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To cite this article: Silvia Coderoni *et al* 2021 *Environ. Res. Lett.* **16** 094044

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Key policy questions for ex-ante impact assessment of European agricultural and rural policies

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Keywords: policy questions, benchmark scenarios, stakeholder engagement, focus group, Common Agricultural Policy

Supplementary material for this article is available online

OPEN ACCESS

RECEIVED
12 April 2021

REVISED
11 August 2021

ACCEPTED FOR PUBLICATION
19 August 2021

PUBLISHED
8 September 2021

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Abstract

Policies in the agricultural and rural sectors are of key importance in shaping their sustainable development. These policies are changing from market-based policies to policies that aim to influence farmers' decision-making. Thus, the scientific literature supporting evidence-based policy-making must develop models that simulate individual decision-making (IDM) by farmers. This study aims to understand key policy objectives, related policy questions and benchmark scenarios relevant to the European agricultural sector to define the research agenda for a suite of IDM models. This research goal has been addressed following a five-step process that involved different research tools and heterogeneous actors, including key stakeholders. Results suggest that environmental policy objectives are the most relevant for European agriculture in the coming decades. Thus, the scenario modelling exercise should focus mainly on the agri-environmental policies' impacts while properly considering the potential trade-offs between economic and environmental objectives.

1. Introduction

Agricultural and rural policies are fundamental in fostering the sustainable development of the agricultural sector and the food system worldwide (Sarker *et al* 2019, HLPE 2020). These policies are increasingly changing to respond to society's concerns regarding food security, food safety, environmental care, animal welfare and rural areas' viability (OECD 2006).

Building on the increasing concerns over environmental and sustainability issues, the European Union (EU) has recently paved the road towards deep policy changes. These include the Farm to Fork (F2F) and European Green Deal strategies (European Commission 2019, 2020), as well as the Common Agricultural Policy (CAP) reform proposals (European Commission 2018), which are aimed at enhancing the environmental objectives of the European agricultural and food sectors.

In this context, the scientific community can play a fundamental role by providing a quantitative ex-ante impact assessment and evaluating the proposed policy changes. These can indeed represent sound support for evidence-based policy-making, allowing the assessment of the effectiveness and efficiency of policy measures, even in the absence of observational data.

However, in the agricultural sector, current simulation models and tools for impact assessments need to be further developed and aligned to key policy objectives (Louhichi *et al* 2018). With the shift from market-based policies to policies aimed at influencing farmer decision-making and farming practices, the understanding of farmer behaviour and the modelling of individual decision-making (IDM) has become increasingly important (Jongeneel *et al* 2020) as the eligibility and uptake of the proposed policy measures largely depend '*on farm specific characteristics (size, specialisation, location, etc.), posing challenges for policy evaluation and raising the need for new modelling tools*' (Louhichi *et al* 2018). In other words, both farm-specific and local policies need modelling at the individual farm level (Buysse *et al* 2007).

Unfortunately, most EU-wide models are aggregate models—i.e. they are based on farm typologies,

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regions or countries that are not completely able to model policies targeted at the farm level (Lansink and Peerlings 1996, Gocht and Britz 2011, Cantelaube *et al* 2012).

In this context, the so-called IDM models have recently become popular tools for modelling agricultural systems and studying the impacts of agricultural and rural policies (Kremmydas *et al* 2018). Such analytical tools allow representing farms' heterogeneity in policy uptake and impacts (Louhichi *et al* 2018), thereby enabling the understanding of policy implications on a small-scale level (An 2012, Magliocca *et al* 2015). These granular insights are made possible by a more precise definition of individual farmers' behaviour and, in some cases, the interactions among farmers and between farmers and other actors in the food (or non-food) supply chain (Helbing 2012, Brown *et al* 2016).

Having established the importance of IDM models in exploring the impact of policy reforms, this study aims at appraising which key policy objectives, related policy questions and benchmark scenarios are presently compelling to the European agricultural sector. We then use this information to set out the research agenda of the Horizon 2020 project 'MIND STEP' (Modelling INdividual Decisions to Support The European Policies related to agriculture) committed to developing a highly modular and customisable suite of IDM models for the agricultural sector. These tools will then be used to support the ex-ante evaluation of future policy settings.

In short, this paper strives to answer the following two research questions:

> Q1: *Which agricultural-policy objectives and related policy questions are relevant and worthy of investigation today?*
> Q2: *Which benchmark scenarios should be investigated in order to capture the most relevant impacts of these policy objectives on EU agriculture and rural areas?*

We pursue these two goals through a five-step process that involves different research tools and actors, including stakeholders, whose engagement played a crucial role in answering the research questions posed.

This approach to research agenda-setting is not new in the literature. For example, Vernier *et al* (2017) define several alternative scenarios in cooperation with stakeholders to support the pesticide action plans in France; Dupré *et al* (2021) develop a prototype bioeconomic model and then engage public actors to identify issues and characterise the scenarios that can be used to explore selected questions; Van Ginkel *et al* (2020) analyse the possible climate-change-induced socio-economic tipping points through a literature review and a stakeholder consultation to guide the future research on the topic that could be policy-relevant; and Holzer *et al* (2018) evaluate the performances of different long-term socio-ecological research platforms with stakeholder collaboration. However, to the best of our knowledge, this study represents the first attempt to define the research agenda of an H2020 project that focuses on integrating IDM models into a suite of simulation tools that better represents policy settings at the farm level.

The remainder of the paper is organised as follows: section 2 presents the background of the analysis; section 3, the material and methods; section 4, the results; section 5, discussion of the results; and section 6 briefly concludes.

2. Background of the analysis

According to the definition of the High-Level Panel of Experts on Food Security and Nutrition of the Committee on World Food Security, '*A food system gathers all the elements (environment, people, inputs, processes, infrastructures, institutions, etc) and activities that relate to the production, processing, distribution, preparation and consumption of food, and the output of these activities, including socio-economic and environmental outcomes*' (HLPE 2014, p 29). Therefore, the first component of the 'food system' is the primary sector, which can deliver sufficient, safe, healthy and affordable food for all.

Addressing food security and nutrition at a global level calls for policies designed to appreciate the complexities of the food system, including its undeniable interactions with other sectors and systems—i.e. ecological, human, energy, economic and health systems, which provide essential inputs into the food system (HLPE 2020). Among human systems, the urban dimension is exceptionally important, as the relationship with the urban environments deeply influences food systems through the growing urban demand for foods and rural-to-urban migration (HLPE 2020).

Such tightly connected systems inevitably produce feedback loops that propagate any shock at any stage back to the origin, either amplified or weakened. Thus, multiple trade-offs exist between the economic, environmental, health, social and cultural dimensions of food systems. For example, food systems overlap with consumer behaviours that affect diets (Downs *et al* 2020), and diets, in turn, control nutritional impacts within populations that affect health systems and also climate change through the impact of diets on greenhouse gases (GHG) emissions (Reisch 2021). However, at the same time, growing climate change weakens the capacity of ecological systems to support the increasing demand for diverse

and healthy food. Therefore, ensuring that ecological, social and economic systems work together is paramount to guaranteeing food security in the long term (FAO 2006).

Consequently, the scope of any research activity involving the primary sector should acknowledge the complex relationships between the food systems and its major drivers of change, namely: biophysical and environmental drivers; technological and innovation drivers; economic and market drivers; socio-cultural and demographic drivers; and political and institutional drivers. (For a detailed representation of a sustainable food system framework, please refer to HLPE 2020, p 13). Concerning the latter, agricultural and rural policies play a crucial role in promoting the sustainable development of the agricultural sector, which is at the heart of food systems (European Commission 2019, Alam *et al* 2020).

In Europe, the CAP is one of the oldest policies. Its objectives, as stated in Article 39.1 of the Treaty of Rome, are to increase productivity through technological progress and the best use of the factors of production (such as labour); ensure a fair standard of living for communities employed in agriculture; stabilise markets; secure the availability of supplies; and enforce fair prices. Hinging on these objectives, the CAP has largely contributed to keeping the EU agri-food sector highly relevant throughout the last 60 years, but, conversely, it has also brought negative impacts on food safety, the preservation of natural resources, and the demographic, economic and social structures of rural areas (Candau *et al* 2005).

For these reasons, the CAP has undergone several reforms to engage with the constantly evolving economic circumstances and citizens' requirements. Eventually, '*a new partnership between Europe and farmers*', based on a new CAP, was established in 2013. '*This new partnership* […] *reflects the desire to reshape the contract of confidence between European citizens and their farming sector*', read the motivations for the 2013 CAP reform (European Commission 2012). However, as new concerns regarding the environmental sustainability of current food practices have emerged in recent years, wide-ranging criticism of the CAP has fostered the 2014–2020 CAP reform process. This makeover of the old common agricultural regulations provides a deeper commitment to address the compelling environmental concerns so urgently risen by the EU citizens (Erjavec and Erjavec 2009, 2015).

The democratic legitimacy of the CAP legislation process substantially increased during the 2013 reform with the introduction of a co-decision mechanism (Knops and Garrone 2015) that sees the participation also of the European Parliament (EP) in the legislative procedure. Despite numerous limitations and areas for improvement, the EP significantly influenced the outcome to become a full co-legislator (Knops and Garrone 2015, Swinnen 2015).

To address the concerns related to its legitimacy, in addition to the co-decision mechanism, the EU has strengthened its approach of evidence-based policy-making, including a stakeholders' consultation approach and a system of impact assessment. Even within the CAP, these two elements have increased their importance. Regarding the stakeholders' engagement, a structured debate with all stakeholders, comprising non-agricultural actors, has been established to evaluate progress towards the CAP objectives and identify future challenges (European Commission 2018).

Regarding impact assessment, reliable simulation models of the farming systems are required to assess the effectiveness and efficiency of policy measures, even in the absence of observational data (Louhichi *et al* 2018).

In this respect, this study wishes to give sound scientific foundations to evidence-based policy-making by designing the research agenda for an H2020 project to develop a modular and customisable suite of IDM models that can better mimic the effect of policies aimed at influencing farmers' decision-making.

3. Materials and methods

To define the research agenda of the H2020 project under development, we carried out the analysis through a five-step process using different research tools and involving different actors. In particular, we set up three main working groups: (1) the research team, led by the authors and occasionally supported by other researchers participating in the aforementioned project; (2) the policy-expert team, consisting of researchers belonging to the project's consortium with high expertise in policy-evaluation and impact-assessment methods; (3) and public and private stakeholders selected through the criteria discussed in section 3.2.

We then addressed our two research questions through a set of qualitative tools, including (1) desk research and virtual meetings coordinated by the research group; (2) desk research and virtual meetings with the policy-expert team on the key policy questions relating to agricultural and rural areas; and (3) consultations with the stakeholders to canvass their opinions on which policy questions deserve attention from the farming-sector perspective and which benchmark scenarios are worth modelling.

We describe the five-step process in detail throughout the next sub-sections and synthesise it in figure 1, which shows the steps followed detailing the actors involved, the tools used and the outputs obtained.

3.1. Key policy questions definition

In the first step of the analysis, the policy team proposed a set of relevant policy questions (one or more

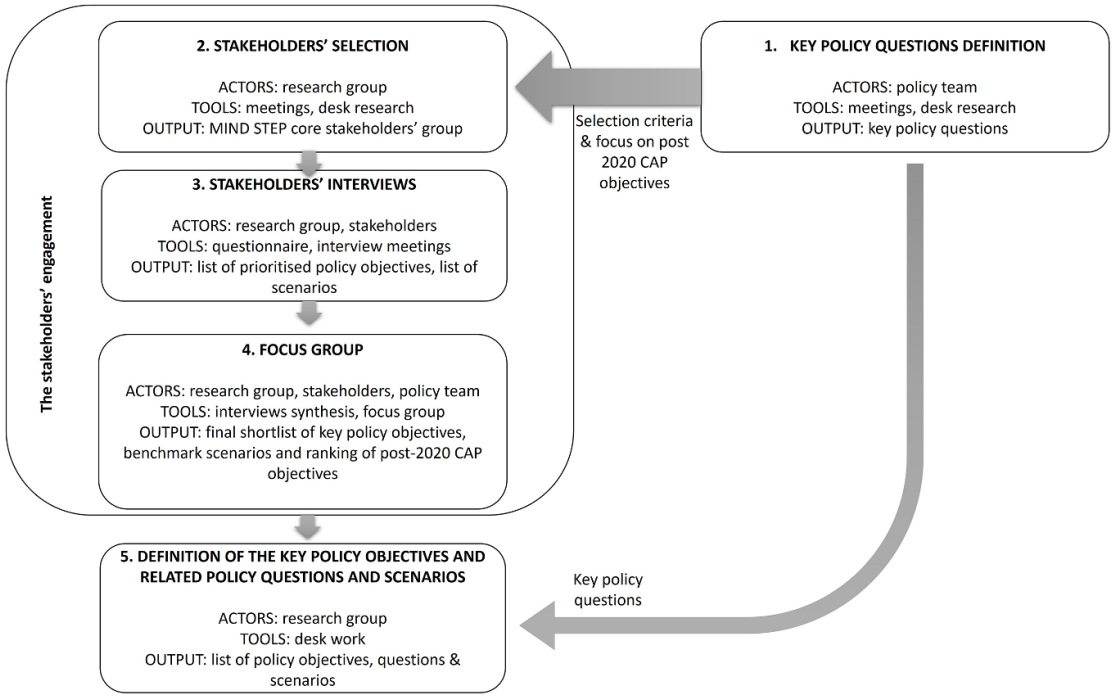

Figure 1. Actors, tools and output of each step of the proposed approach.

questions for each key policy objective of the EU CAP) to be answered by the suite of IDM models and related market models[4] included in the H2020 project model toolbox. The policy team started reviewing both existing policies and future policy proposals and analysed the key global drivers affecting the agricultural sector in the EU. After a preliminary analysis, the group decided to concentrate on the post-2020 CAP objectives for two reasons: (1) this set of goals already covers a wide range of relevant issues, and as a result, they include several far-reaching global drivers (e.g. climate change, environment, food-demand trends, health, energy, technological innovation, etc.); and (2) the CAP reform represents one of the most important policy changes that will impact European agriculture.

Based on the nine post-2020 CAP objectives, the policy-expert team selected highly pertinent policy questions to be evaluated against a set of previously agreed-upon criteria. Through these criteria, we selected policy questions that have the following characteristics:

(a) Have an impact on farmers' individual decisions (or on collective decisions by farmers).
(b) Are related to medium- or long-term issues and affect many farmers, leading to analysis of issues that impact a large share of EU agriculture.
(c) Could be modelled through the project toolbox. This criterion includes, among others, selecting policies for which it is possible to identify a baseline against which to develop appropriate scenario analyses.
(d) Give extra weight to environmental and climate issues in light of the prominence of these objectives for the EU policy agenda.

The work of the policy-expert team provided the key inputs for steps 3 and 5 (see figure 1).

3.2. The stakeholders' selection and interviews

The key part of the work concerned stakeholders' engagement. This pivotal phase involved three different steps (from 2 to 4 in figure 1).

Step 2 of the process consisted of selecting the project's core stakeholders' group. Stakeholders' engagement has been increasingly pursued in research projects and set into sustainability sciences (Neßhöver *et al* 2013, De Vente *et al* 2016, Hagemann *et al* 2020), as it raises the quality and relevance of research by considering more comprehensive information inputs (Reed 2008, Reed *et al* 2009, Ravikumar *et al* 2017, Saidi and Spray 2018, Rochette *et al* 2019). Also, stakeholders' involvement recently has been employed to derive overviews of relevant policy issues (Van Ginkel *et al* 2020).

In the present study, we designed the core stakeholders' group to accurately cover different interest groups, including public- and private-sector representatives, and consider gender balance.

[4] One of the objectives of the H2020 project is also that of creating a link between the results of the IDM models and the market models routinely used for policy impact analysis at the aggregate EU level.

We paid particular attention to the inclusion of two classes of stakeholders: policy-makers and researchers. Since policy-makers at a strategic level are expected to focus on questions with a medium- to long-term time horizon, we strove to involve people who champion, oversee or guide agricultural-policy processes in high-level institutions to foster the dialogue between science and politics (Neßhöver *et al* 2013; Greenhough *et al* 2020). On the other hand, researchers are expected to prioritise policy questions and modelling needs. We expected some familiarity with the project's modelling approach, and they potentially can be interested in using the modelling tools developed in the project.

The final stakeholder group numbered 10 people, representative of each of the following entities: four researchers, two EU policy-makers (from Directorate General Agriculture and Climate), one regional authority, one farmers' association, one consulting company and one cooperative bank. Given the small size and the skewed composition of the group, we defined criteria to mitigate the potential selection bias. For example, we decided to eventually give higher weight to the replies of the underrepresented groups had these situations emerged.

In step 3, we individually interviewed the members of the stakeholders' group. We administered a total of 10 interviews between 19 May and 9 June 2020. Since the COVID-19 pandemic hindered the arrangement of physical meetings, we organised a series of online meetings. The interviews were aimed to supplement the work of the policy-expert team by providing the perspective of heterogeneous interest groups.

We chose to conduct individual semi-structured interviews, as they allowed single opinions to emerge without any external conditioning (Barriball and While 1994). We prepared an informal hierarchy of topics and questions to steer the conversation (Kallio *et al* 2016) and formulated open-ended questions to encourage spontaneous, articulated and unique answers (Dearnley 2005, Krauss *et al* 2009, Baumbusch 2010, Kallio *et al* 2016).

The advantage of semi-structured interviews is twofold: first, informants get the freedom to express their views, and the interview can be more conversational, thus facilitating two-way communication (Barriball and While 1994); second, both the interviewee and interviewer can ask for clarifications. On the cons side, semi-structured interviews are rather time-consuming, and thus they cannot be used for large groups of informants.

Each interview contained the following three questions: (1) '*What agricultural-policy objectives do you consider relevant and worth of investigation today and for what reasons?*'; (2) '*Among the proposed post-2020 CAP objectives, which one do you consider the most relevant, and for what reasons?*'; and (3) '*In this moment, which benchmark scenarios could be useful to investigate to capture their relevant impacts on the EU agriculture and rural sector?*'

Following the suggestions derived from the policy experts' work, we posed a structured inquiry addressing the post-2020 CAP objectives. However, to avoid influencing one interviewee's replies, we designed the first question to be as generic as possible.

The policy-expert team also clearly defined what criteria the stakeholders should follow for selecting the pertinent scenarios. The suggestion was that we remind the interviewees the selected policy issues should comply with the following four requirements:

(a) Have a clear linkage with a relevant EU policy issue related to agriculture (i.e. the CAP and policies related to climate, environment, health, energy, cohesion, innovation, biodiversity, etc.).
(b) Point to a measurable phenomenon (e.g. production, investments, labour use, farmers' income change, structural changes at the farm and sector levels, environmental impacts such as nitrogen input or GHG emissions, etc.).
(c) Have an impact on farm management/IDM by farmers (i.e. policies aimed at influencing farm decision-making, whose eligibility and uptake depend on farm-specific characteristics, like size, specialisation, location, etc.). This has been painted to be particularly relevant, given the focus of the project.
(d) Relate to medium- to long-term fundamental issues (i.e. 5–7 years) and affect a large share of EU farmers (thus excluding short-term policies like temporal restoration after an extreme-weather event or a policy targeted to a specific region or type of farming).

3.3. The definitions of the key policy objectives, questions and scenarios

After the interview sessions, we summarised the results by drafting a brief document shortlisting the policy questions and benchmark scenarios that emerged from the individual interviews.

We presented the document during a focus-group meeting with the stakeholders, policy-expert team and research team (step 4). We chose to discuss through a focus group because this approach is useful for gathering qualitative information to answer specific research questions (Bloor *et al* 2001). Focus groups are also helpful to learn more about a subject and to discover stakeholders' opinions (Morgan and Krueger 1993) while letting spontaneous and unplanned opinions emerge; such opinions might otherwise remain hidden in other social-research methods, such as one-to-one interviews or questionnaire surveys (Gibbs 1997). This type of discussion may also provide the scope and space for interdisciplinary and transdisciplinary conversations, letting interesting cross-cutting issues for future research emerge.

Focus groups are not free of drawbacks. First, the representativeness of the groups may be questionable (Gibbs 1997, Gamboa and Munda 2007). Also, if not adequately moderated, it might be difficult to let the opinion of some participants emerge, as they could be discouraged because of the absence of confidentiality (Gibbs 1997)[5], due to differences in '*social status*' (Bloor *et al* 2001), or because some participants monopolise the discussion (Smithson 2000), perhaps due to power relations (Bloor *et al* 2001). With these caveats in mind, we tried to control all these possible drawbacks during the meeting through an expert moderator of the discussion.

The focus-group meeting was organised on 24 June 2020. Due to the COVID-19 emergency, the focus group took place online. The number of participants was 22. Almost all stakeholders (8 out of 10) attended the meeting, together with the five researchers of the research group and nine members of the policy team. Although the online setting may not be ideal for the discussion, housekeeping rules were clarified before the meeting, and the discussion proceeded rather smoothly.

During the last step (figure 1, stage 5), the research team summarised all the results from the focus-group meeting and complemented them with the work of the policy-expert team. The output of this desk work consists of a shortlist of key policy objectives, related policy questions and benchmark scenarios that are worthy of investigation.

4. Results

4.1. Policy questions reflecting the post-2020 CAP objectives

The policy questions that the project should answer are those defined by the policy-expert team. As mentioned, the team has developed a conceptual matrix in which sensible policy questions get mapped to each of the nine post-2020 proposed CAP objectives. The policy questions were then evaluated against the four above-defined selection criteria and selected according to their relevance to the project. (table S1-available online at stacks.iop.org/ERL/16/094044/mmedia-provides the list of all the key policy questions analysed against the selection criteria).

Overall, all the nine objectives of the CAP are covered by the project modelling tools, but three out of nine (namely: generational renewal, vibrant rural areas and improving the response of EU agriculture to societal demands on food and health) seem less easy to explore, meaning they are not modellable or difficult to model in the H2020 project toolbox.

[5] In the present exercise, these drawbacks should have been weakened by the fact that we already had individual interviews that should have given the possibility to everyone to let his or her opinion emerge in confidentiality.

Figure 2 summarises the results of the evaluation of the policy questions against the selection criteria. Coherently with the project's scope, the policy team has selected only policy questions that impact IDM by farmers. Thus, selection criteria 1 has been satisfied by all the policy questions.

The bulk of the 23 policy questions refers to medium- to long-term fundamental issues. Fifteen out of 23 can be (actually or potentially) modelled by the project's toolbox for quantitative evaluation. For 13 questions, it is easy to identify a baseline of policies against which to develop appropriate scenario analyses. Almost half (10 out of 23) give special weight to the environment and climate change.

4.2. The stakeholders' contribution: The individual interviews and the focus group

The first question stakeholders were asked was, '*What agricultural-policy objectives do you consider relevant and worthy of investigation today, and for what reasons?*' This question has allowed a lack of influence and restricts the discussion to the post-2020 CAP objectives. Almost all stakeholders mentioned environmental topics, highlighting the importance of balancing the economic and environmental performance of the primary sector. What follows are the shortlisted policy objectives included in the brief document prepared for the focus group:

(a) Joint environmental and economic performances: Provision of enough healthy food with minimal impact on the environment and reduced reliance on subsidies, increasing the system's efficiency, climate-change adaptation and resilience.
(b) Provision of environmental public goods with a special focus on climate-change mitigation.
(c) Increasing competitiveness: Make viable farm communities less dependent on subsidies and better risk management.
(d) Foster innovation in agriculture.

During the focus-group discussion, the stakeholders largely agreed with the list, although some further aspects emerged. First, connections in the food supply chain should be emphasised, considering that the recently released F2F strategy aims to comprehensively address the challenges of a sustainable food system. Secondly, among the multiple trade-offs existing in a food system (see section 2), stakeholders pointed that a specific focus should be dedicated to those between economic and environmental objectives and among the environmental objectives themselves, with particular attention on biodiversity issues. Thirdly, short-term versus long-term effects of the different scenarios should be explored.

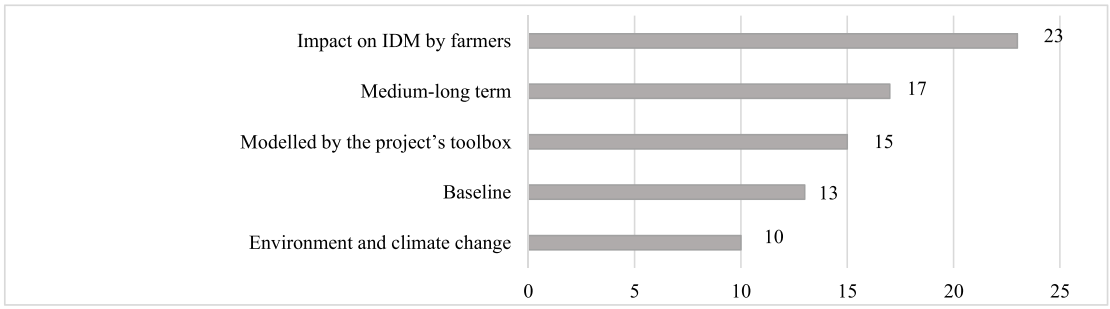

Figure 2. Evaluation of the policy questions against the selection criteria.
Source: Policy-expert team.

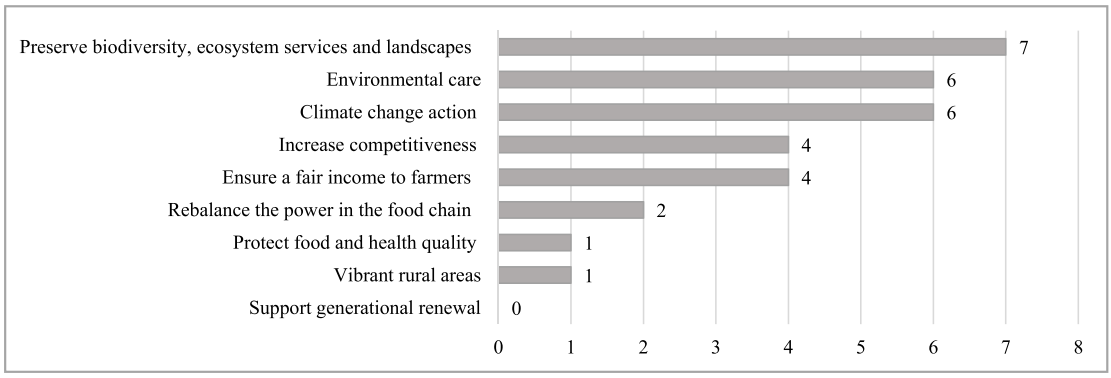

Figure 3. Replies to the question on the most relevant post-2020 CAP objective.
Source: Stakeholders' interviews.

Next, figure 3 summarises the stakeholders' opinions on the relevance of the post-2020 CAP objectives. Each respondent could indicate more than one objective.

Even in this case, a clear focus on environmental objectives emerged, with (a) preserving biodiversity, ecosystem services and landscapes, (b) fostering environmental care, and (c) climate-change action being the most-rated objectives. This ranking is not univocal, as, for some stakeholders, economic objectives were more important, and in general, all stakeholders considered the nine objectives relevant and worthy of investigation.

Finally, the stakeholders were shown the set of proposed benchmark scenarios that emerged from the question '*In this moment, which benchmark scenario could be useful to investigate to capture its relevant impacts on EU agriculture and rural areas?*' administered during the semi-structured vis-à-vis interviews (respondents could provide more than one option). Table 1 summarises the results of this process by classifying the type of scenarios proposed according to their main topic; then, for each topic, it provides two indicators: (1) the number of scenarios suggested by the stakeholders per topic (column 2), and (2) the number of times a topic was indicated in the replies (column 3), as some scenarios have been indicated by more than one stakeholder.

Table 1. Proposed benchmark scenarios grouped by category with the number of scenarios listed and of stakeholders' replies.

Scenario type	Number of scenarios proposed	Number of times cited
Environmental	8	10
Low-carbon scenario	7	9
Animal welfare	1	2
First pillar payment changes	4	4
Cross-cutting issues	5	7

Source: Stakeholders' interviews.

Environmental scenarios include, among others, the creation of markets for ecosystem services and the fostering of their implementation. On the other hand, low-carbon scenarios cover the implementation of different mitigation measures (livestock numbers, nutrient management) and the simulation of top-down policy instruments (e.g. carbon taxes).

The proposed scenarios concerning changes in first pillar payments address the complete removal of subsidies and the re-coupling of support to

environmental services. The latter was often deemed the only rationale for maintaining such payments to farmers.

Cross-cutting issues include, for example, fostering the adoption of risk-management tools.

Finally, the focus-group discussion brought up additional points of attention, emerging as aspects to be considered when designing scenarios. Among these, special attention was given to the possibility to model collective payments to farmers (i.e. the coordination of different farmers to provide environmental outputs).

4.3. Definition of key policy objectives and related policy questions and benchmark scenarios

Table 2 presents the final shortlisted key policy objectives, related policy questions and benchmark scenarios for the ex-ante impact assessment of EU agricultural and rural policies, resulting from the five-step process adopted in this study. In the table, the proposed post-2020 CAP objectives are presented in the ranking resulting from the stakeholders' answers; for each post-2020 CAP objective, the list of key policy questions proposed by the policy-expert team is also indicated. Finally, the table lists the corresponding relevant benchmark scenarios that have been proposed. We classify the policy objectives that emerged from our five-step investigation according to the nine goals of the CAP reform proposal for two reasons: first, stakeholders endorsed the comprehensiveness and relevance of such objectives, and second, these points of action will undoubtedly steer EU agricultural policies in the future.

Exploiting the indications that emerged from the individual meetings and the focus group, we were able to rank the post-2020 CAP objectives from the most relevant to the least compelling. As a result, overall prominent importance has been given to environmental and climate objectives. All the scenarios suggested by the stakeholders have been included in the final list, although they are not homogeneously defined (e.g. different spatial scales, different levels of description detail, etc.), as we wanted to keep the original stakeholder contributions as much as possible without influencing them in any way.

5. Discussion

5.1. Key policy objectives and policy questions

The stakeholders' engagement led to a comprehensive definition of the policy objectives and brought up two major indications: (1) prioritising environmental issues and (2) jointly analysing the economic and environmental performances (at the farm and the territorial levels). In fact, among the post-2020 CAP objectives, the environmental ones were the only ones quoted by most of the stakeholders. Specifically, 7 out of 10 stakeholders quoted the objective 'preserving biodiversity, ecosystem services and landscapes', 6 out of 10 the objective 'fostering environmental care' and 6 out of 10 the objective 'climate-change action'. Although the composition of the stakeholders' group might have stirred the analysis towards a narrower range of subjects, opinions proved to be substantially homogeneous across stakeholder categories. Indeed, all the actors involved indicated as first or second objective one the post-2020 environmental policy goal, sharing, in this respect, a very common vision of future policy goals; thus, mitigation strategies for correcting biases in the focus-group management were not used.

However, what the stakeholders have clearly indicated, is that the environmental objectives are not relevant per se, but they are only relevant if the economic viability of the farming sector is also factored in. This vision was then confirmed by the answers stakeholders gave to the question '*What agricultural-policy objectives do you consider relevant and worthy of investigation today and for what reasons?*' The primary objective was, in fact, the joint environmental and economic performance of agriculture, intended as the provision of enough healthy food with minimal impact on the environment and reduced reliance on subsidies, increasing the system's efficiency, climate-change adaptation and resilience. The second and third objectives, on the other hand, seem to be simply a split of the first one into its components—namely, the provision of environmental public goods and the increase of farmers' competitiveness. Unsurprisingly, the stakeholders considered both to be less comprehensive than the first.

The discussion in the focus group highlighted the importance of trade-offs between the health, environmental, economic and social dimensions, which also is widely stressed by the Commission's CAP reform proposal and the F2F strategy (European Commission 2018 and 2020). In particular, the trade-off between economic and environmental performances and among the different environmental performances have been widely stressed. In general, trade-offs highlight the opportunity costs of one potential choice, and from an economic perspective, one would typically attach explicit costs and benefits to specific sets of actions. Conversely, analysing the trade-offs of interventions in the food system is much more complex and involves estimating potential impacts '*beyond the economic, food security or environmental domain and beyond the sphere of the farmer, consumer or value chain*' (Fresco *et al* 2021). One solution is to consider multiple criteria that make trade-offs explicit, leading to more informed and better decisions (Fresco *et al* 2021). However, this issue is highly related to the definition and use of a proper set of indicators, a task that the MIND STEP project

Table 2. List of policy objectives and related policy questions and benchmark scenarios.

Policy objectives and related key policy questions	Scenario proposed
Preserve biodiversity, ecosystem services and landscapes	
What is the impact of the various policy scenarios on farmland biodiversity?	Creating markets for ecosystem services (e.g. water)
Environmental care (air, soil, water)	
What is the impact of the various policy scenarios on soil protection (i.e. soil fertility, soil erosion, etc) and water quality?	Mandatory reduction of input use (e.g.: −50% use fertilisers, as in the F2F strategy) Mandatory share of UAA cultivated with organic-farming methods (e.g. 25%, as in the F2F strategy) Adoption of collective payments to farmers (e.g. landscape approaches to nutrient policies or agri-environmental payments)
What are the potential impacts of soil-protecting and water-saving technological innovations on some key agricultural indicators?	Create incentives linked to the environmental footprint of agricultural activities Create incentives for energy transition in agriculture (e.g. renewables) Increase the use of EU subsidies for various types of agri-environmental measures
Climate-change action	
What are the likely impacts of climate-change trends on some key agricultural indicators?	[a]
What is the impact of the various policy scenarios on GHG emissions due to agriculture?	Simulate the adoption of subsidies targeted to climate-change mitigation Creating markets for ecosystem services (e.g. carbon) Simulate the adoption of carbon taxes on agricultural production Simulate the adoption of emission trading systems between farms Simulate the adoption of a carbon border-tax adjustment together with other 'domestic' policy instruments Simulate the impact on the agricultural sector of changes in diets (e.g. reduction of meat consumption)
What is the potential impact of technological or management innovation on GHG emissions?	Create incentives to increase carbon sinks by farmers in cropland farming systems Simulate land-use changes derived from different livestock-management options (e.g. more grazing, constraints on feed, constraints on livestock numbers, etc)
Increase competitiveness	
What are the impacts of the various policy scenarios on individual farm productivity, and then at the regional, country and EU levels? What are the impacts of the various policy scenarios on the productivity of the various factors of production? What is the potential role of technological innovation in productivity change? What are the potential impacts of the various policy scenarios on the technological choices by farmers?	Model an increased use of subsidies for innovation adoption (precision agriculture, conservation agriculture, 5G, robotics, artificial intelligence, blockchain, etc)
Ensure a fair income to farmers	
What are the impacts of the various policy scenarios on individual farm income and its distribution across country, regions, type of farms and farm-size classes?	Model the removal of first pillar direct payments

(Continued.)

Table 2. (Continued.)

Policy objectives and related key policy questions	Scenario proposed
What are the impacts of changes in first pillar direct payments on farm income?	Model a further full decoupling of first pillar payments Model a fundamental change in the distribution of direct payments (i.e. linkage of payment to farm labour rather than to farm area or other parameters)
How volatile is farm income under different policy scenarios and global shocks (i.e. climate shocks, price shocks, etc.)?	Model a re-coupling of the first pillar payments to public goods and ecosystem services
What are the potential impacts of risk-management tools on the level and volatility of farm income?	Model the adoption of publicly supported risk-management tools (i.e. subsidised income stabilisation tools)
Rebalance the power in the food chain	
What is the impact of the various policy scenarios on the distribution of value added along the food supply chain?	Simulate the adoption of supply-chain-management tools, such as contracting and producers' organisations
How relevant is the imbalance in market power along the chain in different countries and sectors?	
Can some policy tools contribute to rebalancing market power along the chain (i.e. farmers' cooperatives, producer organisations, etc.)?	
Are high-quality food chains (organic agriculture, geographical indications, etc) a tool for increasing the farmer's share of value added along the chain?	
Protect food and health quality	
What are the impacts of the various policy scenarios on some key indicators of food quality at the farm level (i.e. use of chemicals, use of antibiotics in animal husbandry)?	Introduction of regulations to deal with animal-welfare issues
Vibrant rural areas	
What are the impacts of the various policy scenarios on employment in agriculture and rural areas?	Evaluate the indirect impacts of the previous scenarios on labour and income
What are the impacts of the various policy scenarios on poverty in rural areas?	
Support generational renewal	
What are the impacts of the various policy scenarios on structural change in agriculture?	Simulate farm exit behaviour according to different policy settings
What are the impacts of the various policy scenarios on generation renewal and access by new farmers?	

[a] No scenario was proposed that matched this policy question.

will deal with but going beyond the scope of this paper.

As the policy questions proposed by the policy team are all mapped to each of the nine post-2020 proposed CAP objectives, the key policy questions that the project should answer are linked to the most-rated post-2020 CAP objectives—namely, the environmental ones (table 2). Although almost all these policy questions refer to medium- to long-term fundamental issues, the extent to which they will be modelled by the project toolbox is difficult to establish *a priori*. Indeed, the feasibility of any such analytical exercise largely depends on the specific scenarios defined within each policy question (see next section).

On the other hand, given the status of the current modelling capacity, the policy questions with a clear economic cut are judged readily implemented by the present project's toolbox.

Lastly, the policy questions related to the post-2020 CAP objectives of generational renewal, vibrant rural areas and improving the response of EU agriculture to societal demands on food and health appear less easy to address, given the foreseen project's model's toolbox. However, the impacts of the various policy scenarios on employment and income in agriculture and rural areas can be indirectly evaluated as results of the other proposed scenarios (see next section).

When comparing our results on the most important post-2020 CAP objectives with those obtained from the public consultation 'Modernizing and Simplifying the Common Agricultural Policy' (ECORYS 2017), a clear common focus on environmental objectives emerges. Indeed, the opinions surfacing from this wider EU consultation indicate that people see farmers as suppliers of healthy and safe products while being also responsible for protecting the environment and ensuring animal health and welfare. Therefore, the environmental objectives of the CAP are those that, more than others, justify the high level of interest in keeping a common EU policy on agriculture and rural development into place, with a consensus between citizens and farmers. Regarding the specific environmental challenges, respondents (both farmers and non-farmers) gave clear priority to protecting biodiversity, reducing soil degradation and finding a more sustainable use of pesticides and fertilisers. These results are largely in line with our findings, which point to placing very high relevance on the environmental and biodiversity issues when conducting impact assessments for the EU agricultural sector.

In addition, from the public consultation, the EU level seems to be the appropriate government level of global phenomena, such as mitigating and adapting to the impact of climate change (85% of the respondents), contributing to a high level of environmental protection (73%), addressing market uncertainties (67%) and encouraging the supply of healthy and quality products (62%). This issue would somehow corroborate the EU Commission's goal to establish a new partnership between Europe and farmers based on the CAP (European Commission 2012). However, strong criticism has emerged over the feasibility of this objective (see, among others, Swinnen 2015).

5.2. The benchmark scenarios

Coherently, with the suggestions received by the stakeholders, we record 16 mentions for the scenarios addressing the three environmental and animal-welfare objectives, while another nine touch objectives relating more to competitiveness and innovation. The F2F scenarios-i.e. those simulating the impact of the long-term targets proposed in the strategy (e.g.: −50% use of fertilisers)-also received great attention, but since the interviews took place on the same days the corresponding strategic document was released, these preferences should be considered with due caution. Regarding the other policy goals (rural development, generational renewal, and food safety and quality), the stakeholders suggested only five scenarios, although, as mentioned, many other scenarios will likely produce results that impact these three policy objectives, which will be explicitly evaluated.

In addition to expressing their preferences for specific scenarios (or sets thereof), the stakeholders have also repeatedly stressed two important features that the modelling toolbox should be equipped with: first, contemplating connections between subsectors and heterogeneous actors in the food system; second, focussing on the multiple trade-offs between economic and environmental objectives and among the environmental objectives themselves.

Given the relevance of these remarks, we conversed with the project's modellers to understand the potential of including such representation in developing the modelling framework. The reactions to the first aspect were generally condescending and positive, as connections in the food supply chain are very relevant from a policy perspective.

The project toolbox represents a promising instrument for addressing the complex proposed scenarios. That is, bridging the IDM models and the current EU-wide and global models will allow both addressing policy changes at finer spatial resolution—from global to regional—and considering a wider scope of EU policies related to agriculture, such as the Paris Climate Agreement, the Sustainability Development Goals and, indeed, the F2F strategy. In particular, EU-wide and global models provide a spatially comprehensive set of sustainability indicators beyond

the regions/countries and sectors covered by IDM unit approaches. These typically include food security (availability, access, utilisation, stability), employment, national income, biodiversity, GHG emissions, and land and water use. Given the vast heterogeneity between and within EU countries, with arguably very different geographical, social and cultural contexts across the EU, the flexibility of modelling at the micro-level cannot be understated.

Following stakeholders' suggestions, specific modelling issues have been further detailed as important aspects in scenario analysis. These modelling issues include the differences across countries, regions and sectors, and the relevance of the scenarios' timing and dynamics.

Regarding the different impacts, it has been pointed out that the scenarios proposed do not have external validity, regardless of the context, but in this respect, a differentiation of impacts by member states is foreseen.

Specific focus has been given to the trade-offs between economic and environmental performances and between environmental targets that appeal to the multifunctional value of the agricultural sector, which can also be intended as a source of several non-commodity outputs that exhibit the characteristics of public goods or externalities (OECD 2008). Moreover, since trade-offs hinge on the concept of opportunity costs over sets of potential choices (Buchanan 1991), the modellers suggested that it is always possible to model the trade-offs when these are of the 'money versus adoption' type. On the other hand, modelling the environmental shocks is significantly more challenging, as indicators capturing agriculture's environmental externalities are unavailable. Additionally, modelling the interconnections between agricultural outputs and such externalities is rather challenging from a technical perspective.

Finally, trade-off analysis hinges on the multidisciplinary collaboration between economics and other scientific disciplines (Fresco *et al* 2021). Indeed, the demand for model integration has recently surged, thereby fostering research on combining biophysical and economic components to fully reflect the complexity of multifunctional agriculture (Kragt *et al* 2016). However, this kind of collaboration poses serious challenges that Fresco *et al* (2021) classify into (1) differences in methodology and vocabulary (which include common metrics, data availability and data comparability); (2) resistance from the institutional environment; and (3) disciplinary chauvinism and perceived parasitism.

Another issue that poses interesting methodological challenges concerns the possibility of modelling all the proposed scenarios and investigating any possible overlap. After another brief consultation with all the project's consortium members in charge of modelling, it emerged that 20 out of 25 scenarios can already be implemented through the existing modelling tools, while the remaining five are not yet modellable at present. This first assessment is promising and reveals the potential of the modelling toolbox regarding the scenarios proposed. However, some modelling gaps still exist, particularly when modelling all the proposed scenarios at the IDM unit level.

Take, for instance, the F2F scenario on the mandatory 25% utilised agricultural area (UAA) cultivated with organic-farming methods. The main obstacles in simulating this policy shock at the IDM level are the challenges of modelling farmers' willingness to adopt organic-production practices, which also depends on unobserved economic and non-economic drivers. A similar issue emerges in the scenario 'Simulate the adoption of supply-chain-management tools such as contracting and producers' organisations', in which the IDM representation is very challenging, as some models have no representation of the relationships among supply-chain actors. However, these difficulties should not be interpreted as unmanageable. In fact, acknowledging the current limitations of IDM models and working towards the development of more flexible tools is precisely what lies ahead. Since modelling IDM is the main purpose of the project, efforts will be made to factor in finer behavioural dynamics while aiming for stronger integration of IDM models with the existing aggregate-level tools.

On a side note, modellers also have highlighted the potential overlapping of some scenarios. For example, the simulation of the impacts of GHG-mitigation measures could overlap with the creation of incentives to increase carbon sinks by farmers or with the simulation of land-use changes derived from different livestock-management options. Also, modelling a fundamental change in the distribution of direct payments could overlap with the modelling of a re-coupling of the first pillar payments to public goods and ecosystem services, etc.

To this end, when overlapping scenarios are simulated, they could give interesting insights about the robustness of the simulation—i.e. if results are confirmed by the different scenarios, they could prove to be more robust. The same is true for the use of a model toolbox instead of a single model. In fact, with a model toolbox, simulation results obtained by different models can be compared, thus giving strength to the results if they are similar and presenting interesting complementarities. Moreover, if the results contradict each other, the reasons for discrepancies can be analysed.

Finally, scenarios also present some synergies—e.g. the mandatory reduction of input use could be coupled with creating markets for ecosystem services to provide farmers with an incentive for reducing their input use. Also, the mandatory reduction of input use and the mandatory UAA cultivated with organic methods show some interesting synergies, as

in organic production, chemical use is highly reduced. Synergies between scenarios could give interesting insights on how to minimise or overcome the trade-offs between multiple targets (e.g. economic and environmental performances, among others).

6. Conclusions

This study focuses on identifying key policy objectives, related policy questions and benchmark scenarios that are worth modelling to analyse the IDM response of EU farmers to potential policy changes. Using a mix of desk research, interviews and focus groups, environmental issues emerged as the most relevant and pressing issues that researchers, particularly quantitative-modelling experts, should focus on and put more effort into developing and consolidating tools. Indeed, the common understanding is that modelling the environmental impact of policies is a key activity if one wishes to jointly assess the economic and environmental performances of the EU agricultural sector and the potential trade-offs between multiple environmental objectives. Unsurprisingly, the synthesis of the work yielded a list of key policy questions and related benchmark scenarios with a prevalence of environmental and low-carbon scenarios.

Although the results we present in this paper are only preliminary, they nevertheless provide a promising exercise in gathering valuable opinions and expertise to design the research agenda for developing an IDM modelling approach to support evidence-based policy-making. Further steps of the analysis include selecting proper indicators to capture the impacts of policy changes and identifying detailed bottlenecks and gaps of current models and modelling approaches concerning their ability to simulate the suggested scenarios.

Regarding the policy implications, by providing key policy objectives, related policy questions and benchmark scenarios that could be used to provide reliable simulation models and tools for impact assessment and evaluations, this study aims to represent a first step in the direction of providing a sound basis for the development of evidence-based policy-making.

Of course, this study is not without limitations. First, the representativeness of the stakeholders' sample may be somewhat questionable, although no bias has been detected in the analysis. Secondly, the definition of the scenarios is not always consistent, and some of them tend to overlap. However, this is largely due to our interview strategy: spontaneous yet coincidental replies emerged by not interfering with stakeholders' opinions and giving no strict guidelines to follow in proposing the scenarios.

Finally, several complex methodological issues that underpin scenarios' modelling have not yet been fully explored at this stage of the project, so some scenarios may, in fact, never be implemented in practice. However, it is too early to say which of the more challenging policy setups will eventually be analysed. Still, most future project developments will concentrate on closing the gap between the proposed scenarios and the current IDM modelling capacity.

Data availability statement

All data that support the findings of this study are included within the article (and any supplementary files).

Funding

The study was developed as part of the H2020 MIND STEP project which received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement No. 817566.

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