Extended Abstract
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Paper/Poster Title	**Developing farmer typologies to evaluate the position of Irish farmers towards their Greenhouse Gas emissions**

Abstract prepared for presentation at the 98th Annual Conference of The Agricultural Economics Society will be held at The University of Edinburgh, UK, 18th - 20th March 2024.

Abstract	***200 words max***

Widespread adoption of technologies for greenhouse gas (GHG) emission mitigation are required to meet GHG reduction targets while maintaining levels of food production. In this context, improving our understanding of factors influencing adoption, including farmers' attitudes towards GHG mitigation, is required. Based on a representative sample of 526 farmers across various farm systems in the Republic of Ireland, this study investigates the perspective of farmers towards their farm emissions and conducts a typology analysis that groups like-minded farmers together. Farmers' attitudes are first assessed on five-point Likert scales using nine statements. Principal component analysis (PCA) is applied to survey responses, revealing three components; one dealing with perceived ability to reduce emissions, the second looking at concern towards reducing emissions, and the third gauging perceived social distrust felt by farmers to act on climate change. Subsequent cluster analysis shows four distinct farmer groups which based on their profile were labelled; Unconcerned, Unequipped, Concerned and Mistrusted. Finally, differences in farm and farmer characteristics across groups are examined using a series of statistical tests. With such diverse farmer groups present, understanding each group can facilitate effective and tailored policy and extension.

Keywords	Greenhouse gas emissions, farm typology, attitudes, mitigation, PCA-cluster analysis
JEL Code	Q000 see: www.aeaweb.org/jel/guide/jel.php?class=Q)

Introduction	***100 – 250 words***

Urgent action is needed globally to reduce emissions, increase carbon sequestration and adapt to the changing climate. In the agricultural sector, this will require behavioural change by farmers and the adoption of agricultural innovations.

The adoption of environmentally friendly technologies can be challenging as these are not always associated with private, monetary or lifestyle benefits to farmers (Foguesatto et al, 2020). Additionally, farmers' perceptions of environmental issues

such as climate change are quite heterogeneous and not yet fully understood (Chavas and Nauges, 2020; Upadhaya et al, 2021)

Improved understanding of farmers' perceptions towards greenhouse gas (GHG) emissions is needed to better support the transition towards lower-emitting production systems. In fact, recent literature highlights the importance of paying more attention to the matching of technologies with farmer profiles, viewpoints and objectives for successful uptake (Macours, 2019; Montes de Oca Munguia and Llewellyn, 2020). Given the need to increase farmer buy-in to address environmental issues, it is crucial to identify and understand the heterogeneity in farmers' perceptions towards agricultural GHG emissions.

The results of previous research are of great significance and reference value to this paper, but there is room for further improvement and refinement. Firstly, it is more common for typologies to be conducted on farm characteristics rather than the results of opinion-based statements like in this study. For example, Upadhaya et al, (2021) used PCA and CA to develop farmer typologies based on farm characteristics to inform conservation outreach in agricultural landscapes in Iowa, USA. In Germany, Schulze Schwering et al (2022) used PCA and CA based on farm characteristics to help farmers digitalise and in Ireland, three classes emerged from a typology analysis that looked at nutrient management planning (Daxini et al, 2019). Secondly, of the studies that have conducted PCA and CA on opinion-based statements, the focus of research was not entirely on attitudes towards the reduction of GHG emissions Barnes et al (2009; 2022) used individual perspectives to develop a typology on farmers; however, the research focus was towards water pollution control (2009) and ecological practice uptake (2022). Indeed, Hyland et al (2015) did conduct a typology on perceptions to climate change and although the findings are very relevant, the study focused only on beef and sheep farmers and took a broad approach to climate change perceptions. There is a gap within agricultural literature for a typology that is inclusive of beef, sheep, tillage and dairy farmers and that explicitly focuses on farmer attitudes to the reduction of GHG emissions. Given the challenge ahead for global agricultural emissions to be reduced, this study even goes a step further in its contribution as farmer attitudes are not only identified but significant farm variables between the attitudes are presented, adding in-depth explanations to what farms fall into each category.

The overall objective of this paper is to evaluate farmers' attitudes towards their farm GHG emissions and their perceived ability to reduce on-farm emissions. Using representative Irish farm data from the Teagasc National Farm Survey (NFS), we analyse the heterogeneity across viewpoints by classifying farmers into typologies. Typologies, as defined by Collier et al (2012), are organised systems that are well-established analytic tools in the social sciences. Segmentation through the use of typologies may be helpful in better understanding the various views of a population on a specific topic (Collier et al., 2012). Typologies are also useful, therefore, for policy targeting and the creation of tailor-made extension services in agriculture (Sinha et al, 2022; Upadhaya et al., 2023). Hence, they are well suited to this study.

Methodology	***100 – 250 words***

The data used in this article comes from the 2021 Teagasc NFS. The Teagasc NFS collects data on an annual basis, fulfilling Ireland's statutory obligation to provide data to the EU Farm Accountancy Data Network (FADN) (Council Regulation (EC) No 1217/2009). Data collected includes farm financial data relating to the costs of production and the value of output, agricultural activity levels, as well as information about farm and farmer characteristics such as farm size, farmer age and education status.

Specifically, with the use of survey responses and quantitative methods, a typology analysis is conducted with principal component analysis (PCA) and a two-stage cluster analysis (CA). Differences in farm and farmer characteristics across farmer types are then examined with a series of statistical tests (i.e. one-way anova tests, chi-square tests and t-tests).

For this analysis, the general Teagasc NFS data collection schedule was complemented by a supplementary survey conducted across a sub-sample of 659 Teagasc NFS farmers. Additional survey questions aimed to elicit views about agricultural GHG emission reduction and gather farmer perceptions about their lived reality with regard to reducing emissions.

As explained by Ajzen (1991), attitudes are defined by values, awareness and beliefs about a behaviour. Focusing on GHG emission perceptions, farmers were invited to express their level of (dis)agreement with nine statements that were developed and informed by these three TPB attitude constructs. Levels of (dis)agreement were measured on a five-point Likert scales, ranging from strongly disagree to strongly agree. The nine statements, once developed, were piloted among 35 Irish farmers and data collectors to test the appropriateness of questions. Numerous alterations were made around clarity of statements and phrases before inclusion in the final survey.

Results	***100 – 250 words***

Clear differences between the four farmer types are noted leading to farmers being distinguishable by not just their attitude towards GHG emissions but also by farm and farmer characteristic variables, performance variables and extension variables.

Unconcerned: The 'Unconcerned' are the most unlikely of all four farmer types to have more than one family member involved in farm management (the 'Unconcerned' were dominated by farms operated by one person) and they are also the most unlikely of all four types to have advisory contact, be in a discussion group, be agriculturally trained or use the profit monitor tool. Within the farm system variables, the highest percentage of sheep and/or tillage farmers are seen to be in the 'Unconcerned' farmer type (33%) and this is significant compared to the 'Unequipped' and 'Concerned' but not significant in comparison to the 'Mistrusted' farmers. The 'Unconcerned' have less dairy farmers included in their group compared to all the other three types and less farmers in derogation. The 'Unconcerned' farmers were noted to be similar to the 'Unequipped' for the

continuous variables but were farming with significantly lower stocking rates in comparison to the 'Concerned' and 'Mistrusted'. They were also significantly older than the 'Concerned' and 'Mistrusted' and had significantly smaller figures for gross output/ha, gross margin/ha, interest repayments, hours worked on farm, GHG emissions and the use of nitrogen and phosphorus.

Unequipped: As stated, the 'Unequipped' farmers were noted to be similar to the 'Unconcerned' for the continuous variables except for farm size where they were noted to be operating the smallest land holding of all four farmer types. Similarly to the 'Unconcerned'; The 'Unequipped' were significantly older than the Concerned' and 'Mistrusted' and had significantly smaller figures for gross output/ha, gross margin/ha, interest repayments, hours worked on farm, GHG emissions and the use of nitrogen and phosphorus. Across all farmer types, the 'Unequipped' were the most unlikely to be in a discussion group, be agriculturally trained, use the profit monitor tool and the most unlikely to be involved with full time farming.

Concerned: In comparison to all other farm segments, the 'Concerned' are farming on a larger scale in terms of farm size, gross output/ha, gross margin/ha, family farm income/ha, interest repayments, total hours worked on the farm and GHG emissions. They are the most unlikely of all farmer types to have an off farm job as their hours worked off farm were significantly low and they had significantly the most full time farmers in their group. In stark contrast to the other three farmer types, the 'Concerned' were the most likely to have more than one family member involved with farm management, had significantly more dairy farmers and significantly less sheep and/or tillage farmers included in their group. The 'Concerned; were the most viable of all four farmer types, were the most likely to be involved in a discussion group and the most likely to use the profit monitor tool.

Mistrusted: This farmer type is had significantly less gross output/ha than the 'Concerned' but significantly more gross output/ha than the 'Unconcerned; and 'Unequipped'. This pattern repeats itself for variables such as gross margin/ha, interest repayments, hours worked on the farm and GHG emissions. The 'Mistrusted' were the most similar to the 'Concerned' in regard to farm system and farm characteristics but differed slightly in terms of viability, debt level, farm size, discussion group involvement and commitment to farming full time.

Discussion and Conclusion	***100 – 250 words***

For the EU Green Deal to be a success, all farmers and land owners need to contribute to reduce GHG emissions, not just the larger or the biggest GHG emitters. This is why the inclusivity of farm enterprises in this study is so important. Climate policies, advisory tools and farmer use of mitigating technologies are dependent on farmers' awareness, knowledge and beliefs (Eitzinger et al., 2018, Peltonen-Sainio et al., 2020; Tzemi and Breen, 2016) and these three aspects, with respect to the reduction of GHG emissions at farm level, are heterogonous as found throughout this study. Traditionally, intervention programs were presumed to be universally applicable and hence, universally adopted (Vanclay and Lawrence 1994). Given the

multifaceted nature of the agricultural industry and the varying levels of concern and ability to combat climate change detailed throughout this study, a one size fits all approach to policies or outreach programmes that are focused on the reduction of GHG emissions are not going to be universally applicable to all farmers.

This work is particularly timely due to the urgent need to reduce carbon emissions and support farmers globally in the transition towards more sustainable production systems. Finally, the work completed is novel in its approach to conducting a typology due to its narrow focus on agricultural GHG emission perceptions and the inclusivity of farm enterprises (Dairy, Beef, Sheep and Tillage). The findings from this paper are of huge value to contextualise the challenge of emission reduction at farm-level and should play a pivotal role in future agri-extension design and policy development. Specific interventions may be needed to capture and engage the entire farming population on the issue of climate action and the findings from this study give a great foundation for future work on tailored interventions and farmer outreach strategies.