Canolfan Organig Cymru
Organic Centre Wales

Environmental footprinting for farm businesses

Authors: Laurence Smith, Organic Research Centre, Elm Farm
Tony Little, Organic Centre Wales

May 2013

Cronfa Amaethyddol Ewrop ar gyfer Datblygu Gwledig: Ewrop yn Buddsoddi mewn Ardaloedd Gwledig
The European Agricultural Fund for Rural Development: Europe Investing in Rural Areas

Llywodraeth Cynulliad Cymru
Welsh Assembly Government

Acknowledgements

We would like to acknowledge the developers of the calculators included in this review, who gave freely of their time and expertise. They are:

- Derek Holiday, CLA (CALM)
- Drew and Jan Coulter, North Deanhead Farm (CPLAN)
- Kerrin Buckler, CALU (Managing Energy and Carbon)
- Jonathan Smith, Farm Cutting Carbon Toolkit (Farm Carbon Calculator)
- Sam Adams, Soil Association (Farm Carbon Assessment Tool - FCAT)
- Dr. Shamal Mohammed, HGCA (HGCA Carbon Footprinting and Decision Support tools)
- Dr. Jon Hillier, The University of Aberdeen (The Cool Farm Tool)
- Dr. Ed Moorhouse, Footprints 4 Food (Footprints 4 Food assessment tool)
- Dr. John Tzilivakis, University of Hertfordshire (IMPACCT)
- Dr. Marijke Meul from Ghent University (MOTIFS)
- Dr. Richard Gooday, ADAS UK Ltd (FARMSCOPER)
- Mr. Andrew Wynne (The E-CO_2 project)

Better Organic Business Links – Gwell Cysylltiadau Busness Organig

The Organic Centre Wales has received £2 million funding through the Rural Development Plan for Wales 2007-2013, which is funded by the Welsh Assembly Government and the European Agricultural Fund for Rural Development, to run the Better Organic Business Links (BOBL) project over 3 years (2009-2012). The BOBL project is designed to support the primary producer in Wales and grow the market for Welsh organic produce in a sustainable way. The project will develop new, emerging and existing markets for organic produce whilst driving innovation, at all levels, within the supply chain. It will strive to increase the consumer demand and markets for organic produce, especially in the home market whilst also ensuring that the primary producers are aware of market demands. The project will provide valuable market information to primary producers and the organic sector in general.

Delivery of the project is divided into five main areas of work:

1. Driving innovation
2. Consumer information and image development of organic food and farming in Wales
3. Market development
4. Market intelligence
5. Addressing key structural problems within the sector

1 Executive Summary

As awareness of our impact on the environment has increased, it has become more important to measure and monitor that impact accurately. As a result several calculators have been developed specifically for farms. However, there is little consistency between them in terms of the methodology and the raw data on which the calculations are based, and this means they can give very different answers to the same question.

In general terms, this document sets out to:

- develop a better understanding of how footprinting calculators work;
- explain how and why they differ from one another;
- highlight the issues to consider when choosing the most appropriate calculator for a particular farm or purpose;
- summarise the key features of the main calculators currently in use.

The following specific points are discussed:

- the different purposes for which calculators have been developed;
- the basic principle on which all calculators are based is explained;
- the concept of emissions scopes and their relevance to footprint calculations;
- the allocation of emissions to farm enterprises and to specific products;
- the limitations of footprint calculators with respect to standard datasets, and the difficulties inconsistent methodologies and limited benchmarking data impose on making comparisons between calculators;
- descriptions of the calculators;
- summary of the main characteristics of these calculators in a matrix to facilitate the choice of calculator 'at a glance'.

2 Introduction

As awareness of our impact on the environment has increased, it has become more important to measure and monitor that impact accurately. Environmental footprint calculators have been developed to address this need. Some include wide range of environmental resources such as soil, water and biodiversity, however this report will focus on those that determine **carbon footprints (Box 1).**

Box 1: What is a farm carbon footprint?
A farm carbon footprint summarises the greenhouse gas (GHG) emissions from a farm according to farm inputs and outputs.

Canolfan Hinsawdd Cymru, 2010

Calculating the footprints for farms is more complicated than for other types of business because:

- farms in general are complex systems, and organic farms often more so because they tend to be more integrated and diverse;
- in most industries, the main greenhouse gas emitted is carbon dioxide (CO_2). In agriculture methane (CH_4) and nitrous oxide (N_2O) are much more important. Only about 8% of total agricultural emissions are of CO_2.[1];
- farming and other land based businesses can sequester as well as emit carbon.

Several calculators have been developed specifically for farms, however, inconsistencies between them, in terms of what exactly is included in the assessment and the raw data they use can give rise to a certain amount of confusion.

The aim of this piece of work is to:

- develop a better understanding of how footprinting calculators work;
- clarify how and why they differ from one another;
- highlight the issues to consider when choosing the most appropriate calculator for a particular farm or purpose, with particular reference to organic farms;
- summarise the key features of some of the main calculators currently in use.

3 Why calculate farm footprints?

Broadly speaking there are three reasons why environmental footprints of farms are calculated:

- To help farmers measure, monitor and reduce environmental footprints and subsequently improve the efficiency and performance of their business;
- To inform strategy and policy development;
- As a marketing tool to help environmentally conscious consumers choose the products they buy.

Different calculators are suited for different purposes, and this has a significant impact on the scope and the methodology of the calculators. This theme will be picked up throughout the remainder of this document.

[1] 56% of UK agricultural emissions are due to N_2O; 35% are due to methane; and about 8% are due to CO_2.

4 How carbon calculators work

4.1 The basic principle

The basic principle on which all these calculators work is very simple. There are two components:

- A database with standard figures for emissions (or sequestration rates) associated with an individual item or process;
- Farm specific data (e.g. number of cattle, tillage practices, amount of fertiliser applied).

The calculator then multiplies these two components together to give total emissions associated with each individual parameter as illustrated in Table 1. It then adds them all together to provide an estimate of the total emissions associated with that particular farm or enterprise.

As discussed in Section 3, N_2O and CH_4 are important greenhouse gases. However, their global warming potential is different to that of CO_2 so farm footprints are measured in **CO_2, equivalents (CO_2 e).** A kilogram of CH_4 has the same effect as 25 kg of CO_2, and therefore has 25 CO_2, equivalents. A kilogramme of N_2O has 298 CO_2 equivalents estimated over 100 years.

We also identified in Section 3 that agriculture has the potential to sequester as well as emit carbon. Some calculators attempt to take this into take account when calculating the net Global Warming Potential (GWP) of the farm. In practice, all calculators are a good deal more complicated, but it is important to understand the underlying mechanism.

Parameter	**No. Units**	**Emissions per unit (Kg CO_2 Eqv/ Unit)[2]**	**Total emissions (Kg CO_2 Eqv)**
Diesel	3,000 litres	2.31	6,930
Electricity	1,500 Units (kwH)	0.53	795
Dairy cows including manure (CH_4)	100 Head	2,944	294,400
Beef cattle including manure (CH_4)	15 Head	1,167	17,505
Sheep including manure (CH_4)	150 Head	188	28,200
Grass clover, ha (N_2O)	10 ha	555	5,550
Etc, etc			
TOTAL Emissions			353,380
Sequestration – Natural woodland regeneration on arable land	10 ha	12,517	125,170
Bioenergy crop production on arable land	10 ha	4,520	45,200
TOTAL Carbon Sequestration			**170,370**
Net Global Warming Potential			**183,010**

Table 1: How a carbon calculator works

4.2 Setting the system boundaries

When completing an assessment, a first and very important step is to very clearly define the boundaries of the system and set the **scope** of the measurement. With respect to emissions, the World Business Council for Sustainable Development (WBCSD) has defined three scopes, which have been accepted internationally (Figure 1):

[2] Sources: National Atmospheric Emissions Inventory and Carbon Trust energy and carbon conversion factors. Carbon sequestration figures taken from Falloon *et al*. 2004.

- *Scope 1* refers to direct emissions from sources that are owned or controlled by the company. This includes emissions from diesel used by tractors, propane used by grain dryers, gas for heating, kerosene for boilers etc. It also includes direct emissions from soils and livestock;
- *Scope 2* is a separate category for emissions associated with the generation of purchased electricity consumed on the farm;
- *Scope 3* refers to indirect emissions including those associated with the production, processing and distribution of inputs in to the farming system. These include seed, bought-in grain and compound feed, fertilisers, pesticides and so on.

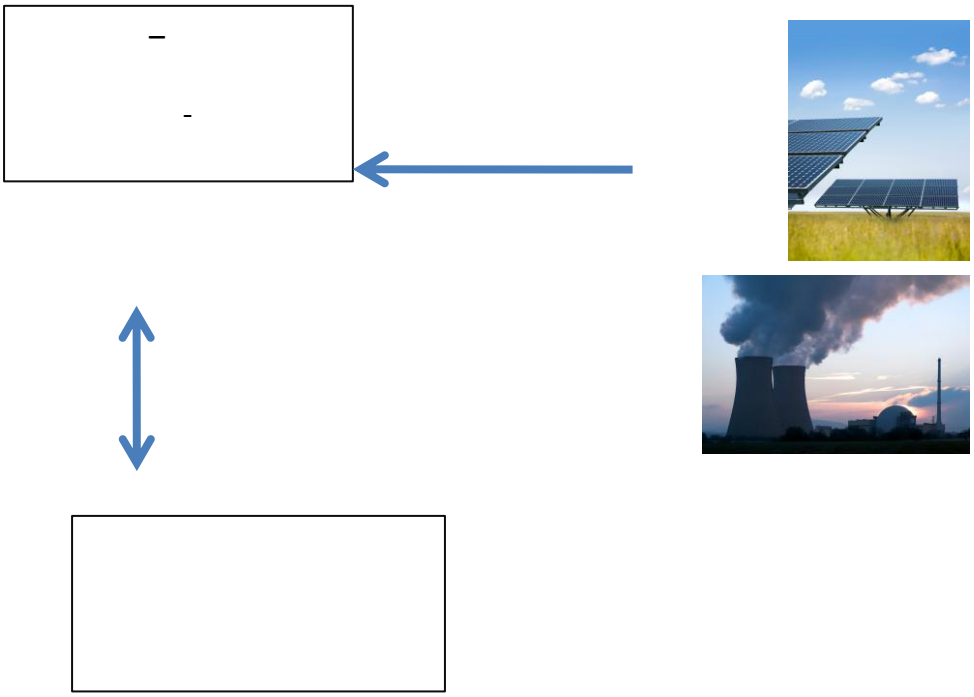

Figure 1: WBCSD Scopes for calculating carbon emissions.

It is sometimes possible to select data for the scope relevant to your purpose. In other cases, the scope is reflected in the calculator's database, so you do not make a conscious decision on the scope of the calculator. In this circumstance it is very important that you are aware of the scopes that are included in the data, and that you understand the implications for the final footprint

4.3 Allocating emissions to enterprises

Although the total footprint of the farm is of interest, more often than not the value of the exercise is in being able to see which aspects of the business make the largest contributions to the total emissions, and to identify practical steps that can be taken to reduce those emissions, improve efficiency and make savings. To do this, it is necessary to allocate emissions to a specific enterprise. Sometimes this is easy and obvious; the energy used to cool milk is clearly a cost of dairy enterprise and it is a simple matter to work out the number of units of electricity per litre of milk.

However, it is not always so straight-forward for integrated systems, typical of organic farming. The problems arise where one item or process serves more than one enterprise, or where one enterprise has more than one product. Box 2 highlights some examples of where this might occur.

The emissions are usually split between the different enterprises, but there is little agreement or consistency about how this is done between calculators.

Box 2: A burden shared……

Clover rich leys build soil fertility which is exploited by a following arable or horticultural crop. They are also grazed or cut for silage, and therefore are also part of the livestock enterprise. The emissions associated with the establishment and management of the ley therefore need to be shared accordingly.

Animal manures are a cost of livestock enterprises, but an input into cropping enterprises

Arable crops produce grain and straw. Straw is used for bedding, which means the emissions associated with its production are also a cost to the livestock. The grain is a product of the arable enterprise, and the carbon costs need to be split accordingly.

4.4 Allocating emissions to products

There is growing interest in footprinting individual products, rather than farms. This process usually accounts for all the environmental impacts associated with a product from raw material acquisition through to production, use and disposal. This approach is often referred to as a **Life Cycle Assessment** (LCA, ISO, 2006). Within the UK, The Carbon Trust has developed an LCA methodology for the UK called the PAS (Publically Available Specification) 2050[3], the guidelines for which can be freely downloaded from the British Standards Institution's Website.

One of the benefits of an LCA approach is that it can help companies identify carbon intensive 'hotspots' in their supply chain and work towards reducing their emissions (Maung, 2009). In addition, such assessments can be used to label the environmental attributes of products in the market place. For example, companies completing a PAS 2050 compliant assessment can apply to the Carbon Trust Footprint Company to display a logo on their packaging indicating their CO_2 footprint, and stating that they are taking action to reduce their impact.

Figure 3: ***Carbon label from Carbon Trust Footprint Company*****.**

[3] PAS 2050: 2011. Specification for the assessment of the life cycle greenhouse gas emissions of goods and services. Published by British Standards Institution (2011). See http://shop.bsigroup.com/en/forms/PASs/PAS-2050 for more information

Life Cycle Assessment methods could also help measure progress towards national and international greenhouse gas reduction targets and it is likely to become more common in future. Data acquisition can be difficult when the supply chain is long however and LCA approaches for carbon footprinting have been questioned on the basis of cost, and the uncertain impact of carbon labelling on consumers purchasing decisions (Bolwig and Gibbon, 2009). There are also some concerns over the application of LCA to agricultural systems, for example the fact that it often does not account for carbon sequestration from permanent grassland management, or the interaction/trade-offs between environmental, economic and social indicators. The debate on how such issues can be resolved effectively is currently ongoing.

This type of assessment can be difficult for non-experts because of the sometimes complex calculations involved, and the need to access emissions data from a variety of sources. A number of organisations in the UK have tried to address this issue through the development of LCA-based calculators. For example the E- CO_2 project, AB Sustain, Agri Assist, Unilever and the University of Aberdeen and ERM have all developed tools which can considerably reduce the amount of time needed to assess agricultural products, using LCA methods. To date the private consultancies listed above have tended to access their farmer/producer clients through retailers, rather than being contacted directly. However, some of the calculators (e.g. the Cool Farm Tool developed at Aberdeen University and the Agri-Assist Calculator) have been developed for use by farmers directly. For more information on these calculators please see section 8 below.

4.5 Carbon neutrality for businesses: the PAS2060 Specification

In 2010 the BSI released the PAS2060 Specification, which sets out general requirements for anyone who wants to achieve and demonstrate carbon neutrality. The aim of the specification is to increase the transparency of claims in this area by providing a common definition and a selection of appropriate methods for offsets. The standard is targeted at organisations, communities or individuals who wish to demonstrate actions being taken to offset their emissions in order to save energy and gain customer confidence. For more information on the Specification please visit: http://shop.bsigroup.com/en/ProductDetail/?pid=000000000030198309.

Figure 4: Carbon neutral label from Carbon Clear Limited (www.carbon-clear.com).

Although it has been larger organisations such as Marks and Spencer Group Plc who have tended to engage with carbon offsetting to date, it is possible that smaller businesses (e.g. individual farms) could also engage, either directly or via a subcontractor. It should be noted however that carbon offsetting is seen as a contentious area as it potentially ignores a range of economic,

environmental and social factors associated with the implementation of offset projects (e.g. the costs of technology and associated biodiversity impacts).

5 Some problems and limitations

5.1 Quality of data

The database of emission factors and input values is the foundation on which any calculator is built and any weaknesses in the dataset will be reflected in the final results. Ideally the standard emission figures should be independently verified and widely agreed upon. In addition there is no industry standard on input data. The problem is particularly acute in two areas:

- *Scope 3 emissions.* This is of particular concern because these sources can account for over 40% of the total emissions from some agricultural systems (Huang *et al.* 2009). The current variation in input data sourcing means there is potential to be selective with the data used, in the interest of promoting one product, or production system over another.
- *Carbon sequestration.* It is very difficult to measure carbon stocks and carbon fluctuations accurately and consistently, especially in soils. There are simply not enough relevant studies to draw on for robust data and this is a fundamental problem that will only be addressed by long term investment in appropriate research.

There is also currently a lack of advanced country and farming system specific data. Many calculators are based on Intergovernmental Panel on Climate Change (IPCC) 'Tier 1' data. This is a default factor for an emission source, for example a universal figure for a dairy cow, within any farming system. There is currently a lack of more detailed Tier 2 (country or farming systems specific) and Tier 3 (advanced country/farming system specific) data on which to base estimates. On-going research within the Defra and Devolved Administration funded Greenhouse Gas Platform is addressing this issue, through the development of country and farm-activity specific emission factors (see www.ghgplatform.org.uk for more information).

5.2 Making comparisons

The range of emission factors and input data required by different calculators makes it very difficult to make meaningful comparisons of farm or supply chain footprints calculated using different systems. For example some will choose to leave out Scope 3 emissions altogether, whereas others will include the full life-cycle of the products being assessed. Being clear about the scope of an assessment and the tier-level of the data that is being used is important to ensuring that (a) like is compared with like and (b) all major sources of emissions are accounted for as accurately as possible.

There are also potential differences in the raw data used, and details of system used to allocate emissions to specific enterprises or products. There are also problems with finding benchmark figures that allow farmers to compare their farms to others of a similar type. This is a particular issue for the organic sector because there are not enough organic farms to make a robust dataset. The best way to make valid comparisons between farms or systems is to use the same calculator each year and compare results over time.

In addition, consumers, retailers and governments must understand that some farms will have inherently higher footprints, for example those who further from the consumer or have lower quality land. This does not imply that these farms, or farmers, are any 'worse' than other systems that do not have to operate under these limitations.

5.3 Limited focus

Calculators that focus on one indicator such as greenhouse gas emissions have also been criticised for having a limited focus, that ignores trade-offs and interactions between a range of sustainability criteria. For this reason there has been a growing interest in the development of assessment tools that take a 'Triple-Bottom-Line' (TBL) approach.

The TBL consists of three Ps: profit (the economic value created by the company, or the economic benefit to the surrounding community and society), people (the fair and favourable business practices regarding labour and the community in which the company conducts its business) and planet (the use of sustainable environmental practices and the reduction of environment impact) (Source: http://www.investopedia.com/). It aims to measure the financial, environmental and social performance of a business over a period of time, taking into account the full cost involved in doing business (The Economist 2009). This approach can a useful method to overcome the risks associated with a narrow focus on one-or two indicators such as greenhouse gases, although it is pointed out that the three TBL pillars, although recognized to be interconnected and interdependent, still "reflect more or less conventional modern disciplinary categories" whereas sustainability should be "an attack on conventional thinking and practice" (Gibson 2001 in Pope et al. 2004).

A number of tools that have been developed for the assessment of agricultural systems against a range of indicators are described in section 9 below. It can be argued that organic farms in particular should consider the wider impacts of their systems using a TBL approach, in order to fully reflect the costs/benefits associated with diverse production systems.

6 Choosing the right calculator

In the end, the choice of calculator is determined by the specific job you want it to do. The clearer you are about what the objectives of the assessment and the scope and degree of accuracy that you need, the easier you will find it to choose. Below are some of the key issues to consider when choosing a calculator, and Box 3 lists some of the characteristics that are particularly important for organic farms.

6.1 Ease of use

This includes factors such as; how easy it is to enter data; how the system takes you through each step of the calculation process; the ease of navigation between different screens or spreadsheets; and the overall 'feel' of the programme (e.g. fonts, colours, amount of information on each screen etc). Ideally the type of farm specific data should be easily available without requiring access to detailed sets of historical data, but this is discussed in more detail below.

6.2 Simplicity vs accuracy

As a general rule, systems should be as simple as possible. However, there is a certain level of complexity below which the results are unlikely to be representative of the situation on the ground. Over and above this, there is a trade-off between simplicity, accuracy and the amount of time required to complete and assessment. At the very least, the calculator should be able to take account of the farm's system type, livestock enterprises and crop types.

6.3 Scopes and datasets

Make sure that the scope of footprint is appropriate for the job you want the calculator to do (see section 5.2 for more information), and that the data tiers (section 6.1) are consistent.

6.4 Interpreting the results

The results should be easy to understand give sufficient detail to identify practical, farm specific steps to reduce the footprint of the business. They may include information such as an indication of the degree of uncertainty inherent in the calculation.

Box 3: Footprints for organic systems

The organic principles place a strong emphasis on ecology, and a strong commitment to safe guarding the environment. This means looking beyond the farm gate, and thinking about the impact of the business in the wider context, and what this implies.

Organic farmers should be interested in Scope 3 emissions, which can account for up to 40% of the total emissions. These include embodied energy in inputs, machinery, buildings etc and the energy required for the transport and disposal of goods. This is a slightly contentious issue. Some argue that Scope 3 emissions are less relevant to farm footprints because farmers are not directly responsible, or in a position to influence them, and in any case the data can be very inaccurate. While both of these points are true, our view is that since Scope 3 emissions can account for such a large proportion of the total footprinting, and reducing emissions across the board is one of the key ways that farmers can reduce the overall burden of their business significantly, they should be included.

Calculators should also include all relevant aspects of the carbon cycle including sequestration, although a lack of fundamental research and robust data makes this difficult at present. They should also ideally consider emissions relative to output to allow for the comparison of various enterprises in terms of production efficiency.

7 Summary of some key carbon footprint calculators

This section summarises the characteristics of the some of the calculators currently available. All the readily available calculators were tested by project staff, using actual farm data where it was available and model farm data where it was not. Assessments of calculators linked to consultancy services were based on discussions with, and information provided by the companies concerned.

7.1 Carbon Accounting for Land Managers (CALM)

Developed by:	Country, Land and Business Association (CLA) Contact: Derek Holiday derek.holiday@cla.org.uk Tel: 0207 4607956
Format	Web based calculator
Availability	Free from the CLA Website (www.cla.org.uk/Policy_Work/CALM_Calculator/)
Purpose	Management tool to: assess the carbon balance of farm businesses; identify practical steps to reduce emissions and improve efficiency; identify opportunities for renewable energy projects.
Ease of use	Easy to use, based largely on drop down menus. It is an intuitive system, requiring only basic computing skills. A step by step guide takes you through the calculation process.
Complexity	Fairly simple system. The exercise takes 30 – 45 minutes to complete providing you have the data to hand.
Methodology	IPPC 2006
Scopes	Scope 1 and Scope 2 data is used. Optional inclusion of Scope 3 data for emissions associated with N fertiliser
Coverage	*Emissions*: Fuel and electricity use (on-farm and by contractors); fertility inputs (N fertilisers, lime imported and exported organic manures); stock; cropping areas and cropping history; tonnes harvested; straw exported; land use changes. Embodied energy in inputs is not part of the main calculation, but there is an option to include it. *Sequestration:* Area of woodland; area of organic soil (peat/fens); land use changes.
Reporting	The report is easy to understand. Practical mitigation advice is generated from a standard 'menu' but is clear and helpful. Reports can be saved and used to monitor changes year on year.

7.2 Farm Carbon Assessment Tool (FCAT)

Developed by:	The Soil Association as part of their Low Carbon Farming project.
Format	A web-based system in which the farmer registers and enters the required data within the web-based tool and then the results are immediately available giving: • A breakdown of the CO_2 eq emissions (tonnes) from energy and fuel use • Nutrient and manure management scores for questions answered, highlighting areas for improvement • Soil and grassland management scores for questions answered, highlighting areas for improvement • Livestock performance indicator results and targets for improvement
Availability	Available for free online at: https://www.soilassociation.org/innovativefarming/lowcarbonfarming/footprintingandbenchmarking
What's it for?	The Farm Carbon Assessment Tool takes an alternative approach to assessing a farm's carbon footprint. Instead of focusing on figures and tonnes of emissions it allows the farmer to look at the aspects of their farm which contribute to its carbon footprint and scores key farm practices in relation to their impact on greenhouse gas emissions – highlighting areas for improvement, providing targeted, technical support and enabling them to monitor their progress towards best practice in relation to low carbon farming and lowering the emissions impact of their farm.
Ease of use	Easy to use. Follow the instructions in a PDF available on the webpage. There is a 5 minute video guide on the web page.
Methodology	Not PAS2050 compliant. Scores key practices (with regards to nutrient and manure management and soil and grassland management) in relation to emissions (scores of 1-5). Calculates the emissions related to energy and fuel use.
What does it cover?	Energy and fuel use Nutrient and manure management Soil and grassland management Livestock production efficiency, fertility and breeding, diet, and health and welfare.

7.3 CPLAN

Developed by:	Drew and Jan Coulter, North Deanhead, Lanarkshire and Ron Smith Contact: Drew Coulter drew@cplan.org.uk
Format	Web based calculator & consultancy; (LCA spreadsheets not publically available
Availability	Web based calculator available in two versions, CPLANV2 and CPLANv2, from the website http://www.cplan.org.uk CPLANv0 is a basic free calculator. CPLANv2 is more comprehensive and therefore more useful. It also reports the statistical uncertainty in the estimated emissions using standard IPCC methodology. This version requires you to register and pay a fee dependent on the number of assessments you wish to perform. CPLANv2 calculations form the basis of a paid consultancy which (a) offers farm specific mitigation advise with reports detailing the reduction of specific actions, and (b) reports results of more detailed calculations for enterprise and life-cycle analysis
Purpose	Management tool to: assess and monitor greenhouse gas balance of whole farm or specific enterprises; identify practical steps to reduce emissions; and improve efficiency. To inform policy, specifically to challenge the basis of reduction emission targets imposed by government/EU agencies by empowering farmers with detailed knowledge.
Ease of use	Very easy to use with simple format and the calculation process is clear.
Complexity	This is a simple system, focusing on direct emissions that are under the control of the farmer The CPLANv0 version takes about 15 minutes to complete, and the CPLANv2 about 30 minutes, provided you have all the information to hand.
Methodology	IPCC 2006 (Tiers 1&2 plus simplified versions of Tier 3) enhanced by UK specific models and data conformant with the UK National Inventory Reports.
Scope	Scope 2 with respect to energy (i.e. purchased electricity). Scope 1 for all other categories. Full LCA following PAS2050 and ISO/TS 14048 guidelines including Scope 3 available as part of paid consultancy.
Coverage	*Emissions*: Energy & fuel use; livestock; fertility inputs (in-organic, on-farm & bought-in manures, legumes); harvested crop residues; soil changes from management, harvested wood (carbon loss). *Sequestration*: Woodland; land use changes.
Reporting	Simple reporting system showing total emissions in categories such as fuel, livestock, crop residues, etc. The basic CPLANv0 reports emissions in Carbon equivalents. CPLANv2reports emissions of CO_2, CH_4, and N_2O as well as the combined CO_2eq and Ceq, and it also indicates the degree of uncertainty inherent in the calculation by providing upper and lower bounds of estimates. Emissions and sequestration are reported for each input line and for combined categories, e.g. individual cattle and sheep herds. General mitigation advice is provided in simple language and by links to external sites. Links to specific GHG reducing products also provided.

7.4 Managing Energy and Carbon

Developed by:	Centre for Alternative Land Use (CALU) Contact: Kerrin Buckler 01248 680450 k.buckler@bangor.ac.uk
Format	Paper based
Availability	Free download from the CALU Website or contact CALU. (http://www.calu.bangor.ac.uk/energybooklet.php)
What's it for?	Management tool; to reduce emissions and improve energy efficiency. Knowledge transfer/ advisory tool to stimulate discussion
Ease of use	As the only paper based system reviewed, it may be attractive to those with very limited computer skills. However, it is more cumbersome than its web or spreadsheet based counterparts. The questionnaire is well structured and the calculation process clearly explained.
Complexity	This by far the simplest system under review. It is intended as 'back of an envelope' system, designed to provide only approximate estimate energy consumption and emissions. 1-2 hours to complete,
Methodology	ADAS
Scope	Scope 2 with respect to energy (i.e. purchased electricity). Scope 1 for all other categories.
Coverage	Electricity and fuel use; livestock, crops
Reporting	The results are very broad brush and a range within which the farm is likely to fall. It is then benchmarked against farms of similar types and size, based on data collected by ADAS from about 900 farms in England and Wales. Generic energy saving and emission reduction advice is provided for each enterprise through a check list system.

7.4 Farm Carbon Calculator

Developed by:	The carbon calculator is led by Jonathan Smith, organic grower from the Isles of Scilly who runs Scilly Organics and is a co-Director of the Farm Carbon Cutting Toolkit with Adam Twine. jonathan@climatefriendlyfood.org.uk
Format	Web-based tool
Availability	Free from the Farm Carbon Calculator website: http://www.cffcarboncalculator.org.uk (version 3 of the tool was launched in February 2013)
What's it for?	• Farm management tool • Marketing tool to attract carbon-conscious consumers.
Ease of use	Easy to use, based on drop down menus. Takes about 30 minutes to complete assuming the relevant data is to hand.
Methodology	Developed by farmers for farmers. It takes a Life Cycle Assessment (LCA) approach and includes embodied energy in all inputs and processes.
What does it cover?	It is aimed primarily at organic farmers, and this is reflected in the input pages. The 'fertility' section for instance, N fertiliser is not included, several options from fertility building crops and compost are offered. Strong emphasis is placed on sequestration, including soil carbon gains, composting, carbon sequestered by hedge rows, wetlands, woodland and orchards. It is also possible to estimate annual sequestration in grassland based on soil organic matter percentage and measurements of bulk density. The output is very detailed, with each part of the carbon equation broken down. Because sequestration is dealt with in more detail than in other tools, this tool often indicates lower net emissions, and some systems are identified as net sequesters of carbon *Scopes:* Scope 1, 2 and 3 data are included in the assessment. This includes emissions that result from the transport of goods to and from the farm and the manufacture of building materials.

7.5 The Cool Farm Tool

Developed by:	Unilever and researchers at the University of Aberdeen
Format	Downloadable software. The farmer enters details about crop area, yield, soil type, fertilizer and inputs, as well as some detailed information on electricity and fuel use (for field operations and primary processing). The results page provides a summary of greenhouse gas emissions as well as a detailed breakdown, so they can see what contributes the most and target reduction activities accordingly.
Availability	Available as a free excel file download from the webpage: http://www.coolfarmtool.org/CoolFarmTool The release of a web-based version is imminent.
What's it for?	The Cool Farm Tool is a greenhouse gas calculator that is free for growers to help them measure the carbon footprint of crop and livestock products. The CFT has been tested and adopted by a range of multinational companies who are using it to work with their suppliers to measure, manage, and reduce greenhouse gas emissions in the effort to mitigate global climate change.
Ease of use	The tool is designed to be simple to use, but scientifically robust in the complex arena of carbon accounting.
Methodology	The tool takes an LCA approach but was not aimed to be PAS2050 compliant and does contain some features which are not in PAS2050 - for example soil carbon accumulation/loss under constant land use as a function of e.g. tillage practice. Feedback to the project team apparently suggests that the tool can be used in a way which is broadly compliant. However they have not verified this.
What does it cover?	The CFT is a farm-level greenhouse gas emissions calculator based on empirical research from a broad range of published data sets. It is designed to be approachable and easy to complete based on information that a farmer will have readily available. The tool identifies hotspots and makes it easy for farmers to test alternative management scenarios and identifies those that will have a positive impact on the total net greenhouse gas emissions. Unlike many other agricultural greenhouse gas calculators, the CFT includes calculations of soil carbon sequestration, which is a key feature of agriculture that has both mitigation and adaptation benefits.

7.6 Footprints 4 Food

Developed by:	Footprints4food, a spin-out company from Bangor University
Format	Once the farmer has selected the crops/farms to be studied and what stages of the process they want to cover (just production on farm or other features of the supply chain as well) they fill in a registration form and obtain a quote for the work. Complete an electronic questionnaire (quantifying all the inputs, outputs and processes). Experts at Bangor University may then contact the farmer for further clarification and then will produce a carbon footprint and a detailed report.
Availability	Available at cost. See website at http://www.footprints4food.co.uk/ for details on how to obtain a quote.
What's it for?	By understanding the amount of greenhouse gases that different parts of the business emit the farmer will be able to plan to reduce them, thereby cutting energy costs and reducing the impact of any future carbon taxes or legislation as well as increasing business efficiency.
Ease of use	Once the electronic questionnaire is completed the experts will contact the farmer if there are any areas needing clarification and then a full report will be produced.
Methodology	The LCA calculations are completed by experts from Bangor University to follow PAS 2050 and Intergovernmental Panel on Climate Change (IPCC) 2006 guidelines.
What does it cover?	Covers the crops/farms specified and the stages specified (production, processing, packaging, retail). The carbon footprint is split into on-farm and post-harvest emissions and the most greenhouse-gas emissions intensive areas of the supply chain are then broken down further. This helps to explain where the emissions come from and will enable the formation of a more detailed carbon reduction plan. Farmers and Growers are starting to use new methodology developed at Bangor University to understand their on-farm carbon balance. Many farms have considerable areas of grassland, woodland patches or plantations, hedgerow and organic soils. All of these store considerable quantities of carbon over a period of time that is difficult to define. At Footprints4Food they use this information to create a balanced picture of carbon inputs and carbon sequestration (removal) on the farm.

7.7 E-CO_2 Project Carbon Assessments

Developed by:	The E-CO_2 project Ltd, Contact: info@eco2project.com Tel: 01270 522645
Format	Carbon advisory assessment that takes place on-farm
Availability	Fee payable
Purpose	Consultancy to help deliver improvements identified through the carbon assessment process. The E-CO_2 project's consultants work with clients on a one-to-one basis to deliver change and improve performance, save money and reduce impact on the environment.
Ease of use	The assessment takes around half a day to complete and our bespoke software processes the information and works out a carbon footprint per unit of output.
Methodology	Carbon Trust Accredited LCA-based Model approved to PAS2050. The Calculations are completed by experts at the E-CO2 project using the tool(s) they have developed
Coverage	Comprehensive coverage of Scopes 1-3 and Land Use Change as determined by PAS2050. Also possible to include carbon sequestration from land-use change (e.g. conversion of arable land to grassland) and woodland. 'What If?' tools have also been designed for use by farmers to give them an understanding of the carbon footprint of their enterprise with the ability to gain an impression of what the environmental cost or benefits might be of altering management practices. Feed calculators have also been developed to calculate the carbon footprint for standard feeds sold by these companies.
Reporting	Full emissions status for the enterprise assessed. Emissions are reported per unit of output (e.g. per litre of milk or kilogram of beef). On-farm consultancy can also be provided following the assessment to deliver change and improve performance, saving clients' money and reducing the impact on the environment.

7.8 HGCA carbon footprinting decision support tool and HGCA biofuel greenhouse gas calculator

Developed by:	Home-Grown Cereals Authority (HGCA)
Format	The HGCA carbon footprinting decision support tool is an excel spreadsheet. The HGCA biofuel greenhouse gas calculator is an excel spreadsheet.
Availability	The HGCA carbon footprinting decision support tool is available to download for free (beta version) from: http://tinyurl.com/l23l458 The HGCA biofuel greenhouse gas calculator is available as an excel spreadsheet on request from research@hgca.ahdb.org.uk
What's it for?	The HGCA carbon footprinting decision support tool allows the calculation of the carbon footprint of individual crops (per tonne and per hectare) and allows the farmer to test different scenarios to see where efficiency gains can be made. The HGCA biofuel greenhouse gas calculator calculates greenhouse gas emissions from biofuels.
Ease of use	The HGCA carbon footprinting decision support tool is an easy-to-use software tool which calculates the carbon footprint of a particular crop. HGCA publication "Understanding carbon footprinting for cereals and oilseeds" provides further information. Most data required to run the tool should be available from existing farm records but, in areas where data is not currently available, default values (based on average figures) can be selected.
Methodology	With regards to the HGCA carbon footprinting decision support tool compliance with standards, although desirable, was neither the aim nor a high priority. The role of the tool(s) was user engagement, education, and identification of possible mitigation options. The HGCA GHG Biofuel Calculator is an MS Excel spread sheet based tool, it is compliant with the European Union Renewable Energy Directive (RED-ready). Given that the calculator tool is RED compliant, it is also PAS 2050 compliant; and life-cycle assessment (LCA) was the approach taken. It contains the calculations for the following bioenergy pathways: o Wheat grain ethanol o Wheat straw lignocellulosic ethanol o Wheat straw electricity, heat, and CHP o Wheat straw soil incorporation o OSR biodiesel
What does it cover?	The HGCA carbon footprinting decision support tool considers each combinable crop separately and produces a carbon footprint of the crop both per tonne and per hectare. The tool offers a straightforward and transparent way to calculate the carbon footprint of a particular crop and to test different scenarios to identify areas in which efficiency gains can be made. The HGCA biofuel greenhouse gas calculator was designed to provide the basis for a credible calculation of the greenhouse gas emissions arising from UK-derived biofuels using specific agricultural and conversion processes. The calculator can be used for wheat to ethanol, oilseed rape to biodiesel and, provisionally, for straw to ethanol.

8 Key characteristics of Carbon Calculators reviewed:

	CALM	CPLAN	Man. Energy & Carbon	Farm Carbon Calculator	Footprint4Food	E-CO_2 project Carbon Assessment	HGCA decision support tool and GHG biofuel calculator	Farm Carbon Assessment Tool (FCAT)	Cool Farm Tool
Developed by	CLA	D & J Coulter	CALU	CFF	Foodprint4Food & Bangor University	The E-CO_2 project	HGCA	Soil Association	University of Aberdeen
Format	Web	Web & Spreadsheet	Paper	Web	Web	Consultancy	Spreadsheets	Web	Downloadable spreadsheet
Availability	Free	1) Free (simple) 2) Pay-click-calculate (more complex) 3) Consultancy (spreadsheet not publicly available)	Free	Free	Available at cost	Available at cost	Decision support tool downloadable for free; calculator available on request	Free	Free
Purpose	Farm management	Farm management; policy development	Farm management	Farm management; certification; marketing	Farm management	Farm management	Farm management	Farm management	Farm management
Ease of use	High	High	Medium	High	High	High	High	High	High
Methodology	IPCC	IPCC plus UK National	ADAS	Climate Friendly Food	LCA - PAS 2050	LCA – PAS 2050	RED-ready and LCA – PAS 2050 for the calculator	Key practices scored in relation to emissions	PAS 2050 partly, but not verified
Scope	1, 2, some 3	1 & 2 on web; 3 consultancy only	1, 2	1, 2, some 3	1, 2, 3	1, 2, 3	1, some 2	1, some 2	1, some 2
Emissions from fuel & electricity	✓	✓	✓	✓	✓	✓	✓	✓	✓
Emissions from Livestock	✓	✓	✓	✓	✓	✓	x	✓	✓
Emissions from soil/ crops	✓	✓	✓	✓	✓	✓	✓	✓	✓
Focus on organic systems	X	x	x	✓	X	x	x	x	x
Sequestration	✓ (Outline)	✓ (Outline)	x	✓(Detailed)	✓	✓	✓	x	✓
Website/ Contact Details	*www.cla.org.uk/Policy_Work/CALM_Calculator/*	*www.cplan.org.uk*	*http://www.calu.bangor.ac.uk*	*http://www.cffcarboncalculator.org.uk/*	*http://www.footprint4food.co.uk/*	*http://www.eco2project.com*	*Decision support tool:www.hgca.com Calculator:research@hgca.ahdb.org.uk research@hgca.ahdb.org.uk*	*http://tinyurl.com/kygo4zd*	*http://www.coolfarmtool.org/CoolFarmTool*

Cronfa Amaethyddol Ewrop ar gyfer Datblygu Gwledig: Ewrop yn Buddsoddi mewn Ardaloedd Gwledig
The European Agricultural Fund for Rural Development: Europe Investing in Rural Areas

Llywodraeth Cynulliad Cymru
Welsh Assembly Government

9 Sustainability assessment tools that consider wider impacts

As described in Section 6, a number of tools have been developed which explore the wider impacts of farming systems/management against a range of environmental, economic and social criteria. Descriptions of some of these tools and details of what they cover are included in the tables below:

9.1 OCIS Public Goods Tool (PG Tool)

Developed by:	The Organic Research Centre (ORC) Contacts: Laurence Smith, laurence.s@organicresearchcentre.com Catherine Gerrard catherine.g@organicresearchcentre.com
Format	Excel-based
Availability	Consultancy, on demand
What's it for?	Triple Bottom Line (TBL) sustainability assessment tool to identify areas for improvement and monitor changes over time.
Ease of use	Readily available data used (farmer's knowledge and questionnaire data). Between 2 and 4 hours needed, focused on the public goods provided by farms- highly communicative and transparent graphical design.
Methodology	The tool is applied by researchers/advisors; they visit the farms and fill in the spreadsheets with relevant data. Results of the analyses are discussed together with the farmers, to tackle the areas to work on and improve. Results for each indicator are scored on a 1-5 scale (5= excellent, 1= very poor) with overall results for the 11 dimensions described below presented in a radar diagram.
What does it cover?	**Environmental dimension: soil management** (analysis, management, winter grazing, erosion, measures taken to reduce erosion risk), **biodiversity** (agri-environmental participation, BAP habitats and SINCS, SSSI, BAP and rare species, conservation plan, awards, habitats), **landscape and heritage** (historic features, JCA and landscape features, management of boundaries), **water management** (measures to minimize pollution and maximize efficiency, flood defenses and runoff prevention, water management plan, water harvesting, irrigation), **manure management and nutrients**, **energy and carbon**, **agricultural systems diversity** (rotational diversity, number of crop varieties and species, livestock diversity, number of marketing outlets, on farm processing). **Social dimension: social capital** (employment, skills and knowledge, community engagement, CSR initiatives and accreditations, public access, human health issues), **food security** (total productivity, local food, off-farm feed, food quality awards, food quality certification, production of fresh produce), **animal health and welfare** (staff resources, health plan, animal health, ability to perform natural behavior, housing, bio-security). **Economic dimension: farm business resilience** (financial viability, farm resilience).

9.2 Monitoring Tool for Integrated Farm Sustainability (MOTIFS)

Developed by:	Faculty of Applied Bioscience Engineering, UCGhent Contact: Dr. Marijke Meul marijke.meul@hogent.be
Format	Excel-based
Availability	In theory, it would be free to use for farm consultants, and they would link it to their accountancy programs (not yet in practice).
What's it for?	Assessing and monitoring tool
Ease of use	Specific data required (usually accurate, combination with expert information; 2-4 days needed for data gathering), aims to grab the complexity of sustainability while visualizing it in a simple way (highly communicative graphical design that needs initial clarification).
Methodology	The tool is still applied by researchers; they visit the farms and gather/measure data to fill in the spreadsheets and then the results of the analyses are discussed together in groups with farmers and farm consultants (always in externally financed projects).
What does it cover?	**Environmental dimension: use of inputs** (*nutrients* [N surplus and efficiency, P surplus and efficiency], *energy* [use efficiency and renewable energy use], *water* [use efficiency and alternative resources use], *pesticides* [use and management]), **quality of natural resources** (*air*, *soil* [organic matter content, pH, P and K content, biological and physical quality] and *water quality* [wastewater management]), **biodiversity** (*genetic* [crops and animals used], *species* [wildlife affected by agriculture] and *habitats diversity* [habitats related to production]). **Social dimension: internal sustainability** (*farmer's pride*, *decision latitude*, *care*), **external sustainability** (*animal health and welfare* [body condition score, dirtiness, skin lesions, locomotion score, teat-end condition, udder condition], *landscape management* [stewardship agreements, small landscape elements, nature conservation, visual nuisance, architectural quality, surrounding landscape], *social services*), **disposable income**. **Economic dimension: productivity and efficiency** (*labour*, *capital* and *land productivity*), **profitability** (*return on assets*, *return on equity*, *labour profitability*), **risk**, **entrepreneurship**.

9.3 Integrated Management oPtions for Agricultural Climate Change miTigation (IMPACCT)

Developed by:	A consortium led by University of Hertfordshire (for EU project ENV.B.1/ETU/2009/0052 'The climate change mitigation potential of an EU farm: towards a farm-based integrated assessment')
Format	An easy-to-follow farm assessment wizard with tick boxes and video guides showing how to work through the assessment. The farmer can select an option to only calculate emissions or to calculate emissions and generate potential mitigation measures for the farm.
Availability	Available without charge as downloadable software from the website: http://sitem.herts.ac.uk/aeru/impacct/index.htm
What's it for?	To help farmers and growers to take action so as to reduce their greenhouse gas emissions and improve carbon sequestration by modifying farming practices. It also supports policy makers in the development and improvement of climate change mitigation policies.
Ease of use	A key consideration in the design of the software has been to keep the user interface as simple as possible in order to ensure ease of use and maximise uptake.
Methodology	The underlying model is both IPCC 2006 and PAS 2050 compliant. In many instances the model goes beyond the IPCC standards using emission factors that are more responsive to site-specific factors such as climate, soil type and farm practices. This makes the tool more responsive to the implementation of best practice for reducing greenhouse gas emissions. The model covers scope 1, 2 and 3 emissions, so includes, for example, indirect emissions associated the manufacture of inputs.
What does it cover?	The IMPACCT system allows users to define the specific characteristics of their business and calculate a bespoke **emissions** and **sequestration** profile for it, in addition to considering the impact of a range of GHG mitigation measures. **Environmental dimension:** The focus is on greenhouse gases and C sequestration, however other environmental indicators are assessed on a +10 to -10 scale derived from expert judgement (e.g. air quality, biodiversity, energy, landscape and heritage, soil quality and water quality). The model calculates a score for each of these 'other-impact categories' associated with the potential GHG mitigation option for a farm. The difference in the impact score is then reported alongside the GHG mitigation potential and consequently users can see if there is a net increase or decrease in any other impacts – thus highlighting any synergies and trade-offs. **Economic dimension:** general indication of the costs and potential savings that might be achieved as a result of mitigation measures. The IMPACCT methodology ensures that farmers have the information to make financially sound, balanced environmental decisions, and allows them to play an active role in climate change mitigation.

9.4 FARMSCOPER – FARM SCale Optimisation of Pollutant Emission Reductions

Developed by:	ADAS. Originally developed as part of the Defra-funded WQ0106 project and has been modified under Defra's Integrated Advice Pilot Study, and is designed to complement the use of the Integrated Advice Packages also developed under this project.
Format	Microsoft excel spreadsheets that enable the user to assess the pollutant losses on a farm, assess the impacts of mitigation methods on the losses from that farm and find a suite of optimal solutions of mitigation methods to achieve differing levels of pollutant reduction.
Availability	Available as a free download from http://www.adas.co.uk/Home/Projects/FARMSCOPER/tabid/345/Default.aspx
What's it for?	FARMSCOPER is a decision support tool that can be used to assess diffuse agricultural pollutant loads on a farm and quantify the impacts of farm mitigation methods on these pollutants. It also determines potential additional consequences of mitigation method implementation for biodiversity, water use and energy use.
Ease of use	Help to users is available within each FARMSCOPER workbook that can be shown on screen or printed off.
Methodology	The pollutant losses were calculated using a suite of mechanistic models for the water borne pollutants and ammonia and default IPCC methodologies for nitrous oxide and methane. FARMSCOPER includes an algorithm model to search for optimal solutions (i.e. relating to or denoting a distribution of solutions such that any redistribution or other change beneficial to one is detrimental to one or more others) for combinations of methods that reduce one or more target pollutants.
What does it cover?	**Environmental dimension:** • The estimation of diffuse pollutant losses at the farm scale • Potential consequences of mitigation methods implementation for biodiversity, water use and energy use. **Economic dimension:** • Quantification of the cost and effectiveness of one of more mitigation methods The tool contains over 100 mitigation methods, including many of those in the latest Defra Mitigation Method User Guide. The mitigation methods included generally represent potential for improved practice within existing farm systems rather than adoption of novel systems or technology. Each is characterised for their impact on nitrate, phosphorus, sediment, nitrous oxide, methane, ammonia and pesticide losses. The tool searches for optimal combinations of mitigation methods. This generates a large number of potential solutions to pollution control which can be analysed to provide insight into the range of possibilities.

10 Key characteristics of Sustainability Assessment Tools Considering Wider Impacts:

	Public Goods Tool	MOTIFS	FARMSCOPER	IMPACCT
Developed by	The Organic Research Centre	Faculty of Applied Bioscience Engineering, UCGhent	ADAS	University of Hertfordshire
Format	Spreadsheet	Spreadsheet	Downloadable spreadsheet	Web (downloadable software)
Availability	On request	Free for consultants	Free	Free
Purpose	Farm assessment and management	Farm assessment and monitoring	Farm assessment and management	Farm assessment and management; policy-makers support
Ease of use	High	High	High	High
Complexity	Medium	High	Medium	Medium
Methodology	Applied by advisors/researchers; data is gathered and results are discussed with the farmers	Applied by researchers; data is gathered and results are discussed in groups with farmers and consultants	IPCC	IPCC and PAS 2050
What does it cover?	Performance assessment of organic farms, identification of strong and weak points, discussion for improvement	Performance assessment and monitoring of organic farms, identification of strong and weak points, group discussion for improvement	Assessment of pollutant loads, quantification of impacts of mitigation methods, identification of pareto-optimal sets of mitigation methods	Scope 1, 2 and 3 emissions: direct from sources owned and controlled by the farm; indirect from the electricity consumed by the farm and from the production, processing and distribution of inputs for the farm
Environmental dimension	✓ (Detailed)	✓ (Detailed)	✓ (Outlined – biodiversity, water and energy use)	✓ (Holistic approach)
Economic dimension	✓ (Outlined)	✓ (Outlined)	✓ (Outlined)	✓ (Costs involved and potential savings)
Social dimension	✓ (Outlined)	✓ (Quite detailed)	x	✓ (landscape & heritage)
Focus on organic systems	✓	✓	x	X
Sequestration	✓ (Energy and carbon indicator)	x	x	✓
Website/ Contact Details	laurence.s@organicresearchcentre.com catherine.g@organicresearchcentre.com	marijke.meul@hogent.be	http://tinyurl.com/anj66sf	http://sitem.herts.ac.uk/aeru/impacct/index.htm

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