledge required to develop EO-based Standards and the difficulty auditing EO data to ensure accuracy and reliability. This cost is related to the time and money that would be required to expand the technical knowledge of the teams involved, as well as the increased demand for resources to take on an expanding workload. It was communicated that this would also isolate a large proportion of producers who, due to a variety of circumstances, may be unable to use EO. These barriers are too great at this current period for EO to be used in environmental Standards. Producers also raised concerns regarding cost/benefit of EO, actionable data and privacy issues, as well as producer mindsets for uptake and use of EO. Producers are often extremely price sensitive, and only undertake new initiatives once they understand the financial return. These challenges need to be addressed before EO can be further implemented into agricultural certification. The benefits identified by stakeholders include the use of EO in research practices and trend mapping, and in monitoring climate change and resulting global effects.

When reviewing the responses for regenerative agriculture, there was a general agreement amongst all stakeholder groups to include more regenerative principles in environmental Standards. As discussed, there were a range of common themes that all participants shared and agreed upon, particularly regarding the challenges and benefits to implementation. Throughout the research, a lack of knowledge was emphasised, and participants agreed there needs to be improved communication between producers and Standard setters as well as providing further guidance to support the transition from conventional practices to more environmentally friendly approaches. Participants felt that regenerative principles were also context/site-specific and would require trial and error, which would result in possible financial losses to the producer. Thus, as a result, participants argued that financial incentives should also be included within Standards to encourage the uptake by producers.

Whilst there were a range of challenges, the benefits of adoption were also discussed, and similar themes were noted between the stakeholders. A greater focus on soil health, particularly with respect to the % of SOM was emphasised as important to include within environmental Standards. This ensures protection of not only the environment but also of biodiversity in and out of the soil. Many highlighted that on-farm biodiversity is critical for ecosystem productivity and function, as well as the potential to sequester carbon, which could be used as a source of income. Other benefits noted include the reduced dependence on agrochemical and fuel use which coincides with an array of financial savings.

Where stakeholders differed included the use of a carbon footprinting tool. Producers argued there should be a recommended tool advised by the business. This would then allow greater uptake for measuring and sequestering carbon. However, in contrast, CBs agreed the range of tools noted by LEAF Marque were sufficient as a single tool may not be internationally relevant. Overall, the points raised by both producers and CBs with regards to this question should be taken into consideration moving forward.

11 Synthesis

Findings from Sections 1 and 2

Throughout this research, there have been a range of discoveries and conclusions. Section 1 reviewed existing regenerative Standards current inclusion of, and engagement with, carbon sequestration, whilst Section 2 examined the potential for Standards to include requirements on carbon thorough remote verification, as well as the potential to include greater requirements on regenerative practices.

The findings from Section 1 concluded that all Standards differ in what is considered and required as regenerative agriculture. Some of the Standards analysed corresponded to the five core principles of regenerative agriculture (see Chapter 5 'Discussion'), however, the majority did not align. Agroforestry, reduced or no tillage, retaining crop residues and the inclusion of perennial crops in crop rotation were stated as being significant crucial practices to support carbon sequestration in a changing climate. Research also found that restoring and maintaining soil fertility is important and can be achieved by implementing the range of recommended regenerative principles.

The results from Section 1 also noted a clear lack of discussion about the use and implementation of EO in environmental Standards. As stated by GOV.UK (2022), many mature UK businesses continue to adopt EO technologies but there is a lack of understanding amongst organisations, including assurance schemes. In addition to this, there appears to be a range of barriers to implementation, as also found in the interviews, of which included perceived high data cost, understanding the tool and platform capabilities, gauging technological possibilities, and establishing a case for investment with many organisations questioning whether it is worth adopting EO.

Similar to the findings in Section 1, the results from the interviews as part of Section 2 concluded there were a considerable number of issues surrounding the uptake and implementation of EO in agricultural certification schemes. All stakeholders noted that limited technical knowledge, difficulty of auditing, accuracy and reliability, and the financial cost are major barriers to adopting EO. It was discovered that such barriers are, at present, too great and that the challenges need to be addressed before EO could be implemented within the certification agriculture, whether that be by a producer, a CB, or a Standard setter. Though the issues were noted, the benefits were also discussed and included the importance EO has in trend mapping, particularly with regards to monitoring climate change.

Further to this, it was discovered through the interviews about regenerative agriculture that there was a general agreement that more Control Points are required in environmental Standards. However, stakeholders believe there is a current lack of knowledge and supporting guidance around implementation and that improved communication between producers and Standard setters is needed. Participants also agreed that regenerative principles are context/site-specific, and adoption would require trial and error which could potentially result in large financial losses. Therefore, financial incentives were discussed by producers to encourage greater uptake. On the contrary, stakeholders also recognised the range of environmental benefits regenerative principles hold on-farm. Protection of biodiversity was the primary benefit discussed, as well as improving the health and fertility

of soil. Other opportunities included carbon sequestration which could be used as a long-term financial gain.

Limitations and Suggestions for future research

i. There were limitations with the methodologies used to undertake the research in the project. The demographic group sizes for the interviews were limited to five producers, two CBs, two Standard setters, and one drone pilot. Additionally, there was only one female participant. It was challenging to gain engagement from all these groups due to the time constraint and it was mentioned by one Standard setter that there was a concern about plagiarism when initially contacted by LEAF for AgriCapture. Further, these participants were accessed only through the LEAF network, which limited the range of stakeholders the research could engage with. Thus, future replications of this research would need to access a wider community of stakeholders to gather a greater variety of opinions. It is also recommended that future research utilise larger participant sample sizes to ensure the results are robust and representative of the different stakeholder groups.

ii. As a suggested improvement, the research would allow more time for data collection, which could enable a greater number of interviews across a large proportion of the production systems. There would also be a greater global representation to increase the varieties of opinions and views from different work production types. The research focused on the UK, within scope of LEAF network's reach, but could further be enriched with input from other countries. For the purposes of this document, the research complemented desk research and enriched our assessment beyond initial requirements, and a European-level approach was beyond scope of the work.

iii. Also, the research would ensure an equal amount of male and female participants which would create a fair and honest result.

iv. Another limitation was the lack of capacity to investigate in greater depth the challenges to integrating EO into assurance schemes that were discovered during the research. This was briefly discussed earlier but a secondary study would be beneficial to explore this further; there are clearly some significant barriers such as technical skills and understanding that need to be addressed.

v. During the interviews, there were occasions when participants gave answers to multiple questions. For example, participants would answer both the challenges and benefits of EO within a single question. Whilst this information was needed, it didn't follow the layout of the questions resulting in additional work to be carried out by the team. To avoid this, a pre-survey could be carried out to gain prior knowledge of the participants understanding of EO and regenerative agriculture. This would also reduce the time spent explaining both topics beforehand.

12 Potential options for a European Regenerative Agriculture Certification

A European-, global-, or indeed widespread regenerative agriculture certification scheme would require a generally accepted definition of regenerative agriculture across geographies and across the value chain: from farmers through to retailers and to consumers.

This is far from reality at present. There are different interpretations of what constitutes regenerative agriculture, and there are differences in the methodology to define it. For example, AgriCapture has used an approach-based definition as stated earlier. We have seen these differences first hand in interacting with regenerative stakeholders from different countries. For example: some attach great importance to integration of livestock and plant production systems while others do not; there are differing attitudes towards use of chemical pesticides and other agricultural practices.

A clear definition is a prerequisite to establishing a robust and widely applicable/accepted certification scheme. Ambiguity is a barrier and creates the potential for malfeasance and misunderstandings. Efforts have been made to develop a common definition, which is discussed in the literature and will not be repeated here, Newton et al (2020). Nonetheless, 'producing with nature' does require some flexibility as it will result in local variability depending on the type of agriculture, socio-economic conditions, and indeed agro-ecological conditions. A definitive reference should be available to distinguish between regenerative and non-regenerative systems, which establishes clear differentiations between the two definitions.

12.1 Possibilities for a voluntary European regenerative agriculture certification framework

It is important to understand the wider context of certification and the logistics of implementing a uniform global Standard. A European Regenerative Agriculture Regulation/Standard, against which businesses could be certified and is coordinated at an EU level requires significant demand for such an initiative to be developed and implemented. Demand in areas such as resources, governance and engagement from Member States and privately owned organisations engaged in regenerative certification, must arrive at a harmonised definition suitable to be implemented via a common standard or regulation. Given that certification of regenerative agriculture is currently carried out solely within the private sector, and despite a shared objective to use regenerative practices, the interpretation, organisational prioritisation of impacts, and commercial sensitivity of the certification market all present challenges to achieving a harmonised Standard. Whilst there are opportunities for cooperation and equivalence between Standard organisations, this requires a high degree of coordination and continual review Standards are developed over time.

Existing schemes can develop "add-on" regenerative labels with additional requirements to their existing Standards, such as the Rodale institute's; an organic plus regenerative certification in the United States. Also, it is likely that new regenerative schemes (or those

reflecting regenerative principles) will emerge from existing or newly established organisations.

Given this paper's focus on the European level, the geographical scale of a potential European regenerative agriculture scheme is important to consider. Current schemes are largely limited to the regional/national level. Specifically, the market where certified products are sold is regional/national even for schemes that have certified farmers located in other countries.

A leap from national to European level is considerable; what are the enabling factors for it to happen? To the best of our knowledge, there is currently no initiative to generate a European regenerative agriculture certification scheme, and we can only hypothesise about possibilities and assess their potential.

The first option would be for a single organisation to scale its scheme into different European markets. Such an organisation could define regenerative agriculture on their own terms, likely reflecting commonly accepted regenerative principles to facilitate cross-border adoption. However, general barriers to scaling in the Single Market are sure to apply (i.e., different languages, different work cultures, different consumer preferences, different legal frameworks, etc.) and be further compounded by agrifood specific challenges, such as the sheer volume of farmers to be reached, high average age of farmers, etc. Any such effort would face a trade-off between simplicity for all stakeholders involved and the robustness of verification. The trade-off will grow sharper at larger scales as the link between the lead organisation and individual participants stretches thinner.

Another option would be for a collaborative approach. Relevant organisations on a regional/national scale could collaborate to establish common guidelines and principles, similar to the initial role of the International Federation of Organic Agriculture Movements (IFOAM) for organic agriculture. A sufficient overlap in principles and quality assurance methodologies could allow for mutual recognition between schemes, e.g., allowing for certain agrifood products under one scheme to have a simplified process to be certified by another scheme. Such an arrangement could move towards a common label overtime, superseding or complementing existing labels, especially if the intensity of collaboration and the number of collaborators increases.

However, the factors of interest and initiative are key to consider in the realm of possibilities; it is hard to imagine that established organisations currently facing growing markets will recognise such complex arrangements as a priority. A collaborative platform similar to IFOAM would likely prove to be a prerequisite to enable this distant scenario.

Could technological tools help? In principle, yes.

The services developed by AgriCapture can be used to remotely verify multiple regenerative claims with high accuracy regardless of location.

However, to translate this potential into a reality would (particularly for a new Standard) require a significant effort to reach users, which would have to be linked with clear and enticing benefits for participating farmers, have interoperability with existing farm management tools to avoid the need for multiple data entry, and be promoted/supported by local organisations with existing networks in the agricultural sector. Also, as shown in

Table 2, as an example, EO-based tools can only address some control points and would not be able to replace/improve other key processes.

Once again, the issue of interest and initiative are important to consider. Establishing such a technology-based European scheme would likely look much like establishing a new regenerative scheme, and technology would not help in addressing the large market barriers (as discussed above) that such an initiative would face.

Integrating EO technology to increase the potential scalability of an existing Standard would also be a theoretical option. However, revising a Standard follows a certain process.

The best practice quality parameters applying to certification of products are implemented globally via ISO17065:2012 which guides certification bodies (CBs) on competence, consistency, transparency, and impartiality and require assessment and accreditation by National Accreditation Bodies. Conformance and accreditation with ISO17065 requires the applicable certification standard to carefully consider its content and how compliance is verified, as well as requiring significant resource and financial costs for CBs.

As part of developing the Standard, LEAF Marque work alongside members from a diverse range of backgrounds in a Technical Advisory Committee (TAC) that oversees the ongoing development of the LEAF Marque Standard. Within the committee, there are producers, market-facers (e.g., retailers, brands, processors), environmental and industry expertise, and permanent observers (e.g., UKAS, CBs) however, permanent observers do not have decision and voting rights. Also influencing the LEAF Marque Standard is the feedback received from stakeholders during the Public Consultation. The Public Consultation is carried out to ensure all stakeholders have sufficient time and opportunity to provide input on revisions of the Standard, and ensures stakeholders see how their input has been considered.

Before reviewing the stakeholder responses, it is important to state what is meant by the technicality of quality assurance. From a LEAF Marque perspective, the Standard is revised every 3 to 5 years to keep up to date with scientific research and industry concerns. As of the 1st October 2022, the v16.0 LEAF Marque Standard was published and became effective as of the 1st April 2023, giving businesses 6 months to adapt their farming practices to meet the modified requirements.

For a Standard to revise their quality assurance to permit some EO-supported processes, they would ultimately have to present strong proof to National Accreditation Bodies that the new process results in better quality assurance model for the Standard, after they have addressed all other procedural requirements outlined above – this work entails a significant effort and is beyond the scope of the AgriCapture project.

12.2 Possibilities for European regenerative agriculture standards defined by regulation

There has been little movement in the direction of legislating regenerative agricultural Standards at the European or the national level, and in the practical sense this remains a distant possibility in the current climate.

It is useful to examine the parallels with organic agriculture. Modern organic agriculture has a long history of around a century, starting out initially as a holistic agricultural approach to promote healthier soils, food, and people. Specific practices and protocols were developed and promoted by multiple organisations in multiple countries. Unlike other 'sustainable' agriculture movements (e.g., conservation agriculture), organic agriculture has a strong appeal to consumers on important concerns relating to food safety and quality, providing a strong 'marketing' edge that could help foster higher farm gate prices for farmers.

The EU's organic control system completed a transition from being governed by privately owned organisation to being embedded in EU regulations at the beginning of the 1990s, following the growing consumer interest and market mainstreaming in the 1970s and 1980s. The organic regulations and the control system are overseen by the European Commission (EC) with the broad objectives of ensuring Member States fulfil their responsibilities, building consumer trust and knowledge of the robust inspection process regardless of the origin of a product labelled as organic. Alongside products grown within the EU there is a strict system in place to control the market access of products labelled as organic which have been produced in countries outside the EU.

There are advantages and disadvantages to legislating regenerative Standards. Organic Standards were legislated to provide a reliable reference for market claims facing consumers, smoothing over differences between voluntary schemes and non-certified claims. On the other hand, rigid Standards can be reductionist or restrictive, preventing evolution of prevalent practices.

In contrast, a voluntary approach-based certification is more conducive to farmer transition as a long-term learning process, with less "dos and don'ts" and more of a "whole picture approach", similar to LEAF Marque.

Regenerative agriculture is (still) largely perceived a holistic approach, aiming to develop and harness natural capital for agricultural production. Although regenerative agriculture claims are hard to verify and enforce without a clear definition and standards, a legislative intervention faces significant trade-offs linked to climate and environmental impact.

There are other options for government action. Governments can support local regenerative ecosystems to further develop their knowledge and tools (e.g., regenerative protocols, new varieties, digital tools, etc.). They can also reorder agricultural subsidies to incentivise implementation of proven practices for different farming contexts and/or desirable results. There is also a significant role for methodologies and tools for effective monitoring, reporting, and verification; government innovation procurement/pre-commercial procurement or other mechanisms can help accelerate their development.

If indeed the regenerative movement is to be harnessed to transform mainstream agriculture, public bodies should contribute to growing local ecosystems involving researchers, businesses, advisors/experts, and civil society organisations. It is such a joint approach that can define what "producing with nature" means in different farming contexts and help to make these approaches both feasible and desirable for farming communities.

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14 Appendices

Stakeholder Interview Schedule: Producers

To Do:

Prior to the interview send a summary document of AgriCapture, the 5 core principles of regenerative agriculture and the v15.0 LEAF Marque Standard to all participants.

Objectives:

(1) To make a feasibility judgement regarding the inclusion of EO in regenerative and environmental Standards through stakeholders in the food supply chain.

(2) To explore how the LEAF Marque Standard can improve its regenerative approaches with specific focus towards carbon Control Points and the barriers and opportunities of implementation.

Demographic Questions	
What type of farming organisation do you work for? (e.g., arable, livestock)	
How long have you been a producer?	
Which assurance schemes does your farm use?	

Questions relating to Earth Observation (EO)
Develop an understanding of the challenges and uses of Earth Observation, and opinions of carbon credits.

Provide background: Earth observation (EO) is the gathering of information about the Earth's physical, chemical, and biological systems. It involves monitoring and assessing the status of, and changes in, the natural and man-made environment.

In recent years, Earth observation has become more sophisticated with the development of remote-sensing and increasingly high-tech 'in-situ' instruments. At present, Earth observation instruments include, but are not limited to:

- Floating buoys – monitoring ocean currents, temperature, and salinity
- Land stations – record air quality and rainwater trends
- Sonar and radar – estimating fish and bird populations
- Seismic and Global Positioning Systems (GPS)
- High-tech satellites

Earth observation (EO) systems are invaluable for assessing and mitigating the negative impacts of human civilization. They can also be used to exploit new opportunities, such as the sustainable management of natural resources. Some specific examples of where EO is included are:

- Forecasting weather
- Tracking biodiversity and wildlife trends
- Measuring land-use change such as deforestation
- Monitoring and responding to disasters, including fires, floods, earthquakes, and tsunamis
- Managing energy sources, freshwater supplies, and agriculture
- Addressing emerging diseases and other health risks
- Predicting, adapting to, and mitigating climate change

Challenges

- Do you think there are any challenges to implementing EO within farming practices?
  Prompt: for example, related to cost (high data cost)/actionable data to farm level/understanding of tool/feasibility

- What do you think the future of EO looks like? Do you see it being used in farming?
  Prompt: How will it adapt to the challenges you've highlighted? Do you think it is necessary for the future of agriculture?

Uses of EO

- Do you think there are benefits to using EO?
  Prompt: yields, water management, land use change, biodiversity trends, monitoring and responding to disasters, predicting, and mitigating climate change
- What is your opinion on the use of carbon credits?
  Prompt: Selling carbon credits for profit and in exchange for pollution allowance

Questions relating to Regenerative Agriculture

Review the requirements of the LEAF Marque Standard, establish the challenges and benefits of implementing regenerative principles in farming practices, and understand the opinions of carbon sampling/credits.

Provide background: Regenerative agriculture is a conservation and rehabilitation approach to food and farming systems. It is a holistic land management practice that focuses on topsoil regeneration, increasing biodiversity, improving the water cycle, enhancing ecosystem services, supporting biosequestration, increasing resilience to climate change, and strengthening the health and vitality of farm soil.

Regenerative agriculture is not a specific practice itself, rather proponents of regenerative agriculture use a variety of sustainable agriculture techniques in combination. Agroecology, aquaculture, agroforestry, biochar, compost, holistic-planned grazing, no-till, pasture cropping perennial crops, and silvopasture are some examples of practices used to create regenerative food systems and healthy natural ecosystems.

LEAF Marque Standard (for those that are certified)

- Do you think the LEAF Marque Standard could improve its requirements for regenerative practices? If yes, what would you like to see in future Standards?
  Prompt: cover cropping etc

- How could the LEAF Marque Standard improve its Control Points on measuring carbon?
  Prompt: the use of carbon sampling and implementation on farm

- Do you think there are any challenges to implementing regenerative principles within farming practices?
  Prompt: financial capacity (e.g., cost), knowledge, time, stigmatism (e.g., organic vs. conventional), yield productivity

- What are the benefits and opportunities within regenerative agriculture?
  Prompt: environmental, longevity (e.g., of soil), carbon storage, financial (long-term benefits – e.g., reduced fertiliser costs)

Standards (for those that are NOT certified)

- Do you think the Standards in general could improve their requirements for regenerative practices? If yes, what would you like to see in future Standards?
  Prompt: cover cropping etc

- How could Standards improve their Control Points for measuring carbon?
  Prompt: the use of carbon sampling and implementation on farm

- Do you think there are any challenges to implementing regenerative principles within farming practices?
  Prompt: financial capacity (e.g., cost), knowledge, time, stigmatism (e.g., organic vs. conventional), yield productivity

- What are the benefits and opportunities within regenerative agriculture?
  Prompt: environmental, longevity (e.g., of soil), carbon storage, financial (long-term benefits – e.g., reduced fertiliser costs)

Stakeholder Interview Schedule: CBs

To Do:

Prior to the interview send a summary document of AgriCapture, the 5 core principles of regenerative agriculture and the v15.0 LEAF Marque Standard to all participants.

Objectives:

(1) To make a feasibility judgement regarding the inclusion of EO in regenerative and environmental Standards through stakeholders in the food supply chain.

(2) To explore how the LEAF Marque Standard can improve its regenerative approaches with specific focus towards carbon Control Points and the barriers and opportunities of implementation.

Demographic Questions	
What is the name of the CB organisation you work for?	
How long have you been an auditor?	
What assurance schemes do you audit?	

Questions relating to Earth Observation (EO)

Develop an understanding of the challenges and uses of Earth Observation, and opinions of carbon credits.

Provide background: Earth observation (EO) is the gathering of information about the Earth's physical, chemical, and biological systems. It involves monitoring and assessing the status of, and changes in, the natural and man-made environment. In recent years, Earth observation has become more sophisticated with the development of remote-sensing and increasingly high-tech 'in-situ' instruments. At present, Earth observation instruments include, but are not limited to:

- Floating buoys – monitoring ocean currents, temperature, and salinity
- Land stations – record air quality and rainwater trends
- Sonar and radar – estimating fish and bird populations
- Seismic and Global Positioning Systems (GPS)
- High-tech satellites

Earth observation (EO) systems are invaluable for assessing and mitigating the negative impacts of human civilization. They can also be used to exploit new opportunities, such as the sustainable management of natural resources. Some specific examples of where EO is included are:

- Forecasting weather
- Tracking biodiversity and wildlife trends
- Measuring land-use change such as deforestation
- Monitoring and responding to disasters, including fires, floods, earthquakes, and tsunamis
- Managing energy sources, freshwater supplies, and agriculture
- Addressing emerging diseases and other health risks
- Predicting, adapting to, and mitigating climate change

Challenges

- Do you think there are any challenges with the auditing of EO?

- If implemented, what are the future challenges of auditing EO?
  Prompt: for example, related to cost (high data cost)/actionable data to farm level/understanding of tool/feasibility

Uses of EO

- Do you think there are benefits to using EO?
  Prompt: yields, water management, land use change, biodiversity trends, monitoring and responding to disasters, predicting, and mitigating climate change

- From an auditing perspective, what is your opinion on the use of carbon credits?
  Prompt: Selling carbon credits for profit and in exchange for pollution allowance. Is this accessible?

Questions relating to Regenerative Agriculture

Review the requirements of the LEAF Marque Standard, establish the challenges and benefits of implementing regenerative principles in farming practices, and understand the opinions of carbon sampling/credits.

Provide background: Regenerative agriculture is a conservation and rehabilitation approach to food and farming systems. It is a holistic land management practice that focuses on topsoil regeneration, increasing biodiversity, improving the water

cycle, enhancing ecosystem services, supporting biosequestration, increasing resilience to climate change, and strengthening the health and vitality of farm soil.

Regenerative agriculture is not a specific practice itself, rather proponents of regenerative agriculture use a variety of sustainable agriculture techniques in combination. Agroecology, aquaculture, agroforestry, biochar, compost, holistic-planned grazing, no-till, pasture cropping perennial crops, and silvopasture are some examples of practices used to create regenerative food systems and healthy natural ecosystems.

The five core principles of regenerative agriculture include:

1. Keep the surface covered as much as possible
2. Limit the amount of physical and chemical disturbance of the soil
3. Combine a wide diversity of plants to increase soil biodiversity
4. Keep living roots in the soil for as much of the year as possible
5. Integrate grazing livestock into the system

- What place does regenerative agriculture have in global food and farming systems?

- Are there benefits and opportunities within regenerative agriculture?
  Prompt: environmental, longevity (e.g., of soil), carbon storage, financial (long-term benefits – e.g., reduced fertiliser costs)

- Are there challenges with auditing regenerative agriculture?
  Prompt: financial capacity (e.g., cost), knowledge, time, stigmatism (e.g., organic vs. conventional), yield productivity

LEAF Marque Standard

- Do you think the LEAF Marque Standard could improve its requirements for regenerative practices? If yes, what would you like to see in future Standards?
  Prompt: cover cropping etc

- How could the LEAF Marque Standard improve its Control Points on measuring carbon?
  Prompt: the use of carbon sampling and implementation on farm

Stakeholder Interview Schedule: Standards

To Do:

Prior to the interview send a summary document of AgriCapture, the 5 core principles of regenerative agriculture and the v15.0 LEAF Marque Standard to all participants.

Objectives:

(1) To make a feasibility judgement regarding the inclusion of EO in regenerative and environmental Standards through stakeholders in the food supply chain.

(2) To explore how the LEAF Marque Standard can improve its regenerative approaches with specific focus towards carbon Control Points and the barriers and opportunities of implementation.

Demographic Questions	
What is the name of the assurance organisation you work for?	
How long have you worked within an assurance organisation?	

Questions relating to Earth Observation (EO)

Develop an understanding of the challenges and uses of Earth Observation, and opinions of carbon credits.

Provide background: Earth observation (EO) is the gathering of information about the Earth's physical, chemical, and biological systems. It involves monitoring and assessing the status of, and changes in, the natural and man-made environment. In recent years, Earth observation has become more sophisticated with the development of remote-sensing and increasingly high-tech 'in-situ' instruments. At present, Earth observation instruments include, but are not limited to:

- Floating buoys – monitoring ocean currents, temperature, and salinity
- Land stations – record air quality and rainwater trends
- Sonar and radar – estimating fish and bird populations
- Seismic and Global Positioning Systems (GPS)
- High-tech satellites

Earth observation (EO) systems are invaluable for assessing and mitigating the negative impacts of human civilization. They can also be used to exploit new opportunities, such as the sustainable management of natural resources. Some specific examples of where EO is included are:

- Forecasting weather
- Tracking biodiversity and wildlife trends
- Measuring land-use change such as deforestation
- Monitoring and responding to disasters, including fires, floods, earthquakes, and tsunamis
- Managing energy sources, freshwater supplies, and agriculture
- Addressing emerging diseases and other health risks
- Predicting, adapting to, and mitigating climate change

Challenges

- What do you perceive to be the challenges related to the inclusion of EO within environmental Standards?
  *Start with the current, and then move on to the future
  Prompt: for example, related to cost (high data cost)/actionable data to farm level/understanding of tool/feasibility

- Do you think EO will be included in future versions of environmental Standards?
  Prompt: How will it adapt to the challenges you've highlighted? Do you think it is necessary for the future of agriculture?

Uses of EO

- Do you think there are benefits to using EO?
  Prompt: yields, water management, land use change, biodiversity trends, monitoring and responding to disasters, predicting, and mitigating climate change
- What is your opinion on the use of carbon credits, and do you think it has a place within environmental Standards?
  Prompt: Selling carbon credits for profit and in exchange for pollution allowance

Questions relating to Regenerative Agriculture

Review the requirements of environmental Standards and establish the challenges and benefits of implementing regenerative principles in Standards.

Provide background: Regenerative agriculture is a conservation and rehabilitation approach to food and farming systems. It is a holistic land management practice that focuses on topsoil regeneration, increasing biodiversity, improving the water cycle, enhancing ecosystem services, supporting biosequestration, increasing resilience to climate change, and strengthening the health and vitality of farm soil.

Regenerative agriculture is not a specific practice itself, rather proponents of regenerative agriculture use a variety of sustainable agriculture techniques in combination. Agroecology, aquaculture, agroforestry, biochar, compost, holistic-planned grazing, no-till, pasture cropping perennial crops, and silvopasture are some examples of practices used to create regenerative food systems and healthy natural ecosystems.

The five core principles of regenerative agriculture include:

6. Keep the surface covered as much as possible
7. Limit the amount of physical and chemical disturbance of the soil
8. Combine a wide diversity of plants to increase soil biodiversity
9. Keep living roots in the soil for as much of the year as possible
10. Integrate grazing livestock into the system

Standards

- Do you think there is a need for more regenerative practices Control Points within environmental Standards?
  Prompt: cover cropping etc

- Do you think there are any challenges to implementing regenerative principles within environmental Standards?
  Prompt: financial capacity (e.g., cost), knowledge, time, stigmatism (e.g., organic vs. conventional), yield productivity

- What are the benefits and opportunities within regenerative agriculture?
  Prompt: environmental, longevity (e.g., of soil), carbon storage, financial (long-term benefits – e.g., reduced fertiliser cost)

- Do you think there is a potential for Standards to align with other carbon schemes to work towards shared aims?

Stakeholder Interview Schedule: Drone Pilot

To Do:

Prior to the interview send a summary document of AgriCapture, the 5 core principles of regenerative agriculture and the v15.0 LEAF Marque Standard to all participants.

Objectives:

(1) To make a feasibility judgement regarding the inclusion of EO in regenerative and environmental Standards through stakeholders in the food supply chain.

(2) To explore how the LEAF Marque Standard can improve its regenerative approaches with specific focus towards carbon Control Points and the barriers and opportunities of implementation.

Demographic Questions	
What is the name of the organisation you work for?	
How long have you worked within the organisation?	

Questions relating to Earth Observation (EO)

Develop an understanding of the challenges and uses of Earth Observation, and opinions of carbon credits.

Provide background: Earth observation (EO) is the gathering of information about the Earth's physical, chemical, and biological systems. It involves monitoring and assessing the status of, and changes in, the natural and man-made environment. In recent years, Earth observation has become more sophisticated with the development of remote-sensing and increasingly high-tech 'in-situ' instruments. At present, Earth observation instruments include, but are not limited to:

- Floating buoys – monitoring ocean currents, temperature, and salinity
- Land stations – record air quality and rainwater trends
- Sonar and radar – estimating fish and bird populations

- Seismic and Global Positioning Systems (GPS)
- High-tech satellites

Earth observation (EO) systems are invaluable for assessing and mitigating the negative impacts of human civilization. They can also be used to exploit new opportunities, such as the sustainable management of natural resources. Some specific examples of where EO is included are:

- Forecasting weather
- Tracking biodiversity and wildlife trends
- Measuring land-use change such as deforestation
- Monitoring and responding to disasters, including fires, floods, earthquakes, and tsunamis
- Managing energy sources, freshwater supplies, and agriculture
- Addressing emerging diseases and other health risks
- Predicting, adapting to, and mitigating climate change

Challenges

- From a technological and data point of view, do you think there are any challenges to implementing EO within farming practices?

- What do you think the future of EO looks like, especially from a tech point of view? Do you see it being used to a greater degree in farming?

Uses of EO

- Do you think there are benefits to using EO?

- What is your opinion on the use of carbon credits?

Questions relating to Regenerative Agriculture

Review the requirements of environmental Standards and establish the challenges and benefits of implementing regenerative principles in Standards.

Provide background: Regenerative agriculture is a conservation and rehabilitation approach to food and farming systems. It is a holistic land management practice that focuses on topsoil regeneration, increasing biodiversity, improving the water cycle, enhancing ecosystem services, supporting biosequestration, increasing resilience to climate change, and strengthening the health and vitality of farm soil.

Regenerative agriculture is not a specific practice itself, rather proponents of regenerative agriculture use a variety of sustainable agriculture techniques in combination. Agroecology, aquaculture, agroforestry, biochar, compost, holistic-planned grazing, no-till, pasture cropping perennial crops, and silvopasture are

some examples of practices used to create regenerative food systems and healthy natural ecosystems.

The five core principles of regenerative agriculture include:

1. Keep the surface covered as much as possible
2. Limit the amount of physical and chemical disturbance of the soil
3. Combine a wide diversity of plants to increase soil biodiversity
4. Keep living roots in the soil for as much of the year as possible
5. Integrate grazing livestock into the system

Questions

- What place, if any, does regenerative agriculture have in global food and farming systems?
- Do you think that environmental Standards in general could improve their requirements for regenerative practices? If yes, what would you like to see in future Standards?
- How could Standards improve their Control Points for measuring carbon?
- Do you think there are any challenges to implementing regenerative principles within farming practices?

End of document

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