Knowledge Transfer & Innovation Fund (KTIF) SG Final Report

1. PROJECT TITLE/APPLICANT

FARM CARBON STORAGE NETWORK

SAC Consulting, part of Scotland's Rural College (SRUC), is responsible for the delivery of this project.

SRUC has a long history dating back over 115 years of support to farming and rural industries and is now working towards Enterprise University status. As a large, modern, and multi-disciplinary organisation with over 1300 staff, it has as a concentration of skills and resources that are unique in the UK. It provides advanced education and training, research and development; advisory and consultancy work on an extensive range of subjects but with particular emphasis on the natural economy including food, land and environment, and business management.

SAC Consulting focusses delivery in four key areas: Agriculture and Natural Capital, Land based business diversification, Food and climate change, and Circular Economy – waste and energy. Our rural office network of 25 offices provides advice and services to farmers, crofters and others in each local area, and our Specialist Consultancy teams, provide a national service. Our strengths include our geographic network and our involvement in local communities, our close links and collaborations with key rural organisations, our evidence-based knowledge transfer and a strong track record in delivering successful and innovative projects.

SAC has a identified a core project team with experts in carbon, soils, drone data capture, data analysis and map production and stakeholder engagement to undertake this project.

2. EXECUTIVE SUMMARY

Farmers are increasingly aware of their need to help tackle the climate crisis, through a combination of reducing greenhouse gas (GHG) emissions and increasing sequestration of carbon dioxide on farms. A farm's soils, trees and hedges act as a carbon sink, which can be difficult to quantify, however technology can help us improve the accuracy of these estimated carbon stocks.

The project set out to provide a quantitative value of the farm's natural assets that would benefit their enhancement for climate and biodiversity action, while increasing the knowledge base of farmers, policymakers, and retailers. To achieve this, 4 core objectives were identified:

- Develop an active network of farmers to share ideas and findings on best practice for increasing carbon sequestration on farms. Participating farms will cover each of the main farming systems in Scotland, dairy, beef, sheep, arable and crofting.
- Calculate baseline carbon storage for each of the representative farms within the network using a combination of LiDAR surveys to calculate above-ground biomass and soil sampling to measure soil organic carbon stock.
- Raise awareness of the value of carbon stored on farms through the promotion of findings and in-person/online events.

- Produce a methodology for measuring carbon stocks and stock changes across Scottish farms.

Five farms were selected to participate in the network, each representing one of the main farming systems in Scotland. These are a dairy farm in East Ayrshire, an upland beef and sheep farm in Easter Ross, a sheep farm in Midlothian, a croft in Tiree and an arable farm in Angus.

Soil samples were taken in each field of the selected farms. Sampling was done in each field and sent to a lab for testing using an elemental analyser. Statistics returned by the lab included soil organic/inorganic carbon (%) and total soil organic carbon stocks (tonnes per hectare).

To estimate above ground biomass carbon stocks, drone-based LiDAR was collected across each site. LiDAR provides extremely detailed 3D data of the surveyed areas, and its above-ground biomass. Once collected, the LiDAR was processed to remove noise and overlapping points, before being run through the newly developed carbon model to extract tree height and crown diameter to calculate the estimated carbon stock.

The results outlined the estimated carbon stock at each farm, highlighting the breakdown between soils, trees, and hedgerows. As expected, soils contained the largest volumes of carbon, followed by trees and then hedgerows. To disseminate our work, findings were collated and shared through case studies, in-person and online events, a technical note, and a web-based GIS story map. All outputs are hosted on the dedicated webpage (Farm Carbon Storage Network | SRUC). The project was also showcased in a range of external outputs including 2 news articles and an upcoming BBC Landward episode.

Several challenges became apparent during the progression of this project, such as the limitations of drone surveys in poor weather conditions and allometric equations for biomass carbon estimates. If approved, the next phase will address these challenges, expanding the network to 10 farms, further strengthening the data set, and ensuring the data derived is relevant to farmer's from across Scotland. The above ground biomass methodology will be enhanced, incorporating localised tree data to improve and tailor biomass carbon estimates.

3. PROJECT DESCRIPTION

The Farm Carbon Storage Network was created to estimate and raise awareness of the value of carbon stored in a farm's natural assets. Farm soils, trees and hedges store large sums of carbon and have huge future sequestration potential, however, if poorly managed these habitats also run the risk of being a large net sources of carbon. Using innovative technology, the value of these natural assets was estimated by combining the results from soil testing and LiDAR (Light Detection and Ranging) aerial surveys. The estimated numbers offer a snapshot of the carbon that was stored on the farm at the time of survey.

With little data currently available on Scottish farms carbon storage, establishing an accurate baseline for the variety of differing agricultural systems in Scotland is crucial for future monitoring and ensuring global and national goals to increase carbon sequestration are met. The network data delivers a better understanding of

the impact, importance, and value of certain farm habitats, identifying management strategies that could be employed to enhance them.

Five farms were selected to participate, each representing one of the main farming systems in Scotland. These included a dairy farm in East Ayrshire, an upland beef and sheep farm in Easter Ross, a sheep farm in Midlothian, a croft in Tiree and an arable farm in Angus. The project took place between July 2022 and March 2023.

4. FINANCE

The project received 100% innovation funding from the Knowledge Transfer and Innovation Fund in July 2022. The total sum awarded was £85,970 was used completely as follows:

Item	Description	Cost
Project development	Setting up farm network, desktop study and methodology, farm drone surveys, farm soil surveys, data processing and analysis of results and production of reports.	£51,748.42
Project management & administration	Project management and administration costs	£5,556.00
Fees for speakers/ facilitators	Specialist event speakers and consultant support for 2 no. in-person events and 1 no. webinar.	£2,235.71
T&S for speakers/facilitators	Travel costs, overnight stays and meals for completing survey works and attending events	£4,517.49
Event venue	Venue hire and catering (2 no. in-person events)	£913.65
Materials	Production of case study/report for each farm (external cost)	£1,080.00
Publicity	Communication of results and findings, meetings and events, production of visual representation of findings	£13,873.12
Other external costs	Soil analysis laboratory costs	£6,045.61
Total		**£85,970.00**

5. PROJECT AIMS/OBJECTIVES

The key project objectives (all of which were achieved) were to:

- Develop an active network of farmers to share ideas and findings on best practice for increasing carbon sequestration on farms. Participating farms would cover each of the main farming systems in Scotland, dairy, beef, sheep, arable and crofting.
- Calculate baseline carbon storage for each of the representative farms with the network using LiDAR surveys to calculate above-ground biomass and soil sampling to measure soil organic carbon stock.
- Raise awareness of the value of carbon stored on farms through the promotion of findings and in-person/online events.
- Produce a methodology for measuring carbon stocks and stock changes across Scottish farms.

6. PROJECT OUTCOMES

The project set out to provide a quantitative value of the farms natural assets that would benefit their maintenance and enhancement for climate and biodiversity action, while increasing the knowledge base of farmers, policymakers and retailers.

A network of five farms was established across Scotland, each representing one of the main farming systems. At each of these farms both soil carbon and above ground biomass carbon stocks were measured to build an estimated total carbon stock for their farms. This was achieved through an innovative approach combining novel technology for above ground biomass measurement with soil sampling and analysis.

Soils are the largest store of carbon after the world's oceans and have a vital role to play in meeting emissions targets. To understand their current value and future potential, measurements and monitoring needs to be established. Across each of the five farms, soil sampling was carried out to a depth of 30 cm and their organic and inorganic carbon stock measured using an elemental analyser.

To better understand the carbon stored in above ground biomass a carbon model was created using available research. Drone mounted LiDAR was first collected for each sites identified above ground biomass. This was then processed to remove noise and overlapping points, before being run through the newly developed carbon model that extracts tree height and crown diameter and uses this information to calculate the estimated carbon stock.

Once all data was collected and processed our results were disseminated through a range of outputs designed to disseminate our findings and engage with stakeholders. Case studies were produced for each farm detailing the results of the findings and providing recommendations to enhance and increase above-ground biomass of trees and hedges and to improve the soil organic carbon. The results of our findings were also disseminated through two in-person events held in Muir of Ord and Edinburgh, and one online webinar. These events aimed to provide a better understanding of carbon stocks and helped to increase awareness of the value of carbon stored on farms. An interactive web-based GIS story map has also been produced to allow users to explore the results in more detail and a technical report has been published detailing our methodology. All reports are available through our dedicated webpage Farm Carbon Storage Network | SRUC.

7. LESSONS LEARNED

The main challenge encountered during this project was the development of the carbon model used to calculate the carbon stock value of the trees and hedges. This process, which took a lot longer than expected, included a review of existing methodologies and equations that could be used to create a new carbon model for this project. Throughout the development of the model a number of uncertainties were highlighted.

These were largely linked to the available allometric equations. Allometric equations can be explained as an equation for predicting the size of an organism based on aspects of its physiology, morphology, and history. In this case the relationship between tree height, crown diameter, diameter at breast height to predict biomass weight and carbon content. These equations are only as good as the data they are

built from, and we struggled to find accessible allometric tree data for non-commercial woodland and hedges in Scotland. As a result, we had to rely on regional, national, and international equations that have been designed for large scale regional use rather than specific sites. This reduces the accuracy of the model, as there was a wide geographical spread between farms, each with different soil types, precipitation rates, and temperatures, all of which impact the growth of trees.

To reduce this source of uncertainty for any future developments, further ground measurements are required across the sites. This would allow the project to start developing a database of allometric data specified to these localised areas that could feed directly into making custom allometric equations for each site. It is expected that there would be a much stronger relationship between each area's biomass and tree size, as well as much higher confidence levels in the models' outputs.

Another challenge during this project was the limitation of drone-based LiDAR surveys in rain, fog, and high winds. The surveys were carried out in the autumn to maximise the surface detection during the leaf-off period; however, this period also correlates with an increase in these conditions. This impacted the ability to complete surveys in a timely manner as, there were multiple occasions where surveys had to be cancelled before or midway through, requiring additional site visits to collect all the required data. Any future work will require further consideration of these conditions in the planning to allow for longer data collection times.

8. COMMUNICATION & ENGAGEMENT

Announcement of project and ongoing communications: Sept – Dec 2022

- Upon commencement of the project and creation of the Farm Carbon Storage Network of farms, an announcement was made via SRUC's media channels announcing funding for the project (Knowledge sharing and innovation projects receive £150k | SRUC).

- An introductory meeting was held (online) with all participants to discuss the objectives and methodology for the project. Contact with farmers was maintained throughout the lifecycle of the project via email and phone calls.

- A webpage was created on SRUC's platform Farm Carbon Storage Network | SRUC to host project information and contact details.

- As survey work progressed, a news release was issued in early December Drones take carbon project to next level | SRUC providing a further introduction to the project. This was widely shared through social media channels and was picked up by national newspapers including The Courier and Farmer's Journal.

- Social media posts were made regularly throughout this period as survey work progressed.

Preparation of final reports and communication of findings: Jan – Mar 2023

- The project team provided an interview to BBC Landward demonstrating the methodology for capturing farm carbon stocks data. This interview is scheduled to be released on the BBC in April 2023.

- Two in-person events hosting 25-30 person each, were held in March to share and discuss the project findings. The first event was held on the 13th March at Muir of Ord, Easter Ross with a second event held on the 21st March in Edinburgh. A webinar meeting was held on the evening of the 27th March ensuring a wider geographic audience could attend.

- A case study has been produced for each of the farms providing map outputs, a reviewing the findings and recommendations to enhance and increase above-ground biomass of trees and hedges and to improve the soil organic carbon. These are available to view and download from the project webpage.

- A web-based GIS story map has also been produced and is available via the project webpage. This provides an interactive visual presentation of the findings allowing users to explore the results on a field-by-field basis.

- A technical report providing details of the methodology used to undertake the survey work has also been produced and is available on the project webpage.

- Social media posts will continue to be made on completion of this project promoting the availability of the results on the project webpage and upcoming Landward interview in April.

9. KEY FINDINGS & RECOMMENDATIONS

The results of this project outlined the estimated carbon stock at each of the chosen farms as well as their breakdown between soils, trees, and hedgerows. As expected, soils contained the largest volumes of carbon, followed by trees and then hedgerows. This should however not negate the importance of hedgerows as the study showed that they hold considerable carbon stocks their density and coverage is not comparable with soils and trees.

A better understanding of carbon dynamics is crucial to the continued environmental and financial sustainability of Scottish agriculture. This project has provided an important initial baseline of data, which should enable future projects to identify and monitor the positive impact of action on the ground.

This project was developed with the goal of being a first phase of a multiyear monitoring programme. To maximise the positive impact of this project we hope to include additional farms in the future to keep strengthening the dataset and ensuring the data derived is relevant to farmers from across Scotland. At the same time the above ground biomass methodology would be further developed, incorporating lessons learned in phase one to enhance its robustness and refine accuracy. This would include the inclusion of more Scottish biomass allometric data to reduce model uncertainty and the collection of further ground truth data to reduce model error and increase model output confidence. Following these improvements carbon baselining would be completed at each additional farm and recalculated for first five farms to ensure the most accurate baseline is being calculated.

Following this expansion, the initial 5 farms will be revisited in year 3 to complete a second round of data collection, to explore changes in carbon stocks over that time and the impact the recommendations explored in the case studies if implemented have had on the carbon stocks.

10. CONCLUSION

Farmers are increasingly aware of their need to help tackle the climate crisis, through a combination of reducing greenhouse gas (GHG) emissions and increasing sequestration of carbon dioxide on farms. A farm's soils, trees and hedges act as a carbon sink, which can be difficult to quantify, however, technology can help us improve the accuracy of these estimated carbon stocks.

Through the formation of the Farm Carbon Storage Network, the project seeks to raise awareness of the value of carbon stored on farms, establishing a baseline for future monitoring. The carbon stock on each representative farm was estimated by combining soil sampling with LiDAR (Light Detection and Ranging) aerial surveys. To Soil samples were taken to 30cm across the farms fields and sent to be analysis using an elemental analyser. The LiDAR datasets were collected using a drone and processed through a carbon model developed in house for estimating carbons stocks for trees and hedgerows.

Following the development and survey stage, results were collated and published through a range of outputs including, case studies, in person and webinar events, a technical note and a web-based story map. All outputs are available on the dedicated webpage (Farm Carbon Storage Network | SRUC). The project was also hosted in a range of external outputs including two news articles and the upcoming BBC Landward series.

Several challenges became apparent during the progression of this project, ranging from the limitations of drone surveys in poor weather conditions to the limitations of available allometric equations for predicting above ground biomass carbon stocks. If approved, phase two, amongst other additions, will address these challenges, expanding the network to 10 farms and incorporating localised tree data to improve and tailor biomass carbon estimates.

If approved, phase two of this project will grow the network to 10 farms, further strengthening the data set and ensuring the data derived is relevant to farmers from across Scotland. Our above ground biomass methodology will be expanded, incorporating lessons learned to enhance robustness, refine accuracy, and improve output confidence. This entails the inclusion of more Scottish biomass allometric data and further ground truthing to tailor results to each site and reduce uncertainties. Outputs will then be produced for the 5 new farms as well as reprocessing the data from the 5 original farms. In addition, we will aim to introduce biodiversity assessments across the network to enhance the understanding of these habitats value.

11. ANNEXES/APPENDICES

- Appendix 1 – Evaluation Report
- Appendix 2 – Communications Report