Extended Abstract
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Paper/Poster Title	**Disentangling the pathway from farmers' awareness to behavioural changes to mitigate diffuse water pollution: evidence from Northern Ireland**

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***
Diffuse agricultural pollution is a notorious problem causing water quality degradation in many river catchments around the world. Awareness-focused approaches have been increasingly applied as complementary measures to top-down regulations and incentive-based policies to address this problem, under the assumption that increased awareness and knowledge of the link between land use management and catchment water quality would lead to farmers' behavioural changes to mitigate diffuse water pollution from their farms. However, the pathway from awareness to behavioural changes is usually not straightforward and more efforts are needed to better understand its influencing factors and underlying mechanism. This research applied a questionnaire survey study in Northern Ireland to investigate the complex relationships between farmers' awareness and behavioural changes in soil nutrient management, their engagement with nutrient management training and planning, their perceived impact of soil sampling schemes, and farm characteristics. The results from a Structural Equation Model show that farmers' awareness of the link between soil nutrient management and catchment water quality is not a direct, significant driver of their behavioural changes, but it can motivate the latter through the effect of engagement in nutrient management training and planning. We discuss policy implications regarding the sustained effect of awareness-focused approaches in driving pro-environment behavioural changes, the effectiveness of soil nutrient management training to facilitate experiential learning, as well as equality issues between large farms and small farms in making changes in soil management practices.	

Keywords	Diffuse Agricultural Pollution, Soil Nutrient Management, Water Quality, Structural Equation Model
JEL Code	Agricultural and Natural Resource Economics; Environmental and Ecological Economics: General Q000

Introduction	***100 – 250 words***
Diffuse agricultural pollution is a notorious problem causing water quality degradation in many river catchments around the world. Decades of efforts to implement top-down regulations and incentive-based policies have not had a satisfactory effect in solving the problem. In recent years, policy makers and researchers have shown a growing interest in awareness-focused approaches, which focus on raising farmers' awareness of the link between land use management and water quality and	

increasing their knowledge of best management practices to mitigate diffuse pollution. The underlying assumption is that improved awareness would lead to adoption of best management practices and ultimately improved water quality. However, the recent literature indicates that the relationship between farmers' environmental awareness and pro-environmental behavioural is not straightforward as expected. There is a strong need to better understand the complex pathway from awareness to behaviour changes and the influencing factors in agricultural land management, so that awareness-focused approaches can be more effectively applied to reconcile the needs of food security, soil health, water quality, and other sustainable development goals.

Based on a questionnaire survey in two river catchments in Northern Ireland, this study 1) evaluated farmers' behavioural changes four after participating in free soil sampling and nutrient management training schemes, and 2) applied a Structural Equation Model (SEM) to investigate the complex relationships between farmers' awareness and behavioural changes in soil nutrient management, their engagement with nutrient management training and planning, their perceived impact of soil sampling schemes, and farm characteristics.

Methodology	***100 – 250 words***

Data: A postal survey was implemented during 2022.12 – 2023.01 to distribute questionnaires to 1,091 farmers who participated in two soil sampling schemes (2017-2019) which provided free soil sampling and testing services and nutrient management training. A total of 144 valid questionnaires were received and used for data analysis, with a response rate of 13.2%.

Variables: we constructed three latent variables for the SEM. The "Behaviour" was determined by six observable variables about whether farmers changed soil nutrient management practices four years after participation in previous soil sampling schemes. "Awareness" was determined by how much farmers agreed with five statements related to the link between soil management and water quality. "Impact" was determined by whether farmers perceived four types of economic and environmental impact of the soil sampling schemes. Other observable variables of the SEM include whether farmers engaged in nutrient management training and planning, and farm characteristics.

Assumptions: we assumed that 1) farmers' behavioural changes were dependent on the level of their awareness, their perceived impact of the soil sampling schemes, and their engagement in soil management training. 2) the level of farmers' awareness was dependent on whether they had engaged in soil management training. 3) farmers' perceived impact of soil sampling schemes was dependent on whether they had engaged in soil nutrient management plans. 4) farmers' engagement in nutrient management plans was dependent on the level of their awareness, their engagement in nutrient management training, and farm characteristics.

Results	***100 – 250 words***

Descriptive statistics: The top 3 adopted practices after farmers received soil testing results and relevant training are increasing the use of lime (72%), purchasing & applying less fertiliser (53%) and changing the timing of applying slurry/manure (52%). Farmers generally had a high level of awareness of the link between soil nutrient management and water quality, with the average scores of Likert-scale questions between 1.00 and 1.47 (full range: -2 to 2). Over 80% of farmers believed the soil sampling scheme increased their knowledge about the soil-water link, while over 65% of them believed the scheme helped increased the crop yields on their farms.

Modelling results: 1) Farmers' behavioural changes were significantly and positively influenced by their perceived impact of the soil sampling schemes and whether they attended nutrient management training. However, farmers' awareness of the soil-water link did not show a significant, direct effect in motivating behavioural changes. 2) Attendance of nutrient management training did not show significant effect in increasing farmers' awareness. 3) Engagement in soil nutrient management plans showed a highly significant, positive effect in farmers' perceived impact of the soil sampling schemes. 4) Although awareness was not a direct driver of behavioural changes, it had a significant effect on farmers' adoption of soil nutrient management plans, which in turn increased farmers' perceived impact of the soil sampling schemes and indirectly motivated behavioural changes. 5) Farmers who attended nutrient management training and who had larger farms were significantly more likely to adopt soil nutrient management plans.

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

This study contributes to the literature on the complex, indirect pathway between farmers' environmental awareness and their sustained pro-environment behavioural changes in agricultural land use management. Our results revealed that farmers' awareness of the link between soil nutrient management and catchment water quality can only indirectly drive their behavioural changes through the effect of engagement in nutrient management training and planning. This insight reinforces previous findings about the role of experiential learning in the adoption of best land management practices.

Policy implications of this study include: 1) awareness-focused approaches, such as soil sampling schemes can result in famers' behavioural changes over time if they can actively engage in soil nutrient management training and planning. 2) The effectiveness of soil nutrient management training needs improvement, such as enhancing experiential learning. 3) Equality issues also need to be addressed so that owners of small-size farms also have the opportunities and capacity to make changes in their soil management practices.

Further research will investigate whether farmers behavioural changes in soil nutrient management ultimately result in improved water quality over the four years. Interdisciplinary research combining social science and catchment water science is needed to address this limitation and will be the direction of our future efforts.