Carbon report 2020

Farm name: Huxhams Cross Farm
Location: Totnes, Devon
Date: January 2020 - December 2020
Enterprises: veg, fruit, small-scale grain, eggs, food processing, distribution
Farm size: 13.5 hectares
Soil type: clay
Annual sales of all produce: 24 tonnes
Sustainable practices: biodynamics, agroforestry, minimum tillage

Key statistics

Total annual carbon emissions	53.16 tonnes CO_2e
Total annual carbon sequestration	117.70 tonnes CO_2e
Total carbon balance	-64.54 tonnes CO_2e
Carbon balance per hectare	-4.78 tonnes CO_2e
Carbon balance per tonne of product	-2.69 tonnes CO_2e

Note: CO_2 stands for carbon dioxide equivalence – i.e. other greenhouse gases are included, but converted to a standard unit to represent the global warming impact of carbon dioxide
CO_2 stands for carbon dioxide

Table 1. Carbon balance 2020

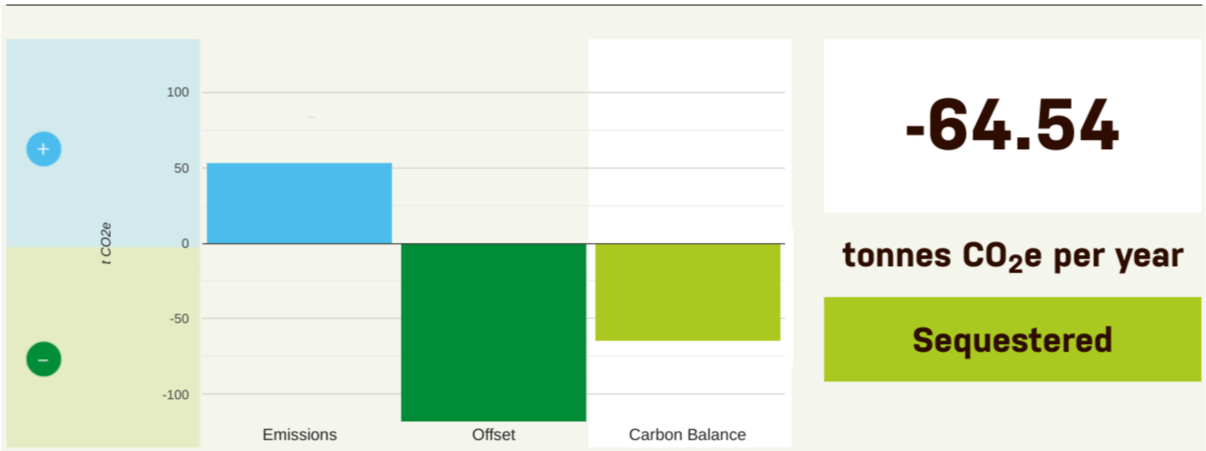
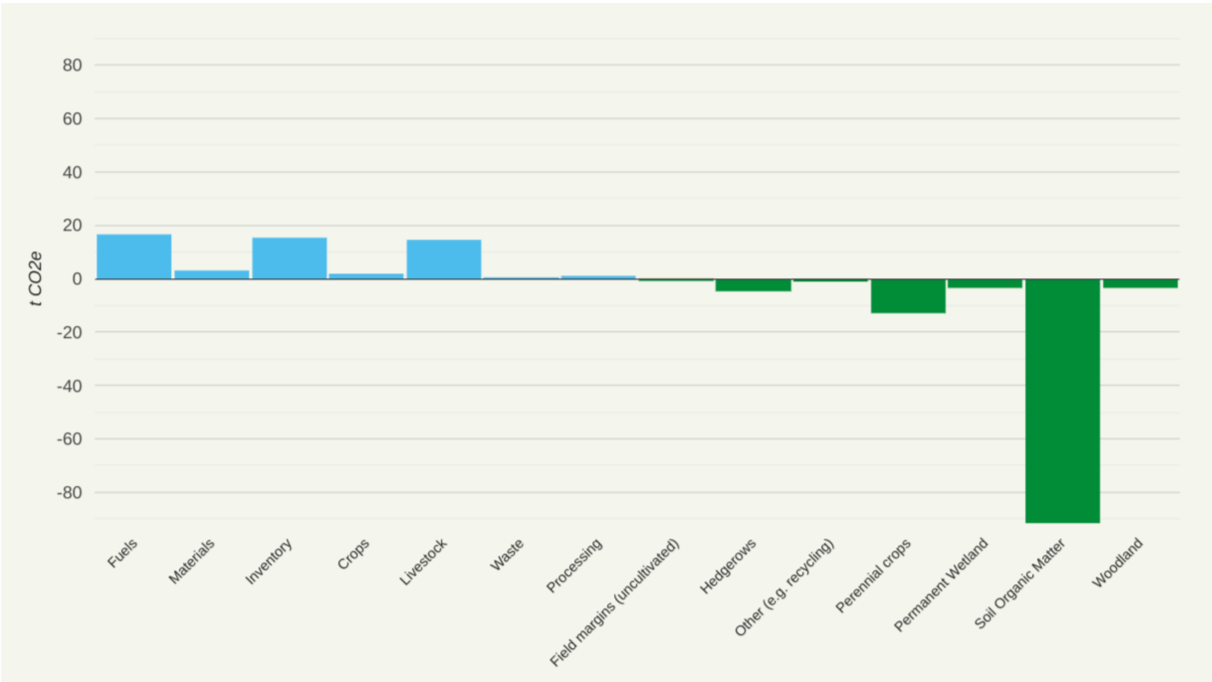


Table 2. Breakdown of CO_2e emissions and offsets for 2020



Emissions	tonnes CO_2e	%
Fuels	16.78	31.56%
Materials	3.26	6.14%
Inventory	15.39	28.94%
Crops	1.82	3.43%
Livestock	14.70	27.66%
Waste	0.35	0.66%
Processing	0.86	1.61%
Total	**53.16**	**100%**

Offset	tonnes CO_2e	%
Field Margins (Uncultivated)	-0.66	0.56%
Hedgerows	-4.61	3.92%
Other (E.G. Recycling)	-0.90	0.76%
Perennial Crops	-12.93	10.98%
Permanent Wetland	-3.53	2.99%
Soil Organic Matter	-91.60	77.82%
Woodland	-3.48	2.96%
Total	**-117.70**	**100%**

Emission sources

Total emissions amounted to 53.16 carbon-equivalent (CO_2e) tonnes.

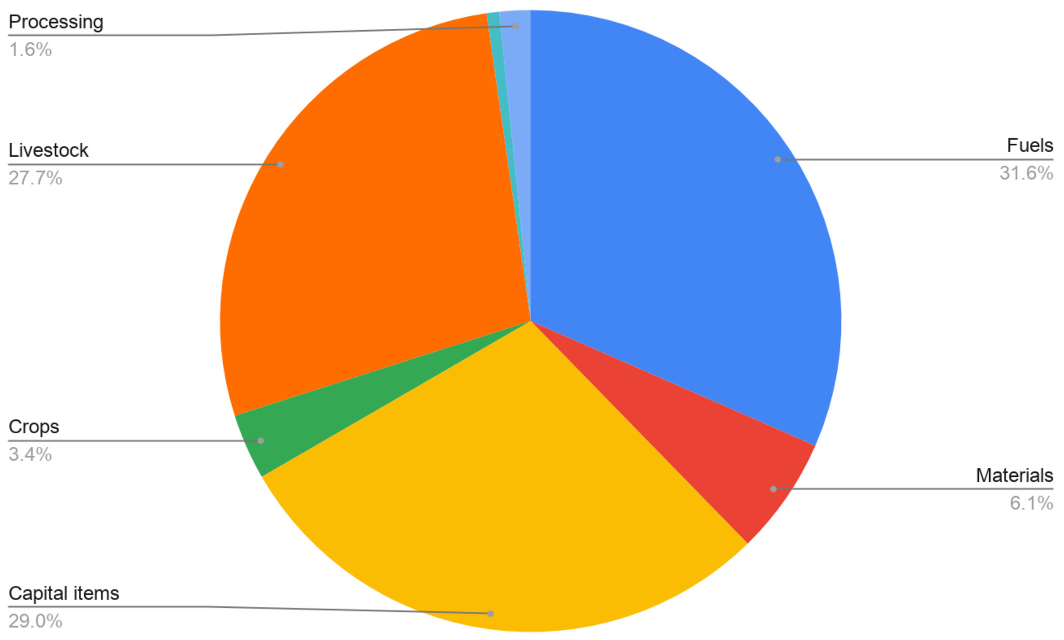


***Figure 1**. CO_2e emissions of the farm.*
Fuels, Livestock and Capital items are the biggest contributors to GHG emissions.

The main source of emissions came from Fuels (31.6%), and Livestock (27.7%). Together, these account for almost 60% of farm CO_2e emissions. Capital items are similarly responsible for a high percentage of emissions, due to the embodied carbon in materials, however this will reduce over time.

In this report I will break down each category and address the sections individually.

Fuels

Fuels accounted for 16.78 tonnes of CO_2e or 31.6% of total farm emissions (Fig. 1). This is mostly due to diesel use for our veg box delivery scheme, and red diesel for our tractor (Fig.2). As well as running a road vehicle, petrol includes the running of a generator to pump water in the summer months, and small farm machinery e.g. BCS. The section ‘contractors’ accounts for the red diesel used in a small number of operations, including ploughing, combining and drilling - predominantly in relation to wheat production.

Electricity on the farm amounted to 7.12% of total farm emissions, and 22.7% of the fuel emissions (Fig. 2). This is despite solar panels providing 5kWh off-grid energy. Electricity is used mainly to run 2 coldstores and for pumping irrigation water, particularly in the summer months. We are looking into switching to a renewable tariff which will reduce our CO_2e emissions. In the future we would like to switch to an electric vehicle. This would reduce our road diesel usage considerably and although it would increase our electricity use, if we switch to a renewable tariff combined with increasing solar panel capacity, we positively affect our CO_2e emissions.

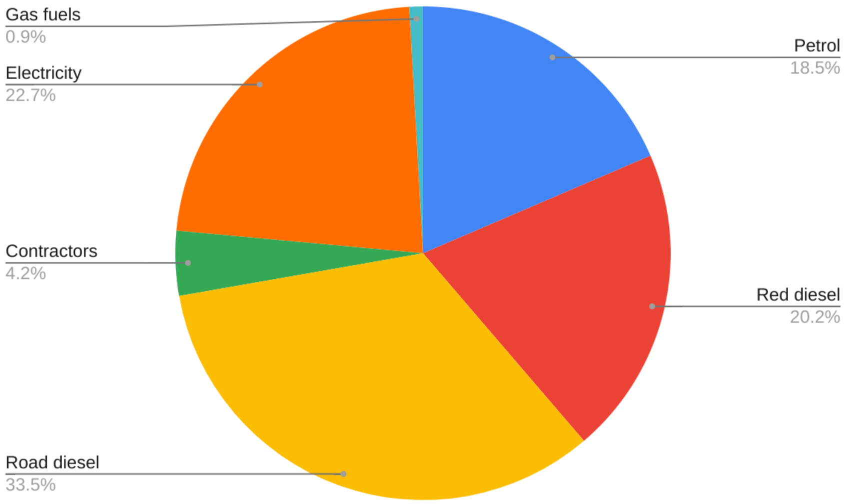


Figure 2. *CO_2e emissions of Fuel used at the farm.*
Fuels account for 16.78 tonnes of CO_2e emissions or 31.6 % of total farm emissions. The chart shows this subdivided into categories. Fuel for vehicles (road diesel, red diesel and petrol) are responsible for 72.2% of fuel emissions, followed by electricity at 22.7%.

Materials
Materials are an important consideration, for example what is the embodied carbon associated with a particular material and are they recycled or reclaimed alternatives?

Materials on the farm, including wood, water, tyres, aggregates, consumables and paper amounted to 3.26 tonnes of CO_2e or 6.11% of total emissions (Fig.1). This is a relatively small amount, however there is room for improvements. The highest was consumables (2.14%). This includes all our packaging - paper bags (2.97%), cardboard boxes (17.01%), polythene bags (12.46%) - used in our veg box scheme. A cost analysis showed that using hessian bags instead of cardboard boxes for the veg boxes was cheaper when considering the number of times a hessian bag can be reused compared to cardboard. Polythene bags are used for salads and greens but unfortunately biodegradable alternatives are currently too costly.

Where possible we recycle and use 2nd hand materials. For example, our polytunnel frames are all 2nd hand, as are our crop covers.

Mains water was responsible for 2.43% of emissions from materials. An estimate of 240m^3 water was used for 2020. We have a rainwater harvesting system which reduces mains water usage. Capacity could be increased.

Capital items (Inventory)
In the Farm Carbon Calculator (FCC), any machine or capital item e.g. building, fencing, polytunnel, under 10 years old is accounted for, and depreciated over 10 years. This accounts for the embodied energy in materials used for large structures or machinery. After 10 years, materials have in effect, “paid their carbon debt” and their CO_2e emissions are null.

It's worth noting that due to the age of the farm (beginning in 2015), at the time of the report, many items came under this bracket.

Capital items accounted for 15.39 tonnes CO_2e or 28.94% of total farm emissions. The highest of this was agricultural buildings - our 200m2 barn (19.82%) which was built in 2018, followed by farm machinery (5.94%). See Fig. 2 for breakdown of capital items. Most of our farm machinery was bought second hand e.g. the tractor and many implements, however due to limitations of the FCC, they have been entered as new. With this in mind, we used the FCC to project a scenario in which the farm building was >10years old and 2nd items had already paid their carbon debt. The results showed the farm would emit 14.26 tonnes of CO_2e less, reducing the emissions of capital items to 3.8% of total farm emissions.

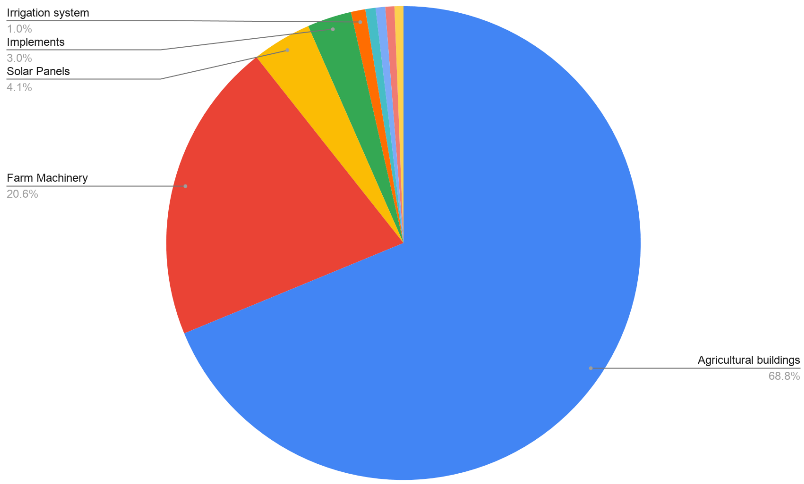


Figure 3. *CO_2e emissions of capital items at the farm.*
Capital items account for 15.39 tonnes of CO_2e emissions or 28.94% of total farm emissions.. The chart shows this subdivided into categories. Agricultural buildings are responsible for 68.8% of emissions, followed by farm machinery at 20.6%. The remaining items account for less than 12% of capital item emissions.

Crops

Green manures, including red, white and crimson clover, vetch and lucerne, contribute 1.82 tonnes of CO_2e or 3.43% of total farm emissions. Numbers are adjusted for non legumes, shorter duration than a year and poor establishment. These emissions are due to nitrous oxide released during nitrogen fixation. This appears to be a negative attribute of green manures, however they can also contribute to a substantial increase in soil organic matter (SOM) levels, which sequesters atmospheric carbon (see later section).

Nitrous oxide emissions from crop residues of arable crops (wheat) contribute a further 1% to total CO_2e emissions. This is due to nitrogen in the crop residue being oxidised in the soil and being released as nitrous oxide.

Also worth mentioning is that our plant raising media is 50% peat from Europe which accounts for 0.74% of emissions.

Inputs
We don't use any inputs. No fertilisers, pesticides or herbicides are used. We occasionally apply biocontrol if needed, e.g. in 2020 we applied 3 x predatory red spider mite solution to crops in the polytunnel to combat red spider mites. We buy in council waste compost which is applied to the soil infrequently to help build fertility (this is account for in the crop section and accounts for 0.17% of total farm CO_2e emissions). Agro-chemicals are responsible for a high percentage of most farm emissions, due to production methods and application. By avoiding agro-chemicals, our CO_2e emissions are greatly reduced compared to other farms. Instead, we adopt sustainable farming practices (see later).

Livestock
Total livestock emissions account for 14.70 tonnes CO_2e or 27.66% of total farm emissions (Fig.1).

The farm has a flock of 150 chickens. The chickens themselves account for 2.60% of total CO_2e emissions or 9.31% of livestock emissions (Fig.4). However the feed accounts for almost one fifth of total emissions (18.55%). The feed is predominantly composed of organic wheat and soya, entered as 70% organic wheat, 30% conventional soya due to input restrictions. In addition the feed is imported from overseas. Although poultry are responsible for a fraction of GHG emissions associated with red meat production, chicken feed is an area we would like to work on and are looking into producing our own feed with the help of a local arable farm.

Chicken manure is much higher in nitrogen than other livestock manures and is therefore susceptible to much higher losses of urea and the potential for subsequent oxidisation to nitrous oxide (N_2O). Methane emissions are nearly all associated with manure storage (chickens digestion does release some methane but it is relatively negligible) and mainly occur in the anaerobic areas of the manure store, and can be reduced by aerating any storage (FCT - website). On the farm, we have mobile chicken coops and manure handling is 100% in field. This reduces our emissions associated with egg production, whilst simultaneously adding fertiliser to the land.

The 2 shetland cows account for 6.79% of total CO_2e emissions. However due to FCC limitations, the data was entered as 'heifers for breeding,' whereas in reality the cows are used for conservation grazing in the wetland meadows. The most significant emission is from 'enteric fermentation' (common to all bovines) from the cows themselves as the microflora in their rumens breakdown the forage, with the subsequent release of methane (CH_4) which is then emitted out by the cow.

There are a range of studies that have shown positive results from increasing the legume content of the forage (the tannins and saponins in certain legumes (and other plants such as garlic) appear to have an anti-methanogenic effect), replacing maize with grass forage and increasing the oil content of the feed (FCT, 2021). The type of grazing system is also important to consider, e.g. mob grazing which mimics large herds found in nature, allowing forage to recover between grazing[1].

[1] Rodale Institute, 2020 *Regenerative Agriculture and The Soil Carbon Solution*

In addition, recent research shows emissions that contribute to climate change can be divided into 2 types; long-lived pollutants and short-lived pollutants. The effect of short-lived pollutants e.g. methane, is very different to long-lived pollutants such as carbon dioxide because they disappear within a few years as opposed to building up in the atmosphere over centuries. This means methane emissions should not be treated as an 'equivalent.' Taking into account the lifetime effects, the GWP of our 2 cows is likely to be much less than reported here[2].

Manure is 100% in field and we produce our own feed. This reduces the GHG emissions of our cows compared to most livestock farming.

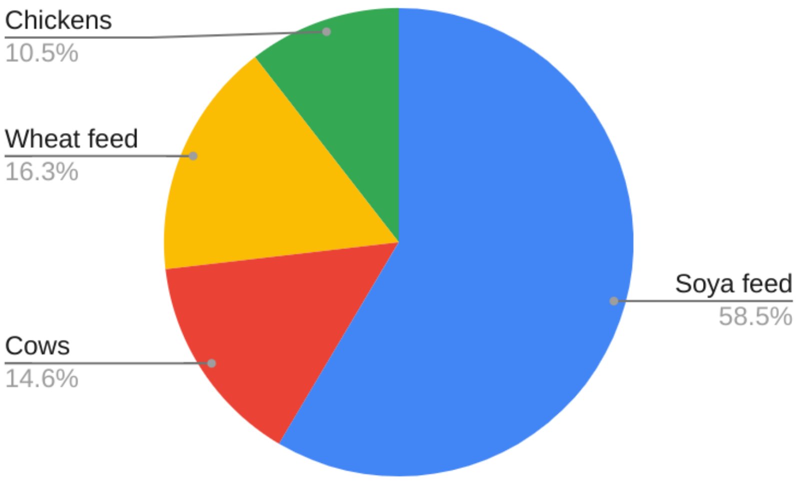


Figure 4. *CO_2e emissions of livestock & feed at the farm.*
Livestock and feed account for 14.70 tonnes CO_2e or 27.66% of total farm emissions. The chart shows this subdivided into categories. Conventional soya is responsible for 58.8% of emissions, followed by organic wheat 16.3%.

Distribution
Our distribution costs and emissions are accounted for in our petrol use in the fuel section. Almost 100% of our produce is delivered direct to the customers, market stall, or local retailers. This contributes to reducing food miles.

Waste
Waste and recycling numbers are estimates. We have our own sewage treatment.

Processing
Processing accounts for 0.86 tonnes CO_2e or 1.61% of farm emissions, the majority of which is glass bottles and jars. Electricity and fuel usage is accounted for in the fuel section.

[2] New methane emissions
https://www.oxfordmartin.ox.ac.uk/news/2018-news-climate-pollutants-gwp/

Sequestration

The total carbon sequestered on the farm (117.70 tonnes of CO_2e) offsets 221% of all carbon emitted by the farm business

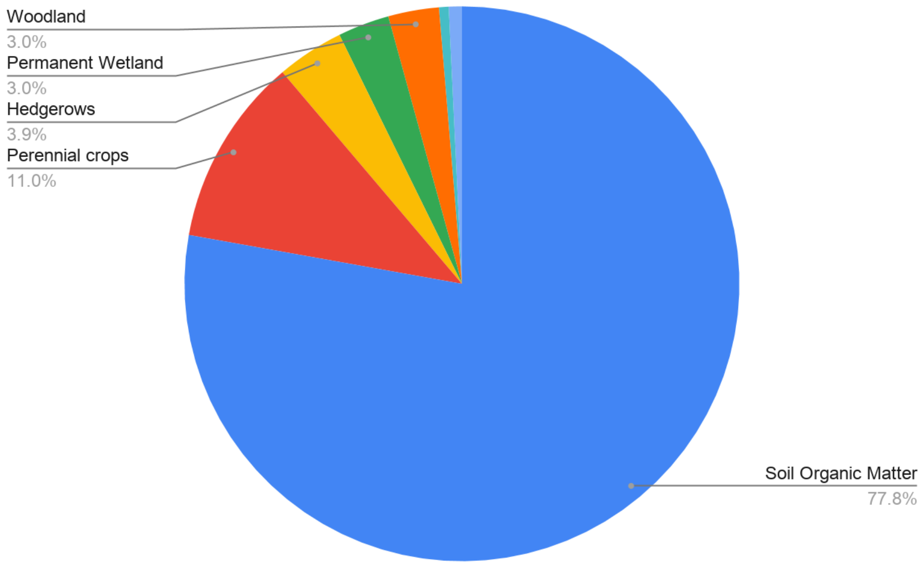


***Figure 5**. Total* CO_2e *sequestration on farm*

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Carbon is sequestered in perennial biomass and soils on farms. On this farm 77.8% of carbon sequestered is due to building Soil Organic Matter (SOM), a total of 91.60 tonnes CO_2e. The 2019 and 2020 results from FCT appeared to show a lot of variation. According to FCT, this could be due to the following;

- high organic matter content fields have more in-field variation in OM; despite returning to GPS logged points, there may be some differences in sample points that lead to overestimation in 2019 and under-estimation in 2020
- bulked samples not being mixed well enough before bagging up and analysis
- differences in lab humidity affecting sample weighings

In light of the above, we took an average across the 2 years and compared it to the 2015 results. Only 3 out of 5 fields were sampled in 2015 due to financial restriction; higher week, billany and the grove. The results suggest that we have increased SOM content by 25% since 2015. Further experiments are needed to analyse the SOM in full and across the whole farm.

In the Soil Association paper Soil Carbon and Organic Farming (2009) a comprehensive analysis of studies is made that examines soil organic matter (SOM) levels in farming systems across the world[3]. There was a huge range of results in temperate organic arable systems, from SOM increases of 0.5% per year through to annual SOM losses. However it confirmed that annual SOM gains of 0.1% are perfectly achievable.

[3] Soil Carbon and Organic Farming 2009 policy paper Soil Association

Perennial crops (10.98%) in the form of young orchards, hedgerows (3.92%), permanent wetland (2.99%) and woodland (2.96%) are the other main carbon sinks. These lower percentages reflect the land usage; over 80% of the farm area is cultivated land. However a policy for creating habitat for wildlife within the fields offers important opportunities, not only for carbon sequestration, but also for increasing biodiversity both above and below ground, e.g. beetle banks. In turn, these can aid pest and disease control by providing habitat for beneficial species, e.g. parasitic wasps. The hedgerows on the farm are allowed to grow tall and wide, accounting for 4.61 tonnes CO_2e. Agroforestry rows are planted up with 3,000 hazel trees, running across the slope to provide ecosystem services and control water flow. In total, the area of field margin is almost 1.7 hectares, and accounts for nearly 0.7 tonnes of CO_2e. A small area of woodland, accounts for 3.5 tonnes of CO_2e. And the 2 areas of permanent wetland (2.35ha total), which are under conservation management practices with the help of our cows, sequester 3.5 tonnes of CO_2e.

Discussion

The production, processing and distribution of food is the world's largest activity. Emissions that result directly from agricultural production account for 11-15% of GHG emissions worldwide. Two of the major agricultural contributors to climate change is the release of carbon held in the soil and use of fossil fuels[4]. We can reduce carbon emissions from soil by slowing or ending land clearing and wetland drainage for agriculture, preventing erosions, reversing the degradation of agricultural soils and reducing tillage. We can reduce fossil fuel emissions by reducing the use of mechanized equipment and cutting back on chemical nitrogen fertilizers[5]. Chemical fertiliser can be replaced with manure or nitrogen fixing plants such as legume cover crops or agroforestry support trees.

The most significant Greenhouse gas (GHG) emissions from arable cropping in the UK are associated with the use of artificial nitrogen fertilisers (60-70% in conventional systems). The other significant operation is cultivation (frequency, intensity, and depth) and the effect that has on Soil Organic Matter (SOM) and subsequent GHG emissions. This is both because of the effect cultivations have on the soil and also because of the fuel use and wear and tear involved with cultivation. There is a growing body of evidence that demonstrates the fewer the number of passes and the less the disturbance to the soil with each pass, the lower the GHG emissions are from the soil. GHG emissions from the soil occur as Carbon Dioxide (CO2) and to a lesser extent methane (CH4) as well as N2O. This is principally as a result of the oxidation of the soil organic matter (SOM) by microbial activity that is stimulated by available oxygen following a mechanical cultivation[6].

Mitigation is not the only issue, farming must also adapt by making itself more resilient in the face of extreme and changing weather. Fortunately most of the carbon-sequestering practices are also adaptation strategies.

[4] The Carbon Farming Solution book, Toensmeier p.12
[5] The Carbon Farming Solution book, Toensmeier p.19
[6] Farm Carbon Toolkit https://www.farmcarbontoolkit.org.uk/toolkit/

Attention to soil management and soil structure is fundamental for all growing systems, and also drainage where appropriate. The UK soil survey estimated that between 1978 and 2003, soil carbon (the principle chemical of soil organic matter) declined by an average of 0.6% in cropped soils. The Countryside Survey records that, between 1978 and 2007, the topsoil carbon concentration in arable soils fell by 11%. The bulk of this reduction was observed between 1998 and 2007[7].

Sustainable farming approaches

At Huxhams Cross Farm we have adopted a number of sustainable or regenerative practices. Our key objectives of the farm are to sequester carbon, support biodiversity, adapt and mitigate climate change, and produce food. We used Permaculture design tools to initially work towards these outcomes. We then used specific management practices, focussing on minimum disturbance, i.e, no ploughing and reduced cultivation, keyline ploughing or 'subsoiling,' constant coverage with living roots, i.e, green manures, growing diverse species and varieties (agro-biodiversity), valuing crop rotation in combination with chickens and in field manure, and reintroducing and building the soil biome with the use of biodynamic preparations. We are a very small farm, but on a larger scale with livestock we would use mob grazing techniques. This report highlights that we are successfully sequestering carbon. The report shows that this is predominantly due to the increasing levels of SOM. Reducing the frequency and intensity of cultivations results in less SOM being oxidised which, combined with the potential improvement in the soil structure from increasing SOM, is a clear management strategy for reducing GHG emissions from arable crops. Overall, regenerative agriculture not only helps to cultivate healthy soils, but supports biodiversity and produces nutritious food (see other report).

The report has also highlighted specific areas with significant CO_2e emissions. As previously mentioned, we hope to switch to an electric vehicle and produce our own chicken feed. We regularly address the wider sustainability of all the activities on your farm including processing of products and packaging. Currently capital items contribute over a quarter of farm emissions, however we can be confident that in the next 5 years this will reduce considerably. Furthermore, based on the meta-analysis by the Soil Association, we can predict our SOM levels to continue to rise and thus creating a greater carbon balance.

The IPCC goals are of reducing emissions by 2030 to 25-30 billion tonnes and to reach net zero emissions by 2050[8]. The report shows how regenerative agriculture over large swathes of land can play a huge role in restoring the natural organic cycle to hold a capacity of carbon of these proportions. Apricot Centre are working with organisations such as the Church to help meet the promises they have made to Net Zero Emissions by 2030. This is one example of innovative farming practices providing a proven source of carbon replenishment through healthy soils and organic life.

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[7] Soil Carbon and Climate Change, Parliament Environmental Audit 2016

[8] IPCC Mitigation Pathways Compatible with 1.5°C in the Context of Sustainable Development https://www.ipcc.ch/site/assets/uploads/sites/2/2019/02/SR15_Chapter2_Low_Res.pdf