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Research article

Do organic farming policies need to be more target-oriented to achieve sustainability?

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ABSTRACT

Organic farming is a key element of the EU Green Deal's Farm-to-Fork strategy, which aims to achieve 25 % of agricultural land being organic by 2030. Within the context of the current organic conversion policy (CAP Strategic Plans for 2023–2027), the aim of this paper is to assess whether a more complex and targeted organic support mechanism delivers greater GHG emissions reduction compared to a simpler but less targeted option. Using the IFM-CAP model, three contrasting organic conversion policy strategies for the EU are assessed: an action-oriented approach, a result-oriented approach focused on the GHG abatement potential, and a combined approach emphasizing cost-effectiveness. The findings reveal significant trade-offs: while the result-oriented strategy is more costly and complex due to higher monitoring requirements, it achieves greater emission reductions per euro spent, mainly by converting high-emitting livestock farms. However, it results in a larger gap to the 25 % organic area target. Conversely, the action-oriented strategy is less costly, focuses on arable farm conversion, comes closer to the 25 % organic area target, but achieves lower emission reductions. Therefore, to achieve environmental benefits from organic farming, it is necessary to focus on farms with higher environmental improvement potential rather than just on the amount of land converted.

1. Introduction

Organic farming has been promoted worldwide to reduce the environmental impacts of agriculture, although there is still a debate in the scientific community about whether organic agriculture actually mitigates negative environmental externalities (Debuschewitz and Sanders, 2022; Tuomisto et al., 2012). In Europe, the EU Green Deal and more specifically the Farm-to-Fork (F2F) strategy (European Commission, 2020), aims to achieve 25 % of total Utilized Agricultural Area (UAA) in the EU as organic by2030[1] (European Commission, 2021). While the objective is clear, the road to get there is still uncertain. Each Member State (MS) has set an annual budget for organic conversion, and designed different interventions related to organic farming in their Common Agricultural Policy (CAP) Strategic Plans (SPs) for the 2023–2027 financial period. However, there is not a coordinated approach that would ensure the 25 % target will be achieved at the EU level, and little effort has been made to assess the impacts on agricultural production or the environment.

MS have a limited budget to cover the costs of organic farming conversion and maintenance (IFOAM Organics Europe, 2021). Given these financial constraints – combined with the ambitious EU-level target and the need to deliver measurable environmental benefits – maximizing the effectiveness of organic conversion policies must be a priority (Schader et al., 2013). So far, MS have primarily pursued an action-oriented approach (providing financial support per hectare to farmers who convert to organic production) rather than a result-oriented approach. This policy choice has not explicitly considered the associated environmental improvements, nor has it encouraged farmers to adopt those practices that could deliver greater environmental benefits (Vainio et al., 2021). Shifting the focus towards the desired outcome and incentivizing farmers to achieve specific environmental targets could significantly improve the cost-effectiveness of the F2F strategy. Result-oriented approaches for agri-environmental measures have been widely supported in the literature as a better alternative to action-based payments (e.g., Pe'er et al., 2022; Bergschmidt et al., 2021; Sidemo-Holm et al., 2018; Stolze et al., 2015; Burton and Schwarz, 2013). In this paper, we define action-based approaches as policies that focus on the area converted (number of hectares), whereas result-oriented

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[1] The organic area in the EU is currently around 9 % according to Eurostat: https://ec.europa.eu/eurostat/databrowser/product/view/sdg_02_40.

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approaches focus on the associated environmental benefits. This paper addresses the question of whether a result-based approach can deliver significantly greater environmental benefits (specifically in terms of GHG emissions) compared with action-based approaches for organic conversion.

Most of the existing literature focuses either on the current implementation of organic support (action-oriented) or on comparing the performance of organic and conventional farms (e.g., Kremmydas et al., 2023a, 2023b; Cortignani et al., 2022; Barreiro Hurle et al., 2021; Bremmer et al., 2021; Rozman et al., 2013; Schader et al., 2013; Acs et al., 2007). Studies that are more directly related to our analysis and focus on the F2F organic target at the EU level include those by Lampkin and Padel (2022) and Kremmydas et al. (2023a, 2023b). Lampkin and Padel (2022) examined the environmental impact of achieving the F2F organic target by considering different growth rate scenarios for organic production. Their results clearly demonstrate the significant environmental benefits of achieving the F2F organic target, but they also indicate the need to substantially increase the budget per MS. This is consistent with the findings of Kremmydas et al. (2023a), who estimated that the EU budget would need to be 4.5 times higher than the current one to achieve the 25 % target. Kremmydas et al. (2023b) studied the effects of organic conversion, focusing on its impact on cropped areas, farm income and production. They found that the reduction in yields due to organic conversion could decrease the production of most crop and animal products in the EU by between −0.5 % and −15 %. Conversely, depending on the scenario, production costs tend to decrease and income increases for some farm specializations, highlighting the trade-offs of organic conversion.

There is a growing body of literature that examines result-oriented approaches in the context of various environmentally-related agricultural policies, such as those addressing climate change, biodiversity, animal welfare, and EU agri-environmental measures (e.g., Baráth et al., 2024; Bergschmidt et al., 2021; Sidemo-Holm et al., 2018; Stolze et al., 2015; Pacini et al., 2015; Burton and Schwarz, 2013). Overall, most available studies focus on either action- or result-oriented approaches separately, and often examine other EU agri-environmental policies rather than organic support specifically. To our knowledge, no existing studies have explicitly compared the environmental outcomes of action- versus result-oriented EU organic policies, nor have they assessed the cost-effectiveness of achieving F2F organic area targets within a limited budget.

This paper addresses this gap by assessing three alternative hypothetical organic conversion strategies for the EU (i.e., which farms should be prioritized for conversion in order to meet the F2F target): (i) an action-oriented approach, (ii) a result-oriented approach, and (iii) a cost-effectiveness[2] approach, which combines the first two. For this, we consider the budget allocated by Member States to support organic farms for the financial period 2023–2027, and analyse the impacts of these three strategies. In addition, we examine the gap in land conversion and the additional budget required to reach the 25 % organic target. We focus on key performance indicators, such as area converted, greenhouse gas (GHG) emissions reduction and impacts on production, to identify the trade-offs between different conversion policy options. Although many other environmental indicators could have been considered in this study, we focus on GHG emissions for two main reasons. First, reducing agricultural GHG emissions is a top priority in both the EU and international climate policy, as the sector is estimated to contribute to around 10–14 % of global anthropogenic emissions (FAO, 2022; Pathak et al., 2022; Nabuurs et al., 2022; European Commission, 2018). Second, GHG emissions result from a range of farming practices—like fertiliser use, livestock, and land management—that also drive other environmental impacts. As such, they serve as a useful proxy for broader environmental pressures (Lambotte et al., 2023; Baldoni et al., 2018). The findings have direct implications for policymakers and contribute to the ongoing discourse on sustainable agriculture and environmental policy within the EU.

[2] Cost-effectiveness: Ratio of the costs and the outcome (effect) of an intervention.

2. Methods

To assess the performance of different organic conversion policies we use the IFM-CAP model (Individual Farm Model for Common Agricultural Policy Analysis v.2; Kremmydas et al., 2022), a comparative static model based on a positive mathematical programming approach designed for the ex-ante economic and environmental assessment of the medium-term adaptation of individual farms to policy changes. IFM-CAP is a farm-level optimisation model of agricultural supply that consists of a number of individual farm models – one for each of the 81, 107 farms in the FADN[3] database covering all EU. The model provides EU-wide geographical and production coverage and it is representative of the effects of CAP policy on EU commercial farms. In IFM-CAP, each FADN farm selects the level of crop and livestock activities (in hectares and head of livestock, respectively) that maximises its expected utility of income for the given yields, variable costs, and prices, under a set of constraints related to the land endowment, animal feed requirements, and policy obligations. The model is calibrated for a baseyear (2017 in this case).

Fig. 1 summarises the steps of the analysis. First, we simulate the conversion of conventional (i.e., non-organic) farms in FADN to organic production (see section 2.1 for a methodological description). Secondly, we estimate the monetary incentive required for each farm to convert, along with the corresponding change in GHG emissions between the current state and organic production. Thirdly, based on the relevant criteria (see section 2.3), we select farms for conversion to organic farming for each conversion policy strategy until the budget for each MS is fully spent. Finally, we estimate and compare the key outcomes of each strategy.

2.1. Organic farming conversion

The approach to modelling organic conversion in the IFM-CAP model is described in Kremmydas et al. (2023a, 2023b). Specifically, Kremmydas et al. (2023b) detail how the IFM-CAP model accounts for changes in performance and management practices associated with organic farming systems. This paper applies the same modelling approach. In summary, the organic conversion modelling in IFM-CAP involves two main aspects. First, it allows for adjustments to the performance-related parameters of converting farms to account for the differences between conventional and organic farming in terms of prices, yields, costs, animal feeding, and unobserved conversion costs.[4] Second, the model considers technical constraints for converting farms to reflect management practices specific to the organic production system. These include crop rotation, nitrogen management, fertilizers and manure management, maximum stocking density, feed self-sufficiency and the minimum share of fodder in the diet. In addition, organic

[3] The Farm Accountancy Data Network (FADN) is a survey that collects and economic and financial data from representative agricultural holdings in the EU. The primary purpose of FADN is to provide a comprehensive and harmonized database that helps policymakers and researchers to assess the economic performance of the agricultural sector in the EU and the impacts of the Common Agricultural Policy (CAP). FADN contains information for around 80,000 commercial farms in the EU for each year from 1989.

[4] The unobserved costs associated with a farm's decision to convert to organic include monetary and nonmonetary factors that are not captured in the underlying data, such as additional labor and investment in organic production required for conversion, costs of access to organic markets, or beliefs and attitudes about the environment. These costs are estimated econometrically (see Kremmydas et al., 2023b for details).

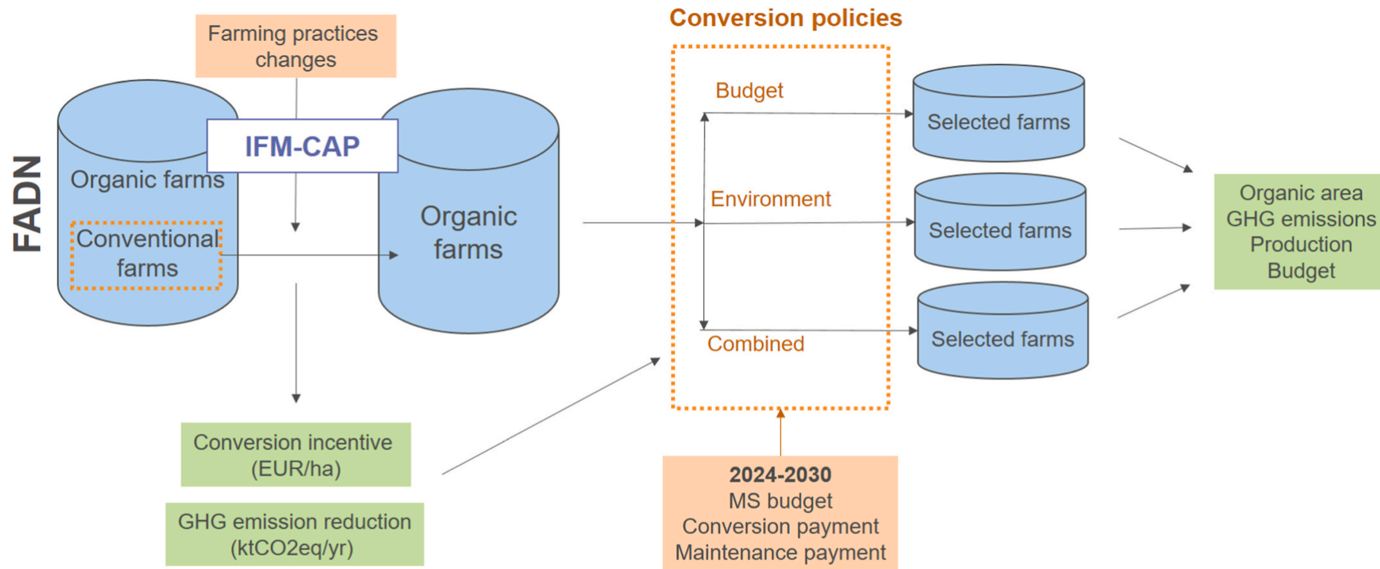

Fig. 1. Modelling farm conversion to organic farming: overview.

payments are applied to simulate farmers' responses to policy incentives. These include conversion and maintenance payments. The conversion payment is a one-off payment paid per hectare intended to compensate farmers for the costs of transitioning to organic farming. In contrast, the maintenance payment is an annual payment per hectare that supports continued compliance with organic practices. The conversion payment is estimated by comparing the expected change in a farm's utility from switching to organic farming, taking into account current payment levels (Kremmydas et al., 2023b). In IFM-CAP, the decision to convert depends on whether the monetary losses associated with organic production (e.g., lower yields and costs due to technical constraints) and unobserved conversion costs are offset by gains from higher organic prices and organic payments.

In the baseyear, the IFM-CAP model includes 73,310 conventional farms and 5,601 organic farms. The remaining 2,196 farms are either mixed farms or farms in the process of conversion. This distribution of farms reflects the pre-policy scenario, prior to the simulation of organic conversion policy strategies. In the policy scenarios, only conventional farms are considered for conversion, while organic farms present in the baseyear are assumed to remain organic. The baseyear serves as the reference scenario, and the simulation results for the policy scenarios considered are evaluated relative to this baseyear.

2.2. GHG emissions calculations

We assess whether the same level of budget expenditure could achieve greater reductions in environmental impact — specifically, GHG emissions — through the various approaches to organic farm conversion considered in this paper.

The IFM-CAP model incorporates an agro-environmental indicators module that estimates the environmental impacts of FADN farms. In this paper, we focus on GHG emissions (N_2O, CH_4 and CO_2) calculated following the latest IPCC guidelines (IPCC, 2019a, 2019b). Using IFM-CAP results for each farm (cropped areas, livestock units, input use, and feed intake), the GHG emissions are calculated for the following categories: manure management, managed soils, enteric fermentation, rice cultivation, urea and liming, machinery and energy use. In most cases, we use a Tier 1 approach using emission factors from National Inventory Reports (UNFCCC, 2023) or IPCC's default values. The exception is enteric fermentation emissions, for which we apply a Tier 2 approach. The analysis is limited to the GHG emissions originated at the farm level. Emissions beyond the farm gate (e.g., from fertilizer manufacturing) and the carbon sequestration potential of organic farming are not considered. Therefore, we acknowledge that the total impact of organic conversion on GHG emissions could be greater than is reported in this paper. A detailed description of the methodology used to estimate GHG emissions can be found in the Appendix.

Using the baseyear data and simulation results, the IFM-CAP model calculates total GHG emissions for each modelled farm in the baseyear scenario and in the policy scenarios. For the farms that were already organic in the baseyear, there is no change in GHG emissions between the baseyear scenario and the policy scenarios. As outlined in section 2.1, the model considers two management practices related to manure and fertilizers for conventional farms that convert to organic farming. First, the application of inorganic fertilizer application is set to zero, as organic farms can only use organic fertilizers. Second, the quantity of manure imported is increased by a percentage estimated based on FADN data. It is assumed that farms that used synthetic fertilizers prior to conversion would rely more heavily on manure to provide crops with the necessary nutrients.

2.3. Conversion policy strategies

We consider three hypothetical contrasting policy strategies that differ in the criteria used to select the converting farms, as follows:

- *Budget*: This strategy focuses on maximizing the number of farms converting to organic production by selecting farms for conversion that require the least monetary incentive (EUR per farm) to convert (i.e., action-based approach). This scenario is likely to be the most consistent with the current implementation of the organic policy in the CAP, as MS typically do not link the organic support to specific sustainability objectives in their CAP SPs.
- *Environment*: This strategy focuses on environmental benefits by selecting the farms that generate the greatest GHG emission reductions (i.e., target-based approach) but are not necessarily the least costly.
- *Combined:* This scenario combines the previous two, based on the concept of cost-effectiveness. Under this policy strategy, the priority is given to farms that can significantly reduce their emissions without requiring substantial monetary incentive to convert to organic farming. The cost-effectiveness of conversion for each farm is calculated as the ratio between the emission reduction and the

conversion payment (i.e., how many tonnes of CO_2 equivalent, CO_2eq, can be reduced for every euro spent on conversion).

All three policy strategies assume the same EU budget as set out in the CAP SP for 2023–2027 (i.e., EUR 5.2 billion for the EU-27). As explained above, the organic budget considered in the scenarios in each MS covers both the cost of one-off conversion payments and annual maintenance payments. There are large differences in the budget allocated to organic farming across MS, depending on the size of the country and the importance of organic farming in the baseyear (see Table A1 in the Appendix). The size of the organic budget in each country is somehow correlated with the proportion of farms already organic for which maintenance payments are allocated. Therefore, in countries with larger organic budgets, the budget left for converting new farms (i.e. conversion payments) may be lower.

For each conversion strategy in each MS, we select the farms for conversion based on the policy-specific assumptions outlined above, ensuring that the entire organic budget is exhausted. This selection process ensures that converting farms receive a one-off conversion payments, while farms that are already organic receive annual maintenance payments. Consequently, our policy scenarios represent a hypothetical situation in 2030 in which the number of organic farms (and the corresponding organic area) is adjusted to utilize the entire organic budget foreseen in the CAP Strategic Plans.

Due to the limited size of organic budget, none of the policy strategies considered in the study achieve the target of 25 % of the area being under organic farming. To assess the implications of achieving the F2F target, we also run a scenario in which this area target is met at the MS level for each of the three policy strategies defined above (Budget, Environment, and Combined). In this case, the 25 % organic target defined in the F2F strategy remains fixed, while the model adjusts the organic budget to cover both the conversion payments and the maintenance costs for organic farms. These F2F target scenarios show the additional emission reductions and the associated additional budgetary costs that may be required to meet the 25 % target compared to implementing the CAP strategic plans. In all scenarios, it is assumed that other policies (e.g. non-organic subsidies) remain unchanged.

3. Results

3.1. Conversion incentive and emission reduction potential

Before presenting the simulation results for the considered policy strategies, we first analyse the variation in potential GHG emission reductions and the associated levels of conversion payments required to induce all conventional farms to switch to organic production. For the same level of organic payment, the reduction in emissions can vary widely depending on which farms convert (Fig. 2). Ideally, policies should target farms that require low conversion payment but have high emission abatement potential (i.e., farms on the right-bottom side of the graphs in Fig. 2). The emission savings reflect the management changes done by farms when converting to organic farming (crop rotation, nitrogen management, maximum stocking density, feed self-sufficiency, and minimum share of fodder in the animals' diet) (Kremmydas et al., 2023a, 2024). For instance, arable farms under organic management would cultivate more nitrogen-fixing crops, resulting in less reliance on mineral fertilisers. For livestock farms, the number of animals per hectare would be reduced under organic farming, disminishing the total emissions of the farm.

The results suggest that encouraging the conversion of certain agricultural sectors could be more cost-effective. On average, livestock farms (especially granivores and dairy farms) require greater financial support per hectare for conversion than other farm types, while fieldcrop farms require the lowest (Table 1). However, livestock farms are the ones that lead to higher GHG emissions on average in the EU, mainly due to enteric fermentation. According to Table 1, the conversion of grazing livestock farms would, on average, be more cost-effective for the EU than the organic conversion of other farm types, followed by farms specialized in dairy and granivores. However, other key aspects such as the impact on production and farm income could also be considered to gain a more comprehensive understanding of the impact of policies.

3.2. Conversion policy strategies comparison for CAP strategic plans

The simulation results show differences in the total area converted to organic production, emission reductions and production changes at the EU level for the three policy strategies considered with the budget allocation under the CAP SP (Table 2). As expected, the Budget strategy leads to the largest converted area (18.3 million hectares) in the EU, since it selects farms that require the least financial incentive to convert (Fig. 3). In contrast, in the Environment strategy, only 10.7 million hectares would be converted to organic farming, as it focuses on the GHG mitigation potential of conversion, prioritizing farms that reduce emissions the most. The Combined strategy results in 14.1 million hectares being converted, balancing both the conversion costs of farms and their potential to reduce emissions.

The amount of land converted to organic production in all three policy strategies is less than what is needed to meet the F2F target of 25 %. In the baseyear, about 9 % of the agricultural area is already organic in the EU, which means that an additional 16 % of the total agricultural area (about 24.1 million hectares) would have to be converted from conventional to organic farming to reach the F2F target.[5] This leaves an organic area gap of 5.8, 13.4 and 10.0 million hectares (or 4 %, 8 % and 6 % of the total EU agricultural area) in the Budget, Environment, and Combined strategies, respectively.

The Environment strategy results in the smallest production reductions in the EU for all categories considered, except for meat, which decreases more than in the Budget strategy and less than in the Combined strategy (Table 2). These results are mainly explained by the fact that the Environment strategy has the lowest area converted to organic production, thus affecting crop activities less. Livestock farms tend to produce more GHG emissions than fieldcrop farms, and so they are more frequently selected for organic conversion in the Environment and Combined strategies. This is reflected in the larger reductions in meat and milk production in the Combined strategy compared to the other two policy strategies. In contrast, the Budget strategy has the largest impact on arable crop production in the EU, as fieldcrop farms require the lowest financial incentive to convert compared to other farms types.

As discussed in section 3.1, which farms actually convert to organics matter in terms of policy performance. To analyse this, we calculated the distribution of converted farms and converted area by farm specialization in the EU for the three policy strategies considered (Table 3). The number of farms converting to organic production in the EU is 23,291 farms under the Budget strategy, 2,159 for the Environment strategy and 12,994 for the Combined strategy (out of the 81,107 FADN farms). The Budget strategy targets smaller farms (in terms of area), less intensive farms and specializing in field crop, as they require lower conversion payments. The Environment strategy targets very intensive livestock farms and larger field crop farms, which could achieve significant emission reductions by converting to organic farming. Intensive farms require a higher financial incentive to convert because they are further away from the organic production system and therefore have higher conversion costs. As a result, the main difference between the Environment and the Combined strategies is that the former focuses more on conversion of fieldcrop farms, while the latter promotes the conversion of permanent and livestock farms, since the reduction in GHG emissions per EUR spent is greater. The converted area is highly correlated with

[5] Note the total agricultural area is 160.5 million hectares in the EU. https://ec.europa.eu/eurostat/databrowser/view/ef_m_farmleg/default/table?lang=en.

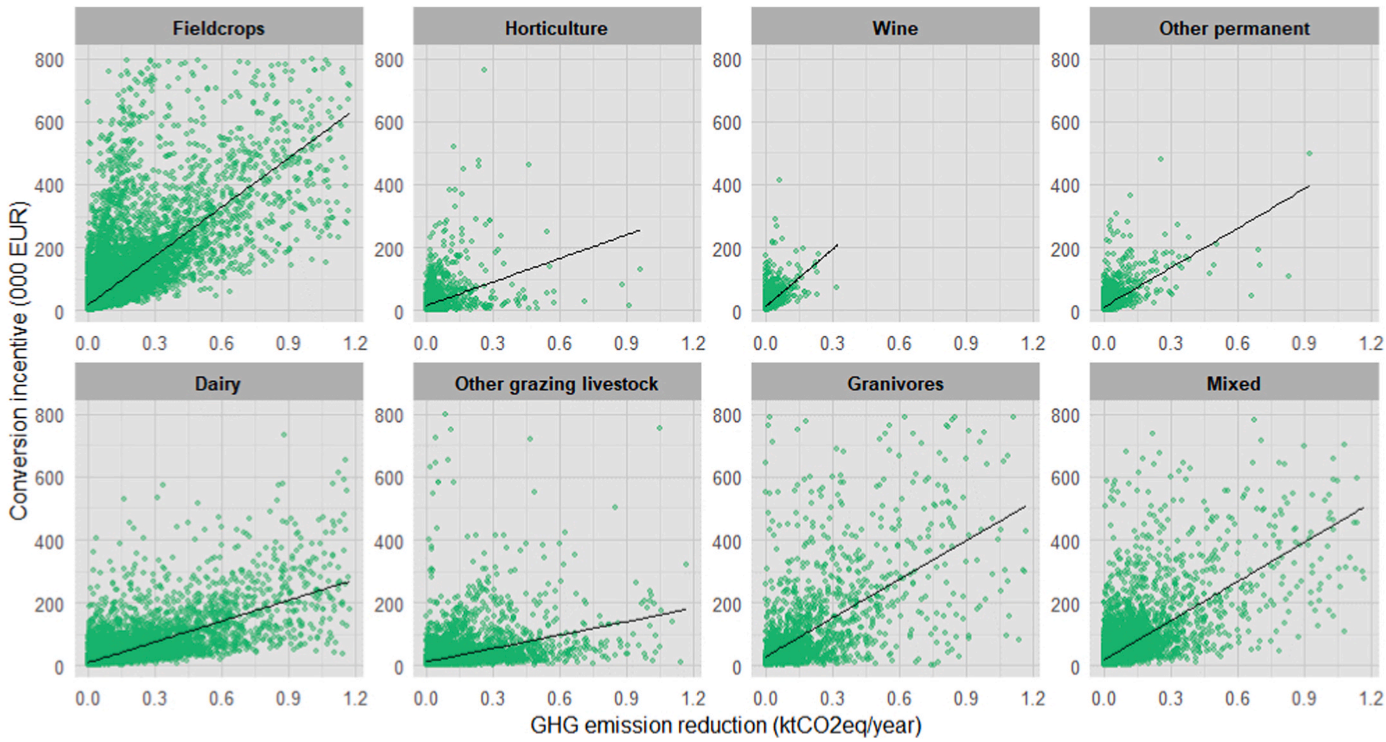

Fig. 2. Conversion incentive and GHG emission reduction potential for each FADN farm in by production specialization.

Table 1
Average utilized agricultural area (UAA), conversion payment, GHG emission and cost-effectiveness of organic conversion by farm specialization in the EU.

Type of farm	UAA (ha)	Conversion payment (EUR/ha)	GHG emissions reduction (t CO_2eq/yr)	Cost-effectiveness (kg CO_2eq/EUR)
Fieldcrops	148	636	1.37	1.3
Horticulture	16	4,976	0.66	2.8
Wine	24	914	0.39	0.6
Other permanent crops	21	999	0.62	1.1
Dairy	95	1,717	4.13	4.5
Other grazing livestock	83	2,819	3.59	6.0
Granivores	75	42,429	3.41	3.9
Mixed	160	784	1.62	1.8

the number of farms converting to organic production across farm specializations in the three policy strategies considered (Table 3).

The simulations show that with the organic budget allocated in the CAP Strategic Plans, emissions in the EU could be reduced by up to 7.3 % in the Combined strategy (Table 2), whereas the Budget strategy delivers the lowest emission reductions at 4.3 %. Contrary to expectations, the Environment strategy leads to lower emission reductions than the Combined one. This is because the Combined strategy also takes into account the conversion payments, allowing more farms to be selected for conversion with the same budget, ultimately resulting in greater overall emissions reductions. This means that selecting the top performing farms in terms of emission reduction potential does not produce the best outcome when the budget is limited. However, selecting farms for conversion based on cost-effectiveness achieves greater overall emission reductions.

3.3. Reaching the 25 % organic target

This section presents the simulation results for the case where the 25 % organic target is assumed to be met in all EU MS for each of the three policy strategies considered. If all EU countries were to reach the 25 % organic target, the total budgetary costs would amount to EUR 6.5 billion in the Budget strategy, EUR 8.3 billion in the Environment strategy, and EUR 7.8 billion in the Combined strategy (Table 4). This implies that the total EU organic payments would need to increase by 25 % in the Budget strategy, by 60 % in the Environment strategy and by 50 % in the Combined strategy compared to the organic budget set in the CAP Strategic Plans.

The reduction in EU emissions in the Environment and Combined strategies is almost double that in the Budget strategy (10.7 % and 10.6 % versus 5.6 %). Although the reduction in GHG emissions is very similar in the Environment and Combined strategies, the budget expenditure in the latter is EUR 520 million lower (Table 4). The results indicate a decreasing cost-effectiveness of additional euros spent on organic payments. As the area converted to organic production increases, the remaining conventional farms that can potentially convert tend to be less cost-effective, requiring higher additional conversion

Table 2
Simulation results by policy strategy in the EU (compared to baseyear).

Policy strategy	Converted area (mill ha)	Emission reduction (%)	Production change (%)			
			Arable crops	Permanent crops	Dairy	Meat
Budget	18.3	4.3 %	−3.5 %	−0.4 %	−2.3 %	−1.4 %
Environment	10.7	6.6 %	−0.7 %	0.01 %	−1.9 %	−1.7 %
Combined	14.1	7.3 %	−0.8 %	−0.6 %	−2.6 %	−1.9 %

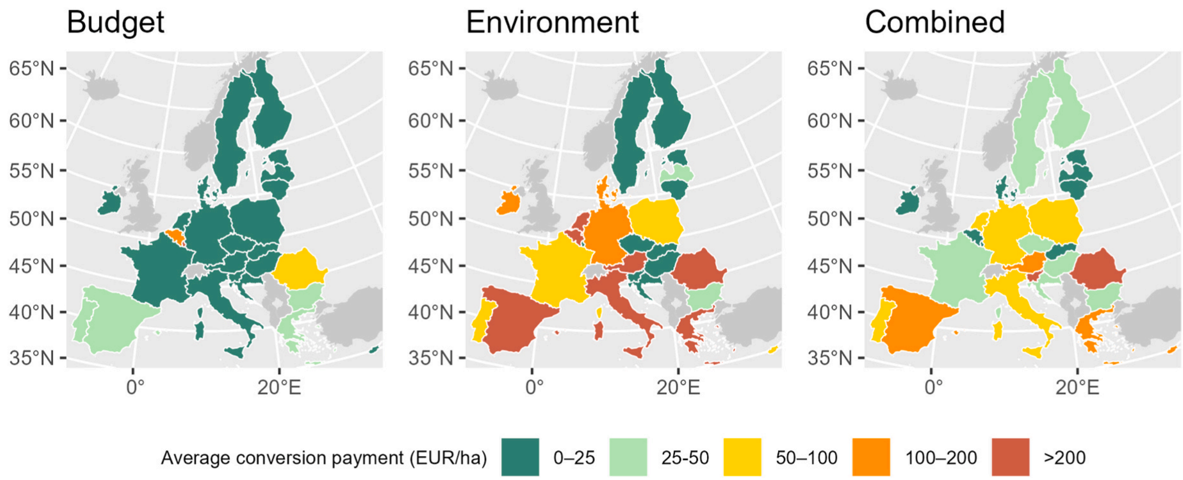

Fig. 3. Average conversion incentives (EUR/ha) for farms converting to organic in each country under each organic conversion policy.

Table 3
Comparison of the simulation results by policy strategy and farm specialization in the EU (compared to baseyear).

Farm specialization/Policy strategy	Farms converting (%)			Converted area (mill ha)		
	Budget	Environment	Combined	Budget	Environment	Combined
Fieldcrops	29	39	18	5.10	5.77	1.38
Horticulture	9	1	3	0.17	0.03	0.08
Wine	5	0	7	0.94	0.01	1.40
Other permanent crops	8	1	12	0.88	0.05	1.78
Dairy	18	26	21	3.00	1.44	2.52
Other grazing livestock	18	20	23	6.19	1.81	5.86
Granivores	5	5	8	0.50	0.50	0.41
Mixed	9	8	8	1.47	1.11	0.71
Total	100	100	100	18.3	10.7	14.1

Table 4
Simulation results for achieving the 25 % organic target in the EU by policy strategy: Organic payments and GHG emissions reductions.

Policy strategy	Organic payments		Emission reductions	
	Total payments (billion EUR)	% change vs. CAP SP*	% reduction	% change vs. CAP SP*
Budget	6.5	25 %	5.6 %	30 %
Environment	8.3	60 %	10.7 %	62 %
Combined	7.8	50 %	10.6 %	45 %

Notes: CAP SP: CAP strategic plans; * Calculated by using simulation results from Table 2.

payments while delivering fewer emission reductions per euro spent.

Similar to the simulation results of the CAP SP scenarios, the Combined strategy leads to larger reductions in meat and milk production, as it prioritizes livestock farms with higher GHG emissions for organic conversion (Table 5). In contrast, the Budget strategy mainly affects fieldcrop production, as these farms have lower financial costs to convert. The Environment strategy lies between these two policy strategies, except for permanent crops, where the production effect is the lowest. The production impacts are much higher in these scenarios simulating the achievement of the 25 % target than those estimated for the CAP SP scenarios, especially for permanent crops. This result shows the trade-offs between reducing the environmental impacts of EU food production while maintaining food security.

4. Discussion

4.1. Comparison of different organic conversion policy strategies

The results for the different conversion strategies examined in this paper show that which farms actually convert matters, highlighting the need to identify the agricultural sectors that would provide the highest environmental benefits from organic conversion. Livestock farming, especially dairy, contributes significantly to agricultural GHG emissions. Yet, organic livestock production currently remains a small proportion of the total. Depending on the sector, organic animal production accounts for 1–7 % of total EU animal production, (European Commission, 2023). Encouraging conversions in this sector could yield substantial

Table 5
Simulation results for achieving the 25 % organic target in the EU by policy strategy: Production change (%).

Policy strategy	Production change							
	Arable crops		Permanent crops		Dairy		Meat	
	% change	% change vs. CAP SP*	% change	% change vs. CAP SP*	% change	% change vs. CAP SP*	% change	% change vs. CAP SP*
Budget	−4.3 %	−23 %	−0.5 %	−20 %	−3.1 %	−35 %	−1.8 %	−29 %
Environment	−2.0 %	−186 %	−0.1 %	−186 %	−3.6 %	−89 %	−2.7 %	−59 %
Combined	−1.3 %	−63 %	−0.8 %	−33 %	−4.4 %	−69 %	−3.0 %	−58 %

Notes: CAP SP: CAP strategic plans; * Calculated by using simulation results from Table 2.

environmental benefits.

Based on the current budget allocated for organic farming under the CAP SP, our results suggest that achieving the 25 % F2F target for organic agricultural area by 2030 is unlikely unless more financial resources are devoted to organic farming. This aligns with the findings of previous studies (e.g., Lampkin and Padel, 2022; Kremmydas et al., 2023a). To reach the F2F target, the total EU organic budget would need to increase by between 26 % and 60 %, depending on the adopted conversion policy.

As demonstrated by the European Commission (2024), in the context of the CAP, organic farming seems to offer the greatest potential for reducing GHG emissions from agriculture among all farming practices supported by CAP Strategic Plans (e.g., crop rotation and diversification, cover crops, ban on mineral fertilisers). The GHG emission reductions estimated in this paper for CAP SPs are consistent with those of Lampkin and Padel (2022). They assessed the environmental impact of achieving the EU's 25 % organic target by 2030, and estimated a potential reduction in GHG emissions of between 3.4 % and 9.5 %. The abatement potential of organic farming is comparable to other abatement technologies currently promoted in the EU agricultural sector. For example, improved manure storage and application could offset 0.6 % and 1.2 % of GHG emissions, respectively, with estimated costs are of 59 EUR/tCO$_2$eq for the covered manured storage and 208 EUR/tCO$_2$eq for manure injection practices (OECD, 2019).

Finding the right balance between environmental sustainability and production effects is critical for the CAP to contribute to the objectives of the European Green Deal (OECD, 2023). Our CAP SP simulations for organic policies highlight a trade-off between production impacts and budgetary costs in action-versus result-based strategies. The former involves minimizing budgetary costs, which leads to larger reductions in crop production. The latter involves prioritizing environmental benefits at higher budgetary costs per converted area, which leads to larger reductions in livestock production. The yield gap, and thus the difference in production between organic and conventional agriculture, could be reduced by using crop varieties that are better suited to low input production systems (Lammerts van Bueren et al., 2011) or by implementing crop diversification practices (Ponisio Lauren et al., 2015). As stated by Tuomisto et al. (2012), both research and policy should focus on developing high yielding farming systems with low negative environmental impacts by combining techniques from both organic and conventional systems. Further investigation is required to better understand the cost-effectiveness of such strategies.

4.2. Implications for policymaking

The EU's goal to make 25 % of agricultural area organic by 2030 is clear and easy to understand and monitor. It demonstrates the EU's ambition to become more sustainable in the way food is produced. However, rather than focusing solely on the area converted as a measure of success, the potential environmental gains and the impacts on production must also be acknowledged. This is important for assessing the consequences of the policy itself and for encouraging those farms that would deliver the greatest environmental benefits through conversion to organic farming. As policies are currently designed, there is a risk that farms engaging in organic conversion are already applying more sustainable practices, meaning the environmental impact could be marginal (Calabro and Vieri, 2024). Indeed, numerous studies have shown that agri-environmental schemes often fail to deliver substantive positive environmental outcomes (Baráth et al., 2024). A recent report by the European Court of Auditors' (ECA, 2024) on organic farming highlighted that the EU strategy lacks quantifiable objectives and a means of measuring progress. Furthermore, the support allocated in the CAP SPs to incentivise an increase in the area under organic farming does not consider environmental outcomes.

Based on our results, an organic conversion policy focused on cost-effectiveness would ensure that the organic budget supports farms that deliver the greatest environmental gains per euro spent. A more targeted payment scheme could reward the best performers (i.e., those with more potential to reduce their negative environmental externalities), in line with the 'public money for public goods' principle (Lampkin, 2023). Although implementing a result-based policy for organic conversion is challenging, due to the difficulty of identifying suitable indicators and ways to measure them easily (Stolze et al., 2015). When comparing the performance of different policy options, the associated monitoring costs must also be considered. The results-based approach is expected to incur higher monitoring costs, since it requires an assessment of the environmental performance of farms to ensure that only the most cost-effective ones are selected. Monitoring costs are expected to be lower for the action-based approach, since this does not require an assessment of the farms' environmental performance. However, policymakers can rely on cheaper alternatives to direct measurement, such as modelling (Bartkowski et al., 2021; OECD, 2022). As Armsworth et al. (2012) argue, the additional implementation costs of more sophisticated policies are worth bearing to ensure the cost-effectiveness of incentive schemes.

Significant diversity in farm types exists within and across regions of the EU (Pacini et al., 2015). Tailoring policies to different farm typologies could therefore improve their outcomes (Huber et al., 2024). The new CAP provides an adequate framework for establishing an organic conversion system appropriate for each MS as it gives MS flexibility to adapt the implementation of the agricultural policy to the local or national level. Measures could target specific farm typologies or introduce a tiered system that rewards farms differently depending on their expected environmental outcomes.

4.3. Research approach and limitations

This paper presents the modelling of organic conversion of individual farms using the IFM-CAP model. When drawing conclusions, one must be aware that our results obviously reflect the assumptions made in the model. One limitation is that the model assumes a fixed farm structure, meaning that farms' production specialization and size remain unchanged following conversion to organic production. In reality, converted farms may make more significant adjustments in production structure and scale than our modelling framework accounts for. Additionally, our simulations for the conversion payment assume that the organic price premium will remain the same even after a significant number of farms convert to organic. However, depending on the demand for organic products, the price premium may decrease as the organic production supply increases. Indeed, empirical studies show that the price elasticity of organic products is typically negative and higher in absolute value than that of conventional products (Nes et al., 2024), indicating that the demand for organic products tends to be more sensitive to price changes. Consequently, an increase in the supply of organic products could lead to a sizable decrease in the price difference between organic and conventional products. As a result, larger conversion payments may be needed to induce farmers to convert than those simulated in this paper. Furthermore, we implicitly assume that organic payments will continue in the medium to long term. We do not account for policy uncertainties related to the future implementation of the CAP, in particular with respect to organic payments. If farmers anticipate policy uncertainties (e.g., a possible reduction in future organic payments), our simulations would overestimate the conversion effects. Lastly, our approach does not capture all factors affecting a farmer's decision to convert to organic production, due to lack of data (Kremmydas et al., 2023b). Factors such as access to organic markets, the costs of organic certification, or farmers' knowledge on organic production methods, would influence their decision to convert.

The main source of data in our model is the FADN, a dataset that was designed for economic analysis and hence the relevant information for environmental assessments is limited. However, data on farm characteristics (size, crops areas and livestock numbers, input use, etc.) can be used as proxy to calculate agro-environmental indicators. This dataset has been used for similar purposes in the past (Baldoni et al., 2023; Sinisterra-Solís et al., 2023; Dabkiene et al., 2021; Coderoni and Esposti, 2018; Syp and Osuch, 2017). FADN data, together with IFM-CAP outputs, allow us to estimate GHG emissions following the IPCC guidelines. Several assumptions had to be made when the level of detail in the FADN data was insufficient, which may affect our simulation results. In addition, the emission factors used for the estimations were average national values coming from each country's National Inventory Reports or default values from the IPCC (IPCC, 2019a, 2019b).

It is important to note that our focus is on the emissions within the farm itself. We have not considered the potential emission reductions upstream or downstream in the supply chain (e.g., we have accounted for emissions related to their application of fertilizers in the field, but not those related to their manufacture or transport). Consequently, the emissions of farms that purchase their inputs externally may be underestimated. In addition, organic agriculture also contributes to climate change mitigation by sequestering carbon in the soil (Ireland Department of AgricultureFood and the Marine, 2014). For these reasons, the mitigation potential of organic conversion could be greater than estimated here.

This paper uses GHG emissions as an example of an environmental performance indicator with which to compare organic and conventional farming. In agriculture, GHG emissions are mostly related to enteric fermentation and thus to livestock activities. To obtain a more comprehensive assessment of environmental performance, the GHG emissions should ideally be combined with other environmental indicators. Indeed, beyond GHG emissions, organic farming provides a wide range of environmental benefits that were not addressed in this paper. For example, organic systems improve soil health by increasing organic matter content, reducing erosion, and improving soil biodiversity and structure. These factors also contribute to greater resilience against climate extremes. Organic production typically avoids the use of synthetic pesticides and mineral fertilizers, thereby reducing the risk of water pollution and pesticide residues in ecosystems (European Commission, 2021; Reganold and Wachter, 2016). Furthermore, organic farming has been associated with higher levels of farmland biodiversity, supporting a greater abundance of pollinators, beneficial insects, and diverse plant species than conventional systems do (Sanders and Heß, 2019). These additional benefits reinforce the environmental rationale for expanding organic agriculture, complementing the climate mitigation effects considered in this paper. A more comprehensive assessment of the costs of organic conversion, environmental outcomes and economic and production trade-offs would be desirable. To achieve this, additional environmental indicators could be used alongside GHG emissions. Farms could then be ranked based on a composite environmental score, calculated from the sum of the normalized values of the considered environmental indicators. Alternatively, a multi-criteria approach could be employed to assign weights to the different environmental indicators included into the analysis.

5. Conclusions

This paper assesses the potential trade-offs and outcomes of different policy strategies designed to achieve the EU's target of allocating 25 % of agricultural land to organic farming by 2030. Using the IFM-CAP model and farm-level data, we simulated three distinct policy strategies – Budget, Environment, and Combined – in terms of whether they are action- or result-oriented, under two scenarios: (i) the budgetary support for organic farming under the current CAP Strategic Plans and (ii) the full achievement of the Farm-to-Fork target.

Our findings show that under the current CAP SP budget, it is unlikely that the EU will reach its target of having 25 % of agricultural land under organic management. Depending on the policy strategy, the gap to the target ranges from 4 % to 8 % of the EU's agricultural area, and the organic farming budget would need to increase by between 25 % and 60 % to achieve the target. Of the three policy options, the Combined strategy – designed to prioritize environmental cost-effectiveness – achieves the highest GHG emission reductions (−7.3 %), but falls 6 % short of the target in terms of hectares converted. Conversely, the Budget strategy – designed to prioritize converting the least costly farms – achieves a smaller GHG emissions reduction (−4.3 %) but comes closer to the 25 % area target. The Environment strategy – which prioritizes environmental improvement – achieves a 6.6 % reduction in emissions but leaves the largest gap relative to the area target (8 %). Livestock farms, particularly dairy farms, offer greater potential for reducing GHG emissions but require more financial support. Overall, results-oriented strategy (Environment) favours the conversion of these farm types. In contrast, action-oriented strategy (Budget) tends to convert more arable land at a lower cost, but with smaller environmental gains per euro spent.

From a policy perspective, our results show that it is very unlikely that the F2F Strategy target can be met with the current budget, and that the associated environmental benefits might not be maximized. A more targeted, results-based approach can deliver superior environmental outcomes per unit of expenditure, according to our results, although it is more costlu and administratively complex. The success of the policy hinges on identifying and incentivizing farms with the greatest potential for environmental improvement. Focusing purely on hectares converted to organic production could result in resources being allocated to farms that would make only a limited additional environmental contribution. To better align conversion efforts with sustainability goals, policymakers could complement land area targets with explicit environmental objectives (e.g., reducing GHG emissions or setting nitrogen input reduction targets). The flexibility provided by the new CAP architecture offers Member States the opportunity to implement more targeted and outcome-oriented support schemes, improving both the environmental impact and cost-effectiveness of organic farming incentives across the EU.

This paper has several limitations. First, the IFM-CAP model assumes static farm structures after conversion, which may underestimate potential production adjustments. Second, the model assumes constant organic price premiums, which may decline as organic supply increases. Third, the analysis does not account for policy uncertainties related to the future implementation of the CAP – particularly with regard to organic payments. Fourth, only on-farm emissions were considered, excluding upstream and downstream supply chain effects. Additionally, the broader environmental benefits of organic farming – such as biodiversity, soil health, and reduced pesticide use – were not fully captured by the GHG metric alone. Incorporating a wider set of environmental performance indicators could provide more comprehensive policy assessments.

Future research should explore multi-criteria policy evaluation frameworks that combine environmental, economic, and social indicators. Incorporating a broader set of environmental metrics and developing composite indicators could help rank farms by overall environmental benefit potential, leading to more comprehensive policy assessments. Moreover, examining the feasibility of implementing such targeted policy approaches across Member States, along with the associated monitoring costs, would support the development of a more efficient organic conversion policy for the EU.

CRediT authorship contribution statement

Dolores Rey: Writing – original draft, Visualization, Methodology, Formal analysis, Conceptualization. **Dimitrios Kremmydas:** Writing – review & editing, Methodology, Conceptualization. **Edoardo Baldoni:** Writing – review & editing, Methodology. **Pavel Ciaian:** Writing – review & editing, Supervision. **Pascal Tillie:** Writing – review & editing, Supervision.

Disclaimer

The authors are solely responsible for the content of the paper. The views expressed are purely those of the authors and may not in any circumstances be regarded as stating an official position of the European Commission.

Declaration of competing interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests:

This paper is about EU policy and the authors work for the Joint Research Center of the European Comission.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jenvman.2025.127342.

Data availability

The authors do not have permission to share data.

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