The Sustainable Intensification of the Irish Dairy Sector

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Abstract

The concept of sustainability is one of the forefront issues in global agricultural production at present, given mounting pressure to increase food production in both a socially responsible and environmentally friendly way. From an Irish perspective the sustainable intensification of agriculture is of particular relevance given ambitious targets to increase milk production by 50 percent by 2020, in the context of European milk quota removal. Alongside this, environmental targets may be specified, meaning that expansion would have to be achieved in a sustainable way. To evaluate dairy farm-level sustainability a series of indicators are developed here using Teagasc National Farm Survey FADN (Farm Accountancy Data Network) data for Ireland from 2012. Three dimensions, reflecting the multifaceted nature of sustainability (economic, environmental and social) are considered. Given the environmental challenges inherent in the sustainable intensification of agriculture, it is encouraging to observe that the more intensive, top performing farms (in an economic sense) emit relatively less greenhouse gases when compared to their less intensive counterparts. Conversely, the better performing farms in economic terms tend to have higher nitrogen surplus per hectare on average. This is consistent with their higher rates of production intensity but poses a challenge in terms of sustainable expansion. That said this analysis demonstrates that the nitrogen use efficiency of milk production is positively correlated with economic performance, with more intensive farms producing relatively more milk per kg of nitrogen surplus. From a social perspective demography also tends to be correlated with economic performance. These indicators allow for the continued assessment of the sustainability status of Irish farming.

Keywords: Sustainable intensification, Sustainability indicators, Dairy quota removal.
JEL codes: Q1, Q5, Q18, Q56.

1. Introduction

Increasing global food demand, driven by population growth (in developing countries) and rising incomes have important implications for food security and sustainability. The FAO (Food and Agriculture Organisation of the United Nations) (2009) estimate that global food production must increase by 70 percent by 2050 given a projected world population of 9.1 billion. As a result global food supply must grow sustainably within the context of increasing competition for natural resources, particularly land and water, competition between food, feed and biofuel, and by the need to operate in a carbon-constrained economy (Thornton, 2010). The term 'sustainable intensification' has been put forward to describe the challenge of increasing the productivity of agricultural land to produce more food in an environmentally friendly way in the face of a changing climate. The phrase has been much used following the publication of the Royal Society report (2009), although it originates from discussions with regard to agricultural development in Africa during the 1990s.

Sustainable intensification refers to the increase in desired outputs with the same or fewer inputs, but with significantly reduced or eliminated environmental degradation. There is a growing demand too on the part of consumers for sustainably produced food. According to Pretty et al. (2010) the goal is no longer simply to maximise productivity but to optimise across a far more complex landscape of production, rural development, environmental, social justice and food consumption outcomes. Similarly, Godfray et al. (2010) argue that a threefold challenge now faces the world: to match the rapidly changing demand for food from a larger and more affluent population to its supply; to do so in ways that are environmentally and socially sustainable; and to ensure that the world's poorest people are no longer hungry. Given limitations on land and water resources the UK government foresight report, the Future of Food and Farming (2011) contends that a significant increase in food production must come through acceleration of the rate of technological change, through the spread and implementation of existing knowledge, technology and best practice, and by investment in new science and innovation.

This paper examines the sustainable intensification of the Irish dairy sector and is structured as follows. Section 2 provides some background on sustainability measurement and includes a brief overview of the Irish dairy sector. Section 3 outlines the methodology employed in the design of sustainability indicators. Results are then reported upon in section 4. Finally, a discussion of results and an overall conclusion are found in sections 5 and 6 respectively.

2. Background

Although the concept of sustainability is very much at the centre of current agricultural policy, debate continues on an actual definition and interpretation (Dillon et al., 2010). The widespread adoption or pursuit of sustainable development, and indicators of sustainability, emerged following the Rio Earth Summit in 1992 (Woodhouse et al., 2000) which for the first time brought the three dimensions of development: economic, environmental and social, into an integrated framework (Rao and Rogers, 2006). There has been, since then, despite the existence of alternative definitions, an overall consensus in emphasising the multidimensional goals of sustainable agricultural development. Bos et al. (2007) state that agricultural sustainability should be viewed from three alternative perspectives: people, planet and profit. This argument is also supported by Pretty et al. (2008) where the authors indicate that the best approach to analysing agricultural sustainability is to assess it through the lens of economic growth, environmental protection and social progress. These definitions of sustainability all have one thing in common in that they emphasize the multidimensional (economic, environmental and social) goals of sustainable development in agricultural terms.

Measuring sustainability at the farm level is challenging. Some argue that precise measurement is impossible as it is site-specific and dynamic. Many studies use an indicator approach where indicators are used as a proxy for movement in '*the desired or undesired direction*' rather than serving as a precisely defined benchmark. Sustainability indicators are quantifiable and measurable attributes of a system that are judged to be related to its sustainability. They are statistical constructs which support decision-making by revealing trends in data that can then be used to develop policy measures or to analyse the results of policies already implemented. The sustainable intensification of agriculture is of particular international relevance at present and is investigated here in the context of the Irish dairy sector. A series of farm-level sustainability indicators for the sector are developed using data from the 2012 Teagasc National Farm Survey (NFS). The NFS is operated as part of the Farm Accountancy Data Network (FADN) of the EU and fulfils Ireland's statutory obligation to provide data on farm output, costs and income to the European Commission. Dairy farms are examined specifically within this paper due to the anticipated expansion of the sector following the abolition of EU milk quota in 2015. The environmental constraints within which production must be increased are acknowledged and the development of such indicators for 2012 serves as a starting point from which future trends in the sustainable intensification of the Irish dairy sector can be examined.

Agriculture remains the largest use of land in Ireland, with two-thirds devoted to it; most under grass for pasture, silage or rough grazing (EPA, 2012a). The agri-food sector's contribution to the economy is large, accounting for 7.7 percent of gross value added in 2011 (DAFM, 2012). The dairy and beef sectors are of particular importance, accounting for half of all food and drinks exports (valued at €2.7bn) in 2012 (DAFM 2013). According to the 2012 NFS (Hennessy et al., 2013a) 19.3 percent of the country's total forage area is devoted to dairy production. The 2010 Census of Agriculture (CSO, 2011) reports the national number of dairy cows as 1.07 million with an average herd size of 58 cows. Government policy envisages further expansion within the agriculture sector as outlined in the sector's development strategy, Food Harvest 2020 (FH2020) (DAFF 2010), a visionary document which sets a target of increasing the value of primary agricultural output by 33 percent by 2020, relative to the average position in the 2007–2009 period. This sector level goal is supported by a number of detailed targets for key agricultural sub-sectors, the most ambitious of which is for the Irish dairy sector; to increase the volume of milk production by 50 percent by 2020 (DAFF, 2010).

The removal of milk quotas in 2015 gives a major food exporting country like Ireland an opportunity to share in the expected growth in global demand for dairy products. However, the delivery of production increases envisaged under FH2020, must be achieved in the context of Ireland's international obligations in relation to the environment; no small task given the share of greenhouse gas emissions (GHG) attributable to the farming of livestock for meat or milk production. Ireland has an unusual emissions profile within the EU, with emissions from agriculture being proportionally higher than for most other Member States. Agriculture is the single largest contributor to the country's overall GHG emissions, accounting for over 30 percent (EPA, 2013) compared to an EU average of 10 percent (EPA, 2012b).[1] The sector also represents a high proportion of non-Emissions Trading Scheme (non-ETS) GHG emissions**.** That said, it should be noted that a recent EU study conducted using a full life-cycle assessment approach found that the Irish system produces the lowest

[1] Emissions from the sector comprise emissions from enteric fermentation, manure management and nitrogen application to soils accounting for on average 45 percent, 27 percent and 22 percent respectively.

GHG emissions in the EU for dairy animals (Leip et al., 2010).[2] More recent analysis undertaken by Hennessy et al. (2013b) using NFS data from 2012 found that approximately 22 percent of Irish milk was produced at a carbon footprint of 1kg of carbon equivalent per kg of fat and protein corrected milk solids. Conversely, approximately 17 percent of milk was produced at a carbon footprint of 1.3 or greater (Hennessy et al., 2013b).

2.1 Sustainable intensification of the Irish dairy sector

Given the FH2020 expansion targets and the production opportunities arising from the removal of EU milk quota, the Irish Environmental Protection Agency (EPA) predict that emissions from the sector will increase by 12 percent over the period 2011-2020 to 21 million tonnes of carbon dioxide equivalents (CO_2eq) on current levels (EPA, 2013). It would appear then that the anticipated expansion of the Irish dairy sector post-quota poses a challenge for the industry given already agreed EU commitments with regard to environmental protection i.e., in the context of an overall commitment by the EU to reduce GHG reductions by 2020, the Irish GHG reduction target is for 20 percent relative to the baseline in 2005 (EPA, 2013). Similarly, in the area of water quality, Ireland has international obligations under the EU Water Framework Directive and the Nitrates Directive.[3] Despite this, the EPA contend that increasing milk production by 50 percent will potentially increase total nitrogen generation from bovine livestock by as much as 14 percent between 2009 and 2020 (EPA, 2012a). Challenges remain therefore with on the one hand an expansionary production policy and commitments with regard to environmental sustainability on the other.

The agricultural sector's approach to increasing production in line with international obligations in relation to the environment is based on a '*sustainable intensification*' model. It is acknowledged that the expansion of the dairy sector must ensure that nutrient management practices will be sufficient to prevent environmental damage to water quality and that significant new mitigation measures must be developed and implemented to reduce emissions of GHGs. To this end a recently published Environmental Analysis Report assessing the potential environmental impact of increased food production as envisaged under FH2020 found that the adoption and use of high-technology and best-production methodologies at farm production level will yield the best environmental outcomes and result in the most effective mitigation measures (Farrelly et al., 2014). Numerous strategies for the sustainable intensification of the Irish dairy sector are being explored to optimise livestock and nutrient management; these include improving the genetic merit of cows, extending the grazing season, reducing beef finishing times, dietary modification, improving nitrogen use efficiency and the use of nitrification inhibitors. In short, the sustainable intensification of the Irish dairy sector will involve the integration of environmental considerations with agricultural objectives and the establishment of farming practices and production methods which reflect the increasing environmental concerns. The development of farm-level indicators here allows for the assessment of the sustainability status of Irish dairy farming into the future.

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[2] Life-Cycle Assessment (LCA) is a holistic systems approach that aims to quantify the potential environmental impacts, for example, GHG emissions, generated throughout a product's life cycle, from raw-material acquisition through production, use, recycling and final disposal. Thus it accounts for all GHG emissions from the farm up to the point of product sale. It is generally expressed on a per unit of product produced basis. The LCA approach attempts to capture all emissions associated with a product. It therefore ignores national boundaries and seeks to enumerate all emissions along the chain, irrespective of country of origin.

[3] Information on the EU Water Framework and Nitrates Directives respectively can be found at http://ec.europa.eu/environment/water/water-framework/index_en.html and http://ec.europa.eu/environment/water/water-nitrates/index_en.html

3. Methodology – Indicator Design

Farm-level sustainability indicators, encompassing three facets of sustainability: economic, environmental and social, are reported on here in an integrated framework to gauge the current sustainability of Irish dairy farming. Indicators were chosen according to their overall suitability within the context of the Irish socio-economic situation and were developed using Teagasc NFS data from 2012. A random, nationally representative sample is selected annually for the survey in conjunction with the Central Statistics Office (CSO). Each farm is assigned a weighting factor so that the results of the survey are representative of the national population of farms. Data on over 1,000 farms are collected to represent the farm population of over 105,000 farms. Farms are assigned into six farm systems on the basis of farm gross output, as calculated on a standard output basis. Standard output measures are applied to each animal and crop output on the farm and only farms with a standard output of €4,000 or more are included in the sample (Hennessy, et al., 2011). For the purposes of this paper, only the data collected on dairy farms is of relevance, resulting in a sample of over 250 specialist dairy farms. The longitudinal nature of the data makes the charting of trends in sustainability over time possible. It should be noted that indicator development is an iterative process as, particularly in the area of environmental sustainability, the development of novel scientific methodologies will necessitate further data collection. As such indicator design will evolve over time. Further detail on the development of farm-level sustainability indicators for Ireland can be found in Ryan et al. (2014). A list of the multi-dimensional indicators considered here is contained in Table 1 below. A description of how each of these groups of indicators (economic, environmental and social) is calculated then follows in turn.[4]

Table 1: Farm-level sustainability indicators

Economic	Environmental	Social
• Productivity of labour	• GHG emissions per farm	• Household vulnerability
• Productivity of land	• GHG emissions per kg output	• Education level
• Profitability	• Emissions from fuel/electricity	• Isolation risk
• Viability of investment	• Nitrogen (N) balance	• High age profile
• Market orientation	• Nitrogen (N) use efficiency	• Work life balance

Although environmental resource management is much discussed in the context of sustainable intensification, an economic evaluation of farm-level performance is vital to any sustainability assessment. As such, five indicators are reported upon here in evaluating the economic sustainability of Irish dairy farms. These capture the broad concepts of productivity, profitability and viability and are discussed in turn. Firstly, productivity is a measure of the efficiency of production and is evaluated here in the context of profit per unit

[4] Recent studies of farm-level sustainability have acknowledged the role that innovation can play in the intensification of the agri-food sector and as such, the concept of sustainability has been broadened to encompass innovation. This is not taken account of here but further detail on the development of innovation indicators representative of farm processes, management practices and farm products can be found in Hennessy et al. (2013b).

of land and income per unit of labour used. Secondly, the profitability of the farm business is assessed as market based gross margin (gross margin less subsidies) per hectare. Thirdly, the economic viability of the farm overall is taken into consideration. An economically viable farm is defined as one having the capacity to remunerate on-farm family labour at the average agricultural wage and the capacity to provide a five percent return on non-land assets. Finally, in an overall evaluation of the economic sustainability status of the farm, its market orientation (the converse of reliance on subsidies) is also taken account of.

The environmental challenges of the further expansion of Irish dairy farming have already been discussed in some detail. To this end the design of farm-level environmental indicators are crucial in the context of an overall evaluation of the sustainable intensification of the sector. The design of such indicators in itself remains difficult but should be eased somewhat as scientific knowledge on the interactions between agriculture and the environment deepens and as environmental policy targets are further developed. A broader discussion on the design of environmental indicators of sustainability can be found in Hennessy et al. (2013b) and Ryan et al. (2014).

In line with the environmental concerns currently being discussed in the context of dairy expansion indicators for the thematic areas of air and water quality are developed here. Firstly, in relation to air quality and climate change concerns, three GHG emission indicators are developed. All are calculated using IPCC (Intergovernmental Panel on Climate Change Methodology) coefficients and conventions.[5] The first indicator is GHG expressed on a per farm basis i.e., tonnes CO_2 eq. per farm while the second is GHG expressed per unit of product i.e., kg CO_2 eq. per kg of milk produced. Thirdly, emissions from fuel and electricity use on the farm (although small relative to the other two measures) are also included.

An evaluation of the risk to water quality is undertaken in terms of the environmental sustainability of Irish dairy farms at present. Firstly, a farm gate nitrogen balance per hectare (imports of nitrogen less exports) is calculated. This is reported as kg nitrogen surplus per hectare. An investigation of the use of nitrogen on farms is useful in this context given the significant environmental and economic implications of the inefficient use of nutrients on-farm.[6] It should be noted that the links between nitrogen balance, (imports of nitrogen less exports) at farm and field level and loss to the environment, are complex and difficult to predict with the nature of such interactions dependent on factors such as soil type, hydrology, weather, farm structures and management practices. Some of the data required to undertake a whole farm balance analysis is not currently available. However, all things being equal, farm gate nitrogen balances are a reliable indicator of agronomic efficiency and environmental pressure (Schroder et al., 2004).[7] Additionally, the use of farm gate balances highlights the

[5] The IPCC method quantifies GHG emissions using a national sector-based approach. The approach estimates emissions associated with agricultural production activity within defined national boundaries. In the case of agriculture it confines itself to the emissions within the farm gate. Emissions associated with imported inputs, such as imported animal feed, imported fertiliser or imported farm animals are not included in this measure. See Hennessy et al. (2013b) for further discussion on the measurement and reporting of GHG emissions from the agricultural sector using the IPCC and Life-Cycle Assessment (LCA) approaches.

[6] See Buckley et al. (2013) for further discussion on nitrogen use efficiency.

[7] Nutrient accounting approaches provide a reliable assessment of nutrient management efficiency at farm or enterprise level while providing an indicator of environmental pressure in terms of risk to water quality. Farm gate or whole farm balance approaches are the most commonly used nutrient accounting systems. The farm gate approach restricts analysis to imports and exports of nutrients over which the farmer has direct control (through the farm gate). Whereas whole farm approaches additionally account for nutrient inputs and exports that are less directly controllable by the farmer, such as atmospheric deposition; biological fixation and

nutrient imports, exports and management practices that are most directly under the control of the farmer.

A second indicator of risk to water quality is a measure of nitrogen use efficiency in milk production, reported as kg nitrogen surplus per unit of product (excess of nitrogen imports over exports relevant to the dairy enterprise). It should be noted here that, as interactions between agriculture and water quality are not yet fully understood, the development of indicators using existing data remains challenging.[8]

Finally, in order to develop agricultural production in a sustainable manner, an understanding of the inter-relationship between the agricultural industry and the wider rural society in which it operates is required. Agriculture contributes to the viability of rural areas, helping to maintain the rural infrastructure. In evaluating sustainability in the past, economic and environmental factors took precedence and income was commonly used as an indicator of social welfare in the literature. There is now a growing recognition of the need to examine overall human well-being and quality of life within the sustainability framework. Welfare is determined not only by economic activity but also by a wide range of additional dimensions of social life. As a result, indicators of social sustainability are designed here to gauge the quality of life of the farming community by identifying and quantifying those '*social life*' dimensions not determined by economic activity.

According to O'Brien et al. (2008) the existence of off-farm employment contributed to the viability and sustainability of Irish farm households and the productivity of farm businesses during the last decade. Due to the economic downturn there has been a contraction in the availability of off-farm employment in recent years. The NFS (2013) reports that the proportion of farms where either the farm holder or spouse had off-farm employment peaked in 2006 at 59 percent and has been in decline since (Hennessy et al., 2013a). The subsequent impact on farm households should thus be examined. As such the presence of off-farm employment on Irish dairy farms is investigated in this paper and an indicator of household vulnerability created. A household is defined as vulnerable if the farm business is not viable and neither the farmer nor spouse is employed off-farm. Furthermore, an insight into the workload of farmers is of value in the context of overall farm sustainability therefore an indicator of work life balance is calculated by taking account of the on-farm hours worked.

Given anecdotal evidence of an ageing farming population, the demographic profile of Irish farmers is also worthy of examination in the context of farm succession and overall sustainability. In this analysis a household is designated as being of high age profile if the farmer is aged over 60 and there are no household members less than 45 years. In addition, a household is classified as at risk of isolation here if the farmer lives alone. Finally, an examination of the education levels of farm operators can also be insightful in a sustainability assessment and as such are taken account of here.

All three dimensions of farm-level sustainability are discussed in the following section and an overall assessment of the sustainability status of Irish dairy farming is made. The development of such indicators allows for the continued monitoring and evaluation of the sustainable intensification of the dairy sector in the aftermath of milk quota abolition.

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mineralisation of nutrients in soils. It is envisaged that the data collection process will be augmented in the future to include data in the area of farm nutrient soil status and quantities of organic manures being imported and exported to allow a whole farm balance approach to be explored.

[8] The issue of data development to improve our capacity to assess and chart trends in the overall environmental sustainability of farming is further discussed in Hennessy et al. (2013b) and Ryan et al. (2014).

Although results are discussed in an Irish context the issues are of relevance internationally, given the so-called agricultural '*Grand Challenges*' of our time.

4. Results

The overall sustainability of Irish dairy farms in 2012 is first reported in the context of economic sustainability, with the other dimensions (environmental and social) then presented relative to the farm's economic performance. By way of introduction it should be noted that 2012 was a somewhat atypical year for milk production in Ireland. Inclement weather adversely affected output and income and was accompanied by a substantial increase in production costs due to elevated feed use. It is worth noting that the system classifications used in the NFS refer to the dominant on-farm enterprise and it is not unusual for Irish farms to be multi-enterprise i.e., the data utilised here relates to specialist dairy farms, many of which also have an on-farm cattle enterprise. It should be reiterated that the design of farm-level indicators using 2012 data should be seen as the beginning of a development capturing the multi-dimensional nature of farm sustainability in the context of dairy expansion, tracking the sustainable intensification of an emerging agricultural sector over time. A discussion across the three facets of sustainability considered here now follows.

The economic indicators designed here relate to the concepts of productivity, profitability and viability. On average, across farms, gross output per hectare (a proxy for the productivity of land) was found to be €3,069 in 2012, with considerable variation around the mean as is evident from the box plot in Figure 1 below. Market based gross margin is an indicator of farm profitability and was found to be on average, €1,440 per hectare in 2012.

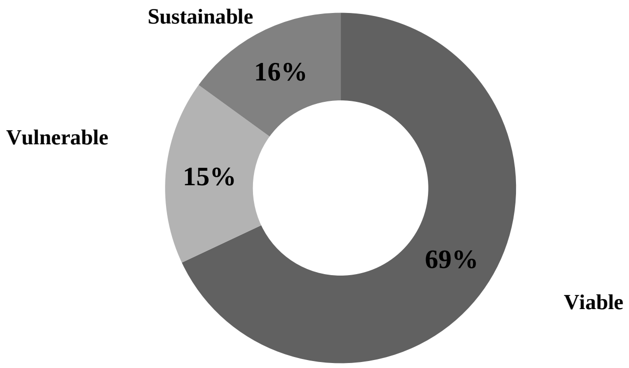
Fig. 1: Output and profitability per hectare Irish dairy farms 2012

With regard to economic viability, the finding that approximately 69 percent of dairy farms were viable in 2012 is positive in the context of dairy expansion.[9] A further 16 percent were deemed sustainable (not economically viable but sustainable due to the presence of off-farm income) with only 15 percent reported as vulnerable (defined as being unviable and not in receipt of off-farm income). One could hypothesise that there will be some further farm consolidation during the expansionary phase after milk quotas are removed with the potential

[9] An economically viable farm is defined having the capacity to remunerate family labour used on the farm at the average agricultural wage and the capacity to provide an additional five per cent return on non-land assets.

exit of some vulnerable holdings from the system. Structural differences across regions (in terms of for example, weather and soil type) are also important factors influencing variation in economic performance across farms.

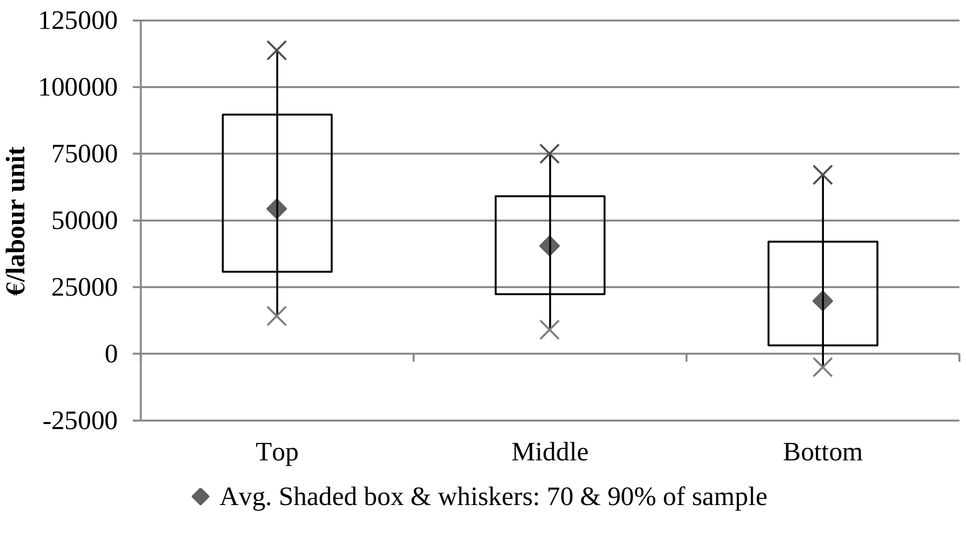
Fig. 2: Viability of Irish dairy farms 2012



Given the variation in economic performance across farms (as illustrated in Figure 1 above) the presentation of the various indicators stratified according to the three gross margin farm groupings (Top, Middle and Bottom performing) is insightful and as such is the approach taken in subsequent charts.

The return to labour invested on-farm is measured as family farm income per unpaid family labour unit employed. The family farm income measure includes a deduction for hired labour; hence the measure only includes unpaid family labour. The average income per labour unit on dairy farms was €38,225 in 2012. This varies according to the economic performance of the farm (as measured by gross margin) as can be seen in Figure 3 below. For the top performing group in 2012 the corresponding figure was €54,348.

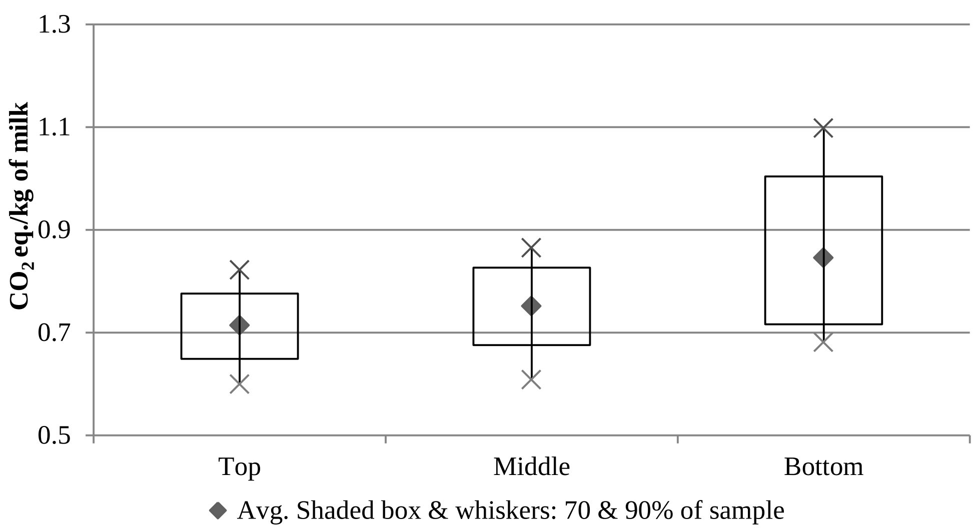
Fig. 3: Productivity of labour on Irish dairy farms 2012



Finally, the market orientation of dairy farms is represented as the proportion of output derived from the market (as distinct from income from subsidies) and was found to be 85 percent on average in 2012. This is a positive finding given anticipated increases in the production and export of dairy produce in a post-quota environment.

A second facet of agricultural sustainability is that of the environment and it is considered here in terms of air and water quality. As already alluded to the scale of GHG emissions from the agricultural sector is one of the main threats to the sustainable intensification of agriculture in a global context. It is encouraging then for the Irish case given dairy expansion targets that, according to this analysis the more intensive, top performing farms (in an economic sense) emit relatively less greenhouse gases per unit of product produced when compared to their less intensive counterparts. The emissions emanating from the dairy enterprise (less those associated with calves and culls) are expressed per unit (kg) of milk produced in Figure 4 below. It should again be noted that the calculations are made using IPCC coefficients and conventions and this does not equate to a carbon footprint measure.[10] Figure 4 illustrates that the top performing one-third of farms, in an economic sense, produces on average 0.71kg of CO_2 equivalents per kg of milk, while the bottom performing one-third of farms produce on average 0.85kg of CO_2 per kg of milk.

Fig. 4: Emissions CO_2 eq. /kg. of milk on Irish dairy farms 2012

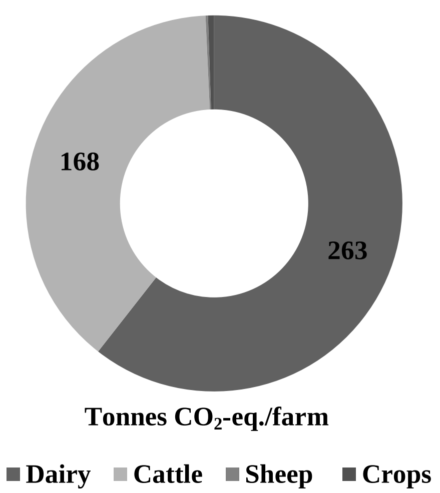


The results illustrate the negative correlation between emissions and economic performance and suggest that those farms performing well economically are also best performing from an environmental sustainability perspective when GHG per unit of output produced is the metric used. It is also interesting to note from the whiskers in Figure 4 that the farms with the highest emissions tend to be in the bottom group (the least well performing in economic terms). Again as already discussed with regard to the economically vulnerable cohort, it is envisaged that dairy expansion post-quota will result in further consolidation and re-structuring within the sector with some of this group exiting. In this regard the fact that the most economically sustainable farms are currently also the most environmentally sustainable farms provides a good starting point for the sustainable intensification of Irish dairy production. Chronicling the GHG performance of farms in the coming years should thus prove a valuable assessment.

[10] It is envisaged that an LCA analysis be undertaken when additional data becomes available.

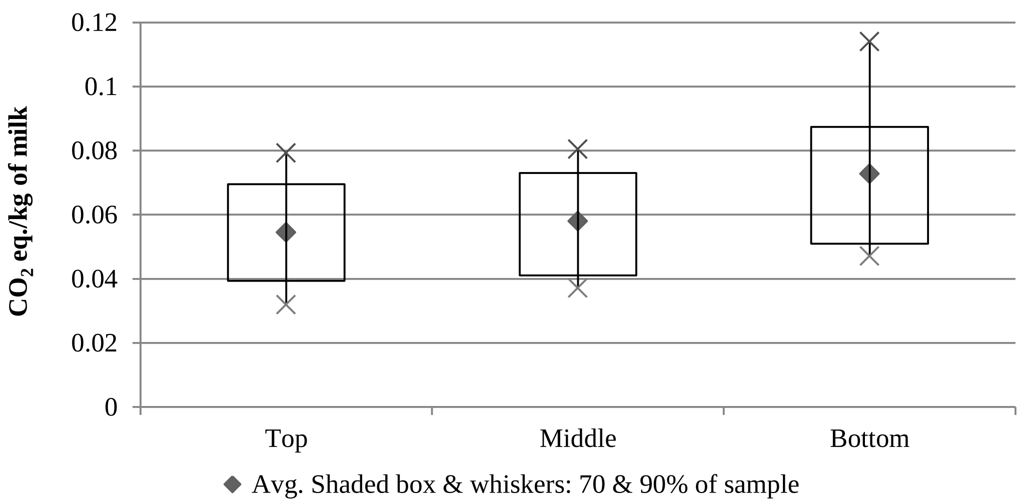
With regard to the measurement of GHG emissions on a per-farm basis, Figure 5 below demonstrates that the average Irish dairy farm emitted 434 tonnes of CO_2 eq. (IPCC coefficients and conventions) in 2012. As already alluded to, farms in Ireland tend to be mixed enterprise and Figure 5 is reflective of this; approximately 61 percent of emissions emanated from the dairy enterprise with 39 percent from cattle and the small remainder from an amalgam of other on-farm enterprises.

Fig. 5: Average GHG Emissions on Irish dairy farms 2012



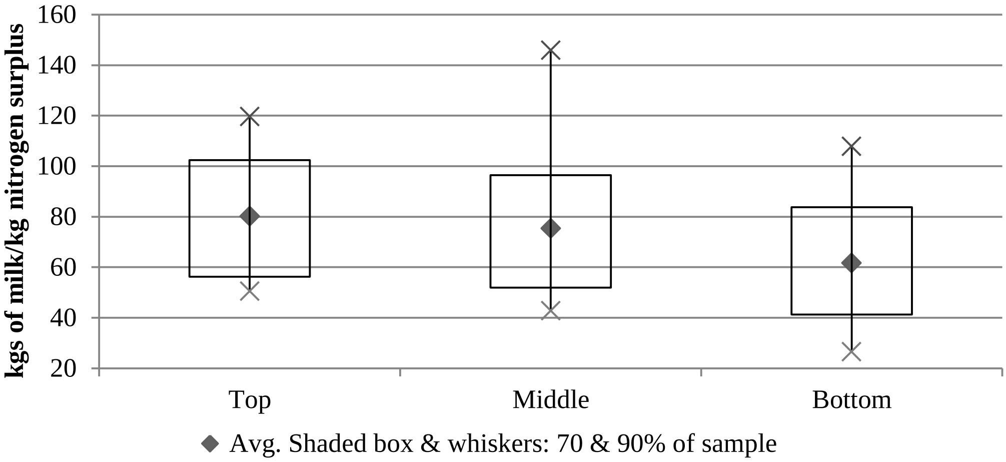
Emissions from electricity and fuel on-farm display a similar pattern with Figure 6 below indicating that the top economic performing farms tend to use electricity and fuel more efficiently and hence have lower emissions per unit of product.

Fig. 6: Electricity & Fuel Emissions/ kg. of milk Irish dairy farms 2012



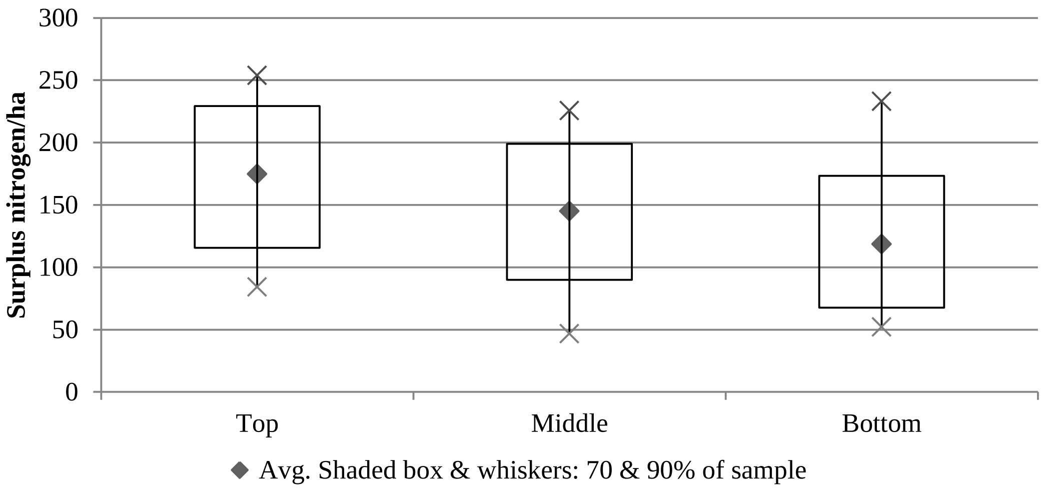
Given data constraints, the risk to water quality of dairy expansion is partly accounted for here by examining nitrogen use efficiency in the production of milk. This indicator is reported as kg nitrogen surplus per unit of product (excess of nitrogen imports over exports relevant to the dairy enterprise). Such analysis demonstrates that the better performing farms (in an economic sense) perform well in this regard; i.e., the nitrogen use efficiency of milk production is positively correlated with economic performance. Figure 7 below demonstrates that the top performing farms produce relatively more milk per kg of nitrogen surplus. This result is reflective of the double dividend achievable from the optimal use of nitrogen i.e., all other things being equal, it can assist in the achievement of environmental water quality objectives (by reducing the risk of nutrient loss), while maximising farm-level economic margins.[11]

Fig. 7: Nitrogen Use Efficiency on Irish dairy farms 2012



The risk to water quality of dairy expansion is further accounted for by examining farm gate nitrogen balance per hectare. In contrast to our previous finding that GHG emissions were negatively correlated to economic performance the finding here is that those better performing farms (in an economic sense) tend to have higher nitrogen surplus per hectare on average. This is demonstrated in Figure 8 below. The finding is consistent with the higher rates of production intensity on these farms, but poses a significant challenge in terms of dairy expansion. This is particularly the case as those economically efficient, intensive farms are most likely to be those considering increasing output when milk quota is removed.

Fig. 8: Nitrogen Balance per hectare on Irish dairy farms 2012

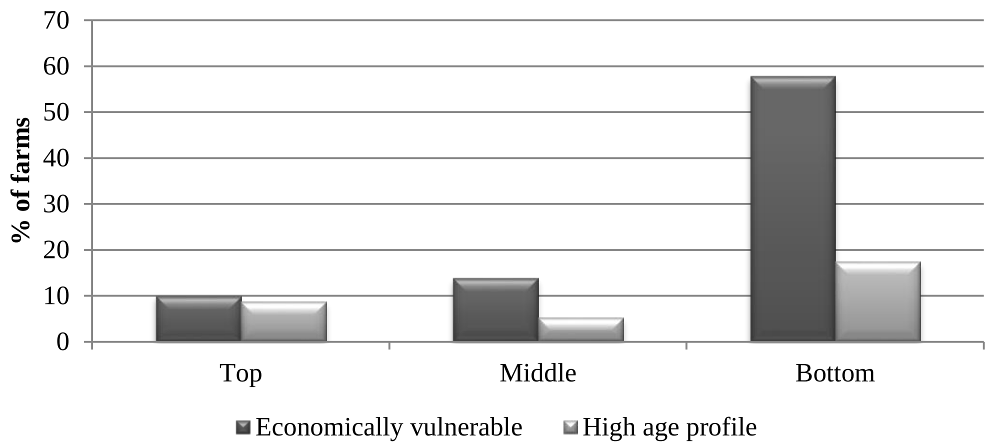


[11] See Buckley et al. (2013) for further discussion on nitrogen use efficiency.

The task of achieving increased output whilst adhering to environmental constraints and commitments under the Water Framework Directive and the Nitrates Directive, would seem to pose, the biggest problem for the sustainable intensification of the Irish dairy sector.

The final facet of agricultural sustainability considered here is that of the overall impact of any planned production expansion on rural society. The social sustainability indicators utilised here assist in gauging the quality of life of the farming community by identifying and quantifying those '*social life*' dimensions not determined by economic activity. The main finding here (as illustrated in Figure 9 below) indicates that demography in particular tends to be correlated with economic performance, whereby the economically better performing farms also tend to have households of a younger age profile. Work-life balance is another issue relevant to social sustainability. In this context dairy farming tends to be quite labour intensive. The number of hours worked by the typical farm operator in an average week was 47 hours in 2012.

Fig. 9: Percentage of economically vulnerable and high age profile Irish Dairy farms 2012



Finally, in relation to education levels amongst farm operators, results indicate that the education levels of dairy farmers are relatively poor on average in comparison with the broader population, with 27 percent having no formal education. A further 31 percent have attained primary level with 40 percent having received post-primary schooling. Only 2 percent of respondents have been in receipt of agricultural education. The results are unsurprising given the age profile of Irish dairy farmers with the average age in 2012 being 52.1 according to NFS data. Additional data collected within the survey in relation to the education levels of other household members will next be examined. This should prove more insightful with regard to farm succession and the future direction of the sector post-quota.

5. Discussion

Indicator results developed here relating to the sustainability of Irish dairy farms are in general positive and bode well for the sustainable intensification of the sector in the aftermath of milk quota in 2015. In particular, the negative correlation between GHG emissions and economic performance is encouraging. Nevertheless, while nitrogen use efficiency is positively correlated with economic performance, nitrogen balance tends to be negatively correlated i.e., the top performing economic farms tend to produce a greater surplus of nitrogen per hectare. From a social perspective demography in particular tends to be correlated with economic performance, whereby the economically better performing farms also tend to have households of a younger age profile.[12]

In summary, the removal of milk quotas in 2015 gives a food exporting country like Ireland an opportunity to share disproportionately in the expected growth in global demand for dairy products. To this end it is envisaged that expansion will bring with it further consolidation and re-structuring within the dairy sector. Crucially, environmental considerations must be a key factor in any such expansion. Improvements in the demographic and education profile of farm operators are expected which should further assist in the sustainable intensification of the sector; resulting in advancements in farm management techniques and an increase in the uptake of innovative practices. It would appear from this analysis that the achievement of increased output whilst adhering to environmental constraints and international obligations poses the biggest challenge for the sustainable intensification of the Irish dairy sector. Sustainability indicators are an important means of improving transparency and accountability and ensuring the successful monitoring, control and evaluation of the sector in the context of future expansion. In the context of milk quota abolition, the design of farm-level indicators here will assist in an on-going evaluation of the sustainable intensification of Irish dairy farming.

From an international perspective, there appears to be a growing recognition for the need for inter-connected policy in this area. Indeed, recent global initiatives facilitated by the FAO are stakeholder focused and include the Livestock Environmental Assessment and Performance (LEAP) Partnership and the Agenda of Action in support of Sustainable Livestock Sector.[13] The former is a cross-sectoral effort to develop common metrics to define and measure environmental performance of livestock supply chains (taking social and economic viability into consideration) while the latter is dedicated to improving practices for a more efficient use of natural resources, focusing on three areas: practices efficiency, grassland management and manure management. Similarly, an EU study in this area, Farm Level Indicators for New Topics in policy evaluation (FLINT) involving nine countries has just begun. The sustainability issue is one of increasing international relevance and is investigated here in an Irish context. As such country-specific assessments similar to that undertaken here can contribute to the accomplishment of a harmonised methodology in the area of agricultural sustainability.

6. Conclusion

The sustainable intensification of agriculture worldwide raises a number of key challenges not least given the inherent conflict between increasing agricultural output and the need to operate in a carbon-constrained economy. Similarly, the sustainable intensification of the Irish dairy sector brings with it environmental challenges for water, soil and air quality and biodiversity. The ambitious growth targets set out for the sector in FH2020 must be achieved in line with a reduction in the carbon intensity of agriculture. In light of the sustainability assessment undertaken here it would seem that there is potential for the Irish dairy sector to benefit from the market opportunities arising on the removal of EU milk quota. The sustainable intensification of the Irish dairy sector will involve the integration of environmental considerations with agricultural objectives and the establishment of farming practices and production methods which reflect increasing environmental concerns. The

[12] It should be said that this paper does not draw any conclusions about cause and effect in this regard.
[13] Further detail on these initiatives can be found at http://www.fao.org/partnerships/leap/en/ http://www.fao.org/ag/againfo/resources/en/publications/tackling_climate_change/index.htm

development of farm-level indicators here allows for the assessment of the sustainability status of Irish dairy farming into the future.

Sustainability looks set to remain firmly at the centre of future international agricultural policy given the continued need to increase food production in both a socially responsible and environmentally friendly way. In a European context it is envisaged that agricultural sustainability will be further incentivised in any future reform of the Common Agricultural Policy. The debate on the multidimensional aspects of sustainability, the general perspectives of '*people, planet and profit*' and how best to measure them looks set to continue.

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