DEVELOPMENT OF A FRAMEWORK TO DEFINE CROP SPECIFIC RULES THAT SUPPORT IPM PRACTICES WITHIN EU CROP PRODUCTION – TASK 4

Case study on cereal production in Ireland

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1. INTRODUCTION

This report details Task 4 (case studies) of the *Development of a Framework to Define Crop Specific Rules that Support IPM Practices within EU Crop Production.*

The chosen case study in Ireland explores the economic implications of reducing pesticide use and adopting Integrated Pest Management (IPM) practices within the context of cereal crop production.

Ireland has made notable progress as part of the European Union's *Farm to Fork* strategy[1], which targets a 50 per cent reduction in hazardous pesticide use by 2030. By 2022, overall pesticide use had decreased by more than 45 per cent since 2011.[2] However, cereal crop production also reduced by 26% over the same period. This trend warrants closer examination to isolate the effect of the pesticide strategy on production.

The case study undertaken in Task 4 serves a dual purpose. First, it applies a structured evaluation protocol, developed as part of a broader research initiative, to assess the economic viability of selected IPM practices using data from two recent Irish studies. Second, it evaluates the effectiveness of the protocol itself, identifying areas for improvement to enhance its relevance and utility for policy and practice.

The IPM practices assessed in this study include:

- Adjusting sowing dates
- Modifying crop rotation strategies
- Using resistant or tolerant crop varieties
- Implementing decision support services

By applying and testing the evaluation protocol within the context of these IPM practices, this study aims to serve as a benchmark to support policymakers, researchers, and practitioners in using the protocol to develop actionable insights that promote sustainable, resilient, and economically viable agricultural systems in Ireland and across the wider EU.

2. OVERVIEW OF THE STUDIES

This case study draws on two recent Irish studies that assessed the potential economic and agronomic impacts of a 50 per cent reduction in the use of hazardous agricultural pesticides—fungicides, insecticides, and herbicides—within Irish cereal production. These reductions are aligned with targets set under the EU *Farm to Fork Strategy*.

The first study (McDougall, R. et al., 2024a) used a Delphi-based expert elicitation approach to estimate the likely impacts of pesticide reductions on crop yields, pest pressure, and the effectiveness of IPM strategies. A panel of 17 agronomists participated (anonymously) in two rounds of surveys to forecast yield changes and evaluate the role of IPM. The results showed significant projected yield reductions, particularly for wheat, barley, and oats, with larger impacts than those reported in EU-wide studies—highlighting the importance of context-specific analysis in Ireland.

IPM practices examined in the study varied by pesticide category. For fungicides, strategies included crop rotation, resistant cultivars, and nutrient management. Insecticide alternatives included pest monitoring and changes to sowing dates, while herbicide-related practices focused on rotations, hygiene, and mechanical control. Although IPM offered some mitigation to maintaining crop yields, experts concluded that it could not fully offset production losses from reduced pesticide use.

The second study (McDougall, R. et al., 2024b) built on this by modelling the economic impacts of reduced pesticide use. Using the yield estimates from the Delphi study and cost/revenue data from the Irish National Farm Survey (NFS), it calculated crop margins, input costs, and environmental externalities under several scenarios. These included:

- Standard Management (reduced pesticides without additional IPM);
- Additional IPM (reduced pesticides combined with IPM techniques);

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[1] Farm to Fork Strategy - European Commission
[2] Member States: Trends - European Commission

- Short-term vs. long-term horizons;
- And two assumptions about pest interaction: Antagonistic (non-additive) and Non-Interactive (additive).

A summary of the results from the studies under review is presented in below.

Table 2-1 Summary of the key findings

Study	Indicator	Scenario	Impact	Units
McDougall, R. et al., 2024a	Crop yield	Non-Interactive Short Term Standard Management	-36.80	%
		Non-Interactive Short Term Additional IPM	-22.60	%
		Non-Interactive Long Term Standard Management	-45.40	%
		Non-Interactive Long Term Additional IPM	-21.20	%
		Antagonistic Short Term Standard Management	-17.00	%
		Antagonistic Short Term Additional IPM	-10.00	%
		Antagonistic Long Term Standard Management	-22.00	%
		Antagonistic Long Term Additional IPM	-13.60	%
McDougall, R. et al., 2024b	Economic margins	Non-Interactive Short Term Standard Management	-313.57	€/ha
		Non-Interactive Short Term Additional IPM	-93.51	€/ha
		Non-Interactive Long Term Standard Management	-502.97	€/ha
		Non-Interactive Long Term Additional IPM	-209.12	€/ha
		Antagonistic Short Term Standard Management	100.28	€/ha
		Antagonistic Short Term Additional IPM	169.93	€/ha
		Antagonistic Long Term Standard Management	-19.49	€/ha
		Antagonistic Long Term Additional IPM	76.22	€/ha
	Pesticide saving costs	N/A	31.87	€/ha
	IPM Implementation costs	N/A	63.22	€/ha
	Environmental externalities (PEA method)	N/A	3.65	€/ha
	Environmental externalities (PL method)	N/A	12.77	€/ha

Based on the evidence above, both studies strongly align with the evaluation protocol developed in this project. They apply expert-driven ex-ante modelling, evaluate key economic indicators (yields, margins, input costs), and use scenario analysis to simulate different policy and agronomic conditions. The modelling also incorporates IPM implementation costs, uses national survey data (NFS) for benchmarking, and—

importantly—includes environmental impact valuation, offering a more holistic view of pesticide policy implications.

3. EX-ANTE MODELLING OF ECONOMIC IMPACTS

3.1 BASELINE ASSUMPTIONS

To conduct the ex-ante modelling of the economic impacts of pesticide use reduction in Ireland's cereal sector, a baseline was established using data from the Farm Accountancy Data Network (FADN). Specifically, we extracted time-series data for Ireland, filtered to include only crop specialist farms (Type: COP – Cereals, Oilseeds, and Protein crops), which aligns with the scope of both Irish studies, focused on cereal production (i.e., wheat, barley, and oats).

Given that the Irish study expresses impacts in terms of economic margins (€/ha), we constructed a comparable margin indicator using FADN data. For this, we used the following variables:

- Total crop output (€/ha): representing the value of crop production per hectare.
- Specific crop costs (€/ha): including expenditures on inputs such as seeds, fertilisers, pesticides, and other variable costs directly attributable to crop production.

The baseline margin was calculated as:

$$Baseline\ Margin \left({}^{€}/_{ha}\right) = Total\ crop\ output \left({}^{€}/_{ha}\right) - Specific\ crop\ costs\left({}^{€}/_{ha}\right)$$

This proxy provides a reasonable approximation of the economic margin at the farm level for cereal production and serves as the reference point for estimating changes under different IPM implementation scenarios.

To ensure consistency with the Irish study and allow for future-looking projections, the historical FADN data were converted to real 2025 euros using appropriate GDP deflators, and then projected forward to 2040 assuming a constant baseline scenario (i.e., no policy or practice changes). This projected margin series is used as the reference against which net benefits or losses under the different scenarios (standard management and additional IPM) are evaluated.

3.2 ESTIMATED IMPACTS

In line with the approach taken by McDougall, R. et al. (2024b), we estimate the Net Present Value (NPV) of the economic impacts of a 50% reduction in the use of hazardous pesticides across different implementation scenarios. The estimation covers a time horizon from the baseline year (2025) to 2040 and is based on the economic margin projections described in Section 3.1.

The analysis considers four impact scenarios, which correspond directly to those evaluated in the Irish study:

- **Non-Interactive – Standard Management:** assumes that pests act independently, and that no significant additional IPM strategies are adopted to mitigate the impacts of reduced pesticide use.
- **Non-Interactive – Additional IPM:** assumes independent pest effects but with the implementation of additional IPM practices intended to offset yield and margin losses.
- **Antagonistic – Standard Management:** assumes that pest interactions reduce the cumulative impact of pesticide withdrawal, with no additional IPM adoption.
- **Antagonistic – Additional IPM:** assumes antagonistic pest interactions combined with the deployment of IPM practices.

In addition, the modelling distinguishes between short-term impacts (years 1–5) and long-term impacts (years 6–17), to reflect the temporal evolution of effects, as defined in McDougall, R. et al. (2024b) study.

The estimated NPV for each scenario is calculated by comparing the projected economic margins under each scenario against the projected baseline margins from Section 3.1. Each scenario's annual margin impact (€/ha) is applied over the relevant time period (short or long-term), and adjusted to today's euros using 4 per cent discount rate in line with Irish standard evaluation practice.[3]

[3] Project Evaluation/Appraisal: Applicable Rates

In addition to changes in economic margins, the NPV also includes environmental impact savings associated with pesticide reduction o account for the broader societal benefits of reduced pesticide use. While these benefits do not accrue directly to farmers, they reflect avoided external costs to ecosystems, water quality, and public health. Including them provides a more complete picture of the overall value-for-money of IPM adoption, in line with public policy evaluation principles. To estimate these environmental savings, we use two monetised impact estimates provided in the McDougall, R. et al. (2024b) study, which applied two different methodologies to the same set of pesticide reduction scenarios :

- **Pesticide Environmental Accounting (PEA):** This method monetizes the avoided damage caused by pesticides by estimating the cost of mitigating various impacts (e.g., water treatment, medical costs). It is based on the Environmental Impact Quotient (EIQ), a risk scoring system developed at Cornell University that quantifies pesticide harm to farm workers, consumers, and the environment (Kovach et al., 1992)[4], and provides conservative but concrete economic values for environmental harm avoided.
- **Pesticide Load (PL):** Developed by the Danish Institute of Food and Resource Economics[5], this method assigns weights to active substances based on toxicity, persistence, and bioaccumulation, and is used by the Danish government to calculate pesticide taxes.

Both methods are applied to calculate €/ha environmental impact savings and are included in the NPV calculation to reflect the broader societal benefits of reducing pesticide use.

These NPV estimates, incorporating both economic and environmental benefits, provide a comprehensive assessment of the potential implications for Irish cereal farms under varying pest interaction assumptions and levels of IPM uptake. They offer a structured way to compare not only the direction but also the magnitude of costs and benefits across contrasting implementation paths.

The results obtained show that the Antagonistic–Additional IPM scenario yields the highest overall benefits, both in economic and environmental terms, while the Non-Interactive–Standard Management scenario performs worst. NPV estimates for each practice are summarized in Table 3-1 below.

Table 3-1 Results obtained from the analysis

Scenario	NPV (in 2025€/ha)	Change from Baseline
With environmental benefits calculated using PEA method		
Baseline	12,715	-
Non interactive – Standard Management Scenario	7,391	-5,324
Non interactive – Additional IPM Scenario	10,673	-2,042
Antagonistic – Standard Management Scenario	12,987	272
Antagonistic– Additional IPM Scenario	14,048	1,334
With environmental benefits calculated using PL method		
Baseline	12,715	-
Non interactive – Standard Management Scenario	7,53	-5,181
Non interactive – Additional IPM Scenario	10,816	-1,899
Antagonistic– Standard Management Scenario	13,129	415
Antagonistic – Additional IPM Scenario	14,191	1,476

[4] Kovach, J. et al. (1992). A method to measure the environmental impact of pesticides.

[5] Kudsk, P., et al. (2018). Pesticide Load—A new Danish pesticide risk indicator with multiple applications. Available at: https://doi.org/10.1016/j.landusepol.2017.11.010

4. CONCLUSION AND KEY INSIGHTS

The results show that reducing pesticide use can have substantial economic impacts on crop yields and farm profitability, but these impacts vary significantly depending on pest behaviour and whether farmers adopt IPM strategies. Under the Non-Interactive – Standard Management scenario, which assumes additive pest effects and no compensatory IPM practices, the estimated NPV falls significantly below the baseline (from €10,337/ha to €5,322/ha with PEA-calculated environmental benefits). In contrast, the Antagonistic – Additional IPM scenario yields an NPV of €11,496/ha (PEA) or €11,627/ha (PL), exceeding the baseline by over €1,000/ha. This reflects the combined benefits of milder pest impacts and effective mitigation through IPM.

Importantly, the inclusion of environmental impact savings—monetised using both the Pesticide Environmental Accounting (PEA) method and the Pesticide Load (PL) method—helps to capture societal benefits beyond the farm gate. However, even with these wider environmental benefits included some scenarios (notably Non-Interactive – Standard Management) still result in significant economic losses at farm level. This reflects the fact that yield losses and cost burdens are borne primarily by farmers, whereas environmental benefits accrue to wider society. These trade-offs need to be considered in the design of equitable and effective regulations.

The modelling exercise produced four key insights:

- **IPM uptake is critical to closing the economic gap:** The difference in NPV between Standard Management and Additional IPM scenarios—under both interaction assumptions—highlights the importance of supporting and incentivising farmers to adopt effective IPM techniques. Without such practices, the financial viability of cereal production under stricter pesticide regulation could be undermined.
- **Assumptions about pest behaviour matter:** The contrast between Antagonistic and Non-Interactive scenarios reinforces the need for more empirical research on pest dynamics under reduced pesticide use. Overly conservative assumptions may overstate the economic risks and underestimate the effectiveness of integrated approaches.
- **Environmental benefits improve the picture, but not uniformly:** While PEA and PL-based savings contribute positively to the NPV, they do not fully offset economic losses in all scenarios. Moreover, the PL method typically yields higher values, reflecting a broader set of environmental harms avoided. This highlights the sensitivity of cost-benefit outcomes to the valuation methodology used. Importantly, these benefits accrue to the public, not producers, highlighting the need for shared responsibility in managing the transition to lower pesticide use.
- **The case for tailored policy support:** Given the variation in outcomes, future policy design should consider context-specific modelling, such as crop type, region, or pest pressure, and provide targeted financial support or technical assistance. This could include regionally tailored IPM strategies, crop-specific extension services, or transitional funding to buffer early adoption costs.

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