Agriculture and provision of public goods

How helpful is sustainability assessment using a structured tool to a farmer in terms of developing actions to improve sustainability?

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Declaration

I declare that the work reported in this thesis was devised and carried out by myself, and has not been accepted in any previous application for a degree. All information drawn from other sources, and any assistance received has been acknowledged in the appropriate place.

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Summary

The hypothesis that sustainability assessment can help with agricultural sustainability was tested. Does sustainable farming provide public goods? Are practical farming decisions relating to sustainability assisted by sustainability assessment tools?

The aim of the Public Goods (PG) sustainability assessment tool is to identify sustainable farming practices. The PG tool was assessed for robustness by running the tool on the same farm twice, using data from conventional and organic systems, to see if the tool was sensitive to changes in farming practice. A second study used the tool to assess seven farms, and interrogated the farmers' opinions and attitudes to sustainability with a semi structured interview based on a questionnaire.

Findings concluded that sustainable farming management practices can result in providing public goods. The use of the Public Good tool as a sustainability assessment tool can help identify sustainable farming management practices. The value of the assessment lay less in the scores produced than in the process. The farmers reported sustainability practices constructed learning during the PG tool assessment.

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1 Introduction

Although agriculture has been characterised by some economists as a 'twilight industry' farmers constitute the largest group of natural resource managers on Earth. Europe, often understood as an industrial, urban hub, has 13.7 million (full-time) farmers with an average farm size of about 12 hectares. Over 77% of the EU's territory is classified as rural (47% is farm land and 30% forest). And half of the EU population live in rural areas, both farming communities and other residents (EU, 2013). Therefore farms are an important part of planning, not just for food, but for climate change, biodiversity, clean water, and other ecosystem services.

There are rising contradictions between the challenges of primary production (food and fibre from land) and all the other priorities assigned to or taken on by farmers. These include: dealing with world hunger, reducing food waste, managing soil, reducing inputs and managing nutrients, increasing productivity, biodiversity on farms, lowering energy and carbon use, eco system services, avoiding environmental degradation, improving animal welfare, management of landscape and land, social capital and responsibility, economic viability, greenhouse gas emissions and climate change.

The goal for the agricultural sector is no longer simply to maximize productivity, but multiple, complex goals of production, rural development, environmental, social justice and food

consumption (Pretty et al., 2010). The question, can farmers provide public goods as well as food; will be addressed in the literature review below.

1.1 What is the problem?

As a number of high-level global challenges are all happening at the same time, population increase, competition for scarce resources, climate change and environmental degradation; they impact and exacerbate each other. This is particularly true for farming:

Unless the footprint of the food system on the environment is reduced, the capacity of the earth to produce food for humankind will be compromised with grave implications for future food security. Consideration of sustainability must be introduced to all sectors of the food system, from production to consumption, and in education, governance and research. (Beddington, 2011 , p12)

1.2 Rationale - investigating agriculture and sustainability.

As a farmer in Ireland and a post graduate student of organic farming with a research background in sustainable development the link between sustainability and farming is important.

Recently academic, policy and business attention has focused on 'sustainable intensification' in increasing food production and reducing the impact of this production on the environment.

However this concept is highly contested; it is championed by agri-business and criticized by environmentalists as productivism under another name.

'Sustainable agricultural intensification is defined as producing more output from the same area of land while reducing the negative environmental impacts and at the same time of increasing contributions to natural capital and the flow of environmental services' (Pretty, 2008)

This is a difficult balance to achieve; improving the quality of the product may be compromised by increasing intensification. One way to do this is to decouple sustainable intensification as a concept from specific production targets. Sustainable intensification aims to optimise productivity along with a range of environmental outcomes (Garnett and Godfray, 2012).

Defra have abandoned the term 'sustainable intensification' for 'climate smart agriculture' defined as 'an agriculture that sustainably increases productivity, resilience (adaptation), reduces/removes greenhouse gases (mitigation) while enhancing the achievement of national food security and development goals' (FAO, 2007).

Farmers need a simple, accessible way to measure, demonstrate and improve sustainability on their farms. This research project has two objectives: can sustainable farming management practices result in providing public goods? This is addressed in the literature review below. The second objective, if the Public Good farm sustainability assessment tool can be a method of delivering sustainability is investigated with farm surveys and interviews.

1.3 Literature Review

The literature survey below will investigate sustainable development, the global limits to growth. Next the relationship of environmental sustainability, sustainable development and environmental justice is explored. This leads on to a discussion of Public Goods and regulation (paying farmers for environmental services). The relative strengths of organic versus conventional farming in providing public goods are assessed.

How to define a 'sustainable farming practice' is investigated, followed by a description of farm sustainability assessment tools, and how they work. The Public Good tool is researched, and a comparison made with the Bord Bia Origin Green tool.

1.3.1 Limits to growth

The Brundtland Report (WCED, 1987) claims that *'Growth has no set limits in terms of population or resource use beyond which lies ecological disaster'*. However it is acknowledged that; *'The environment does not exist as a sphere separate... the ''environment'' is where we all live'* (Dryzek, 2005, p153).

There have been a number of investigations into the implications of population growth and requirement for resources. Limits to Growth 'what-if' simulations have tested scenarios over

different timescales. Results were published in 1972 and updated 1992 and 2002 (Meadows, 1974, Meadows, 2005).

Other investigations have been carried out on the earth's carrying capacity, and have identified a 'great acceleration' (Costanza et al, 2007 , p346) in global negative indicators. These include exponential growth of human population, carbon dioxide concentration in the atmosphere, global temperature, use of oil based fertilizer, marine stocks fully exploited and species extinction. The concern is that some of these accelerations could tip the world eco system over into a negative feedback loop which may trigger unprecedented changes in the planet, and decimate the human population.

Rich countries maintain order at the expense of the global periphery, by importing energy and exporting pollution, but this cannot continue (Biel, 2008).

1.3.2 Relationship of Environmental Sustainability, Sustainable development and Environmental justice

The Brundtland Report definition: *"Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs"* (WCED, 1987) was redefined by International Union for Conservation of Nature IUCN (IUCN, 1991) '…*to improve the quality of life, whilst living within the carrying capacity of ecosystems'*

Sustainable development has since entered the policy agenda in practical action and indicators. There has also been an emergence of contrasting approaches: strong Environmental Sustainability (ES) argues that natural capital must not be spent, we must live off the 'interests' versus weak ES which postulates that natural capital can be spent as long as it can be substituted.

The concept of environmental justice (EJ) has been sidelined by the sustainable development discourse, except by environmental social theorists such as Agyeman who suggest EJ is '*the need to ensure a better quality of life for all, now, and into the future, in a just and equitable manner, whilst living within the limits of supporting ecosystems'* (Agyeman et al., 2003 ,p6)

1.3.2.1 Understanding socio-economic conflicts and changes

Discourse analysis (discourse being coded ways to represent the world within power relations, social relations, values, institutions and material practices) is an approach which examines the social construction of environmental problems developed from the social theorist Harvey (Harvey, 1996)**.** Discourse analysis explains why farmers are the focus of attention and pressure.

Additionally, a farm intersects three types of scale (time, space and human institutions). Farms manage biodiversity at many scales, while producing food. Figure 1 below elegantly captures the complexity of farms. Sustainagility is sustainability with resilience to deal with change.

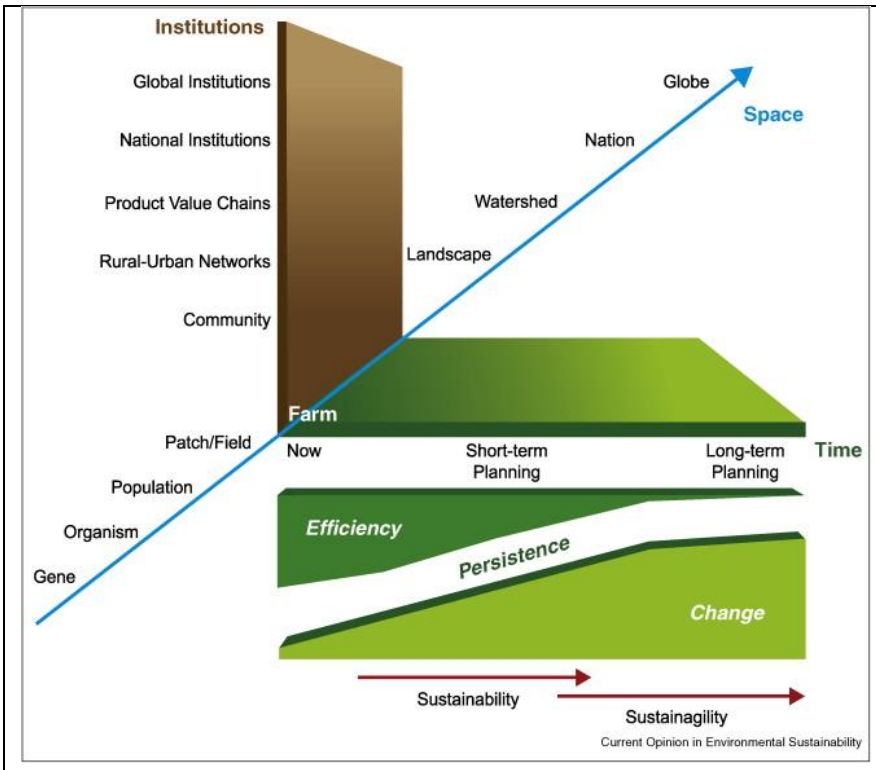

Figure 1: Farms in context social, spatial, time (Jackson et al., 2010)

Figure 2 below is a framing device which illustrates where farmers are also positioned as weak, grassroots actors in the socio-economic conflict of climate change. As grassroots actors, farmers are poised at an uncomfortable place. They are a focus of attention by social hierarchies concerned with 'sustainability and the environment' yet farmers have little political capacity to affect policy, to exert control over the impacts on them. However they are controlled and regulated in many ways by institutions and rituals – EU regulation, world prices for food and excluded from decision making roles in environmental crisis resolution.

Scale and actor involvement

Actor	Global scale (greenhouse warming)		
	Contribution (and potential benefits)	**Impact (costs)**	**Resolution**
States	State manufacturing and energy production and industrial policies	Potentially great impact for poor low-lying states	Cooperation and agreement between states
Grassroots actors	Relatively small	Potentially great for those worst affected but unable to respond	Excluded
Business	Manufacturing and energy production, avoidance of pollution controls	Not yet but potentially reduced profits as regulation increases	Voluntary guidelines, respond to state policies
Multilateral institutions	Advice and loans to states an industry	Limited criticism	Input in global negotiations
Environmental NGOs	None	No costs (may slightly increase funding)	Public education, advocacy, lobby states and business

Source: Bryant and Bailey (1997: 35).

Figure 2: Farmers as Grass Roots actors (Bailey and Bryant, 1997)

So is the answer to pay farmers for providing ecological services? The next section will investigate the aspect of farm regulation, in relation to CAP.

1.3.3 Public Goods and regulation (paying farmers for environmental services)

EU funds subsidise farmers, both to protect the production of safe food, but also to provide public goods. The State of Food and Agriculture 2007 (FAO, 2007), highlights the environmental services or public goods provided by farmers. These include positive services, such as

groundwater recharge and scenic landscapes; and negative, such as water pollution by animal waste, and soil erosion. There is focus on how farmers can be induced to increase their provision of public goods, and payment is one of the inducements.

The aims of CAP are stated to be: viable food production and stable and safe food supply at affordable prices for consumers and sustainable management of natural resources along with balanced development of rural areas throughout the EU (EU, 2013).

Paying farmers in the EU is therefore designed with multiple functions to support farming that provides food security in a context of climate change and assist rural areas. Public goods provided by farmers are likely in the future to justify EU subsidies paid to the agricultural sector (Gerrard *et al*., 2011).

The next section will investigate how organic farming as opposed to conventional can provide public goods.

1.3.4 Organic v. conventional farming

Does organic mean sustainable? Can bringing the principles of organic agriculture fully into practice make organic the mainstream approach to sustainability?

Organic farming can perform better than conventional farming when it comes to sustainability on certain specified measurements, such as biodiversity or greenhouse gas emissions. These measurements highlight large differences between farms too.

Farming covers a huge range of habitats and farming activities and sizes. Large intensive pig and poultry (followed by dairy and tillage enterprises) tend to have more negative effects on the environment, due to the effect of pollutants such as slurry on to the environment, and the effect of pesticides and herbicides on plants, animals, birds and the soil. Upland and pastoral farming (either conventional or organic) tend to have less environmental impacts, and can have environmental benefits. Examples include Romanian hay meadows or Scottish Machair; where traditional farming protects the biodiversity and the environmental system.

Environmental damage is caused by 'intensive agriculture', rather than by conventional farming per se. Agricultural intensification is responsible for the widespread declines in European birds, mammals, insects, invertebrates; the reduction in water quality and soil quality and depth over the past fifty years (Soil Association, 2000, Yeates et al., 1997).

'*dramatic declines in both range and abundance of many species associated with farmland have been reported in Europe, leading to growing concern over the sustainability of current intensive farming practices'* (Hole et al., 2005).

A number of studies, including a meta study compared the environmental impacts of organic and conventional farming in Europe. Organic farming practices were shown to generally have positive impacts on the environment (Tuomisto et al., 2012). Impacts included: higher levels of biodiversity; soil quality; water quality, air quality; lower environmental pollution from pesticides; reducing nitrate runoff, phosphorus loss; human pathogens; ammonia; carbon

dioxide, nitrous oxide. Organic farms tend to have lower inputs, nutrient balancing, energy efficiency, and controlled wastes (Shepherd et al., 2003).

One of the key benefits is ecological services, which is particularly supported by organic farming: soil forming and conditioning, stabilising soil, waste recycling, carbon sequestration, nutrient cycling, predation, pollination and habitats. (IFOAM, 2013)

There is a large body of evidence therefore that organic farming does provide environmental benefits over conventional, even when agri-environmental schemes are taken into account for conventional farms.

There are three major reasons for this:

- organic farming practices (e.g. encouraging predatory insects and wildlife habitats)
- organic standards (e.g. prohibiting artificial herbicides and pesticides) and
- organic farm type (typically smaller and mixed – animals and tillage)

(Bengtsson et al., 2005, Hole et al., 2005, Lampkin, 2002, Smith et al., 2011, Woodward et al., 2010)

European governments, recognizing organic environmental benefits, have committed to increase organic land from the EU average of 4.5%. Holland proposes 5% increase per year, UK to 6% organic land. Switzerland, Sweden, Finland and Italy have around 10% organic land and

Austria has 15.5%, the largest proportion in Europe (Soil Association, 2013, Soil Association, 2011a).

Organic payments and equity however, needs to be improved; Austrian organic farmers receive €291 per hectare organic payment against UK payment of €87 per hectare (Soil Association, 2011a).

The purpose of funding is to encourage the development of environmentally sound practices within conventional agriculture as it is not currently doing. An examination of the public funding to support agriculture generally reveals that 13.7 million EU farmers are paid by EU taxpayers €92 billion CAP in the five years 2007-13. 20% of farmers receive 80% of the aid. Only 25% of this funds environmental aspects of farming (EU, 2013). This could be considered a waste of public funds for gaining environmental benefits from farming. Note that organic farming is recognised by the EU as delivering environmental benefits, and should be better supported in the next CAP budget.

In conclusion, organic farming is proven to deliver environmental benefits over conventional. Therefore those interested in issues such as water quality, soil conservation, biodiversity of farmland animals and birds and economically valuable environmental services; organic farming should be supported.

1.3.5 How can we define how, and in what way a farm is sustainable?

Methods of ascertaining the sustainability of farm include sustainability assessment. This is a form of impact assessment that places emphasis on delivering positive net sustainability gains (Bond et al., 2010).

These assessments are a complex issue, as has been illustrated above; farms are multidimensional incorporating economic, social, environmental aspects. There is no consensus on what sustainability assessment is or how it should be applied (Dillon et al., 2014). Bond and Morrison-Saunders (2010) have some useful suggestions about what a good assessment should include; positive progress, workable concept of sustainability, formal mechanisms for tradeoffs and recognize the multidimensional nature.

However interest in sustainability assessment is going to continue to grow, and increased pressure will come on farmers to demonstrate their sustainability through sustainability assessments. There are a number of assessment tools which have been developed, which the next section will examine.

1.3.6 Farm sustainability assessment tools

Applying a questionnaire to a farmer on sustainability measures is one way of defining farm sustainability through assessment tools. Measures can include:

- energy efficiency

- carbon sequestering/carbon footprinting
- soil stabilization
- animal welfare
- nutrient recycling
- pest and disease management
- economic sustainability,
- social sustainability,
- water use

There are many and multiplying numbers and types of farm assessment tools relating to environmental, financial, energy, biodiversity etc. A number of these tools have been developed in the UK, Europe and worldwide. Below a list of tools identified during this research:

- Public Good tool
- RISE
- FiBL field tool
- Carbon footprint tool available on the Organic Centre Wales website
- Nutrient budgeting e.g. PLANET
- HDB tool for sustainability – Agricultural and Horticulture Development Board
- Financial assessments e.g. Teagasc eProfit
- CALM (carbon and GHG)

- Soil Association Tool (interesting and comprehensive)
- Low Carbon C
- Bord Bia Origin Green for farmers and food processors

1.3.6.1 Sustainability tools and indicators

Sustainability tools tend to use indicators to classify and measure aspects of the world and record them. We measure what is important (indicators arise from values) and they summarise and condense the huge complexity of our environment to manageable information. This is unavoidably a simplification, a quantification in order to communicate complex information (Singh et al., 2009).

However indicators are not value free or simple to identify and use. There are systemic, normative and procedural issues to be considered:

Is a system properly described by means of the set of indicators used? (systemic)

How to assess if the studied system is sustainable? (normative)

How the assessment was carried out? (procedural) (Binder *et al.*, 2010)

1.3.6.2 Advantages of farm based assessment tools

Assessment tools for farms fall into two broad categories, farm based and expert, and farm based assessment tools have certain advantages over expert assessment tools. They are a simple, measurable way to assess a farm's sustainability on different areas.

Farm based assessments are a relatively easy procedure, usually standardized and reproducible using pre-selected indicators. This can allow for benchmarking and comparison among different systems' (Binder et al., 2010).

Assessment tools using indicators can bring sustainability into agriculture in real and understandable ways for the farmer.

Farmers are innovators, they observe, trial, learn and change practices. This is demonstrated by farmers' enthusiastic take-up of farming apps and software, innovation networks, farmer field schools, and field labs (MacMillan and Benton, 2014).

The process of undergoing the assessment gives system knowledge and goal knowledge about sustainability (Binder et al., 2010) and can highlight practical ways in which farming can deliver environmental services: wildlife, soil, water and climate.

1.3.6.3 Disadvantages of farm based assessment tool

The indicators are developed without stakeholder (farmer) participation, and may not be appropriate. Transformational knowledge, or how to get from the present to a more sustainable situation, is rarely generated during the assessment process (Binder et al., 2010). Further research and practical studies are carried out in this research to identify more disadvantages and strengths below.

The next section describes the Public Good (PG) tool, the sustainability assessment focused on during this research.

1.3.7 The Public Good Tool

The Organic Research Centre developed the PG tool as a farm sustainability assessment for Natural England. It assesses each individual farm across eleven areas or 'spurs':

See below Figure 3 representation of spur scores and subheadings that make up these spurs (ORC, 2014).

Spur	Score
Agri-environmental management	3.0
Landscape and heritage features	3.8
Soil management	4.0
Water management	4.0
Fertiliser management	2.8
Energy and carbon	3.0
Food security	2.2
Agricultural systems diversity	3.5
Social capital	3.8
Farm business resilience	4.0
Animal health and welfare management	2.5

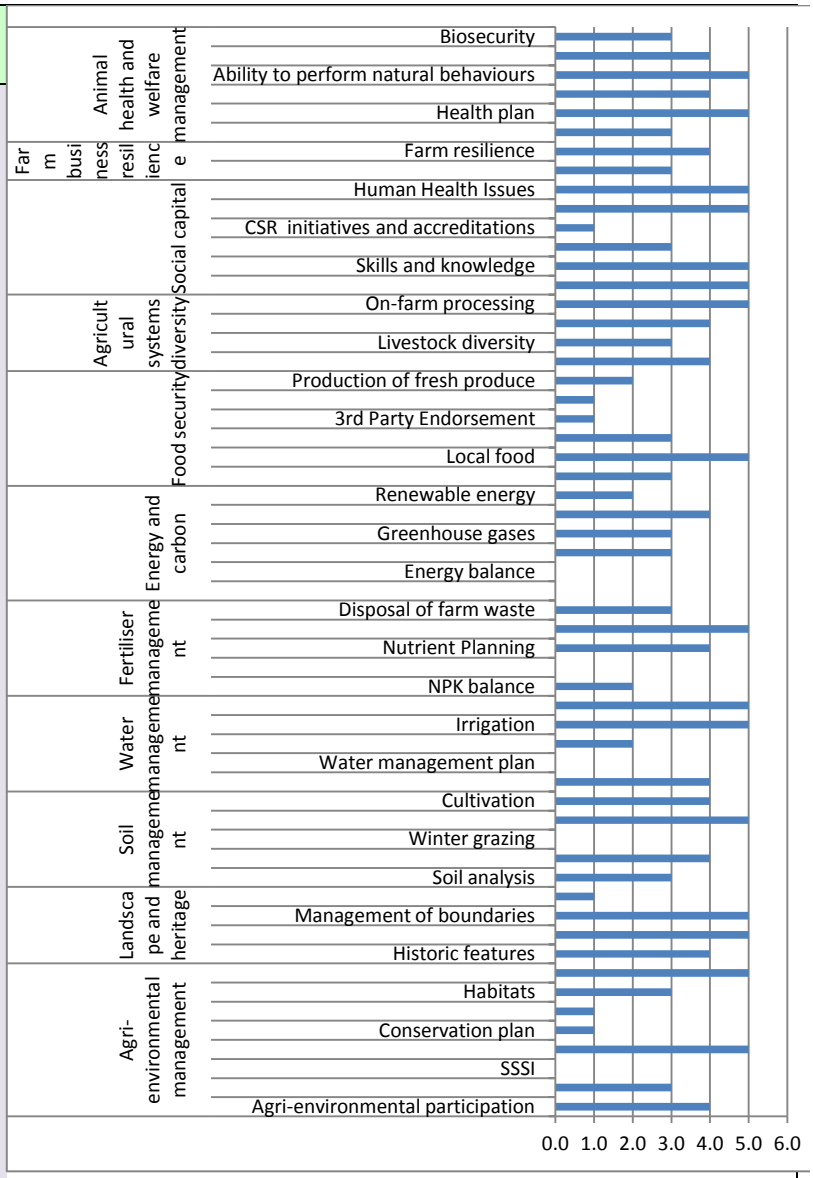

Figure 3: PG spurs with sample scores

Breakdown of spurs into subsections (not all shown)

The tool is an excel workbook with a worksheet for each spur, investigating each area in more depth. The farmer will already have most information required (from farm accounts, cropping records, animal health plan), and is expected to be able to complete the questionnaire in four hours. The finished worksheets present the information in a spider web giving a visual diagram

which identifies where a farm is strong or weak for all the measures of sustainability which are assessed. Figure 4 below shows a sample spider web, lower scores in red and orange section, and higher scores in green.

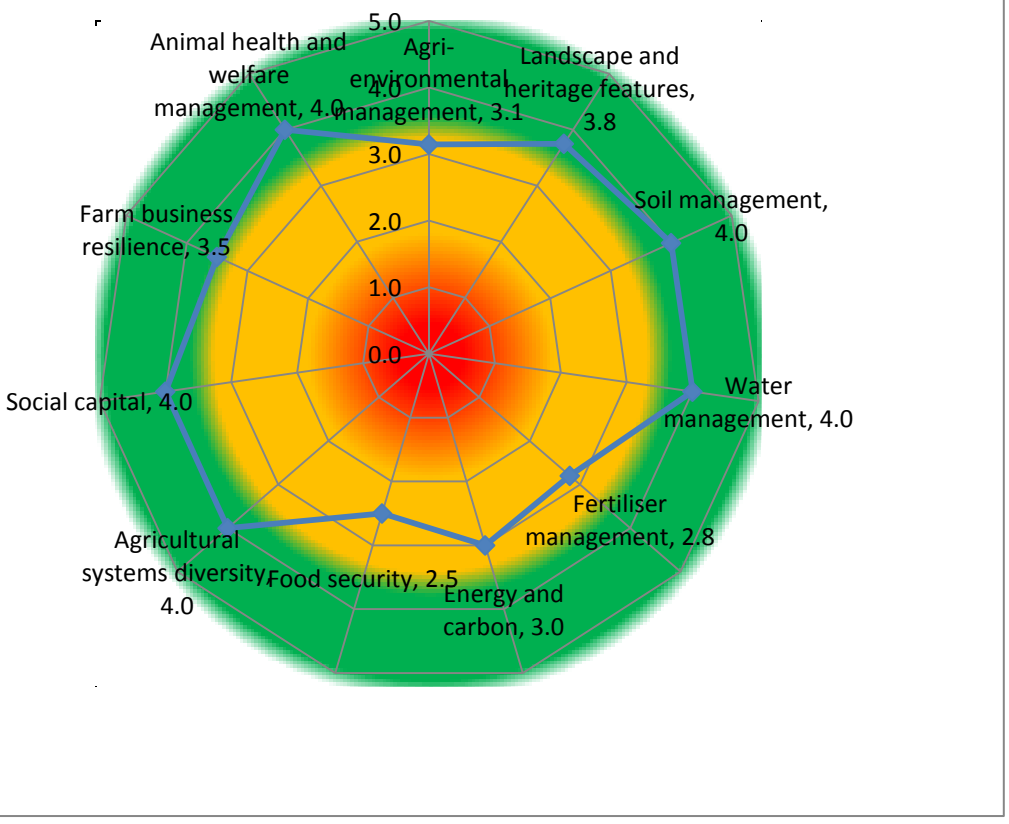

Figure 4: Spider web diagram sample PG results

Critical success factors for the PG tool have been established by recent studies comparing the 'quick scan' PG tool with expert studies (Marchand et al., 2013, De Mey et al., 2011). See Table 1 below with a list of factors, and how the PG tool measures on each.

Table 1: PG tool critical success factors

Critical success factor	PG tool
Compatibility	Quick, available data, irrelevant of which accountancy etc system is used
User-friendliness	Results immediately available, assessment takes 2-4 hours
Data availability	From the knowledge of the farmer
Transparency	All spurs are valued 0-5, and answers can be tracked back in the excel file
Data correctness	Farmer knowledge is used, bias can creep in
Communication aid	Graphical spider web design and bar charts are communicative
Complexity	Does not deal with the complexity of sustainability, focuses on the public goods a farmer can provide

1.3.8 Public Good tool and the Bord Bia Origin Green tool

Bord Bia (the Irish Food Board, with responsibility for food export) has developed an ambitious sustainability assessment tool, Origin Green, aimed to cover all Irish farmers and food manufacturers. The intention is to market Irish food as inherently sustainable, claiming independent verification to prove it (Bia, 2009). Origin Green was generated to support Ireland's Food Harvest 2020 plan (FH2020); as the sustainability verification for FH2020 of projected greatly increased milk production (up 50% by volume) and beef production (Brady *et al*, 2010).

The rationale is as follows: Ireland's climate and soil can support sustainable farming. The dairy industry shares the lowest carbon footprint in the EU with Austria. The beef industry, the largest net exporter in the northern hemisphere, is also among the lowest. With agriculture requiring 70% of freshwater supplies for irrigation, Ireland's water stress index is one of the lowest in the world.

The Sustainability Plan includes at least 4 targets from 7 key areas (Energy, Waste, Biodiversity, Social, Raw material, Water, Emissions). Participants must select ambitious targets, with justifications and implementation plans.

For farms the costs are relatively high – application is €700 and once approved there is a yearly fee of €350 to pay for external verification. This is carried out by SGS, an international verification and certification company. Origin Green participants must upload their Sustainability Plan Documentation to a website to allow for reporting progress annually. Assessment of these reports will be made by SGS. No routine auditing will be carried out; random inspections are envisaged to ensure compliance.

To date three hundred and thirty eight companies have signed up for the Origin Green Programme, most are large food companies rather than farms. (E.g. APB group, Dawn Meats, Dairygold). Only fifty five of these have submitted plans.

This study did not compare the Bord Bia Origin Green assessment with the PG tool on real farm data, for instance on the seven farmer survey. Time and access limitations applied here. The

Origin Green assessment is a commercial assessment, outsourced to a specialist company, with a cost of €700 per assessment. The assessment framework was not freely available.

Additionally a double assessment would have been too much to expect farmers to undertake. The 2-2.5 hours was long enough for the farmers surveyed.

Having investigated the Origin Green sustainability assessment, it is unlikely to lead to an increase in public goods from farming for the following reasons:

- Developed by a food exporting body, not from agriculture or agriculture research
- Developed as a sustainability label for the increased food production from FH2020 which will need a market
- Consumer facing, a marketing tool for international buyers, rather than a genuinely sustainability assessment tool
- Attempt to use same sustainability assessment to apply to farming and food manufacture
- Verification processes appear weak, no auditing
- Poor specification of indicators and how these will be measured
- Top down approach, imposed on farmers
- Not specified how farmers will develop more sustainable practices due to this certification
- Expensive for farmers – nearly the same cost as organic certification every year

Why not encourage Irish farmers to convert to organic (an internationally accepted measure of farming sustainability) rather than developing another assessment?

The aim of the literature review above was to investigate how sustainable farming management practices can result in providing public goods. The section below details the research aims and objectives.

1.4 Aims and Objectives

The hypothesis to be tested is that sustainability assessment can help with agricultural sustainability.

The research objective: (Does sustainable farming provide public goods?) has been addressed above in the literature survey. The next query: (Are practical farming decisions relating to sustainability assisted by sustainability assessment tools?) will be investigated in the following research.

Is there a link between the provision of public goods (environmental goods/ services provided by farmers/ sustainable farms) and sustainability assessment tools such as PG tool?

Does the PG tool identify management practices which are sustainable? How do these practices provide public goods?

Objective	How it will be met
1. Estimate how sustainable farming management practices can result in providing public goods.	Literature review
2. Estimate if the use of the Public Good tool as a sustainability assessment tool can help identify sustainable farming management practices.	Running the tool Questionnaire Interviewing farmers Critical analysis of the PG tool Comparison with Bord Bia sustainability assessment tool

1.5 Experimental Strategy

The following methodologies were selected to investigate Objective 2: if the use of the Public Good tool as sustainability assessment tool can help identify sustainable farming management practices. Quantitative and qualitative methodologies were used, and are discussed below.

1.5.1 Quantitative Methodology

The robustness of the Public Goods tool as a reproducible and sensitive tool which could identify and measure changes in the farming system was investigated. This was tested by running the tool twice on the researcher's own farm, but using data to reflect a conventional farming system and data to reflect an organic farming system.

The following practical issues in running the PG tool were tested:

- Was the tool relevant to Irish farming systems?
- Were the questions localised enough for Irish farming systems, legislation and geography (PG is a UK tool)?
- How long it took to run the tool – number of spurs and worksheet questions?
- How easy/hard was it to provide the answers from the farmer's knowledge (e.g. diesel records, fertiliser data)?
- How many yes/no questions were asked – with pre-determined scoring marks assigned?

Working with a small number of farms in depth, the next step investigated if the PG tool could identify differences in farming system on different farms. The researcher approached and obtained agreement from seven farmers to administer the tool on their farms. These farms were selected with a range of sizes and farming systems.

See Table 2 below with details of the methodologies used to investigate Objective 2: Estimate if the use of the Public Good tool as a sustainability assessment tool can help identify sustainable farming management practices.

Table 2: Methodologies and aims summary for administering the PG tool

Methodology	Aim	Justification
Quantitative (some Qualitative) Running the tool on Brookfield Farm, currently conventional Running the tool on Brookfield farm using data from a recent organic conversion plan for the farm	Investigate if the Public Good tool is robust, reproducible and sensitive. Does the PG tool identify differences in farming system on the same farm?	The use of Brookfield farm twice (same size, mixed tillage, forestry and livestock farming system) but comparing a conventional and organic system to identify differences in farming systems using the PG sustainability assessments. Administering the tool involves some elements of judgment. Qualitative analysis is necessarily part of the assessment process.
Quantitative (some Qualitative) Running the tool on 7 further farms, conventional and organic, with a range of sizes and farming systems.	Does the PG tool pick out and clearly highlight differences in farming system on different farms?	Administering the tool involves some elements of judgment. Qualitative analysis is part of the process.

1.5.2 Qualitative Methodology

An assessment of the opinion of a number of farmers' attitude to the tool and relevance of the tool was also carried out.

The researcher relied on personal contacts and good relations to get agreement for the tool assessment. As the tool required answers on sensitive data about farm business and compliance with EU regulations, it was important to be in a position of trust with the farmers.

It was not feasible to access a large number of farmers for the assessment, although several more farmers agreed in principle, time limitations meant that the research was carried out on seven farms.

Farmers in the survey were 'self-selected' – all interested in sustainability, all agreeable to having the tool applied to their farm and discussing afterwards.

To establish if the seven farmers agreed that undergoing the PG tool assessment process identified sustainable farming management practices, the researcher interviewed the farmers with a semi structured interview before and after the tool administration. See Table 3 below for the summary experimental strategy.

Table 3: Methodologies and aims summary for discussing the PG tool

Qualitative Methodology	Aim	Justification
Interviewing farmers with a questionnaire with open questions, yielding a semi structured interview before and after the PG tool assessment.	What did the farmers interviewed think of the tool? E.g. Too simple? Too complicated? Part of farm planning for sustainability? Acting as a handy 'definition' of sustainability? Does going through the PG tool assessment process identify sustainable farming management practices? How helpful are sustainability assessment tools to a farmer in developing actions to improve sustainability? Would the farmers think that the use of this tool could help identify sustainable farming management practices on their farms? Can the process deliver practical ways in which the farmer can deliver improved environmental services: wildlife, soil, water and climate?	A semi structured interview using a questionnaire carried out with farmers personally known to the researcher. Quantitative data would not give the information required on these aspects.

2 Materials and Methods

2.1 Public Good tool in action – applied to Brookfield Farm

The PG tool was initially tested on Brookfield Farm which is a mixed arable and livestock conventional farm (Brookfield conventional). The second stage of testing ran the PG tool on Brookfield Farm as a converted organic system (Brookfield organic) using data from a detailed, time lined, nutrient planned and costed organic conversion plan. This had been researched and produced as part of the three year MSc course.

The aim was to compare the tool results on the two systems and identify if the tool was sensitive enough to illustrate sustainability differences between Brookfield conventional and organic.

2.1.1 Brookfield farm information and conventional v. organic system

The table below summarises details of Brookfield farm current conventional system and the proposed changes following an organic conversion. Table 4: Brookfield Farm systems summary

Table 4: Brookfield Farm systems summary

Farm Location	Brookfield Farm Barony / Municipal Borough : Lower Ormond Parish : Kilbarron County : Tipperary North Townland : Brookfield GPS co-ordinates: Latitude = 53.0100, Longitude = -8.2735 Lat = 53 degrees, 0.6 minutes North Long = 8 degrees, 16.4 minutes West
Farm size in hectares (ha)	26 ha
Soil Type and pH	Grey Brown Podzolic soil, Patrickswell series, a medium loam based on calcareous rocks. Total organic matter 6.9% - 8.7% pH range 6.47-6.66 – slightly acid soil
Farm elevation and latitude	45-75m above sea level, 53 degrees N.
Rainfall and climate details	Cool-temperate west maritime, average precipitation 1000 – 1200 mm
Previous experience of growing arable grain legumes, specialised machinery	None
Single purpose grain legume crop feed or additional Nitrogen (N) fixing?	N fixing as an additional benefit, but grain removal reduces N availability Feed: If grain is fed on farm, N is returned as manure
Current enterprise type – conventional mixed system: Arable ha v. forage ha and relative proportions (c. 85% arable, 15% forage)	17 ha arable, 3 ha forage; 6 ha forestry Mixed system – arable and livestock (and forestry). No rotation in place to ensure fertility building (ley) and fertility exploiting (arable/horticultural crop) phases v. Livestock

	system – long-term pasture systems Ruminants: (Cattle, sheep, deer, goats) 15 lambs (conventional) Monogastrics (poultry, pigs) None currently
Proposed organic rotation details: length in years, crop types, relative proportion of forage/arable areas (c. 50% arable, 50% forage)	10 ha arable 10 ha forage 6 ha forestry Mixed system – arable and livestock (and forestry). 6 year rotation 2 years grass clover ley / Winter wheat /Oats/ Spring Beans/ Spring barley, undersown with grass/clover Ruminants: (Cattle, sheep, deer, goats) 100 lambs (organic) Monogastrics (poultry, pigs) None currently Generally young and growing animals have the greatest feed requirements for amino acids (Nicholas et al., 2007)

2.1.2 Farm audit – Brookfield conventional Current Farm Enterprises

- 17 hectares tillage winter barley following 2013 winter sown oil seed rape.
- 6 hectares broadleaf forestry planted in 1996
- 3 hectares recently seeded pasture, grazing sheep, horses and making conserved forage (silage and hay when possible) for winter.

2.1.2.1 Livestock

- Lambs as a direct sale from farm to restaurants and end customers.
- Sheep treated as if they were organic (but not certified). No routine vaccinations,

medications as advised by the vet.

- Lambs bought from quality assured breeder (flying flock, no breeding ewes)
- Charolais cross, well adapted to environment
- Well adapted to forage-based system
- Current level of intensity – stocking rate ½ of full rate (1 ha per 6 sheep)
- Housing system – not necessary for lamb fattening
- Stockman skills development needed
- Sheep pen infrastructure needed.
- Health problems 2012, fluke, pasturella, orf, resolved by 2013

2.1.3 Proposed organic rotation

Figure 5: Proposed 6 year Organic rotation for Brookfield farm

Figure 5: Proposed 6 year Organic rotation for Brookfield farm above illustrates Brookfield farm proposed organic rotation[1], (Soil Association, 2011b) starting with 2 years of grass clover ley to feed grazing stock and build nitrogen and organic matter in the soil.

Winter wheat follows, a nutrient demanding high value crop. Oats, with a low fertility requirement follows wheat. A grain legume, spring field beans (Taylor, 2002) grows well in loamy soil with deep taproots. This stock fodder crop replaces nitrogen and conditions soil.

The final crop before grass clover ley is spring barley, undersown with grass/clover to establish the soil cover quickly before the winter.

2.1.4 Differences between Brookfield conventional and Brookfield organic

The main farm system differences from Brookfield conventional:

- 6 year Organic rotation – 3 tillage fields of 17 ha total to be split into 5 fields c. 3 ha each
- More diverse crops

[1]Soil Association Standard **5.1.10**
Where rotation is possible, the annual rotation you use for each area of land must:
- balance the use of fertility building and fertility depleting crops
- include crops with various root systems
- include a legume crop (for example clover or beans), and
- leave enough time between crops with similar pests and disease risks.

- 50% drop in arable cropping area to 10 ha
- increase in grassland area to 10 ha and
    - lamb fattening enterprise, increase in livestock numbers from 15 - 100
    - continue direct sales lamb to customers increase to 100 / year
- No artificial fertilisers, pesticides or herbicides
- Reduction in fossil fuel use projected

2.2 Public Good tool on seven farms

The PG tool was run on seven further farms. All farms were located within 1 hour's drive (time and geographical reasons). All the farmers were personally known to the researcher, this made it feasible to persuade them to undergo the sustainability analysis and the interview questions. The selected farmers had an interest in sustainability. (This fact could imply bias which may affect assessment results – which will be considered in discussion)

As wide as possible range of farm sizes, farmer age, farm system, organic and conventional was selected.

The farmers were interviewed before and after the tool administration.

Table 5 below summarises the farms, named Farmer A to G. The data includes a classification by dominant farm system and land use broken down by type in hectares.

Table 5: Farm by classification and land use

Farmer	A	B	C	D	E	F	G
Classification	Horticulture	Lowland beef and sheep	Cereals	General cropping	LFA Beef and sheep	Cereals	Horticulture
Total arable	2.1	0	50.0	30	0	103	0.6
Total grass (perm)	7.5	116	22.5	155	23	47	5.0
Total woodland	5.0	70	30.0	1	0.5	5.5	0.0
Other land	2.2	10	4.0	2	0.25	33.5	0.0
Total built-up land	0.0	5	1.5	2	0	0.75	0.0
Total area	16.8	201	108.0	190.0	23.8	189.8	5.6

2.2.1 Interview questions before the tool was administered.

The answers to the following questions recorded either in the laptop or taking notes. This gave an opportunity to discuss with the farmer their feelings about sustainability before running the tool.

1. What do you think of sustainability?
2. How would you define sustainability?
3. How does sustainability relate to farming?

A sample PG tool spider web diagram was shown at this stage, so the farmer would know what they might expect at the end of the process.

2.2.2 Running the PG tool

All the answers were entered into the laptop as they were received. Typically this took between two to two and half hours.

2.2.3 Interview questions after the tool was administered

4. What do you think of the results?
5. Are you surprised, or did you expect these results?
6. Would this change your practices?
7. What do you think about the tool - is it straightforward to use?
8. Would you consider this tool part of farm planning in the future? (a good addition for farm planning advice) Or something just for 1 off reference?
9. Would you recommend to someone else i.e. another farmer?
10. In your opinion is the tool comprehensive? Which additional analysis tools may be needed (e.g. Humus balance, nitrogen surplus)
11. Does the tool need localising for Irish situation?
12. Final comments

2.2.4 Ethics

Prior to the meeting it was explained to each farmer that the purpose was to run the PG tool on their farm system. A few contextual questions on sustainability would be asked before and after the tool assessment, their answers would be recorded in notes.

It was explained that the data collected belonged to the farmer, not the researcher. The data in the possession of the researcher would be destroyed once the research was written up and the degree awarded.

2.2.4.1 Results communication

At the meeting each farmer was provided with a printed copy of the SRUC ethics form, with the details of the research and my contact details. All farmers signed the ethics sheet, and some requested that their data would be used anonymously.

A copy of the results was provided to each farmer as soon as the tool was complete, either as a printout and used as a discussion tool or viewed on the laptop screen. Every farmer was provided with a copy of their summary results and full excel data by email. By request the summary results were printed out and posted.

3 Results

This section presents the results found from the research described in the Materials and Methods chapter above.

3.1 PG tool assessment results comparing Brookfield conventional and Brookfield organic

Figure 6 and Figure 7 below illustrate graphically in spider web format the differences the PG tool calculated between Brookfield conventional and Brookfield organic farming systems.

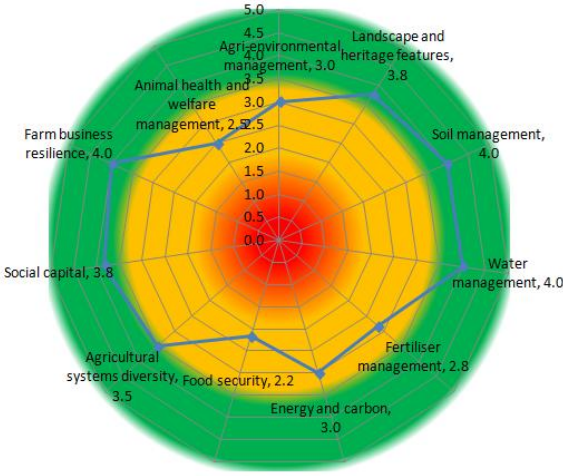

Figure 6. Brookfield conventional PG tool results

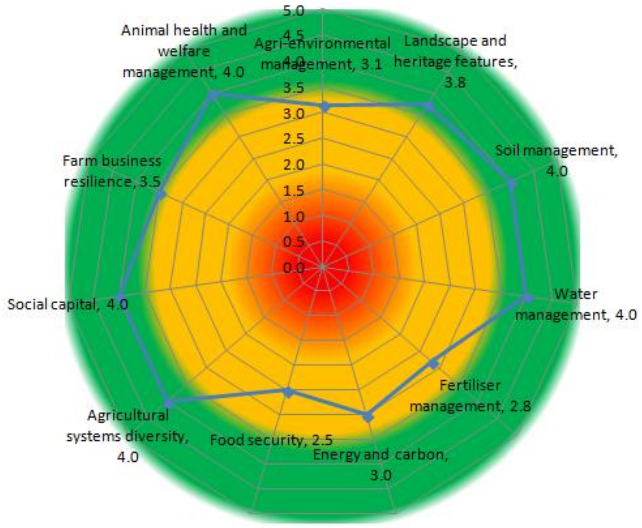

Figure 7: Brookfield organic PG tool results

See Table 6 below for comparative scoring details. The table colour coding follows the PG tool spider diagram.

Scores 0-1.5 are coloured red (no scores in this area).

Scores in the range 1.5-3.5 are coloured orange.

Scores in the range from 3.5 to 4.5 are coloured green.

There were minor scoring improvements on five spurs, a minor decrease for one score, and no difference for five spurs.

Table 6: Scores comparison. Brookfield organic and Brookfield conventional

Spur	Brookfield organic Score	Brookfield conventional Score	Scoring Difference
Agri-environmental management	3.1	3.0	0.1
Landscape and heritage features	3.8	3.8	0.0
Soil management	4.0	4.0	0.0
Water management	4.0	4.0	0.0
Fertiliser management	2.8	2.8	0.0
Energy and carbon	3.0	3.0	0.0
Food security	2.5	2.2	0.3
Agricultural systems diversity	4.0	3.5	0.5
Social capital	4.0	3.8	0.2
Farm business resilience	3.5	4.0	-0.5
Animal health and welfare management	4.0	2.5	1.5

The study was based on existing data for Brookfield conventional. The answers for Brookfield organic worksheets were in some situations based on existing data, but in others a projection into the future, albeit based on a detailed organic conversion plan.

E.g. the biodiversity spurs and the animal health and welfare spurs were necessarily estimated.

The results for the two farming systems were very similar. This comparative study was possibly less objective, subject to researcher bias, as the farm is managed by the researcher. There was a temptation to assume better practice in the future, with an organic farming system in place.

As the farm size and features (soil type, climate etc) remain the same, and the basic farming system (mixed arable and livestock) is not changed, merely differently proportioned, so similar results would be expected for a number of spurs, which was the case.

Spurs which showed no change in calculated figures included landscape and heritage, soil management, water management. It would have been expected that the soil management spur calculation be affected, but nutrient use rather than soil spur is affected by change from conventional management.

The tool also produced similar results for other spurs: fertilizer management, energy and carbon, which might not be expected to produce the same result after a conversion to organic.

The reason why fertilizer management score did not change is because scoring relies on e.g. management of the fertilizer spreading equipment and prompt integration of manure into the soil. The scoring does not highlight differences in organic as opposed to conventional practice, as long as good practice is adhered to.

There are slight differences in results (0.1) for agri-environmental management. Larger

differentials emerge on the results for food security, agricultural systems diversity, social capital, animal health and welfare. Farm business resilience is the only spur that shows a reduced score.

Again the spur total score is too blunt an instrument to highlight differences in practice.

See Appendix 1 for the full data sets.

3.2 Results for seven farm survey

Figure 8 below shows the seven farms A to G, graphically representing relative size and farm system.

There is a range of farm sizes, from 5.6 ha to 190 ha, three under 30 ha and four over 100 ha. The farm systems all vary too, representing a range of farm types typical in Ireland. This includes small field scale and polytunnel vegetable production, cereals and sheep, beef cattle rearing and finishing, cereals, beef cattle and forestry, sheep and forestry, and vegetables and beef rearing. The only main farming system not represented is dairying. Three of the farms are certified organic, Farms A, E and G, and these are also the three smallest farms.

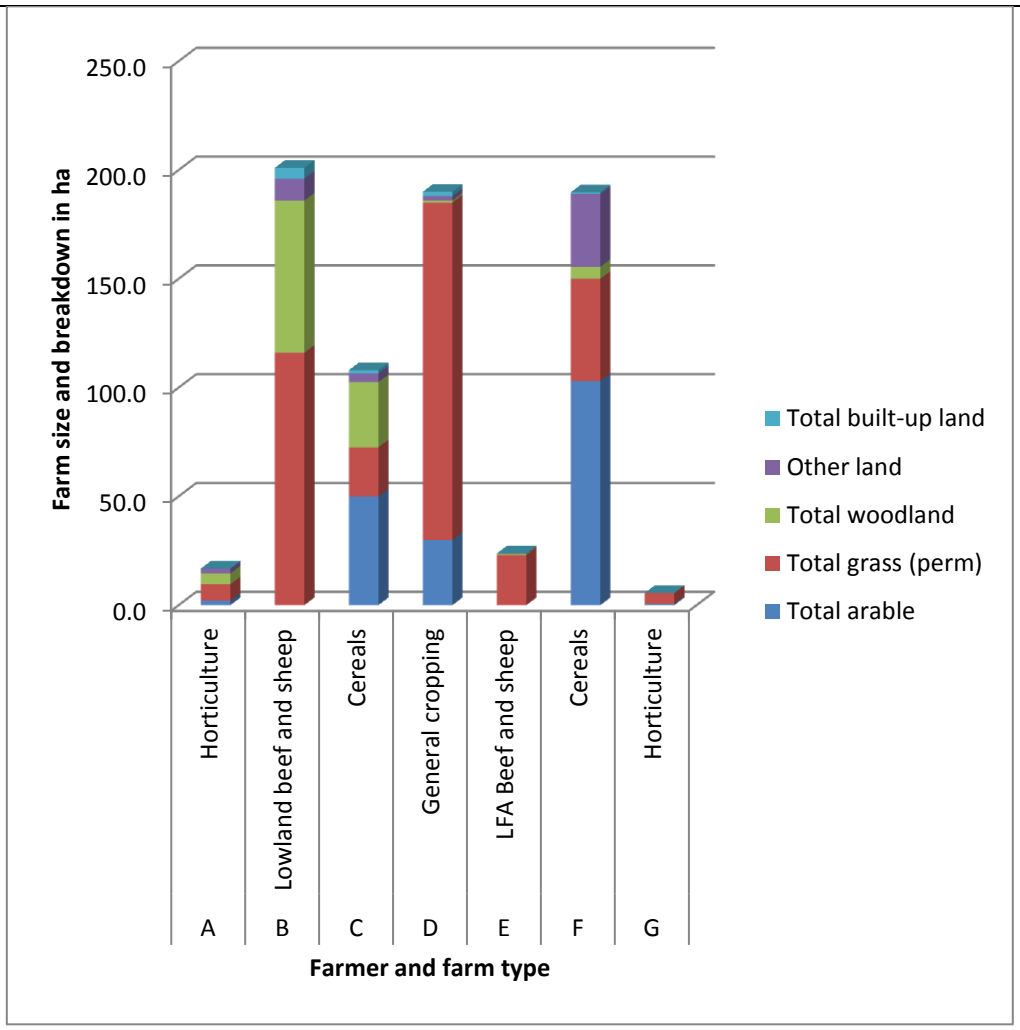

Figure 8: Chart showing the 7 surveyed farms by relative size, breakdown of land use in ha

3.2.1 Interview questions before the PG tool was administered.

The three open ended questions asked by the researcher before the tool was administered were intended to prime the interviewer in the process of thinking about sustainability, and investigate how they might define it in the context of their farms.

See Table 7 below for the answers recorded. Some interviewees did not answer all the questions, some answered very fully.

Table 7: Answers to sustainability questions

Question	Farmer	A	B	C	D	E	F	G
1	What do you think of sustainability?	Very important and several aspects - inc. financial environmental	Doesn't work if you take out more than you put in.	It is crucial to farming.	Very good idea		Have thought about it a lot.	Feeding the soil, building/enhancing biodiversity.
2	How would you define sustainability?	Taking from the soil, but putting back into the soil so there is no net loss to your soil.	Easier to define locally, relatively easy nationally, (in terms of food surpluses) Globally sustainability is difficult to define. Antagonistic	Essential to overall guardianship of nature. Protection of biodiversity. Realistic balance between requirements of production and the demands of populations and the capability of harvesting without detriment to future maintenance of biodiversity.		Feeding the soil, building/enhancing biodiversity	Ensure that you leave the earth the same or better than when you started farming for future generations.	It means a closed system. Produce sold within 10-15 miles. Restrict fossil fuel inputs. Use horses for farm work.
3	How does sustainability relate to farming?	So to continue farming without depletion to the asset that is your farm	Farming has to be sustainable. Rotations, balancing farmgate inputs v. food outputs. Particular attention to soil and minerals.	Ensuring safe food into the future	Don't believe in chopping and changing a farming system. There are ups and downs, climate, livestock losses. Stick with a system and specialise		Sits closely with farming – don't deplete soils. But increase production and profit.	It means a closed system

3.2.2 Results of the PG tool

The scores for the eleven spurs were analysed and collated. Table 8 below shows the highest and lowest scores for each farmer and each spur. The lowest score is 0 and the highest 5. The table colour coding follows the PG tool spider diagram.

The table colour coding follows the PG tool spider diagram. Scores 0-1.5 are coloured red (no scores in this area). Scores in the range 1.5-3.5 are coloured orange. Scores in the range from 3.5 to 4.5 are coloured green. There was a single score in 5, and this is coded dark green.

There was some consistency across the farms in spur scoring. For agri-environmental, fertilizer management, energy and carbon, all farms scored between 2 and 3. Higher scores were generally achieved for landscape and heritage; soil management and animal health and welfare, with an average of 3.9 and 3.6 and 3.7 respectively.

Inconsistent scoring spurs (with a variance across the farms assessed from 2 to 4) included food security, agricultural systems diversity and social capital. Another inconsistent spur was water management, with a range of 2.3 to 5.

Farm business resilience scored the highest and the most consistent spur, with a range from 4 to 4.5 and an average of 4.1.

Table 8: Spur scores collated

Spur/Farmer	A	B	C	D	E	F	G	Average
Agri-environmental management	2.6	2.5	3.6	2.3	3.3	3.0	3.0	2.9
Landscape and heritage features	3.7	3.8	3.5	4.3	4.3	4.3	3.3	3.9
Soil management	4.0	3.5	3.7	3.3	3.6	3.7	3.5	3.6
Water management	2.3	3.3	3.3	3.3	3.5	5.0	3.8	3.5
Fertiliser management	2.6	2.7	2.7	2.5	2.2	3.0	2.8	2.6
Energy and carbon	2.7	2.5	2.8	2.3	2.0	3.5	2.8	2.6
Food security	3.8	2.5	3.5	3.7	2.7	3.3	4.3	3.4
Agricultural systems diversity	4.5	4.7	2.3	2.3	4.3	4.8	4.8	3.9
Social capital	2.3	2.5	3.0	3.0	2.8	3.3	3.7	3.0
Farm business resilience	4.5	4.0	4.0	4.0	4.0	4.0	4.0	4.1
Animal health and welfare management	3.3	3.7	3.0	3.8	4.3	4.0	3.8	3.7

3.2.3 Interview questions after the PG tool was administered.

After the PG tool was administered to the farmer, eight further questions were asked and

recorded.

The intention was to understand what the farmers interviewed thought of the tool. The researcher was also identifying if going through the PG tool assessment process helped the farmers identify sustainable farming management practices.

Question 4. The responses to the question 'what do you think of the (overall) results, were you surprised?' was answered both yes and no.

Question 5. Four of the seven farmers said doing the assessment and getting the results would change their practices in some areas, and specified these in some detail.

- *'Yes, I feel bad about not harvesting rainwater, although no issue here with water in east Galway. And biodiversity should be thought about'*
- *'I'll change the buffer strips and fencing water courses, would like to do more. Think animal health and welfare plan is best practice. Highlights areas to improve. E.g. plan for biosecurity. Made me think of areas for improvement. Water management and biosecurity.'*
- *'Yes, I'll change my energy practices. I'm also thinking about stopping artificial fertiliser and using pig slurry instead.*'

One wanted to review the results more closely before deciding. Three would not change their practices.

Question 6. This question echoed question 4, and was not answered by all farmers.

Questions 7 and 8 and 11, asking what the farmers thought of the tool, would it form part of farm planning, and does the tool need to be adjusted for Ireland's regulations (REPS and AEOS for example) had a range of responses.

- *'Should be part of farm planning. Profitability is important, but being aware of the environment and how to improve it.'*
- *'Possibly, but I don't know how to interpret the results yet.'*
- *'This tool would need to be localised. Some things not relevant like the biodiversity action planning'*

Question 9. Would the farmers recommend the tool to another farmer? Received a generally positive response:

- '*Yes. Organic and conventional (farmers)'*
- *'Would say there is something to be learned. And the questions pose questions in my own mind'*
- *'Yes, would recommend. Especially people who would be interested and not necessarily organic'*

One farmer was trying to think of specific farmers to recommend; *'Would recommend, but wouldn't know who would be interested. Maybe (Farmer F)?'*

Question 10, did the farmers think the tool was comprehensive had all positive responses.

Farmer G considered it a definition of sustainability in itself (the spurs and worksheets adequately defined sustainable farming).

Question 12. Any final comments? This triggered a conversation in a number of cases, and every farmer had something to say.

- *'I expected sustainable development assessment years ago, not surprised it's arriving now.'*
- *'My farm system isn't mixed; it is a grass based system. Maybe scoring should be higher and more rating given for a fully mixed farm – growing own straw and barley... e.g. I have to go to Dublin to get organic straw.'*
- *'Pleased to learn about beetle banks – didn't know about them.'*
- *'I enjoyed doing it.'*

One response was cautious about the general applicability of the tool:

- *'Scoring depends on how the developers think about rating and ranking. How is it put together? It's dangerous to rely on a false sense of comfort. The data is not absolutely true. It needs to be individualized, and it would need to be more specific to my farm.*'

Table 9: Questionnaire post PG tool Q12 below lists the answers to Question 12.

Table 9: Questionnaire post PG tool Q12 and responses

12	Final comments?	The farmer and farm are intertwined – e.g personal sustainability (firewood etc) and farming sustainability	I expected sustainable development assessment years ago, not surprised it's arriving now.	Scoring depends on how the developers think about rating and ranking. How is it put together? It's dangerous to rely on a false sense of comfort. The data is not absolutely true. It needs to be individualized, and it would need to be more specific to my farm.	Could use this as a measure of comparison for beef farmers – to improve their sustainability	My farm system isn't mixed, it is a grass based system. Maybe scoring should be higher and more rating given for a **fully mixed farm** – growing own straw and barley... e.g. have to go to Dublin to get organic straw. Pleased to learn about beetle banks – didn't know about them.	Do the tool assessment in winter, when farms are less busy! I was on the board of CORE – national sustainability body for industry	I enjoyed doing it.

3.2.3.1 Farmer feedback

- All the farmers were really interested in the results – immediate presentation of results was welcomed. It was preferable to have a printout of the results, rather than looking at the spider web on screen.
- The results were interesting for the farmers, but they were more interested in the process of assessment – going through the worksheets relating to different spurs.
- All the farmers were interested in sustainability, although they all defined it more narrowly at the start of the discussion, before the tool assessment.
- The farmers felt the assessment raised critical and searching questions

- A number of farmers volunteered that doing the assessment helped define for them what sustainability meant for farming practices
- All the farmers agreed with the 'expanded' definition of farming sustainability after the assessment was complete.
- A number of farmers said they would change their practices as a result of the PG assessment.
- Farmers reported they enjoyed doing the tool, they welcomed the opportunity to be involved
- Research for organic /extensive / low input production had been lacking
- Some questions rank very highly for assessment in a spur, potentially giving skewed results (e.g. a yes answer gives a score, but this is not assessed further)
- Farmers felt it took some time (typically 2.5 hours to complete)
- It is really a tool for an advisor, the researcher and farmers interviewed do not consider it a self-administered tool.

3.2.3.2 Correlation between organic farms and sustainability results

The three organic farms, A, E and G were investigated to see if there was a correlation between higher sustainability scores and organic status.

See Table 10 below showing the organic average scores against the entire seven farms.

Table 10: Organic average score v. 7 farm average

Spur/Farmer	A	E	G	Organic Average		Average 7 farms
Agri-environmental management	2.6	3.3	3.0	2.9		2.9
Landscape and heritage features	3.7	4.3	3.3	3.8		3.9
Soil management	4.0	3.6	3.5	3.7		3.6
Water management	2.3	3.5	3.8	3.2		3.5
Fertiliser management	2.6	2.2	2.8	2.5		2.6
Energy and carbon	2.7	2.0	2.8	2.5		2.6
Food security	3.8	2.7	4.3	3.6		3.4
Agricultural systems diversity	4.5	4.3	4.8	4.5		3.9
Social capital	2.3	2.8	3.7	2.9		3.0
Farm business resilience	4.5	4.0	4.0	4.2		4.1
Animal health and welfare management	3.3	4.3	3.8	3.8		3.7

Organic farms scored higher on agricultural systems diversity – with an average score of 4.5 against the 3.9 seven farm average. Soil management, food security, farm business resilience and animal health and welfare scored slightly higher than the conventional average (0.1 and 0.2).

Water, fertilizer, social capital and energy all scored slightly lower (0.1) than the conventional farms on average. Agri-environmental management received the same score as the seven farm average. Overall there was a large degree of consistency across the organic average and the overall average score for each spur.

Averaging the four conventional farm scores and the three organic farm scores gave results for every spur in the same colour band – orange and green. See Table 11 below for illustration, and Appendix 3 for the full list of questions and answers.

Table 11: Average organic and conventional scores

Spur/Farmer	Organic Average	Conventional average	Average 7 farms
Agri-environmental management	2.9	2.8	2.9
Landscape and heritage features	3.8	3.9	3.9
Soil management	3.7	3.5	3.6
Water management	3.2	3.8	3.5
Fertiliser management	2.5	2.7	2.6
Energy and carbon	2.5	2.8	2.6
Food security	3.6	3.3	3.4
Agricultural systems diversity	4.5	3.5	3.9
Social capital	2.9	3.0	3.0
Farm business resilience	4.2	4.0	4.1
Animal health and welfare management	3.8	3.6	3.7

4 Discussion

The hypothesis that sustainability assessment can help with agricultural sustainability was tested and the results presented in the previous chapter. This discussion chapter will investigate the question; are practical farming decisions relating to sustainability assisted by sustainability assessment tools?

The aim of the Public Goods (PG) sustainability assessment tool is to identify sustainable farming practices. The PG tool was assessed for robustness by running the tool on the same farm twice, using data from conventional and organic systems, to see if the tool was sensitive to changes in farming practice. A second study used the tool to assess seven farms, and interrogated the farmers' opinions and attitudes to sustainability with a semi structured interview based on a questionnaire.

During the course of the assessments some positive aspects of the PG tool emerged:

4.1.1 Positive aspects of the PG tool

- Comprehensive, as far as the farmers were concerned.
- Get to talk about all farm issues, including business resilience and food security
- Spider web gives good visual feedback
- Possible to use in the farm's business plan

- Does not need preparation time in advance by the farmer, but it is useful if the farmers do have data ready.
- There is potential to collate farm assessments (with caution for the objectivity of the scoring system) so it is possible to evaluate the environmental impacts of a farming region or a farming system (beef finishing, or horticulture).

4.1.2 Issues identified during the research

- The absolute values that came out of the Public Good tool could be considered objective, (are presented as if they are objective) however they are not, as researcher judgement is needed for many questions and answers.
- All the spurs are ranked the same, and in certain areas this is not appropriate; for example, Ireland is one of the least water stressed countries in the world, however water management is given the same score as agri-environmental management and farm business resilience.
- There are some yes/no answers that can completely change the scoring for spurs.
- Hidden valuation of indicators, although it is possible to drill down deeper in excel and interrogate the scoring and results. This was not part of the scope of this research, except for obvious calculation errors which were apparent in 'faulty calculation' warnings from the excel programme.

- Would have expected a bigger difference in scoring between organic and conventional farms. This is not necessarily a flaw in the PG tool. It may be appropriately calculated, due to the relatively extensively managed farms that were surveyed.
- The farmers were all self selected, and had an interest in sustainability. This is demonstrated by the relatively high proportion of forestry on their farms. This interest may skew the results in favour of finding that the PG tool does help with sustainability measures on farms.
- Design of the tool focuses on agri-environmental management rather than directly measuring biodiversity indicators (Leach et al., 2012)
- Lack of standard data for Ireland, especially in the agri-environmental framing actions

4.1.3 The PG tool assessed

A comprehensive model developed with which to assess sustainability tools; and discussed in the literature review; is applied below to the PG tool (Binder et al., 2010).

The PG tool combines fast, easily measurable indicators, with indicators providing a site-specific complex system perspective and includes stakeholders during the assessment process.

There is representation of the fundamental elements of the agricultural system described by means of the set of indicators used. The assessment tool is both relatively simple but includes a degree of complexity as necessary.

The PG tool has predetermined definitions of sustainability built in. This results in indicators

with no latitude for alteration, therefore the tool is top down, non participatory in goal setting. The indicators have a clearly structured methodological procedure for scoring and ranking. Ecological, economic and social perspectives of sustainability (a multi-dimensional definition) are included. Indicators referring to the three dimensions are measured separately and not aggregated in a single index. The results from these methods can be relatively easily discussed with farmers.

It is possible to assess the performance of a farm over time. Therefore evaluation of the farm system changes and effects of policy strategies is possible. To some extent collated results could aid in benchmarking across similar farm systems or regions.

The post assessment aspect is critical for embedding the knowledge in practices. The PG tool is strong on system knowledge about which indicators depict a farmer's system. Goal knowledge about what would be sustainable are developed and communicated during the process of applying the tool.

Transformational knowledge, how to get from now to a future sustainable system is partly generated though the procedure.

There could be a follow-up phase where results are reported, management advice developed, and changes in indicators monitored over time.

4.1.4 Further discussion

The limitations of the PG tool in sensitivity terms, identifying sustainability 'goods' and 'bads' from farm data became apparent during the course of this project. A study is currently being carried out on beef systems using a modified version of the PG tool, and the tool was found not to show adequately illustrate scoring differences between intensive and extensive farming systems (Choi, 2013). This was not found to be a serious problem, as the research became focused less on the objective robustness of the tool, and more on the attitudes and learning potential of the farmers about sustainable practices.

Findings concluded that sustainable farming management practices can result in providing public goods (in the literature review). The use of the Public Good tool as a sustainability assessment tool can help identify sustainable farming management practices. The value of the assessment lay less in the scores produced than in the process. The farmers reported sustainability practices 'constructed learning' during the PG tool assessment.

There is need for sustainability assessment tool approaches that are more case- and site-specific. There is also need for tools that are broader in order to be accessible to a wide user group for differing case circumstances. Arguably tools also need to be standardised to give more transparent results (Ness et al., 2007). Successful assessment tool development must meet these challenges with better assessment tool guidelines and data availability.

4.2 Limitations of the study

Beyond the obvious limitations of time and research resources, due to this study being carried out by a single part time researcher, there were limits to the scope of the research, detailed below.

- PG tool rankings, scoring and assumptions methodology were not interrogated during the research.
- It was beyond the scope of this study to drill into the 'hard data' behind the tool.
- This research did not investigate what additional analysis tools may be needed to give fuller hard data (e.g. Humus balance, nitrogen surplus, etc).

This research focussed on:

- How sustainable farming practices can result in providing public goods (through literature survey)
- A comparison of the spider web and spur scoring results across the two and seven farms assessed
- The farmers' opinions on the usefulness of the PG tool in defining sustainability for farming
- The farmers' opinions of the potential of the tool to change their practices to become more sustainable.

4.3 What I would do differently

The researcher relied on knowledge of the PG tool gained on two 2 day workshops held by the STOAS research project in Switzerland and England in December 2012 and June 2013. These workshops were designed to compare the PG tool with other European farm sustainability assessment tools.

Despite help and advice from the organizers and researchers in the STOAS project, and access to the tool, it was challenging from this research basis to start using the PG tool in academic research on active farms with live farmers.

Future investigations into the robustness and appropriateness of a tool would be aided by training and information sessions with the tool developer and farm advisor.

5 Conclusions

The first research objective; how sustainable farming management practices can result in providing public goods; was researched through the literature survey. It was found that public goods are provided by sustainable farming practices, and these tend to be greater from organic farming practices. In the future there is likely to be greater focus on the provision of public goods from sustainable farming, due to EU funding decisions.

As the research developed, demonstrating the robustness of the PG tool became of less importance. The value of the tool for sustainability was in the process of carrying out the tool assessment, less reliant on the resulting scores. The positivist view; that an assessment can provide objective truth; was found less important than the construction of knowledge with the farmers.

Measuring where a farm is weak and helping the farmer improve could help deliver environmental and economic and social sustainability. However this is beyond the focus of this assessment and research. The PG tool provides feedback to the farmer, not advice on improvements.

It is important that the goals of agricultural production are discussed more widely, and by multidisciplinary researchers, practitioners, policy makers and society. It is clearly not just a food production goal. The answers on the provision of other public goods need to come from carefully considered positions.

Sustainability is a value laden concept, and treating it as though it were objective means that it runs the danger of becoming meaningless. To decide how we define sustainability in the context of farming we need to have debates about what we value, not defer to some poorly thought out metric.

If farming sustainability is to be improved, society should think more about what goes into it, and less about how to measure it. Sometimes a poor measure is worse than none at all.

By acting as though sustainability is easily defined and measurable, food industry/ government bodies are glossing over contested issues. For instance, the Bord Bia Origin Green sustainability assessment tool comes from the position that we all agree about what sustainability is, which is not the case.

A sustainable supply of food relies on agricultural innovation, but current investments neglect a key area – farmers themselves - for improving yields. Scientists, farm advisors, agri-industrial marketers are not the providers of sustainable farming, farmers are. Treat farmers as part of the solution for sustainable farming, not as part of the problem.

5.1 Suggestions for further work

Further research is needed on-

- What practices are most helpful for environmental benefit?
- How to change practices on farms to move towards sustainability

- Knowledge exchange – how to disseminate information to farmers, linking farmers and current research
- Measuring results – in long term how a farm has improved over time

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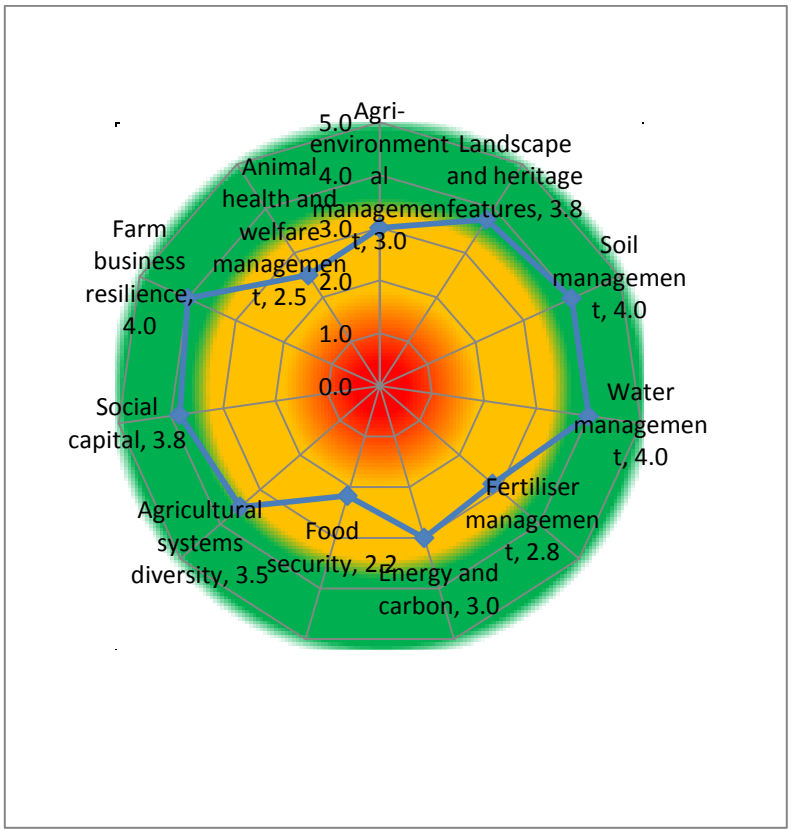
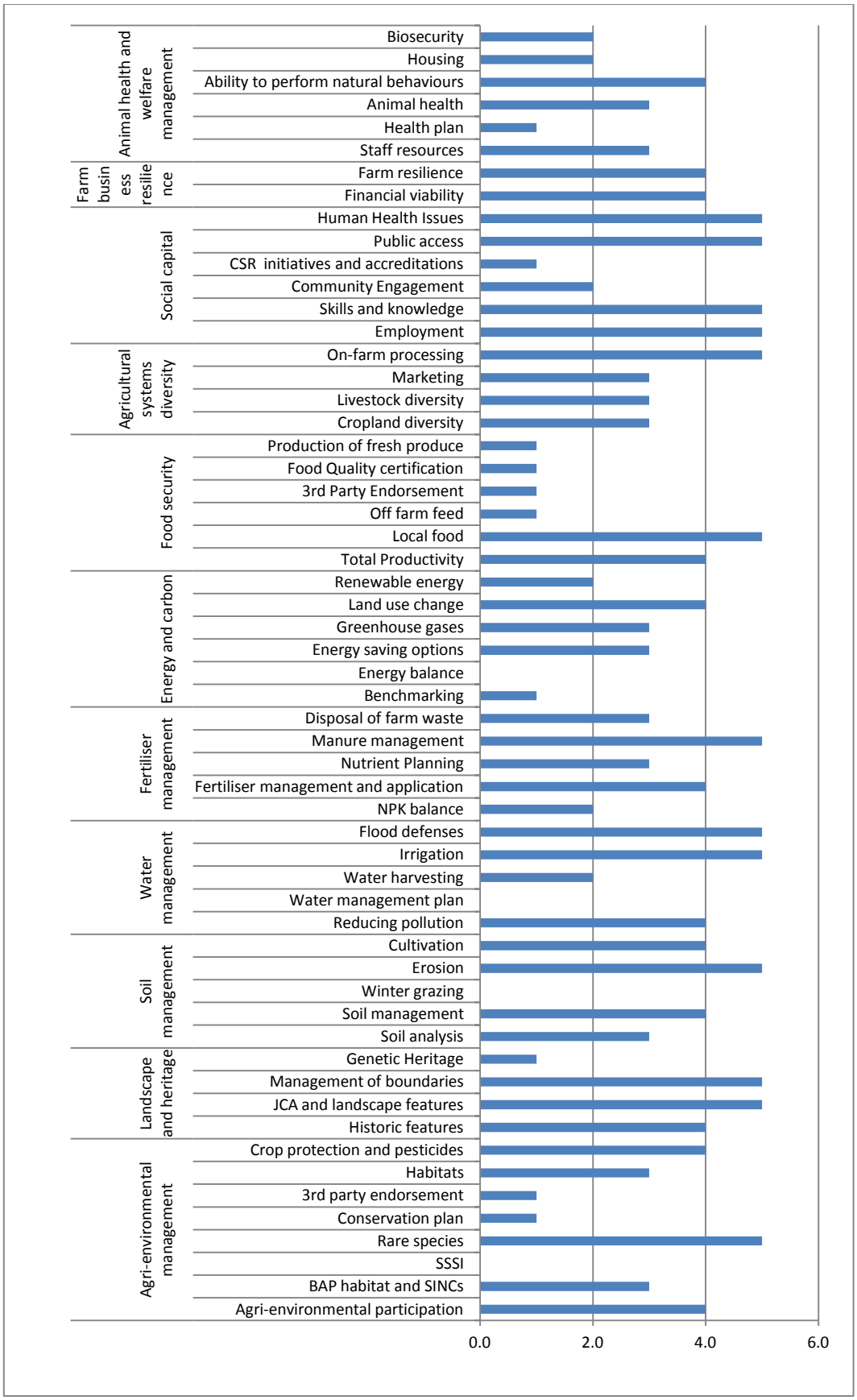
Appendices

Appendix 1 Brookfield Sustainability Assessment results

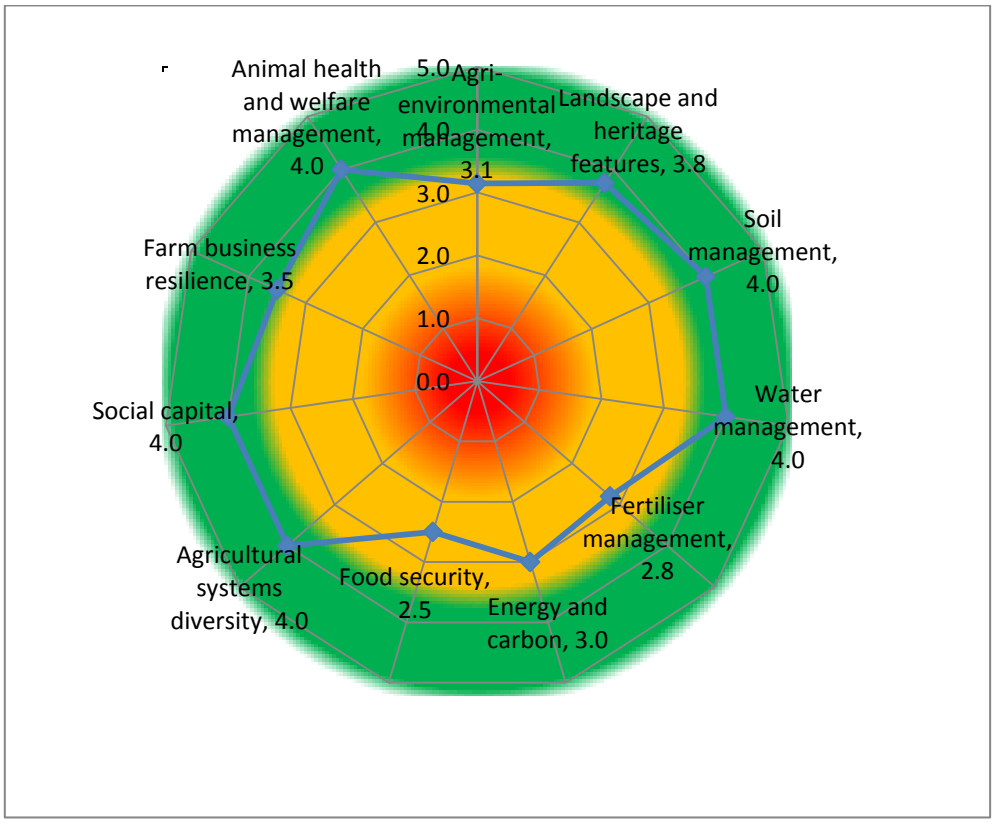
Brookfield Conventional



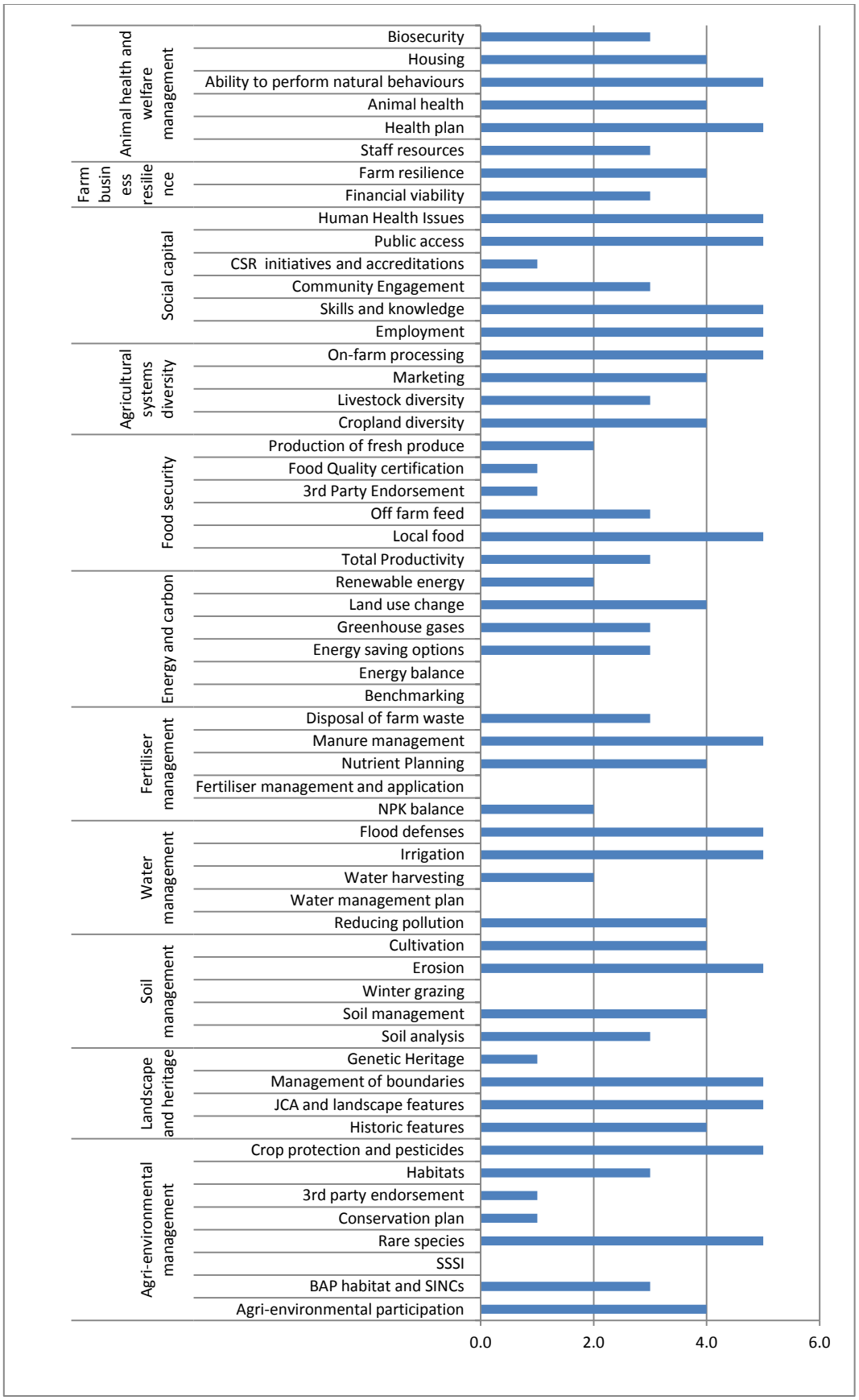
Spur	Score
Agri-environmental management	3.0
Landscape and heritage features	3.8
Soil management	4.0
Water management	4.0
Fertiliser management	2.8
Energy and carbon	3.0
Food security	2.2
Agricultural systems diversity	3.5
Social capital	3.8
Farm business resilience	4.0
Animal health and welfare management	2.5


Animal health and welfare management
Biosecurity
Housing
Ability to perform natural behaviours
Animal health
Health plan
Staff resources
Farm business resilience
Farm resilience
Financial viability
Social capital
Human Health Issues
Public access
CSR initiatives and accreditations
Community Engagement
Skills and knowledge
Employment
Agricultural systems diversity
On-farm processing
Marketing
Livestock diversity
Cropland diversity
Food security
Production of fresh produce
Food Quality certification
3rd Party Endorsement
Off farm feed
Local food
Total Productivity
Energy and carbon
Renewable energy
Land use change
Greenhouse gases
Energy saving options
Energy balance
Benchmarking
Fertiliser management
Disposal of farm waste
Manure management
Nutrient Planning
Fertiliser management and application
NPK balance
Water management
Flood defenses
Irrigation
Water harvesting
Water management plan
Reducing pollution
Soil management
Cultivation
Erosion
Winter grazing
Soil management
Soil analysis
Landscape and heritage
Genetic Heritage
Management of boundaries
JCA and landscape features
Historic features
Agri-environmental management
Crop protection and pesticides
Habitats
3rd party endorsement
Conservation plan
Rare species
SSSI
BAP habitat and SINCs
Agri-environmental participation
0.0
2.0
4.0
6.0

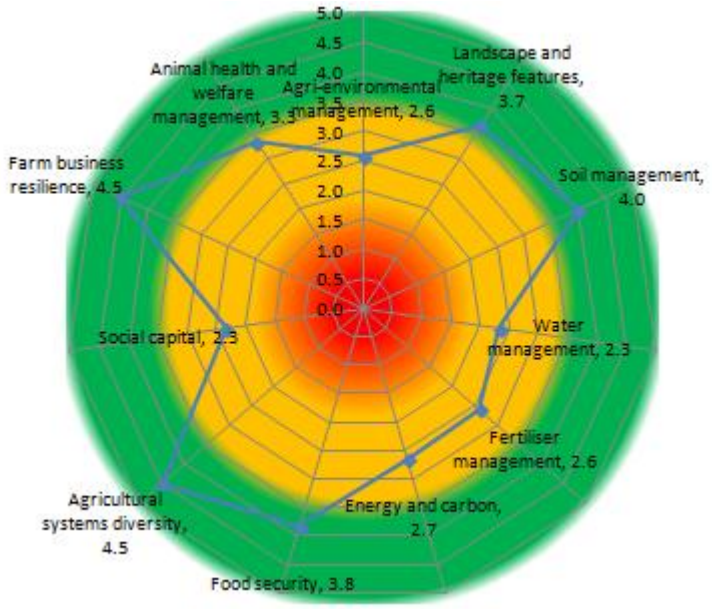
Brookfield Organic



Spur	Score
Agri-environmental management	3.1
Landscape and heritage features	3.8
Soil management	4.0
Water management	4.0
Fertiliser management	2.8
Energy and carbon	3.0
Food security	2.5
Agricultural systems diversity	4.0
Social capital	4.0
Farm business resilience	3.5
Animal health and welfare management	4.0

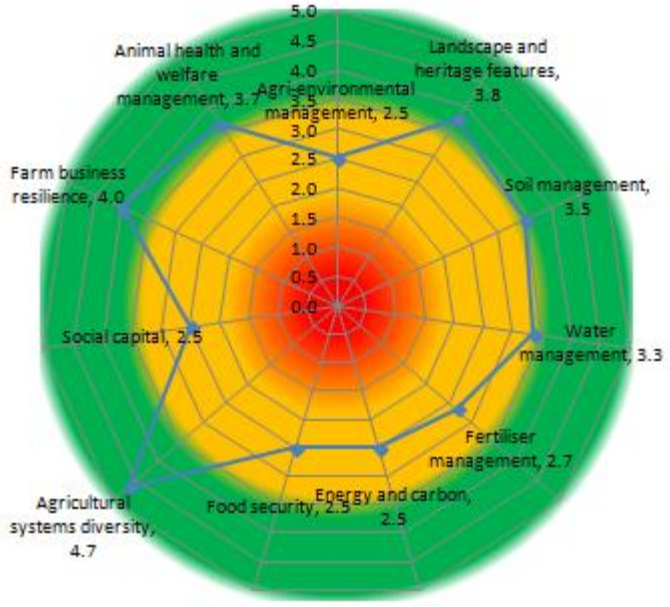

Animal health and welfare management
Biosecurity
Housing
Ability to perform natural behaviours
Animal health
Health plan
Staff resources
Farm business resilience
Farm resilience
Financial viability
Social capital
Human Health Issues
Public access
CSR initiatives and accreditations
Community Engagement
Skills and knowledge
Employment
Agricultural systems diversity
On-farm processing
Marketing
Livestock diversity
Cropland diversity
Food security
Production of fresh produce
Food Quality certification
3rd Party Endorsement
Off farm feed
Local food
Total Productivity
Energy and carbon
Renewable energy
Land use change
Greenhouse gases
Energy saving options
Energy balance
Benchmarking
Fertiliser management
Disposal of farm waste
Manure management
Nutrient Planning
Fertiliser management and application
NPK balance
Water management
Flood defenses
Irrigation
Water harvesting
Water management plan
Reducing pollution
Soil management
Cultivation
Erosion
Winter grazing
Soil management
Soil analysis
Landscape and heritage
Genetic Heritage
Management of boundaries
JCA and landscape features
Historic features
Agri-environmental management
Crop protection and pesticides
Habitats
3rd party endorsement
Conservation plan
Rare species
SSSI
BAP habitat and SINCs
Agri-environmental participation
0.0
2.0
4.0
6.0

Appendix 2 Sustainability assessment results: 7 farm survey



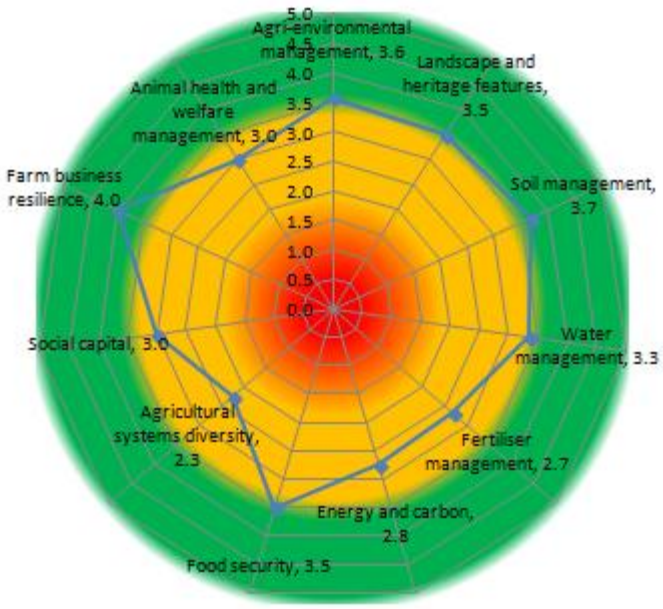
Farm A

Spur	Score
Agri-environmental management	2.6
Landscape and heritage features	3.7
Soil management	4.0
Water management	2.3
Fertiliser management	2.6
Energy and carbon	2.7
Food security	3.8
Agricultural systems diversity	4.5
Social capital	2.3
Farm business resilience	4.5
Animal health and welfare management	3.3



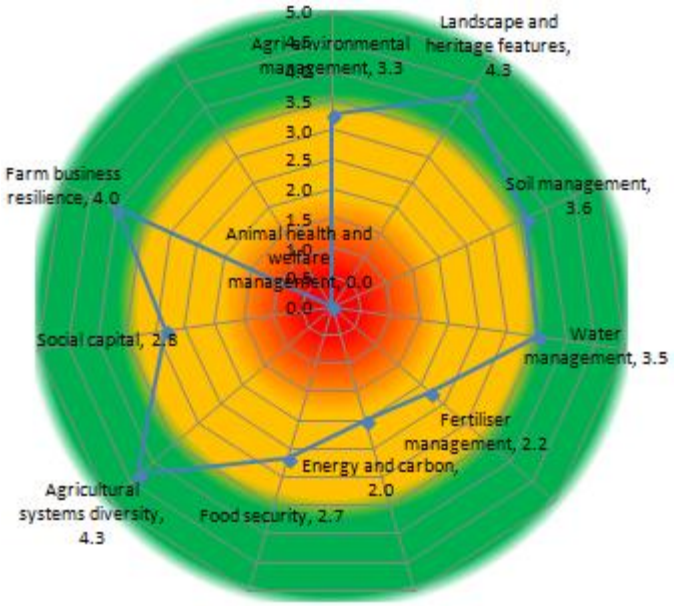
Farm B

Spur	Score
Agri-environmental management	2.5
Landscape and heritage features	3.8
Soil management	3.5
Water management	3.3
Fertiliser management	2.7
Energy and carbon	2.5
Food security	2.5
Agricultural systems diversity	4.7
Social capital	2.5
Farm business resilience	4.0
Animal health and welfare management	3.7



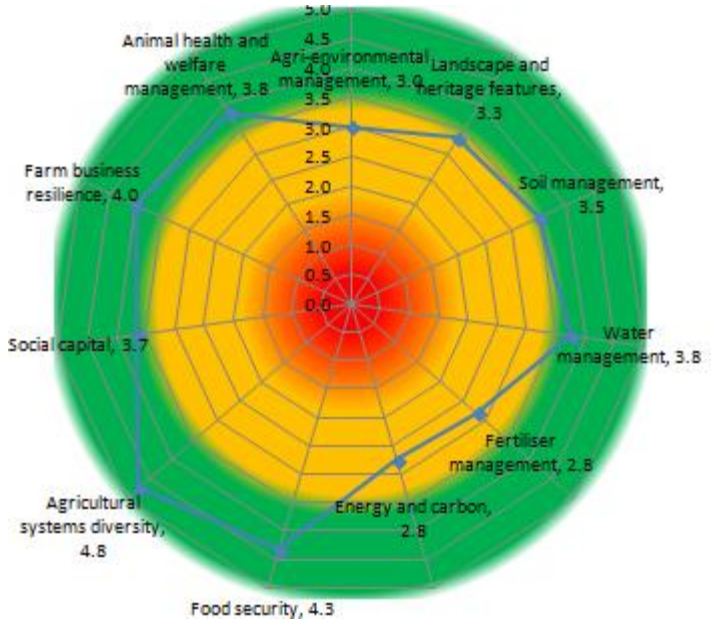
Farm C

Spur	Score
Agri-environmental management	3.6
Landscape and heritage features	3.5
Soil management	3.7
Water management	3.3
Fertiliser management	2.7
Energy and carbon	2.8
Food security	3.5
Agricultural systems diversity	2.3
Social capital	3.0
Farm business resilience	4.0
Animal health and welfare management	3.0



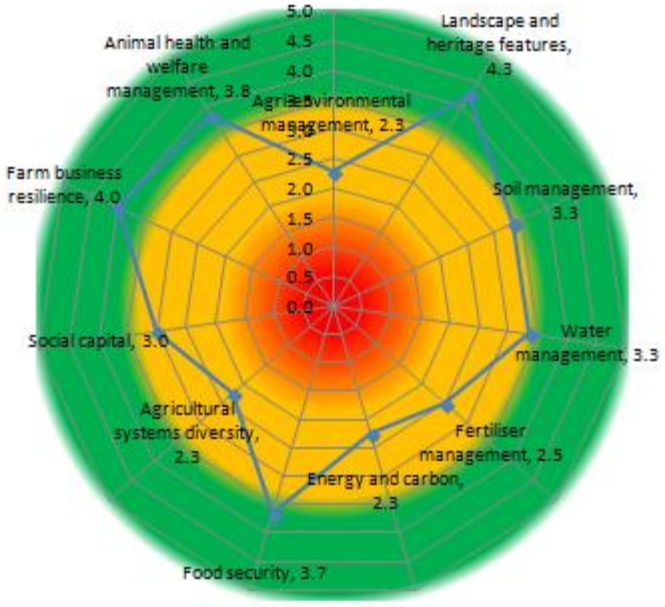
Farm D

Spur	Score
Agri-environmental management	2.3
Landscape and heritage features	4.3
Soil management	3.3
Water management	3.3
Fertiliser management	2.5
Energy and carbon	2.3
Food security	3.7
Agricultural systems diversity	2.3
Social capital	3.0
Farm business resilience	4.0
Animal health and welfare management	3.8



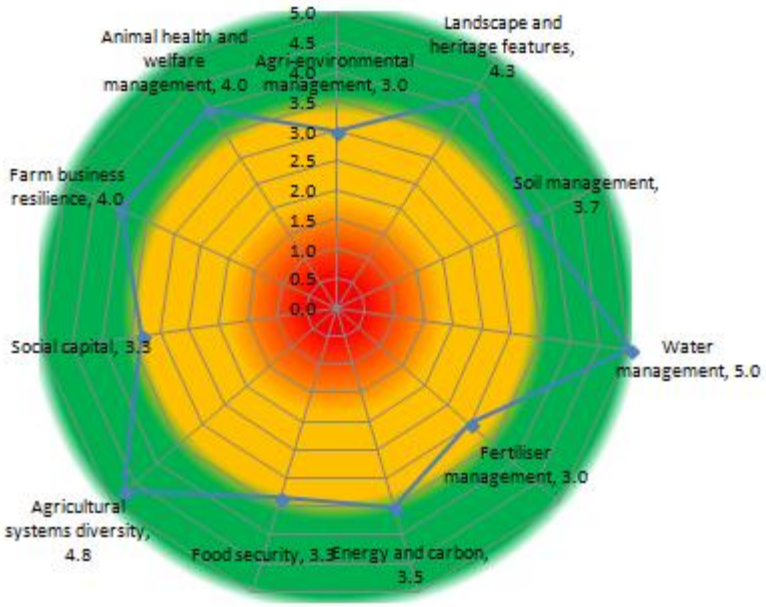
Farm E

Spur	Score
Agri-environmental management	3.3
Landscape and heritage features	4.3
Soil management	3.6
Water management	3.5
Fertiliser management	2.2
Energy and carbon	2.0
Food security	2.7
Agricultural systems diversity	4.3
Social capital	2.8
Farm business resilience	4.0
Animal health and welfare management	4.3



Farm F

Spur	Score
Agri-environmental management	3.0
Landscape and heritage features	4.3
Soil management	3.7
Water management	5.0
Fertiliser management	3.0
Energy and carbon	3.5
Food security	3.3
Agricultural systems diversity	4.8
Social capital	3.3
Farm business resilience	4.0
Animal health and welfare management	4.0



Farm G

Spur	Score
Agri-environmental management	3.0
Landscape and heritage features	3.3
Soil management	3.5
Water management	3.8
Fertiliser management	2.8
Energy and carbon	2.8
Food security	4.3
Agricultural systems diversity	4.8
Social capital	3.7
Farm business resilience	4.0
Animal health and welfare management	3.8

Appendix 3: Sustainability Assessment Questionnaire responses

Question	Farmer	A	B	C	D	E	F	G
1	What do you think of sustainability?	Very important and several aspects - inc. financial environmental	Doesn't work if you take out more than you put in.	It is crucial to farming.	Very good idea		Have thought about it a lot.	Feeding the soil, building/enhancing biodiversity.
2	How would you define sustainability?	Taking from the soil, but putting back into the soil so there is no net loss to your soil.	Easier to define locally, relatively easy nationally, (in terms of food surpluses) Globally sustainability is difficult to define. Antagonistic	Essential to overall guardianship of nature. Protection of biodiversity. Realistic balance between requirements of production and the demands of populations and the capability of harvesting without detriment to future maintenance of biodiversity.		Feeding the soil, building/enhancing biodiversity	Ensure that you leave the earth the same or better than when you started farming for future generations.	It means a closed system. Produce sold within 10-15 miles. Restrict fossil fuel inputs. Use horses for farm work.
3	How does sustainability relate to farming?	So to continue farming without depletion to the asset that is your farm	Farming has to be sustainable. Rotations, balancing farmgate inputs v. food outputs. Particular attention to soil and minerals.	Ensuring safe food into the future	Don't believe in chopping and changing a farming system. There are ups and downs, climate, livestock losses. Stick with a system and specialise		Sits closely with farming – don't deplete soils. But increase production and profit.	It means a closed system

Question	Farmer	A	B	C	D	E	F	G
4	What do you think of the results? Are you surprised?	Could be better results. No, not surprised.		Ok, not surprised	No, not surprised	Satisfied about soil and habitat management. Financial aspect important, surviving is important. Diversifying is important, as SFP will be lowered	No, not surprised	Think I'll have to look at diesel consumption
5	Would this change your practice?	Yes, I feel bad about not harvesting rainwater, although no issue here with water in east galway. And biodiversity should be thought about.	Not on a first reading - would need to review results more closely.	Would need to be more specific to my farm	No, but room for improvement. Profitability is important, and it's part of sustainability.	I'll change the buffer strips and fencing water courses, would like to do more. Think animal health and welfare plan is best practice. Highlights areas to improve. E.g plan for biosecurity. Made me think of areas for improvement. Water management and biosecurity.	Yes, I'll change my energy practices. I'm also thinking about stopping artificial fertilizer and using pig slurry instead.	Diesel consumption, more efficient vehicle. How we interpret what diesel use means. Encourages me to look at all areas again, water, hedgerow management
6	Did you expect these results (in every spur?)	Yes	Didn't expect some topics (spurs)		Yes, expected results	Energy and carbon, was surprised that is was high. Saving money by having chickens		Not surprised

7	What do you think about the tool?	a. It's ok and straightforward if administered by (the researcher). b. 2 hours time was ok c. I wouldn't do it by myself d. Probably wouldn't do otherwise Results printed out would be helpful.	Wide subject matter (spurs), but maybe it needs to be.	Good tool.	Good tool.	Quite a few aspects were not relevant, e.g. Location is everything – specific details of the farm will affect the yield/ water management etc. This isn't taken into account	I enjoyed doing the tool. It provokes thought.	Quite good. As a method for sustainability assessment
8	Would this tool form part of your farm planning? E.g with an advisor? Or is it just a 1 off?	a good addition for farm planning advice I'd do it again, but not for a while 3-5 years	No farm planner, so wouldn't be part of my planning.	Possibly, but I don't know how to interpret the results yet.	Yes it should be. Farm planner was good, for dairying. But beef system – need to be good at it. Focussed on buying and selling.	This does suggest ideas for soil, water, landscape management. Provokes thought e.g. for carbon, v. Important. If the grass system is improved then animals can be out for longer grazing Selling animals –food security aspect. Organic in Ireland v. Small so sales have to be national. Don't score poorly for organic farmers selling nationally	Should be part of farm planning. Profitability is important, but being aware of the environment and how to improve it.	One off reference.

9	Would you recommend this tool to another farmer?	Yes. Organic and conventional	Would recommend, but wouldn't know who would be interested. Maybe Farmer F?	Yes, definitely	Yes I would.	Would say there is something to be learned. And the questions pose questions in my own mind	Yes	Yes, would recommend. Especially people who would be interested, and not nec. organic
10	Did you think this tool was comprehensive?	Yes. Nothing to add	Yes, very	Comprehensive – pretty good for most farms. More details would be good.	Yes it should be. Farm planner was good, for dairying. But beef system – need to be good at it. Focussed on buying and selling.	Yes it was. Does it ask for solutions? E.G should we not be moving away from the use of slurry. And use FYM or compost instead	Very comprehensive	Yes, comprehensive. Did it act as a definition of sustainability - yes.
11	Does it need to be localized and altered for Ireland?	Yes		Needs to be specific to a particular farming system, rather than hitting so many types. May be more useful focused in a regional environmental farm type	Needs to be localised. Some non applicable, some of the environmental management. Didn't do REPS because limited to 100 acres	This tool would need to be localised. Some things not relevant like the biodiversity action planning	Yes	This tool would need to be localised. Some things not relevant like the biodiversity action planning

12	Final comments?	The farmer and farm are intertwined – e.g personal sustainability (firewood etc) and farming sustainability	I expected sustainable development assessment years ago, not surprised it's arriving now.	Scoring depends on how the developers think about rating and ranking. How is it put together? It's dangerous to rely on a false sense of comfort. The data is not absolutely true. It needs to be individualized, and it would need to be more specific to my farm.	Could use this as a measure of comparison for beef farmers – to improve their sustainability	My farm system isn't mixed, it is a grass based system. Maybe scoring should be higher and more rating given for a **fully mixed farm** – growing own straw and barley... e.g. have to go to Dublin to get organic straw. Pleased to learn about beetle banks – didn't know about them.	Do the tool assessment in winter, when farms are less busy! I was on the board of CORE – national sustainability body for industry	I enjoyed doing it.