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Sustainability levels in Irish dairy farming: a farm typology according to sustainable performance indicators

Feeding the world's population in a sustainable manner is one of the key challenges facing the future of global agriculture. The recent removal of the milk quota regime in the European Union has prompted an expansionary phase in dairy farming, especially in Ireland. Achieving this expansion in a sustainable manner is crucial to the long-term survival and success of the Irish dairy sector. In this paper we examine the sustainability of Irish dairy farming, defining 'sustainability' as economically profitable, environmentally friendly and socially efficient. A typology of Irish dairy farms has been created using data on profitability, environmental efficiency and social integration derived from the Teagasc National Farm Survey. Economic, social and environmental performance indicators were determined and aggregated and then used in a multivariate analysis for the identification and classification of farm clusters. The purpose of this study to classify Irish dairy farms using performance indicators, thereby, assisting policy makers in identifying patterns in farm performance with a view to formulating more targeted policies. Two of the three clusters elicited from the analysis were similar in regards to their respective indicator scores. However, the remaining cluster was found to perform poorly in comparison. The results indicate a clear distinction between 'good' and 'weak' performers, and the positive relationship between the economic, environmental and social performance of Irish dairy farms is evident.

Keywords: economic, environment, social, less favoured areas, policy, multivariate analysis

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Introduction

Irish milk production expanded dramatically in the 1970s and early 1980s. However, a milk quota system was introduced in the European Union (EU) in 1984 and restricted growth in Irish milk production until April 2015. The removal of the milk quota regime in April 2015 has presented a significant opportunity for many EU Member States to increase milk production. The Republic of Ireland (hereafter referred to as Ireland) seems set to exploit its natural advantages associated with dairy production in a no-quota environment. Recent Irish Government strategies such as Food Harvest 2020 (DAFM, 2014) set a target to increase milk production volume by 50 per cent in the first five years following milk quota removal (against a base period of 2007-2009).

The sustainable intensification of the Irish dairy sector is a key challenge, particularly in light of the mounting pressure to increase food production in both a socially responsible and sustainable way. The sustainable performance of farms has been the subject of growing research attention in recent years. One approach to measuring farm performance is the construction of indicators that can measure the overall performance of farms. Indicators are synthetic variables describing complex systems and can measure various aspects of sustainability (Castoldi and Bechini, 2010). In this context, sustainable performance evaluation covers, in most cases, three pillars of sustainability: economic, social and environmental. Indicators have been developed by several evaluation programmes across Europe and studies that use this approach provide a holistic evaluation of sustainable performance at farm level (Firbank *et al*., 2013). Indicators can be used to quantify farm performance through variables that can be derived from easily accessible datasets (Donnelly *et al*., 2007; Bockstaller *et al*., 2009). In an Irish context, several researchers have used indicators to quantify farm performance using qualitative and quantitative methodologies and indicators that best reflect the main aim of their research (Newman and Matthews, 2007; Mauchline *et al*., 2012; Dillon *et al*., 2014; Ryan *et al*., 2014).

Until now, most of the work on the sustainable performance of Irish farms has focused on the performance of each farming sector. However, differences can be identified between farms within a sector. In view of this heterogeneity, it might be beneficial to classify farms into types of sustainable performers (Happe *et al*., 2006; Valbuena *et al*., 2008). Such classification allows for the identification of differences between farms within a sector and can assist our understanding of how farming may evolve. The process can inform the design of targeted farm policies and enable policy solutions that address the problems of different farming groups (Morgan-Davies *et al*., 2012). Farm typologies have been widely used to assess policy impacts and decision-making processes (e.g. O'Rourke *et al*., 2012; Micha *et al*., 2015).

This study develops a typology of Irish dairy farms based on farm performance using multivariate statistical analysis and Teagasc National Farm Survey (NFS) data. While there are many studies of sustainability, this study which uses the NFS indicators is novel as only a few studies have used nationally representative datasets (see Dillon *et al*., 2014 and O' Brien *et al*., 2015 for a review of the literature in this area).

Methodology

To classify farms into clusters of sustainable performers, multivariate analysis was performed as suggested by Köbrich *et al*. (2003), which identifies farm groups based on performance indicators that have been normalised and weighted according to importance (Nardo *et al*., 2005). The

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sustainability of farm groups is evaluated by comparing performances relative to a frontier value of the top performers in the sample.

Data

This study uses performance indicators (Table 1) that express the economic, environmental and social sustainable performance of Irish dairy[5] farms as classified by the NFS (Hennessy *et al*., 2013). The NFS, which is part of the EU's Farm Accountancy Data Network (FADN), has collected data from a nationally-representative sample of farms in Ireland annually for over 40 years. Economic, agronomic, demographic and farm infrastructure data are collected from approximately 1,000 randomly-selected, nationally-representative farms by means of a detailed farm management questionnaire that is administered through face-to-face interviews.

Farm classification

The approaches proposed by Koebrich *et al*. (2003) and Nardo *et al*. (2005) were combined and used to guide the methodology applied. Development of the theoretical framework was followed by correlation testing, quantification and optimum scaling, data normalisation, weighting, principal component analysis and cluster analysis (Figure 1). Initially, potential outliers were identified and eliminated. Outliers were identified using z-scores; observations that have an absolute value of modified z-score greater than |3.5| were eliminated. The process was not applied to categorical variables. The selected indicators were first tested for correlation using a Pearson correlation matrix to examine their validity as variables to be used in the multivariate analysis. If two or more variables had a Pearson correlation coefficient ≥ 0.8, only one would be retained in the analysis (Field, 2009). However, no such correlation coefficients were observed.

As part of the multivariate analysis, principal component analysis (PCA) was used (Pallant, 2010). However, Linting *et al*. (2007) suggest that binary categorical variables cannot effectively be used in PCA. Hence, categorical variables had to be transformed into numeric ones using optimum scaling (Takane, 2014). The SPSS 18 CATPCA package (IBM, Armonk, North Castle NY) is a tool that can perform a non-linear PCA that uses optimum scaling to transform nominal variables into numeric values through non-linear regressions. Optimum scaling can also be used to address the problem emerging in multivariate analysis of variables that range within only very small intervals (Gómez-Limón *et al*., 2012).

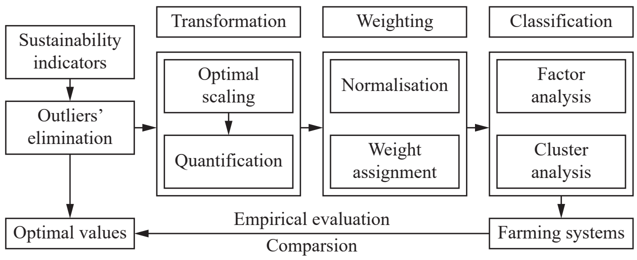

Figure 1: Conceptual framework of the methodology applied in this paper.

Source: own composition

[5] Dairy farms are those where the dominant enterprise is milk production, meaning that the largest share of their agricultural output comes from this activity.

Table 1: Teagasc National Farm Survey economic, environmental and social indicators used in the study and their optimum values.

Indicator	Measure	Unit	Optimum value
Economic			
Productivity of land	Gross output per hectare	EUR / hectare	The maximum value in the dataset. The performance rate for these indicators is calculated by dividing the cluster average by the optimum value. The latter is the highest in the dataset.
Profitability	Market based gross margin per ha	EUR / hectare	
Productivity of labour	Income per unpaid labour unit	EUR / labour unit	
Market orientation	Output derived from the market	Per cent of total output*	
Viability of investment	Farm business is economically viable**	1 = viable, 0 = not viable	The cluster average is compared to the optimum value, which is assumed at 100 per cent.
Environmental			
Greenhouse gas emissions / EUR 1000	IPCC estimate / EUR 1000 gross output	tonnes CO_2 equivalent / EUR 1000 gross output	The minimum value in the dataset. The performance rate for these indicators is calculated by dividing the optimum value by the cluster average. The former is the lowest in the dataset.
Greenhouse gas emissions from fuel and electricity / EUR 1000	IPCC estimate / EUR 1000 gross output	kg CO_2 equivalent / EUR 1000 gross output	
Nitrogen balance / farm	Risk to water quality	kg N surplus / farm	
Social			
Household vulnerability	Household income sustainability (1 = Farm business is not viable/no household off-farm employment)	Per cent of total sample	100 per cent. Performance rates are the percentage of viable household and educated farmers in each cluster.
Education level	Agricultural educational attainment (0 = N, 1 = Y)	Per cent of total sample	
Household viability	Age profile: household has a member < 45 years old (binary, 1 = yes)	Per cent of total sample	0 per cent. Performance rates are the percentages of households that are not vulnerable and do not face isolation risk for each cluster.
Isolation risk	Farmer lives alone (binary, 1 = yes)	Per cent of total sample	
Work-life balance	Work load of farmer	Number of hours worked on farm	The minimum value in the dataset. The minimum value of hours worked on farm for work-life balance.

* Total output includes subsidies

** An economically viable farm is one that has the capacity to remunerate family labour used on the farm at the average agricultural wage and the capacity to provide an additional 5 per cent return on non-land assets

Source: own composition; see Hennessy *et al.* (2013) for a full description of the indicators

To facilitate the interpretation of results, the scaled indicators were normalised to a (0-1) scale (Nardo *et al*., 2005). The non-linear PCA regressions used for optimum scaling in the previous step produced principal components, a number of which were retained following the Kaiser criterion (eigenvalue > 1). The loadings of the retained components were used to assign weights to the indicators using the same method as Nardo *et al*. (2005), and Gómez-Limón and Riesgo (2009). Weighting is an important step as it ensures the robustness of the variables that will be aggregated.

A linear PCA was applied to the dataset of normalised weighted indicators. The number of components to be retained follows the Kaiser Criterion (eigenvalue > 1) and only the component loadings with a value higher than 0.35 were accounted for in the analysis (Field, 2009). Hierarchical cluster analysis (Ward's method) was used to identify the number of clusters and this was followed by K-mean cluster analysis to indicate the cluster centres and the number of farms in each cluster.

To evaluate the emerging clusters according to performance, the average value of the indicator for each cluster was compared to the optimum indicator. The level of sustainability performance was calculated as a percentage of the optimum performance of the entire sample. Optimum values are the values of the indicators for the best performing farms of the whole dataset (Table 1)[6].

[6] We acknowledge that this method of establishing the optimum value is data-driven and is one of the many methods that can be considered for this purpose.

Table 2: Teagasc National Farm Survey socio-demographic variables used in the study.

Variable	Measure	Unit
Full-time farming	1 = yes, 0 = no	Categorical
Utilised agricultural area	Area of agricultural land used	ha
Parcels	Number of parcels on the farm	Numeric
Dairy livestock units	Dairy units in farm	Numeric
Household members	Family size	Number of individuals in the household
Less favoured areas (LFA)	1 = in LFA, 2 = not in LFA	Per cent of sample
Gender	1 = male, 2 = female	Per cent of sample

Source: own composition

Table 3: Calculated indicator weights based on non-linear PCA component loadings.

Indicator	CATPCA component			
	1	2	3	4
Productivity of land	0.13			
Profitability	0.16			
Productivity of labour	0.14			
Market orientation		0.19		
Viability of investment		0.13		
Greenhouse gas emissions/EUR 1000				0.38
Emissions from fuel and electricity/EUR 1000	0.14			
Nitrogen balance/farm		0.24		
Household vulnerability		0.15		
Education level			0.29	
Household viability			0.37	
Isolation risk				0.08
Work-life balance				0.24

See Table 1 for units of measurement
Source: own calculations

The elicited clusters were linked to selected socio-demographic variables from the original NFS dataset that included demographics and farm structure, subsidies, and variables related to certain management decisions such as the use of advisory services, stocking rates and the grazing season length (Table 2). To determine statistical significance, one-way ANOVA tests and least significant difference (LSD) post-hoc tests were used for continuous variables. Contingency analysis Chi-square tests were applied to discrete variables.

Results

After the elimination of eight outliers, 250 farm records remained from the 2012 NFS dataset. The Pearson correlation matrix showed that all 13 indicators were valid for analysis. The optimum scaling process produced an intermediate dataset of scaled variables that were normalised. Using the component loading of the yielded components the weights to be assigned to each normalised indicator were calculated (Table 3).

The linear varimax rotated[7] PCA performed on the dataset of weighted indicators yielded four principal components, explaining 67.4 per cent of the original variance (Kaiser-Meyer-Olkin = 0.76). The component loadings for each indicator are presented in Table 4 and detailed results of the cluster analysis and a comparison to the entire sample are presented in Annex 1 and Annex 2.

Performance of farms is presented as a percentage of that optimum value for each cluster. A similar comparison was made to evaluate the performance of the entire sample. Table 5 expresses performance (efficiency) rates for the entire sample and for each cluster, when compared to the related optimum value. These clusters were further analysed for identification of their socio-demographic characteristics (Table 5 and 6).

[7] Varimax rotation is performed following the methodology of Field (2009), as it helps generate more robust correlation coefficients between the principal components and the initial variables.

Table 4: Principal component loadings resulting from linear PCA.

Indicator	Component			
	1	2	3	4
Productivity of land		0.89		
Profitability		0.73		
Productivity of labour	0.81			
Market orientation		0.78		
Viability of investment	0.93			
Greenhouse gas emissions/EUR 1000				-0.61
Emissions from fuel and electricity/EUR 1000	-0.67			
Nitrogen balance/farm		0.79		
Household vulnerability	-0.92			
Education level			0.64	
Household viability			0.76	
Isolation risk				-0.43
Work-life balance				0.68

See Table 1 for units of measurement
Source: own calculations

Table 5: Performance rates (%) through comparison of the mean with the optimum indicator for three clusters of dairy farms and for the entire sample, and statistical differences between them.

Indicator	Optimum value (i.e. 100%)	All farms	Cluster A	Cluster B	Cluster C	Sig.
Representation		100	53.6	30.8	15.6	
			Efficiency			
Productivity of land	6,404	48.3*	53.1[a]	43.2[b]	41.5[b]	0.00
Profitability	3,558	41.1	46.5[a]	34.9[b]	34.6[b]	0.00
Productivity of labour	141,725	28.7	33.5[a]	24.8[b]	19.8[b]	0.00
Market orientation	0.96	89.7	90.5[a]	89.5[a]	87.6[a]	n/s
Viability of investment	100%	73.2	79.1[a]	74.0[a]	51.3[b]	0.00
Greenhouse gas emissions/EUR 1000	60.8	63.1	67.7[a]	55.2[b]	66.1[a]	0.00
Emissions from fuel and electricity/EUR 1000	0.00	12.7	17.1[a]	10.7[b]	8.41[b]	0.00
Nitrogen balance/farm	24.6	16.9	16.4[a]	16.1[a]	21.8[b]	0.00
Household vulnerability	0.00	76.0	79.9[a]	79.2[a]	56.4[b]	0.00
Education level	1.00	74.4	85.8[a]	80.5[a]	23.1[b]	0.00
Household viability	1.00	9.60	0.75[a]	1.30[a]	56.4[b]	0.00
Isolation risk	0.00	94.0	98.5[a]	88.3[b]	89.7[b]	0.005
Work-life balance	300	12.1	11.0[a]	13.6[b]	14.2[b]	0.00

See Table 1 for units of measurement
* The mean values used for these calculations can be found in Annex 1 and Annex 2.
Different superscripts within a row indicate statistically significant differences among types ($p<0.05$)
Source: own calculations

Table 6: Demographics of the three clusters of dairy farms.

Socio-demographic variable	Sample	Cluster A	Cluster B	Cluster C	Sig.
Full-time farming	96.4	98.5[a]	96.1[a]	89.8[b]	0.04
Utilised agricultural area	61.2	65.0[a]	59.9[a]	50.6[b]	0.03
Parcels	3.36	3.40[a]	3.28[a]	3.51[a]	0.83
Dairy livestock units	73.3	80.0[a]	71.7[a]	53.4[b]	0.00
Household members	3.64	3.96[a]	3.57[a]	2.60[b]	0.00
Less favoured areas	61.6	54.5[a]	68.8[b]	71.8[b]	0.04
Gender					0.04
Male	98.8	100[a]	98.7[a]	94.9[b]	
Female	1.2	0.0	1.3	5.1	

See Table 2 for units of measurement
Different superscripts within a row indicate statistically significant differences among types ($p<0.05$)
Source: own calculations

Farm typology

The key characteristics of each cluster of farms are as follows.

Cluster A (53.6 per cent of farms in the sample)

The average farm size is 65 ha; divided into 3.35 land parcels and comprising of 80 livestock units. Farms of this cluster show the highest performance rates. Indeed, the productivity of land performance of farms of Type A exceeds the average performance across the NFS dairy farm sample and farms of this type are highly market oriented (90.5 per cent) and viable (79.1 per cent). The cluster sustainability performance score for productivity of labour and profitability are 33.5 and 46.5 per cent respectively. This cluster is quite efficient in terms of sustainable greenhouse gas (GHG) emissions but scores low in GHG from fuel and electricity and nitrogen (N) balance. The performance score for household vulnerability is 79.9 per cent, meaning that such farms have a sustainable source of income from the farm and/or from an off-farm source. Almost all of the farmers (98.5 per cent) are full-time farmers (Table 6). The work-life balance performance score is low, indicative of the significant amount of labour that is required to operate this type of farm (Table 6). There is a low risk of isolation with farm households comprising, on average, 3.96 members. However, farms show extremely low performance in terms of household viability (0.75 per cent).

Farms of this cluster are significantly more productive (land and labour) and profitable than the other two clusters. This is combined with significant differences in household composition as few farmers live alone and their households have the most members (Tables 5 and 6). Conversely, farms are least efficient in terms of work-life balance.

Cluster B (30.8 per cent of farms in the sample)

In this cluster the average farm size is 59.9 ha, the average herd size is 71.7 livestock units, and 68.8 per cent farms are located in a less favoured area (LFA). Farms performed relatively well on most aspects examined, with performance scores close to the sample average. Land productivity is below average but farms are highly market oriented. Profitability and labour productivity are lower than the sample average but viability is quite high. Farms have an average GHG emissions performance score of 55 per cent and performance scores for GHG emissions from fuel and electricity and N balance are low. In terms of social performance, household viability is only 1.3 per cent, indicative of an ageing farming population. However, farmers do not face isolation risk and the average household is comprised of 3.57 members. Similar to Cluster A, education level is high and work-life balance is below the sample average. The farm household appear to have sustainable income sources (household vulnerability efficiency = 79.2 per cent) although 96 per cent are full-time farmers.

Farms share similarities with Cluster A farms in terms of certain social indicators such as high household vulnerability (off-farm income), education level, household viability and off-farm employment. However, Cluster B farms are less efficient in terms of isolation risk and there is a significant difference in work-life balance. The performance of Cluster A and Cluster B farms with respect to the viability of investment is statistically indistinguishable. Nevertheless, Cluster B farms have a statistically lower performance score for the productivity and profitability indicators. There is no significant difference in N balance between Cluster A and Cluster B. However, there is a significant difference in GHG emissions efficiency between both clusters, with Cluster B farms scoring a significantly lower climatic impact. Cluster A and Cluster B have very similar farm and household characteristics; Cluster B farms are, however, on average smaller in terms of land area farmed and herd size: they also have smaller households on average.

Cluster C (15.6 per cent of farms in the sample)

Mean farm size is 79.9 ha, divided into 3.51 parcels with an average herd size of 53.4 units. Most farms within this cluster (71.8 per cent) are located in LFAs. Land productivity is below the average and profitability and labour productivity are also relatively low. Farms are highly market oriented (87.6 per cent), but only 51 per cent are viable investments. Farms are also quite environmentally efficient with GHG emissions performance score at 66.2 per cent. Farms are the most efficient in terms of N balance (rate = 21.8 per cent). Only just over half the households appear to have sustainable income sources, and 89.7 per cent are full-time farmers. The cluster is comprised of mostly young households, as 56.4 per cent have low age profiles, and small households (2.64 members). Farms are more efficient in work-life balance that the rest of the sample. The percentage of female farmers in this cluster is 5.13 per cent.

Farms score relatively poorly on most economic indicators and certain social ones. Cluster C farms also differ from other clusters in structural characteristics. There are fewer full-time farms, more small farms and more households with a female presence. Regarding social performance, Cluster C farms score significantly lower for off-farm employment and education level in comparison to Cluster B, but there are more young farmers.

Discussion and conclusion

Our findings indicate that, in order to meet the goals set for Irish dairy farming in the context of sustainable intensification, there is a need for a range of policy solutions to address the heterogeneity present within the sector. Given these caveats, certain policy suggestions arise from these analyses that address the issues of each system separately.

Interestingly, no cluster has a high score for productivity of labour. This, combined with very low scores across clusters on work-life balance, could lead to the conclusion of overall labour inefficiency in the sector. Intense labour combined with low labour productivity has been highlighted in studies in Ireland (O'Brien *et al*., 2006) and in the dairy sectors of other nations (e.g. Ruiz *et al*., 2009). One of the reasons advanced is the lack of hired labour, as Irish farms tend to be family farms. Hurley and Murphy (2015) found that the higher the profitability, the lower the workload of the farmer as extra labour can be hired. However, our typology shows that more profitable farms are less efficient in terms of work-life balance. It is also worth noting that farmers in Cluster A and Cluster B have attained higher levels of education in comparison to Cluster C.

GHG emissions from Cluster C are lower than the other clusters elicited (Table A1). Clusters A and B share social and structural characteristics but differences in GHG efficiency are observed. Studies suggest that a relationship exists between good economic and GHG emissions performances (Ryan *et al*., 2015; Dillon *et al*., 2014). Cluster C is almost as efficient in overall GHG emissions as Cluster A, although its economic performance is similar to Cluster B. However, the social performance and the structure of Cluster C farms are very different. The similarities in environmental performance between 'good' and 'weak' economic performers could be explained by differences in farm size (Crosson *et al*., 2011; Adler *et al*., 2015).

We observe a similar N use sustainability score for Clusters A and B but it is much higher for Cluster C. Higher N surpluses (hence, lower efficiency) are consistent with productivity and intensity (Dillon *et al*., 2016). However, we find that despite land productivity differences between clusters A and B, N use performance scores are similar.

Cluster A performed best in terms of sustainability. As this cluster is highly market oriented, the creation of new, or maintenance of existing market channels, is essential. Also, a policy towards reducing dependence on subsidies would help these farms invest in becoming entirely self-sustained. An example of how this could be achieved would be the gradual reduction of direct land subsidies and the creation of a subsidy framework that rewards market orientation, in accordance with the rural development targets of the EU's Common Agricultural Policy. This farm cluster has lower rates of overall GHG emissions but indicated higher N surpluses per hectare, which is to be expected as they are operating at higher levels of intensity. Therefore, improvement of the N balance could be achieved through farmers' further environmental education and, therefore, the provision of information would be an appropriate policy goal (Buckley *et al*., 2015). Policy makers could take advantage of the fact that a high percentage of farmers in this system are educated and design the appropriate measures to help improve environmental performance (Ondersteijn *et al*., 2003). The cluster has a quite low efficiency in labour allocation which could be a negative driver. Incentives towards hired labour in agriculture could improve the work-life balance and at the same time create a better environment for a variety of social groups in rural areas.

Cluster C is smallest in terms of its membership and performed poorly against many of the indicators assessed. A strictly economic approach would demand farms of this cluster eventually to be taken over by farmers of the two other clusters and be run more efficiently. However, Irish social structures and issues such as attachment to land and cultural identities create barriers to such forms of land exchange (Cassidy and McGrath, 2014). A policy framework addressing the problems of the sustainable development of these farms could include the encouragement of farm diversification and multifunctionality (Feehan and O'Connor, 2009). Farm diversification allows for the optimum allocation of land to farm functions that are useful to agriculture but can include diversified activities (van der Ploeg and Roep, 2003). Farms in cluster C were characterised by being located in LFAs and evidence has shown that farm multifunctionality (diversification) as a strategy is being increasingly accepted and successfully implemented in LFAs in various countries (López-i-Gelats *et al*., 2011; Fleskens *et al*., 2009).

The nature of farms in Cluster B allows for more flexible policy targets, as we believe the main aim of these farmers is to switch to the best performing cluster. Policies towards the sustainable development of these farms could focus on encouraging the engagement of younger farmers and enhancing environmental sustainability through education and best management practice promotion (through extension activities such as discussion groups). Also, the large proportion of LFA farms, the relatively low levels of land profitability, combined with the high scores of off-farm income and market orientation, suggest the need for further measures such as diversification or initiatives encouraging farm co-operation and other joint ventures that could help these farmers reach the levels of Cluster A.

To conclude, the classification of farms into types based on their sustainability performance is essential for understanding how sustainably intensive dairy farms can be developed in Ireland. This paper limits itself in the quantitative aspects of sustainable performance scores using the Teagasc NFS indicators. Further research could explain the reasons behind these scores and explore the social implications. The typology created in this study confirms that we cannot expect farmers with different characteristics to adjust to similar policies, and for policies to be effective it is necessary to target distinct groups (Brodt *et al*., 2006). As the demands for a more intensified dairy sector are likely to increase dramatically in the near future, it is essential to know that a unified policy for the entire sector might not be feasible, but a more targeted policy that would help each group to react positively to potential changes.

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Annex

Annex 1: Descriptive statistics of qualitative indicators for the three clusters of dairy farms and representation of farms per cluster.

Indicator	Sample		Cluster A		Cluster B		Cluster C	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Productivity of land	3,090	978	3,401	939	2,768	846	2,660	1003
Profitability	1,462	599	1,655	595	1,243	502	1,231	568
Productivity of labour	40,689	28,925	47,501	30,908	35,199	24,033	28,119	24,433
Market orientation	0.86	0.05	0.87	0.05	0.86	0.05	0.84	0.07
Greenhouse gas emissions/EUR 1000	2.63	0.43	2.45	0.27	3.00	0.48	2.50	0.30
Greenhouse gas emissions from fuel and electricity/EUR 1000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Nitrogen balance/farm	145	57.7	150.3	58.6	181	56.1	113	47.4
Work-life balance	2,470	534	2,731	361	2,203	509	2,106	612

See Table 1 for units of measurement
Source: own calculations

Annex 2: Descriptive statistics for the quantitative indicators for the three clusters of dairy farms (per cent).

Indicator	Sample	Cluster A	Cluster B	Cluster C
Viability of investment	73.2 (N=183)	79.1 (N=106)	74.0 (N=57)	51.3 (N=20)
Household vulnerability	24.0 (N=60)	20.1 (N=27)	20.1 (N=16)	43.6 (N=17)
Education level	74.4 (N=186)	85.8 (N=115)	80.5 (N=62)	23.1 (N=9)
Household viability	9.6 (N=226)	99.3 (N=133)	98.7 (N=76)	43.6 (N=17)
Isolation risk	6.0 (N=15)	1.5 (N=2)	11.7 (N=9)	10.3 (N=4)
Total		53.6	30.8	15.6

See Table 1 for units of measurement
Source: own calculations