Assessing the economic, environmental and social characteristics of UK farming systems

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Abstract

Agricultural land supports the production of food, fibre and fuel using multiple farming system; these range from small organic family farms to large conventional industrial units. These diverse systems provide an ever changing landscape in which researchers are attempting to find an optimum approach to balance production against other economic, environmental and social parameters.

The UK Government has commissioned a three year project to develop methodology to assess the economic, environmental and social characteristics of UK organic and conventional farming systems. In the first year, the project team described the complete range of current UK farming systems, from intensive arable production to extensive livestock, both organic and conventional, and described thirty-two systems to cover the majority of all UK farming systems. The project team also described forty indicators to cover the economic, environmental and social characteristics of those farming systems. The economic indicators are developed from the UK's Farm Business Study, the environmental indicators from the Cranfield University's LCA model and the social indicators from previous UK studies.

The second year was occupied data collection to support the chosen indicators. The project is now in its third year and is exploring approaches to bring these diverse indicator sets together to assess the benefits and dis-benefits that may accrue to different farming systems and how the results can be used to increase the sustainability of farming systems whilst reducing resource use and maintaining biodiversity.

The project is using different reporting and functional units to provide answers to different farming system scenarios. The approaches have already been presented to UK focus groups but we would like the opportunity to present to an international audience so that their feedback and analysis can be incorporated into the final methodology.

Introduction

The UK agricultural landscape contains a diverse range of farming systems, from organic multi-enterprise family farms to large mono-cultural arable establishments, and from lowland dairy units to upland sheep flocks. All of these farming systems have different environmental, economic and social characteristics which define their contribution to, and impact on, society. Any change in the faming landscape might alter the relationship between land-use, food production and environment. In order that UK farming and food production can be made more sustainable, a sound evidence base is required to enable comparisons to be made between the different farming systems, with research required into the characterisation and quantification of their environmental, social and economic sustainability. The aim is to assess the advantages and dis-advantages of individual farming systems and to score them on their overall contribution to societal needs.

The environmental impact of different crops and livestock products has received considerable attention from researchers in the last twenty years and the major environmental impacts have been described in detail (Williams et al., 2006; Lillywhite, 2009; Garnett, 2009) while farming systems analysis has been undertaken by Nemecek *et al*. (2011a, 2011b). Several LCA studies also highlight the huge variation in the environmental impacts between farms for the same product (Alig *et al*., 2008; Mouron *et al*., 2006).

However, the body of work associated with economic and social outcomes is smaller. Agricultural economic data in the UK is provided in the Farm Accounts for England (Defra) and is aggregated into nine main farm types and while this approach provide a good overall assessment of farm economic activity it cannot be used for the fine scale analysis required for the diversity of farming systems that exists in practice. Social and socio-economic analysis was used by Lobley et al (2009) to examine the contribution of organic farming systems but has not been used across diverse conventional and organic systems.

Despite many shared approaches, it is possible that every farm employs a unique farming system since the farming system employed is dependent on not just the different mixture of crops and livestock but is also influenced by location, weather, soil type and therefore management. It is not possible to examine every farming system so the aim of this UK Government commissioned study was to define and quantify the individual characteristics that contribute to the overall sustainability of selected farming systems and to present the results in a holistic framework to allow an overview of the environmental, social and economic contributions that are made by very different farming systems.

Method

Description of farming systems

The first phase of the study identified and described the main farming systems found in the UK. The current UK classification system recognises 25 main farm types but in practice these are all sub-divided and upwards of 100 types may exist. For example, the UK system recognises one specialist poultry system although different approaches (conventional, organic), production systems (broiler, layers) and welfare systems (caged, barn, free-range) mean that multiple systems are in use. Equally, wheat can be grown conventionally or organically, and within conventional systems, production may be described in various ways, including conventional, minimum tillage or low input.

In order that the methodology should be as compatiable as possible with existing Defra systems, the current classification system was used as a starting point and expanded to include variations of various enterprises, e.g. poultry, dairy and grazing livetsock and where necessary to divide production into conventional and organic approaches. This approach was limited for some enterprises by data availability, e.g. organic broilers production, since insufficient data was collected to make the data significantly robust. A final list of 34 farming systems is described, to represent all UK agriculture (Table 1).

Farming System	***Sample size***	**Farm business income (ha^{-1})**	**Biodiversity (habitat EQ)**
Cereals, oilseed and protein crops (conventional)	*356*	£225	13%
Cereals, (organic)	*20*	£242	39%
General cropping (conventional)	*199*	£314	12%
General cropping (organic)	*18*	£401	37%
Top fruit, orchards and vineyards	*40*	£1,124	13%
Protected horticulture (glasshouse and polytunnels)	*87*	£35,740	5%
Field vegetables (conventional)	*36*	£3,526	11%
All organic horticulture – veg + protected + fruit	*8*	£657	24%
Pigs – intensive, permanently housed (conventional)	*36*	£15,416	7%
Pigs – outdoor bred/indoor finish (conventional)	*12*	£1,844	10%
Pigs – (organic)	*0*		
Poultry – table, intensive (conventional)	*20*	£22,298	8%
Poultry – table, free range (conventional)	*0*		
Poultry – table (organic)	*2*		
Poultry – eggs, intensive (conventional)	*6*	£20,055	2%
Poultry – eggs, free range (conventional)	*22*	£2,314	12%
Poultry – eggs (organic)	*2*		
Milk – high intensity	*134*	£600	18%
Milk – medium intensity	*135*	£568	20%
Milk (organic) - medium intensity	*22*	£703	29%
Milk – low intensity	*134*	£397	21%
Milk (organic) - low intensity	*22*	£441	30%
Sheep specialist (conventional)	*165*	£249	39%

Sheep specialist (organic)	*12*	£280	52%
Specialist beef (SDA)	*49*	£169	30%
Specialist beef (SDA)	*5*		
Beef – intensive finishing (conventional)	*4*		
Beef and sheep – upland (conventional)	*142*	£274	26%
Beef and sheep – upland (organic)	*15*	£328	45%
Beef and sheep – lowland (conventional)	*250*	£299	25%
Beef and sheep – lowland (organic)	*37*	£246	42%
Horses	*34*	£664	29%
Mixed – mainly cropping (conventional)	*127*	£245	20%
Mixed – mainly cropping (organic)	*16*	£298	39%

Table 1. The 34 farming systems included in the methodology

Identification of characteristics and indicators

The major individual characteristics that can be use to define the majority of the farming systems were identified and quanitifiable indicators selected to represent them. Forty indicators were chosen to cover economic, environmental and social impacts and had to be capable of differentiating between farming systems with respect to environmental, economic and social outcomes (Table 2). The economic indicators were mainly developed from the UK's annual Farm Business Study (FBS), the environmental indicators from Cranfield University's LCA model (Williams *et al*., 2006) and the social indicators from previous UK studies (Lobley et al., 2009).

Economic Indicators	
Financial	
Profitability	*Total farm output less variable and fixed costs*
Net worth	*Balance sheet value of assets after all other claims*
Net investment	*Amount invested in capital equipment less depreciation*
Return on capital	*Profit before interest and tax divided by capital employed*
Resource efficiency	
Resource use	*Fertiliser and crop inputs*
	Fossil energy
	Water
	Nutrients (NPK)
	Purchased feed

Land and capital	*Rent and interest charges*
Labour	*Labour costs, taking account of both paid and family labour*
Business resilience	
Production specialisation/diversification index	*Shannon index, sum(pi ln (pi))*
Autonomy	*Dependence on internal versus external resources*
Environmental Indicators	
Direct energy use	*e.g. diesel*
Indirect energy use	*e.g. fertiliser, purchased feed*
Emissions of CO_2	
Emissions of CH_4	
Emissions of N_2O	
Eutrophication potential	
Acidification potential	
Pesticide amount/impact	
Water use	*Green/blue*
Land use	*Grades 1 to 5 or by site class for grass*
Abiotic resource use	
Biodiversity	*Remaining mean species abundance*
Social Indicators	
Social capital - bonding	
Social capital - bridging	
Social capital - linking	
Self-perception and quality of life	
Business governance	*Working and employment conditions*
Succession and forms of succession	
Sources of knowledge	
Business intentions	
Animal welfare	*Mortality rates*
	Stocking density
	Compliance with regulations

Indicator Values

Values for the economic indicators were calculated from Farm Accounts in England (Defra) and averaged over the last three reporting periods. Values for the environmental indicators were obtained from a modified version of Cranfield University's LCA model (Williams et al., 2006) with the addition of an aggregated biodiversity indicator. To represent biodiversity, the remaining ecosystem quality (EQ) (defined as the mean species abundance relative to the undisturbed situation) was estimated for each farming system. Values were derived from FBS data on land-use composition and managment intensity, and dose-effect relationships between pressure factors and biodiversity from meta-analyses (Reidsma *et al*., 2006; Alkemade *et al*., 2009). EQ values could then be assigned to each combination of land-use type, intensity level, and type of managment (organic and non-organic). These values were then multiplied by the proportion of the total land area in that category, with the summation giving an overall EQ value for each farming system. Values for the social indicators were collected by farmer interview with one or two interviews per farming system being conducted.

Economic and environmental values were initially calculated on a per hectare basis but this will be one of three functional units used in the finished methodology; the others will be a unit of weight and a unit of total system productivity. Social values were collected at individual farm level and subsequently transposed into a numercial score.

Results

Overview matrix

For the methodology to be considered useful, a holistic matrix or framework is required that allows the user of the methodology to obtain an overall assessment of a comparison of multiple farming systems. Certainly the assessment should provide a score for each of the three pillars (economic, environmental and social) that are included in the methodology but ideally an overall single score per farming system. Although this cannot possibility capture the detail that is inherent in individual farming systems, at policy level it is a useful feature to include. Currently, all values for the farming system/indicator combinations are stored in a spreadsheet so the next phase of the project will be to develop approaches that aggregate them first into their pillar categories and then into a single overall score. The initial approach will allocate an equal weighting to each indicator but it is our intention to use expert and focus group opinion to determine if that approach is valid and whether different weightings should be applied to different individual or groups of indicators.

Validation

The new methodology will be tested and validated through the use of a number of case studies. Data for this purpose will be extracted from previous Defra studies and collected from a number of farms representing some of the different farming systems identified by the project. A comprehensive validation process will be undertaken and involve running multiple scenarios on different farming systems and assessing the results qualitatively and statistically to ensure that the method is robust and fit for purpose.

Discussion

The 34 farming systems identified are intended to represent the majority of UK agriculture, with systems included where they are considered to be both sufficiently different from other systems, and abundant enough in the UK agricutlural landscape to warrant inclusion. They are not intended to be numerically representative of the weighting of different farming systems. For example, 13 out of 34 of the systems are organic, whilst only around 5% of the total agricultural area in the UK is organic.

Provisional results for two of the indicators are reported in Table 1 (columns 3 & 4). For the economic indicator, ”farm business income”, as might be expected, the more intensive production systems, horticulture, pigs and poultry, have the largest incomes on a per hectare basis. An interesting comparison can be made between organic and conventional systems, with organic systems performing generally favourably compared to their conventional equivalents. Provisional analyis suggest that an exception to this might be organic horticulture, which reported smaller turnover on a unit area basis than conventional horticulture. For the biodiversity indicator, highest scored were obtained by grass-based, low intensity systems, whilst the lowest ones were obtained for the more intensively housed livestock systems. The indicator is capable of differentiating the biodiversity value between different systems within the same production system, for example between free range and intensive egg production, and between organic systems and their non-organic counterparts.

Not all of the farming systems identified are represented by a sufficiently large sample size in the FBS to enable calculations to be made from this data set (minimum farm number was considered to be five). However, these farming systems remain in the final list as this situation may change in future revisions of the FBS. Furthermore, new farming systems may evolve in the future, and so, to a certain extent, the method has been future-proofed by ensuring that the indicators chosen are sufficiently robust that they could be applied to newly emerged farming systems. The range of values that an indicator can take is also sufficiently large in order to accomodate future changes.

Working with 34 farming systems and 40 indicators has generated a considerable volume of data and it is not yet obvious how to aggregate and categorise the data in a manner which is fair and unbias to all farming systems. The next phase of the project will address this issue. But the method will need to address the challenge of dealing with different scales (such as field, enterprise, farm) and production basis (area or unit of production). In the current phase of the project, indicators have been calculated on a per hectare basis, but work is underway to develop a production based output (total system productivity). This would theoretically enable allow the output of such a diverse range of systems to be compared represents a significant challenge. It will need to incorporate outputs of both food and non-food crops, including crops for direct human consumption as well as animal fodder crops. Non-edible crops will include flowers, fuel and fibre.

Farming systems are constantly changing and evolving in response to consumer and policy demands. The development of more than one functional unit will enable the spreadsheet matrix to be interrogated with various scenarios. For example, as to how a shift from non-organic to conventional production might be expected to impact both total energy use and production outputs, or how the intensification of livestock production might impact the rural economy.

The aim of feeding an increasing global population while at the same time reducing the environmental impact of agricultural production and maintaining the social fabric of society is one of the most challenging issues of modern times. The ability to assess multiple farming systems on multiple criteria and to understand the benefits and compromises which must be made to obtain the correct balance between the three pillars of sustainability is a powerful tool. It is hoped that the methodology being developed within this study is a step in the right direction.

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