Sustainable Food Procurement for Local Prosperity:

Contribution of small, agroecological farms to Net Zero

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September 2023

Executive summary

Background

The Food Procurement for Local Prosperity project sets out to create an evidence base to prove that the public sector can procure efficiently from local producers using methods that benefit the natural environment and local prosperity. It piloted the use of Food Hubs in Powys and Carmarthenshire as a mechanism for local producers to provide the scale and technology needed to supply the public sector effectively, whilst still delivering on a vision of a connected, local and environmentally-sound model. This element of the project focused on carbon, and the contribution local souring can make to achieving Local Authority net zero targets.

Agroecology, small farms and net zero

Small, local agroecological farmers can make that contribution through:

- Reducing or eliminating external inputs such as Nitrogen fertilisers and pesticides.
- Increasing soil organic matter, which is a major carbon sink.
- Increasing the diversity of crops, for example setting up agroforestry systems which increase tree cover while contributing to overall productivity of the farm.
- Integrating livestock and cropping enterprises to maximise resource use efficiency.
- Participating in direct and short supply chain food systems, leading to a reduction in food miles.
- Using smaller and older machinery and implements which reduces the carbon embedded in farm infrastructure.

Incentivising carbon footprint calculation

While carbon footprint calculation has an important role in evidencing those benefits, uptake among farmers and growers is limited for a number of reasons:

- Many farmers and growers perceive it has limited direct and immediate benefits.
- It can be time consuming, particularly at the data gathering stage.
- Some tools are difficult to use.

Materials were produced showing how carbon footprint calculation will become more prevalent in the future, and highlighting the potential benefits including:

- Facilitating access to future markets such as public procurement and carbon markets
- Facilitating access to government support in the future
- Increasing financial and environmental performance of the business
- Streamlining record keeping; The data collection framework used for carbon footprint calculation will also support other administrative tasks.
- Investing time in establishing data collection systems initially means that subsequent calculations will be much quicker and easier.

Data collection framework

An existing spreadsheet-based data collection framework to was adapted and annotated to meet the specific needs of this project and small growers more widely.

Case Studies

Growers who had already been involved in the project were invited to participate as case studies. In addition, several other producers who might potentially supply the hub in the future were also approached. Data was collected through the framework described above and entered into the Farm Carbon Toolkit Calculator. Data from all the footprint calculations were reviewed and analysed. The study provided some useful indicators of the contribution small agroecological horticulture can make to Net Zero, and therefore begins to make the case to Local Authorities to procure more food from these types of businesses. It also helped to raise the awareness of the importance of carbon footprinting among growers in terms of accessing not just the public procurement market, but other sources of public funding in future. It played an important role in helping growers establish data collection systems and establish baselines which will greatly facilitate future foot printing exercises.

It also highlighted some learnings for future work:

- There is a need to refine data collection systems, so that growers are in a better position to generate and access information more quickly and easily. This will reduce the amount of estimation requires and improve the robustness of the data.
- Where horticulture is part of wider business or farm, there needs to an agreed approach to allocating carbon costs between the different businesses.
- A ‘one off’ calculation is insufficient to take account of the considerable variation that will occur from year to year, and does nor enable comparisons to be made to a baseline (for example the all-important increase in SOM

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1 About the project

1.1 Background

The Food Procurement for Local Prosperity project sets out to create an evidence base to prove that the public sector can procure efficiently from local producers using methods that benefit the natural environment and local prosperity. It piloted the use of Food Hubs in Powys and Carmarthenshire as a mechanism for local producers to provide the scale and technology needed to supply the public sector effectively, whilst still delivering on a vision of a connected, local and environmentally-sound model. This element of the project focused on carbon, and the contribution local souring can make to achieving net zero targets.

In order to strengthen the evidence base to support local sourcing, the project commissioned a number of studies, including a previous piece of work on carbon footprint calculation carried out by Mabbet Associates. They produced some important findings, but found engagement with growers difficult. They identified a number of challenges and barriers to wider take up of carbon foot printing by producers. They also identified a need to work more closely with procurement officers to further clarify mechanisms by which small agroecological producers contribute to Net Zero, and how the benefits might be best captures in carbon footprint calculation methodologies.

1.2 Aims

This study therefore aims to:

- Increase understanding of the benefits of carbon footprint calculation, and therefore its uptake, among growers.
- Further refine the metrics and data requirements of local procurement officers to support the case for sourcing more food from local, agroecological food producers.
- Identify an appropriate carbon foot printing calculation tool that would meet the requirements of procurers]
- Develop a framework which would facilitate the collection and collation of data that will subsequently be feed into that tool.
- Support growers to carry out carbon footprint calculations using the above
- Produce benchmarking data based on the above.

1.3 Activities

These aims were achieved through a number of activities, including

- Reviewing the outputs of the Sustainable Food Procurement for Local Prosperity project to date
- Meeting with local authority procurement advisors to clarify their aims and data requirements.
- Preparing materials to increase the uptake of carbon footprint calculation by farmers and growers
- Reviewing the main carbon footprint calculators and setting out the rationale for choosing the Farm Carbon Toolkit

- Adapting an existing data collection and collation framework to the specific needs of the project and small horticultural producers more widely.
- Carrying out farm carbon footprint calculations with growers

2 Background and context

2.1 Policy background

Globally, food and farming contributes about 30% of all GHG emissions. While there are no specific reduction targets for agriculture, England, Wales and Northern Ireland have set a target to achieve net zero GHG emissions by 2050, and Scotland by 2045. Reductions in emissions from food and agriculture will therefore make a significant contribution to reaching those targets. This recognised in a wide range of laws, policies and strategic plans including the Wellbeing of Future Generations Act, and the Agriculture (Wales) Act 2023 and other policies at UK government level.

In this context, being able to measure carbon emissions and sequestration across the entire food chain is becoming increasing important.

2.2 A procurer's perspective

The Welsh Government net zero targets apply at national level. However, to a very large extent it is through actions at local level that they will be achieved. To this end, Local Authority action plans have been developed, which in Carmarthenshire include 'Net Zero Carbon Action Plan, Project Zero Sir Gâr 2021 (CCC)' and the 'Draft Public Services Board (PSB) Food Strategy and Action Plan'.

As part of these strategies, Carmarthenshire County Council developed 'Future Generations Menu'. The purpose of the Menu is to design public menus that are sustainable in terms of the environment and which also result in public funds being spent within the foundational economy and local communities. With respect to Carbon, the 'My emissions' database was used to show the impact of the balance of ingredients in meals, and made the carbon case for a reduction in meat and increase in grains, pulses and fresh produce.

However, it did not explore the impact sourcing more those ingredients locally, or take into consideration the farming systems by which those ingredients were produced. It did note, however, that 'In the public sector, for reasons of price, seasonality and ease of bulk ordering, very few ingredients are bought locally and imported processed food is heavily relied on. As a result carbon emissions are relatively high; for every 1kg of food bought for school meals 2.5kg of CO_2 is emitted9. Across the year, meals bought by the primary schools alone in the Welsh public sector account for more than 24,300,000 kg of CO_2e[10].'

The report, however, did not provide information or evidence on how local souring from environmentally sustainable farms would reduce that. This work aims to make some contribution to answering that question.

2.2.1 Principles of Agroecology

In order to understand how agroecological farms can contribute to net zero, it is first necessary to understand what is meant by this term. This has been a subject of intensive debate for many years, but a degree of consensus has been reached around the 10 'elements' set out by FAO:

Diversity	Agroecological systems are highly diverse. From a biological perspective, they optimize the diversity of species and genetic resources in different ways.
Synergy	Diversified systems combine annual and perennial crops, livestock and aquatic animals, trees, soils, water and other components to enhance synergies in the context of an increasingly changing climate.
Efficiency	By enhancing biological processes and recycling biomass, nutrients and water, agroecological producers are able to use fewer external resources, reducing costs and the negative environmental impacts of their use.
Resilience	Diversified agroecological systems are more resilient – they have a greater capacity to recover from disturbances including extreme weather events such as drought, floods or hurricanes, and to resist pest and disease attack.
Recycling	By imitating natural ecosystems, agroecological practices support biological processes that drive the recycling of nutrients, biomass and water within production systems, thereby increasing resource-use efficiency and minimizing waste and pollution
Co-creation & sharing of knowledge	Agroecology depends on context-specific knowledge. The co-creation and sharing of knowledge plays a central role in the process of developing and implementing agroecological innovations to address challenges across food systems including adaptation to climate change.
Human & social values	Agroecology places a strong emphasis on human and social values, such as dignity, equity, inclusion and justice. By building autonomy and adaptive capacities to manage their agro-ecosystems, agroecological approaches empower people and communities to overcome poverty, hunger and malnutrition, while promoting human rights, such as the right to food, and stewardship of the environment so that future generations can also live in prosperity.
Culture & food traditions	Culture and food traditions play a central role in society and in shaping human behaviour. However, in many instances, our current food systems have created a disconnection between food habits and culture. This has contributed to a situation where hunger and obesity exist side by side, in a world that produces enough food to feed its entire population.
Responsible governance	Agroecology calls for responsible and effective governance to support the transition to sustainable food and agricultural systems. Transparent, accountable and inclusive governance mechanisms are necessary to create an enabling environment that supports producers to transform their systems following agroecological concepts and practices.

Circular and solidarity economy	Agroecological approaches promote fair solutions based on local needs, resources and capacities, creating more equitable and sustainable markets. Strengthening short food circuits can increase the incomes of food producers while maintaining a fair price for consumers. These include new innovative markets,29,30 alongside more traditional territorial markets, where most smallholders market their products.

Table 1: FAO Elements of Agroecology

2.2.2 Agroecological principles and net zero

These principles translate into a contribution to net zero in a number of ways including:

- **Efficiency:** The manufacture and use of synthetic inputs, on which intensive agriculture rely heavily, are a major source of GHG emissions. In 2018, the last year for which data exists, the synthetic N fertiliser supply chain was responsible for estimated emissions of 1.13 $GtCO_2e$, representing 10.6% of agricultural emissions and 2.1% of global GHG emissions. Pesticide manufacturing represents about 9% of the energy use of arable crops, and about 3% of the 100-year Global Warming Potential (GWP) from crops. By significantly reducing and in many cases eliminating these inputs, agroecology significantly reduces emissions.

- **Synergies:** Soil is a major carbon sink, second only to the oceans in terms of the total amount of carbon sequestered. Up to 60% of that is contained in organic matter. By some estimates, a 1% increase in soil organic matter leads to the sequestration of an additional 57 tonnes of carbon/ ha/ year. By using fertility building leys and cover crops, combined with judicious use of manures and composts, agroecological farming systems help to increase soil organic matter levels, and therefore carbon sequestered.

- **Diversity:** The diversity of crops is also an important factor in increasing sequestration and minimising carbon losses. Agroforestry systems, for instance, increase the amount of tree cover while contributing to overall productivity of the farm. The integration of livestock and cropping enterprises is an important part of maximising efficiency: fertility leys in crop rotations can be used to produce milk and meat, thus using the same resource to produce more than one product; the manures from livestock support the growth of crops, thus optimising the recycling of nutrients within the system, and achieving an associated reduction in carbon emissions.

- **Circular and solidarity economy:** Small farms tend to participate in local and short supply chain systems; this is partly to adhere to the agroecological principles and partly out of economic necessity (small farmers are simply unable meet the volume, price and continuity demands of supermarket supply chains). This implies a significant reduction in food miles. The contribution this makes in terms to reducing of carbon emissions is still an issue under debate. Detractors point to the inefficiency of transporting smaller volumes (in terms of CO2e/ tonne of product); it is more efficient to move 24 tonnes of food in one lorry that in 8 x 3t transit vans). They also highlight that that local food outlets are rarely one stop shops in the same way that supermarkets are, and therefore consumers have to make more trips to fulfil their food shopping needs. Proponents argue the long supply chains means that food often has to travel several hundred miles to be processed and packed (sometimes in separate and distant locations) and delivered, and it is the short supply chain nature of local food systems that delivers the carbon benefits.

- **Carbon embedded in infrastructure:** Small farms often have less, older infrastructure. For example, tractors and implements are fewer in number, lower in power, and nearly always older (many small farms are using machinery produced in the 60's and 70's). Therefore, the carbon embedded in infrastructure – which is significant - is lower and written off over more years.

3 Increasing the uptake of carbon footprinting

3.1 Prevalence of carbon footprint calculation on UK farms

Given significance of reducing net carbon emissions, and the fact that establishing farm carbon footprints is a first and fundamental step in doing so, it might reasonably be expected that carbon footprint calculation was widely practiced by UK farming businesses. In reality, this far from the case. It is difficult to find data showing the extent to which carbon footprint calculation is currently being carried out on UK farms. However, a recent review by Farmers' Weekly, of the 3 leading calculators suggested that, combined, they have about 16,000 regular users. Official government statistics estimate there are about 111,300 farmers in the UK, but this does not include small farms and small holdings that are not receipt of government support and there likely to be a significant underestimate. This means, at best, about 15 % of farm businesses are measuring their carbon footprints.

3.2 Barriers of the uptake of carbon footprint calculation

It is crucial that we understand the reasons behind this low take up. The published literature is virtually silent on the matter. However, anecdotal feedback from farmers, growers, advisors, and toolkit developers can give us some insight.

At the heart of the matter is the perception that it has limited direct and immediate benefits to farmers and growers. The calculators do provide insight into the areas of the business that are responsible for emissions and can help drive management changes to improve environmental and financial performance. However, many farmers and growers remain unconvinced about the impact of the calculation process per se. Perhaps paradoxically, this is particularly the case for organic and agroecological farmers and growers who perceive their systems are intrinsically lower carbon. The following comment is broadly representative of many organic farmers: 'What's it going to tell me - That I need to maximise fuel and electricity efficiency? That I should consider renewable energy sources? That should minimise fertiliser and other inputs? That I need to build soil organic matter? That I manage need to my hedgerows well and maybe plant more trees? I already know that. Indeed, as an organic farmer, it's the whole basis of my system' (personal communication)

In future, it is highly likely that carrying out carbon footprint calculations could facilitate access to significant external funding – for example carbon markets, and publicly funded support schemes. It could also facilitate access to new food markets, most significantly in context of this work, public procurement. However, at the present time, many of those opportunities are not sufficiently developed, or not well understood by growers – or both.

Another barrier, encountered by Mabbet Associates in their previous work, is the amount of time it takes carry out the assessment, and the 'clunkiness'/ non intuitive nature of the calculators themselves. Much of the time is taken up but gathering the necessary data initially, but it is also important that the tool is as easy to use as possible.

3.3 Incentivising carbon footprint calculation.

The implications of the above are that we need to a solid case for the benefits of carbon footprint calculation for growers. To this end a separate document was prepared for producers, the key messages of which are:

- **Carbon footprint calculation will facilitate access to future markets.** This is especially true of public procurement markets, as highlighted throughout this report. The carbon market is likely to become an increasing important income stream in the future and establishing your baseline and demonstrating your progress will become more and more important.
- **Carbon footprint calculation will facilitate access to government support.** Net zero is a major driver for all public policy and agricultural support schemes. While the details are yet unclear is highly likely that carbon footprint calculation will become a requirement of at least some support schemes in the future.
- **Carbon footprint calculation can be a useful management tool.** The calculator highlights the areas of the business where the emissions are highest and the opportunities for sequestration greatest. While it may not provide startling insights, margins in farming and growing are tiny and it is small incremental changes that make the difference between profit and loss and enhance environmental performance.
- **The calculation process can streamline your record keeping.** The data you need to collect for the calculator overlaps extensively with those you need of other purposes, for example management, accounting, quality assurance schemes such as organic certification. If your record keeping system is robust it will be relatively simple to use the calculator. If it isn't, the exercise will help you organise your information in way that is useful for other purposes.

4 Selection of carbon footprint calculator

4.1 Overview

There are several Carbon Footprint calculators available. However, they are all slightly different in terms of:

- The Scopes they measure: Scope 1 is the carbon directly used by the farm; Scope 2 is the carbon associated with the production of the energy it purchases; and Scope 3 is the carbon for which the farm is indirectly responsible, for example the carbon embedded in the manufacture and use of fertilisers.
- Whether sequestration is included
- The standard data they use to attach CO_2e to specific products, inputs and processes.
- The extent to which they are appropriate to agroecology and horticulture.

Generally speaking there is no right or wrong system. Tool selection is a matter of picking the right tool for the job.

4.2 Our requirements

Section 2.3.2 identified the ways in which small, agroecological farms contribute to net zero. It there follows that the calculator we choose needs include metrics that reflect this those characteristics,

4.3 Review of existing calculators

Over time 3 leading tools have emerged, which between them represent the vast majority of carbon footprint calculations carried out the UK, they are: The Farm Carbon Toolkit, Agrecalc and the Cool Farm Tool. Their key characteristics are set out in Table 2.

The Cool Farm Tool can be discounted immediately. It does not cover a include sequestration; it is not appropriate for the crops and systems we are interested in; and itexpresses emissions in terms of Kg CO2e/ Kg of product rather than whole farm.

Agrecalc and the Farm Carbon Toolkit meet most of our requirements. However, the Farm Carbon tool kit is considered more appropriate because:

- It includes more detailed, and more appropriate, metrics for horticulture.
- It is specifically designed with organic and agroecological systems in mind, and therefore has the metrics appropriate to these systems.
- It is more ‘user friendly’ and intuitive.
- The tool is supported by a suite of resources, including spreadsheets to facilitate the gathering of necessary data.
- The toolkit is free for growers to use.

5 Data collection framework

As highlighted in Section 3.2, gathering and organising the data into an appropriate format, prior to entering it into the footprint calculator is the most time consuming part of the foot print calculation exercise. In fact, very little of the data required is specific to carbon footprint calculation; Yields, fertiliser applications, seed purchases, energy bills and the like are all part and parcel of the management records growers need to keep to run their businesses. The data collection framework facilitates the pulling together of all that information in a single place. It is based on an Excel spreadsheet, developed by the Farm Carbon Toolkit. It has separate tabs for each of the sections of the calculator, explains what information is needed and why and includes some handy hints on where to find the appropriate information. The spreadsheet was modified and annotated to make it more appropriated to small scale horticultural producers for example:

- Highlighting sections that are less relevant to horticulture and there can be skipped.
- Providing guidance on how multiple cropping on the same piece of land in the sa,e year can be tackled
- Providing standard data for metrics some growers may not have to hand (e.g. soil bulk density, average fresh weight yields of green manures.

	Farm Carbon Toolkit	**Agrecalc**	**Cool Farm Tool**
Scopes	1, 2 & 3	1, 2 & 3	1, 2 & 3
Sequestration included?	Yes	Yes	No
Horticulture appropriate?	Yes – Wide range of market garden crops included. Developed with input by market gardeners, so the small areas, multiple crops in a year, short term leys etc	Partially – Focused on field scale systems, so while the main field crops are included, things like mixed salad leaves are not. Multiple cropping and short term leys not included	Partially -
Agroecology appropriate?	Yes. Includes rotations, fertility building leys copes well with integrated farming systems	Yes. Includes rotations, fertility building leys & copes well with integrated farming systems	No – Limited resource allocation between crops/ enterprises
Easy of use	Very intuitive	OK, but least easy to complete of the three	Very intuitive
Level	Whole farm, enterprise	Whole-farm, product and enterprise	Calculated by product
Time to complete	30 - 45	45 – 60 minutes	10-15 minutes

Table 2: Comparison of key characteristics of main Carbon footprint calculators

6 Case studies

6.1 Selection of case study farms

Growers who had already been involved in the project were invited to participate as case studies. In addition, several other producers who might potentially supply the hub in the future were also approached. All growers were small, agroecological producers (as defined in Section 2.21). Brief descriptions are included in Table 3 below.

Farm	Size (Ha)	Description
A	1.0	Recently established no dig market garden, selling predominantly through a small box scheme delivering to homes and collection points within a 7 mile radius of the farm. They also market to a small number of restaurants.
B	3.2	Small market garden, selling from a farm shop on site. The farm is also the base of an organic wholesaling and delivery company
C	1.8	A CSA project, providing shares to about 45 families, and supplying local shops and restaurants. It is a separate business based on a 120 mixed organic farm. The market garden complemented by larger scale, more mechanised field cropping
D	0.11	Recently established no dig market garden, selling predominantly through local shops, pop up shops, local food hubs and restaurants and cafes.

6.2 Methodology

6.21 Approach

- Potential participants were contacted to invite them to participate. Background information on the project was provided, along with a short document outlining what was involved and the potential benefits of participation.
- A 30-minute introductory meeting (online or in person) was held with each grower, during which they were introduced to the Farm Carbon Toolkit, and the data collection framework (Appendix 2)
- Growers then gathered the necessary data and entered it into the framework.
- The data was entered into the Farm Carbon Toolkit Calculator. The structure and the function of the calculator, and the data sources used are described here.
- A follow up meeting was organised to support growers through the carbon footprint calculation itself.
- Data from all the footprint calculations were reviewed and analysed. Benchmark averages were calculated, and common themes with respect the potential to contribute to Net Zero targes with identified and commented on.

6.22 System boundaries

A clear understanding of the system boundaries – what is and what is not included in the calculations – is essential to the interpretation of the results of the footprinting exercise.

- Where there were other activities on the site (e.g. the wholesale business on Farm B and the mixed organic farm on site C), the vegetable business was treated as a separate enterprise. For example, on farm C manure from the adjacent farm businesses was considered imported fertility. Only fuel and electricity costs directly relating to vegetable production was included.
- Where growers lived on site domestic energy costs (e.g. heating and lighting the dwelling) were not included
- The fuel costs of employees travelling to and from work was not included.
- Delivery costs to retail outlets are included, but the carbon costs of customers accessing produce (e.g. the cost of customers travelling to Site C to pick up shares, or to local shops) was not included.
- Carbon costs of contractors is included. This is calculated using standard data (e.g. the average emissions / ha for ploughing and harrowing).
- Carbon embedded in infrastructure (buildings, polytunnels, machinery, implements etc) is written off over 10 years. Items more than 10 years old have been deemed to have 'paid their carbon debt' and their associated emissions are not included in the calculation.
- 'Waste' is considered materials that are taken off the farm for disposal. For example, trimmings from the packhouse or shredded cardboard boxes that are shredded, that are composed on site and therefore the nutrients returned to the soil are not considered waste. Old polytunnel coverings that are sent off the farm for recycling are included in waste.
- In cases where businesses are buying in produce to supplement their offer (for example in the Case of Farm A) these are not included in the calculations. This is a major limitation, but in this context is the carbon footprint of the production for the procurement market that is of most interest.

6.3 Results

6.3.1 Overview

The results of the carbon foot printing exercises are summarised below in Table 4, and the results for individual businesses are presented in Appendices 3 – 6

	Category	Description	A		B		C		D	
			(t Co2e)	%	(t Co2e)	%	(t Co2e)	%	(t Co2e)	%
Emisions	Fuels	Liquid fuels and electricity used diretly for production and storage of crops	0.56	10	0.36	10	3.64	44	0.01	1
	Materials	Carbon embedded in materials used on the farm including new building materials, fencing, crop and ground covers, packaging, office materials etc	0.93	59	2.17	59	1.57	18	0.58	48
	Inventory	Carbon embedded in existing infrastucture, machinery implments etc less than 10 year old	0.00		0.00		0.52	6	0.07	6
	Crops	Emmision from soil, organic fertisilisers, green manures soil ammendments, growing media etc	0.26	31	1.12	31	2.46	29	0.55	45
	Inputs	Synthetic fertilisers and pesticides	0.00		0.00	0	0.00	0		0
	Waste	Waste taken off the farm for recycling or disposbale (not crop residues/ processing waste etc composted on site)	0.00		0.00	0	0.00	0	0.00	0
	Distribution	Fuel in tranporting product to market outlset	1.11		0.00	0	0.37	4	0.00	0
	Processing	Value added processing	0.05	0	0.00	0	0.00	0	0.00	0
	TOTAL Emissions		**2.92**	**100**	**3.65**		**8.56**		**1.21**	
Sequesration	Soil OM	*Increase* in soil organic matter	0.00		0.00		0.00	0	0.00	
	Cultivated Peat soils		0.00		0.00		0.00	0	0.00	
	Woodland		0.54	21	0.00		0.00	0	0.00	
	Hedgrows		0.40	16	0.83	17	0.79	27	0.55	97
	Perenial Crops	E.g. Orchards, soft fruit, willow coppice	0.00		1.32	27	0.95	32	0.00	
	Field Margins		1.59	63	2.77	56	1.21	41	0.00	
	Wetland		0.00	0	0.00	0	0.00	0	0.00	
	Habitat	E.g. Rough pasure, beetle banks, scrub	0.00	0	0.00	0	0.00	0	0.02	3
	Landuse change	E.g. ploughing up pasture for horticulture	0.00	0	0.00	0	0.00	0	0.00	
	Total Sequestration (t Co2e)		**2.52**		**4.92**		**2.95**		**0.57**	
Net Carbon		Whole Farm (t Co2e)	**0.40**		**-1.27**		**5.61**		**0.64**	
		Per Tonne of product (t Co2e)	**0.39**		**0.14**		**0.80**		**1.28**	
		Per Hectare (t Co2e)	**0.39**		**0.40**		**2.46**		**3.22**	

Table 4: Summary of carbon footprint calculations for case study farms

The there was considerable variation in carbon footprint, and the net carbon emissions between the business by all three measures (Whole farm, per tonne of product and per Ha of land). It is important that these figures are not interpreted as one farm being 'better or worse' than another, but they are reflective of different contexts and systems. For example, the high net carbon emissions of Farm D are due in large part to a higher fuel consumption, and of red diesel in particular. This is a reflection of the larger, more mechanised scale field vegetable system, which is essential to supply relatively large volumes of staple crops such as potatoes, of field brassica that the public procurement market requires, but has a higher carbon footprint compared to very small scale no dig systems exemplified by Farms A and C.

The way the calculator is set up can also have implications for how the carbon costs of materials are calculated. These are not written off over period of time in the same way inventory is, even though they may last several years. For example, farm C purchased over 4,000m^2 of Polypropylene ground covers (Mypex), which typically has a lifetime of 8 – 10 years, but the carbon cost of that is concentrated in one year.

6.3.2 Contribution to Net Zero

It is possible to make some comments on the extent to which these case studies supportthe claims made in Section 2.2 around the contribution small agroecological farming systems make to Net Zero target.

- **Efficiency.** None of the farms in the study used any synthetic fertilisers or pesticides (recorded under inputs in the calculator). As highlighted previously, these are a major source of GHG emissions.
- **Synergies.** As highlighted in section 2.2.2, taking biological approaches to fertility helps to build soil organic matter (SOM), which is turn is a major carbon sink, and contributes significantly to reducing net emissions. However, a lack of data on the SOM levels on all farms meant that we were not able to demonstrate this on the case study farms. The key measure is the *increase* in SOM compared to a previous baseline. None of farms had the necessary 2 data points for the comparison to be made, and most did not even have a base line measurement. While it is likely that the production systems on all four farms are building SOM, in the absence of any data to prove it, it is impossible to say for certain.
- **Diversity:** The contribution of higher diversity on small farms to net zero was reflected in carbon sequestration potential of the case study farms. Field margins were an important source of sequestration. This is reflection of the complexity of the cropping system. The farm is made up a very large number of small plots/ beds, each a margin around it. This massively increases the total length/ area of uncultivated areas compared to, say, a 1 ha field of brassicas. On many farms, the presence of permanent crops – top fruit orchards or willow coppice – alongside the annual crop cropping systems made a significant contribution carbon sequestration
- **Circular and solidarity economy:** While this study did not examine whether local food systems reduce food miles, the circular economy is demonstrated through the very low levels of waste generated by the case study farms. In practice, this is due using recyclable or reusable packaging, such crates and cardboard boxes, the latter being composted and the nutrients returned to the soil. The tool does not use a full life cycle analysis, so while the carbon footprint of the manufacture of polythene bags is accounted for under 'materials', the disposal of those bags but customers is not

attributed to the farm. Nevertheless, the data does clearly highlight the low waste characteristics of small, agroecological farms.

- **Carbon embedded in infrastructure:** The data clearly showed that small farms have very little carbon embedded in on farm infrastructure, recorded under the 'inventory' section on the calculator. For many farms this was recorded as '0'. This is not because farms don't use machinery, or implements. Rather it is reflection that the equipment on the farm is more than 10 years old, and therefore the carbon debt has been written off. There are two main reasons for this. Firstly, over the last few decades mainstream horticulture systems have tended to scale up, using larger and more sophisticated machinery. This, in turn means most of the equipment suitable for small scale systems was manufactured 30 or 40 years ago. Secondly, the low profitability of small-scale horticulture means that it is often difficult to justify the investment in new machinery, so even when new machinery is available, it is often not possible to invest in it.

6.4 Challenges and limitations

There are number of limitations to this exercise in terms of providing hard evidence of the contribution of small scale farms to next Zero

- The sample size is small. As highlighted above, event with the 4 farms participating in this study there was considerable variation, which is turn is a reflection of the diversity of systems, conditions and circumstances characteristic of small scale horticultural systems.
- The data were patchy. Sometimes it was completely absent, and information on SOM data is a case in point. More often, is was a case of it not being accessible; the form in which the data was needed for the calculator was often not the form in which growers kept. This meant that some of the data were estimates rather than actual figures.
- In cases where the horticultural business was part of wider business, or farm, for example B and C, it was difficult to separate out the proportion of, say the electricity or water costs, that could be attributed to the horticultural business alone.
- The information provided a snapshot of the business in one specific year. As highlighted above the carbon footprint will vary from year to year depending on markets, crop production, purchase of materials, expansion/ contraction of the business, new habitat and a host of other factors. In order together means data it is important that the foot printing is carried out on a regular basis over a period of years.

7 Conclusions and recommendations

- The study provided some useful indicators of the contribution small agroecological horticulture can make to Net Zero, and therefore begins to make the case to Local Authorities to procure more food from these types of businesses.

- The study helped to raise the awareness of the importance of carbon footprinting among growers in terms of accessing not just the public procurement market, but other sources of public funding in future

- The project played an important role in helping growers establish data collection systems and establish baselines which will greatly facilitate future foot printing exercises.

- There is a need to refine data collection systems, so that growers are in a better position to generate and access information more quickly and easily. This will reduce the amount of estimation requires and improve the robustness of the data.
- Where horticulture is part of wider business or farm, there needs to an agreed approach to allocating carbon costs between the different businesses.
- A ‘one off’ calculation is insufficient to take account of the considerable variation that will occur from year to year, and does nor enable comparisons to be made to a baseline (for example the all-important increase in SOM

Appendix 1: Carbon Sequestration Data for Potential of Publicly Supported Agriculture

Based on Research Evidence from Farm of Huxhams Cross Farm (Apricot College, Dartington) - 34 Acres

- Carbon Sequestration -4.78 tonnes per hectare (-2.69 per tonne of product) in mixed enterprise (veg, fruit, grain, eggs, processing, distribution) - (-1.92 per acre)
- Social Impact of 1420 visitors, (63% positive and applicable social engagement)
- Economic - £200,000 turnover (£140,000 from own produce), 6 FTE and 3 Apprentices,

To achieve the levels associated with UFSM demand (67% take up) we would need 160 tonnes of product (vegetables) therefore by achieving a modest target of 80% localised regenerative supply over 5 years we could reach 430 tonnes of carbon sequestered per/annum, year upon year.

The total acreage of productive arable land required to meet this demand would be 70 acres - 30 hectares.

The expected increase in carbon footprint of food procured in relation to UFSM (based on current supply chain) is 125% (2.7 tonnes per annum)

Rough estimated of investment required to deliver this is £2.2m over 5 years (approx £1,023 p/tonne)

Foundational Economy Context

Based on the assumptions of an 80% uptake of free school meals out of the existing cohort of circa 13,500 = 10,800 pupils eating 5 meals a week for 40 weeks in the school year = 2,160,000 meals per year across the county.

As part of the current statutory guidance on 1 portion of veg per meal this = 16kg per child per year (80g p/meal). 172.8 Tonnes of vegetables per school year. Interestingly this is roughly the same as the whole supply chain estimate for Hwyel Dda Health Board meal provision.

At the current average cost of £0.76 p/kg this equates to £131,328.

At the local and/or organic average cost of £1.31 p/kg this equates to £226,368.

An increase of £95,000 (72%)

This increase also need to be put into context as part of the meal and typical school - the initial increased cost (for fresh vegetables) of £1,758 (from £2,432 to £4,192) per 40,000 meals (typical amount per school per year under UFSM), an increase of £0.044 p/meal - only a 5% increase as part of the meal.

Potential annual reinvestment into the Welsh Foundational Economy for Carmarthenshire in line with targets of would be -

3 years - £68,000 (30% fresh vegetables used in meals)

5 Years - £230,000 (50% doubled as proportion of fresh veg in meal is doubled)

10 Years - £408,000 (90%)

Total over 10 years = £2.7m

The community could potentially see an £8.1m return in social, economic and environmental value.

This ideally would be realised by investment in employment through food producing SMEs - (2 Full Time Jobs per £35,000 income) = 23 careers (jobs paying a living wage) created and sustained in primary horticulture production alone.

This could extrapolate to a Wales-wide figure £6.8m annually. (based on the calculation that Carmarthenhsire is home to 6% of the welsh population)

Productive Horticulture VS Tree Planting

Trees -

1111 per hectare (ideal spacing)

-30,300 kg of Carbon captured per ha after 4.1 years (28 kg per tree once established after 4 years with care and maintenance of plot) - Lefebvre, D., Williams, A.G., Kirk, G.J.D. *et al.* Assessing the carbon capture potential of a reforestation project. *Sci Rep* 11, 19907 (2021)

-30t per hectare

Productive horticulture

-4.8t per hectare (baseline)

Add in the reduction of carbon emissions associated with the current supply chain of school food. (1.24kg Carbon per meal X 2m meals = 2,500 tonnes Carbon) X 30 hectares required = (144+2,500) = 2,644/30 = 88t per hectare (with a maximum "ceiling" within primary school food provision at 30 hectares"

Big Picture

Below are the wider needs of the county, very much the highest ambition/needs, not taking into consideration any product associated with production that would leave the county.

The eatwell guide suggests daily 400g (5 portions of a variety of fruit/vegetables), 70-90g Protein, 400g starchy carbohydrates (aim for whole grain varieties with less processing), 3 portions of dairy or alternative (600ml milk, 150g yoghourt, 90g cheese).

To achieve 75% of total recommended consumption of food for the usual population of Carmarthenshire (0.75/187,900 = 140,925) produced locally this would equate to per day 56,370kg of fruit/veg, 12,683kg of protein, 56,370kg of starchy carbohydrates, 84,555 litres of milk.

The goals for 2030 would be annual sustainable (ideally regenerative) production of 20,440 tonnes of fruit and vegetables, 4,635 tonnes of protein, 20,440 tonnes of starchy carbohydrates, 30,842 litres of milk or dairy alternatives. - interestingly the carbon sequestration of this total amount of product (76,357 tonnes) annually through regenerative methods would be (-205,400 tonnes)

To achieve this through tree planting you'd require 6,847 hectares at the same displacement of potential food production.

To produce this amount and variety of vegetables/fruit alone would require (2.2tonnes per acre = 44,968 acres) 18,198 hectares. And the same again for starchy carbohydrates. Carmarthenshire has 206,000 hectares of arable land, 19,000 of which new grass, 156,000 permanent grass, 10,000 grazing, 17,000 woodland.

Currently Carmarthenshire only produces **XXX** of fruit/vegetables per year, predominantly for closed markets like veg box schemes.