Study on feeding strategies to diversify the protein sources used in different livestock production systems in the EU

Final report

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c. The Association Française de Zootechnie (AFZ)
d. The CEREOPA (Centre d'Etudes et de Recherche sur l'Economie et l'Organisation des Productions Animales)

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ACRONYMS

AECM	Agri-Environment-Climate Measure
ANF	Antinutritional Factors
BMEL	German Federal Ministry of Food and Agriculture
CAP	Common Agricultural Policy
CBAM	Carbon Border Adjustment Mechanism
CP	Crude Protein
CSR	Corporate Social Responsibility
DDGS	Distillers Dried Grain with Solubles
DG	Directorate-General
EAFRD	European Agricultural Fund for Rural Development
EC	European Commission
EIP	European Innovation Partnership
EU	European Union
EUR	Euro
FADN	Farm Accountancy Data Network
FAO	Food and Agriculture Organization of the United Nation
FEFAC	European Feed Manufacturers' Federation
FNI	Farm Net Income
GAEC	Standards for good agricultural and environmental condition of land
GHG	Greenhouse Gas
GFLI	Global Feed LCA Institute
GMO	Genetically Modified Organism
HP	High protein
LCA	Life Cycle Assessment
LU	Livestock Unit
LULUC	Land Use and Land Use Change
MS	Member State
Mt	Million tonnes
NCA	National Competent Authorities
NGT	New Genomic Techniques
OP	Operational Programme
PA	Prospective Aliment (model)
PAPs	Processed Animal Protein
PDO	Protected Designation of Origin
PES	Payment for Environmental Services
PGI	Protected Geographical Indication
PO	Producer Organisation
protein	Rural Development Regulation

RM	Rapeseed Meal
SCP	Single Cell Proteins
SFM	Sunflower Meal
SSD	Subcluster Studied in Detail
SQ	Study Question
SWOT	Strengths, Weaknesses, Opportunities and Threats
ToR	Terms of Reference
UAA	Utilised Agricultural Area
VCS	Voluntary Coupled Support
WFD	Water Framework Directive

DEFINITION OF KEY WORDS

Throughout the study, we will define **livestock systems** and their feeding strategies at different scales: European Union-wide, in several Member States and at the scale of one Member State. Therefore, several specific terms are used depending on the scale of work:

- **Typical livestock production systems**: Livestock of the same animal species at European Union level, which share common features, such as livestock production system, farm structure, market share and production volume, supply chain structure, sources of feed, characteristics of the regions, access to different feed material.
- **Cluster:** Livestock of the same animal species on the scale of several Member States (between 2 and 4), which share common features, such as livestock production system.
- **Subcluster:** Livestock of the same animal species on the scale of one Member State, which share common features, such as livestock production system.
- **Compound feed**: A mixture of products of vegetable or animal origin in their natural state, fresh or preserved, or products derived from the industrial processing thereof, or organic or inorganic substances, whether or not containing additives, for oral feeding in the form of a complete feed.
- **Concentrates**: A feed used with another to improve the nutritive balance of the total and intended to be further diluted and mixed to produce a supplement or a complete feed. Raw materials composing concentrates can be: crops, co-products (oilseed meals and other coproducts), or non-plant based sources (e.g., fishmeal, see SQ5).
- **Feed additives:** Any intentionally added ingredient not normally consumed as feed by itself, whether or not it has nutritional value, which affects the characteristics of feed or animal products[1].
- **HiPro:** refers to an oilseed meal with a higher crude protein content obtained through a technological process that reduces the fibre content of the oilseed and thus increases the protein content by concentrating it.
- **Protein crops:** legumes (including mixtures of legumes and grasses), and soya bean[2].
- **Extensive and semi-extensive breeding system:** Extensive breeding is a pastoral system characterized by a low animal density, few feed complementation, and pastoral areas that can be far from the farm, while semi-extensive breeding is increasing, with pasture areas that are more directly accessible from the farm, animals that can easily return to the barn at night or during the night and receive other feed that grass.

[1] Glossary | FAOLEX Database | Food and Agriculture Organization of the United Nations.
[2] Definition according to the Coupled Income Support.

1 GENERAL INTRODUCTION

1.1 METHODOLOGY

This section provides a synthetic overview of the methodological approach to the study, with a particular focus on horizontal aspects and on selected key methodological tools. The specific methodology for answering the twelve study questions (SQs hereinafter) is outlined at the beginning of each dedicated section.

1.1.1 Overall approach

The overall approach to the study is structured around **four main tasks**: **structuring**, **observing** (data collection), **analysing** and **reporting**. The study methodology presented here was agreed with the European Commission (EC), and constitutes the output of the "structuring" task. The **data collection strategy** used a combination of tools (outlined in Section 1.1.2) to gather from both primary and secondary sources ("observing" task) the evidence and insights needed to:

1. Develop the **descriptive part** of the study (section 1.3).
2. Elaborate answers to the **twelve study questions (SQs)** (Section 1.3), by applying the related methodology ("analysing" task). Study questions are listed in Table 1 hereunder, with a reference to their respective section in the report.
3. Draw the **conclusions stemming from the study**, identifying the opportunities and limitations to diversify the sources of feed, with particular regard to protein feed, for different livestock species and different production systems in the European Union (EU) ("reporting" task).

Ten case studies allowed a deeper investigation of the studied topics for different species of interest and for specific segmentations (conventional versus non-conventional production, with the latter further distinguished into non-GM, organic and Protected Designation of Origin / Protected Geographical Indication (PDO/PGI)): the rationale for their selection is explained in Section 1.2.

Table 1: Study questions - list

No.	Study question	Section in the report
SQ1	Which are the dominant feeding strategies observed in the typical livestock production systems in the EU, and what are the main drivers behind?	2.1
SQ2	How could the typical feed composition be diversified to include more EU-grown feed taking into account the impact of possible feed alternatives on nutrition values of different feed sources (energy, protein content digestibility, and other nutrients characteristics)?	2.2
SQ3	What would be the main drivers for livestock producers and feed manufacturers to use more EU grown feed sources?	2.3
SQ4	What is the potential of diversifying feedstuff and sources through other imported feed sources, e.g. labelled under recognised sustainability schemes, in order to increase supply chain resilience and public acceptance of feed sources?	2.4
SQ5	Which other strategies could facilitate the diversification of EU feed sources, such as adapting animal breeds, changing production methods, using of feed additives in view of optimizing protein shares and feed ratio compositions, etc.?	2.5
SQ6	How would different replacement scenarios impact the competitiveness and economic viability of the livestock production system analysed at economic operator level (livestock producers, arable crops producers and feed manufacturers)?	2.6
SQ7	Which production systems and which feed sources have the highest potential for economically viable diversification strategies at EU level?	2.7
SQ8	How are supply chains currently organised for both, feed and animal products, in view of their contractual arrangements as well as defined process and quality requirements? Which consequences would different replacement scenarios have on the organisation of supply chains, for both, feed and animal products?	2.8
SQ9	How could supply chains for both, feed types and the animal product(s), be improve<<d to facilitate diversification of feed sources?	2.9
SQ10	Which actions / policy instruments / sector strategies are most promising to facilitate feed diversification?	2.10
SQ11	What are the main drivers for changing land use to increase the availability of the EU feed supply?	2.11
SQ12	How would the defined scenarios for diversification provoke/require land use changes and/or adjustments in livestock production systems at aggregated EU level? What environmental impacts associated with this change could be expected?	2.12

Source: Consortium

1.1.2 Methodological tools for data collection, analysis, answering the study questions

This section describes the tools that were used for collecting and analysing the relevant evidence, elaborating the final judgment for individual SQs, and drawing the overall conclusions of the study. Besides "classic tools" for data analysis such as intervention logic analysis, statistical treatment of primary and secondary data (including Farm Accountancy Data Network (FADN) analysis), analysis of qualitative information provided in the case studies and the surveys at EU level enabling for generalisation, supply chain analysis, etc., two additional specific tools were also used: i) a modelling approach for the simulation of impacts of the scenarios on operators of the studied clusters; ii) a peer review group to consolidate the findings and conclusions of the study. Table 2 provides an overview of the combination of data collection tools and analytical tools that were used in the study, whereas the subsections that follow provide a more detailed explanation of three key analytical tools used in the study: supply chain analysis (Section 1.1.2.1); FADN analysis (Section 1.1.2.2); modelling tools (Section 1.1.2.3).

Table 2: Overview of the different data collection and analytical tools used in the study

Method / Tool	Brief description
Data collection tools	
Desk research / Literature review	Desk research drew on the available literature and datasets to characterise the key elements in the descriptive chapter (e.g., typical livestock production systems) and the key elements for addressing the SQs (e.g., drivers of diversification of feeding strategies). The relevant sources are listed in a bibliography section at the end of this report.
Case studies	Case studies played an essential role in the data collection strategy for the study. Desk research, interviews, modelling, and workshops with stakeholders were carried out in the framework of case studies. Case studies were aimed at assessing possible scenarios for feed diversification (see below, "modelling"), taking into account the specificities of each livestock cluster and subcluster covered by the study.
In-depth interviews	Interviews were used to gather qualitative information from several types of stakeholders at EU level: European Commission services, business stakeholders, NGOs and also consultants and academics. The study team carried out semi-structured interviews on the different study topics. Interviews often complemented the information gathered through the surveys (see below).
Surveys	Surveys allowed to gather more quantitative data from stakeholders in 27 Member States. The surveys were targeted at feed manufacturers, national competent authorities, and downstream business stakeholders. Survey results were processed by using statistical analysis (see below).
Results from other SQ	SQs are tightly linked to each other. As a consequence, the replies to some SQs were based – among others – on the findings of other SQs.
Analytical tools	
Stakeholder analysis	The analysis of the information collected through interviews and surveys was differentiated, wherever relevant and feasible (i.e., the panels of stakeholders were sufficiently representative, albeit not in statistical terms). The analysis was especially aimed at assessing whether a consensus / a wide convergence on a particular position emerged among the consulted stakeholders.
Statistical analysis	Statistical analysis allowed to elaborate: i) quantitative data retrieved through desk research from databases and other sources; ii) the replies to the surveys.
Market analysis	Market analysis allowed the study team to analyse the potential of alternative feed materials from an economic standpoint, with a view to elaborating feed diversification strategies.
Legislative analysis	The relevant EU and national legislation was analysed, mainly with a view to identifying the key policy-related drivers for the elaboration of feed diversification strategies. EU's international commitments, notably in the WTO to analyse the feasibility of possible policy options as presented in SQ10.
Modelling	The outputs of the modelling activities (stemming from simulations run for a number of diversification scenario in the framework of case studies) provided essential evidence for answering a number of SQs.
Peer review group	A peer review group formed by three experts working in the fields covered by the study was consulted to ensure the soundness of the methodology and the quality of the study outputs.
Matrix tabulation	This specific tool was used to make qualitative assessments by attributing a "score" to combinations of several items.
Workshops or online meetings	Workshops or online meetings were held in the framework of case studies to share, discuss, revise the information regarding feed diversification scenarios and the results from the modelling activities. The most representative stakeholders were invited to participate in these meetings and to contribute to the discussion.

Source: Consortium

1.1.2.1 Supply chain analysis

The supply chain analysis was especially important for answering SQs 8 and 9, but also to put the answers to SQs 6 and 7 in the appropriate context. It combines qualitative and quantitative methods and tools, in the framework of the so called "system approach" (which considers all the individual elements of a study object, as a single integrated entity, i.e., a "system")[3]. The analysis focused on the three key dimensions that characterise a supply chain:

1. Its structure, defined by the number of stages (farming, first and second processing, distribution) and by the number, type and size of actors which operate at each stage;
2. Its organisation, defined by the linkages between the actors (direct or indirect control, cooperation/coordination, etc.) and by their geographical distribution;
3. Its functioning mechanisms, i.e., the tools which enable and regulate the interaction between actors (regulations, agreements, contracts, etc.).

The study focused in particular on the aspects of points 2 and 3.

1.1.2.2 FADN analysis

The FADN provides detailed accounting data at farm level in the EU. It is a unique micro-economic database harmonised at the European level and enables information to be computed about the structure of holdings and their economic results for different agricultural holding types. The FADN follows the economic results of a sample of farms across the EU. Each holding has a specific weight, calculated so that weighted averages accurately represent the EU agriculture as well as a given agricultural sector at the regional, national and EU levels. The weighting system is based on three dimensions: regions, Standard Output (SO)[4] and Farm Types.

In the study, datasets from the FADN were analysed in SQ6 with the purpose to understand how different scenarios for the diversification of EU feed sources could impact the competitiveness and economic viability of different livestock production systems. Due to the high number of variables available, FADN data were analysed through the R software.

The limitations of FADN data were duly considered in the interpretation of the results of the analysis: for instance, FADN does not include all agricultural holdings in the EU, but only those that can be considered commercial professional holdings on account of their economic size. Furthermore, the FADN results cannot be displayed when the sample contains less than 15 farms, due to obligations concerning the protection of confidential business information. Most importantly, the FADN database refers to holdings, rather than to specific activities (arable crop farming, livestock farming etc.). The FADN does not display analytical accounts and does not provide the allocation of costs and net value added for livestock activity specifically, but only for farming systems in which livestock is included. Thus, to analyse the competitiveness and economic viability of specific livestock systems, samples of specialised holdings must be used.

[3] A qualitative method often used in the framework of the system approach is the critical factors analysis, which allows a qualitative investigation on the factors exerting an influence on the functioning of a certain system (or on specific aspects of it), such as an agribusiness supply chain. All the factors that are able to exert a positive or negative influence in this regard are identified as critical factors. Critical factors can facilitate (promoting factors) or hinder (limiting factors) the functioning of the system (or of specific elements of the same). In the study, the critical factors analysis was applied wherever the available evidence base did not allow for a quantitative assessment of the relative importance of each variable in explaining an observed phenomenon.

[4] The Standard Output is the average monetary value of the agricultural output at farm-gate price of each agricultural product (crop or livestock) in a given region. The SO is calculated by Member States per hectare or per head of livestock, by using basic data for a reference period of 5 successive years (Farm Accounting Data Network An A to Z of methodology, 2020).

1.1.2.3 Modelling tools

The role of modelling activities in the overall approach to the study is outlined in Section 1.2. Further details on the use of modelling in the framework of case studies are provided in Section 1.2.

Two modelling tools, the EU-level model *FeedMod*, and the *Prospective Aliment (P.A.)* model, were used in the study (Figure 2). Both are based on the least-cost optimisation method, which is used by feed manufacturers to formulate feeds at the least cost, for a particular set of technical, biological, and economic data. The relevant parameters include: animal types and the related nutritional requirements; types of feed materials, the related nutritional values, prices, and available volumes, and the inclusion limits of each feed material in the diets. Data are fed to a linear programming model, which minimises the cost of a given diet (the so-called "formula") to define a list of feed materials and their inclusion rates in a way that satisfies the constraints imposed on some parameters (e.g., a maximum total cost of the diet). Using such models for research and prospective purposes, as it was done in the study, is particularly interesting as it mimics the behaviour of real-life operators, especially feed manufacturers.

The Prospective Aliment (PA) model includes 9 regions and therefore 9 fictitious factories. Each raw material proposed in the model (around eighty) is assigned a factory delivered price for each region. This price is made up of the market price (nearest supplier) plus approach costs (transport). By taking all these factors into account, we can obtain a precise approximation of the cost of using raw materials, and above all their delivered-to-factory price ratio, which will be decisive in the manufacturer's choice.

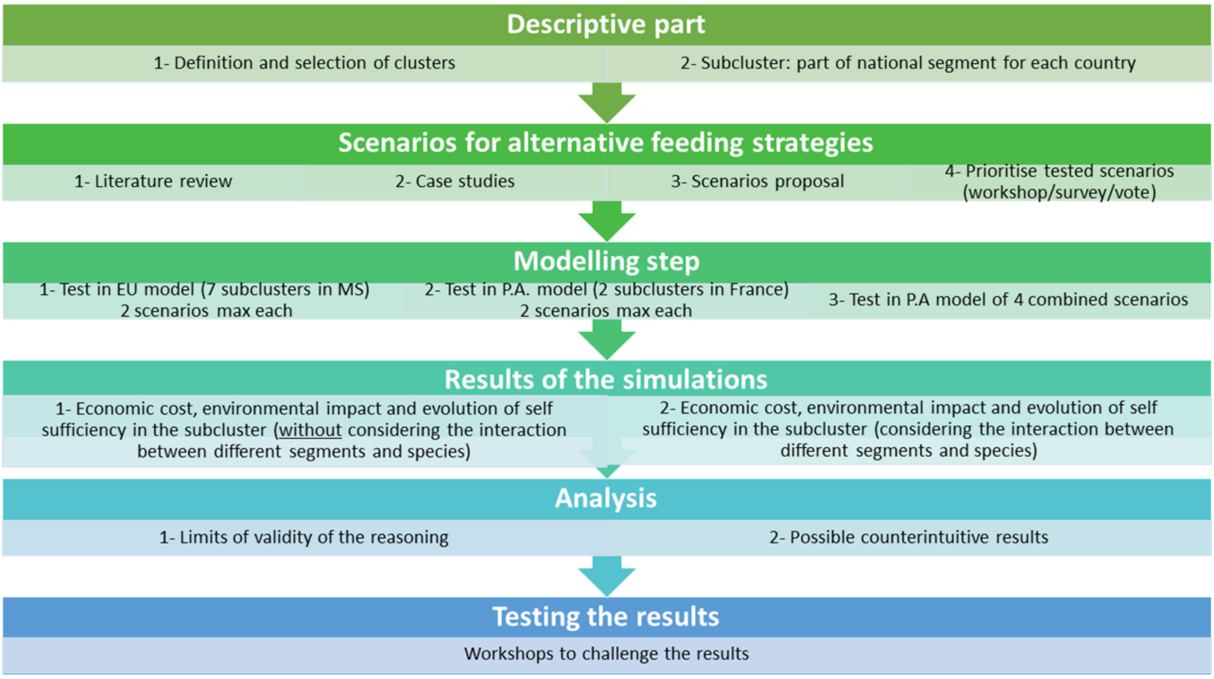
The FeedMod model, in its normal operation, includes empirical equations that predict shipping costs for pairs of price series and "target plants", i.e. theoretical feed manufacturing plants in a region within a Member State (MS). Those equations work under the requirements that feed prices are derived from specific price series that can be strictly associated to those target plants. In addition, the FeedMod model requires all the prices for all the feed materials included in the model. These conditions are met in the normal operation of the model, where the user can be provided with all the relevant price series in real time, and where the geographical distribution of the target plants as well as the choices of livestock are fixed. FeedMod can only work when data are known with certainty.

The models for German pigs and dairy cows were relatively close to the original ones, so FeedMod could be run without many changes: in those 4 scenarios, the model does include shipping costs estimated by the original equations. Unfortunately, these conditions could not be met for the other scenarios. In five scenarios (Beef FR/IT and Sheep SP lambs), we found that FeedMod was not suitable for the modelling, so we used other tools (Optim'Al and GR 2020). In the other five scenarios (Pig SP, Sheep SP ewes, Broiler PL), the nature of the subcluster (livestock production, production areas, feed materials, specific scenario requirements) was such that we had to adapt the FeedMod model. Notably, estimates for shipping costs could not be calculated in a reliable way for all the feed materials. It was thus found preferable to not include them rather than to add extra "noise" to the scenario input data.

One common exploratory use of these models is to check for shadow prices, i.e., the minimum prices at which individual feed materials are or would be included in a diet. Also called interest prices, they correspond to the price at which the first ton of the alternative feed tested is used by the manufacturer without changes in the cost of the manufactured feed. This implies that to be introduced in the composition of manufactured feed/of the ration, the market price must match the interest price.

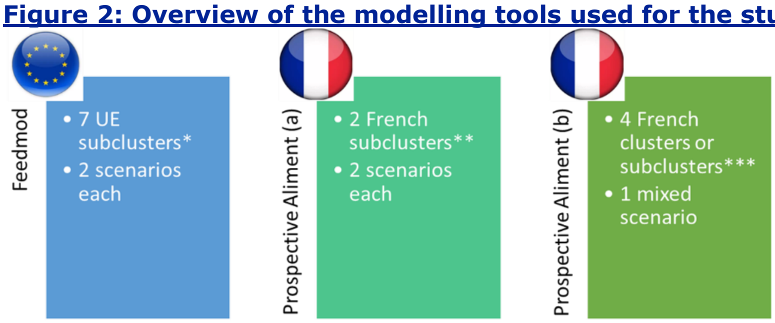
The models also allowed to calculate the quantities of each feed material entering a diet, and the total amount of feed materials used for each animal production system.

Figure 1: The role of modelling activities in the overall approach to the study



Source: Consortium

Figure 2: Overview of the modelling tools used for the study



Source: Consortium

** Conventional pigmeat/Germany; non-conventional pigmeat/Spain; non-conventional dairy cattle/Germany; conventional broiler/Poland; conventional beef/France; non-conventional beef/Italy; conventional sheep meat/Spain*

*** Conventional dairy cattle/France; conventional dairy goat/France*

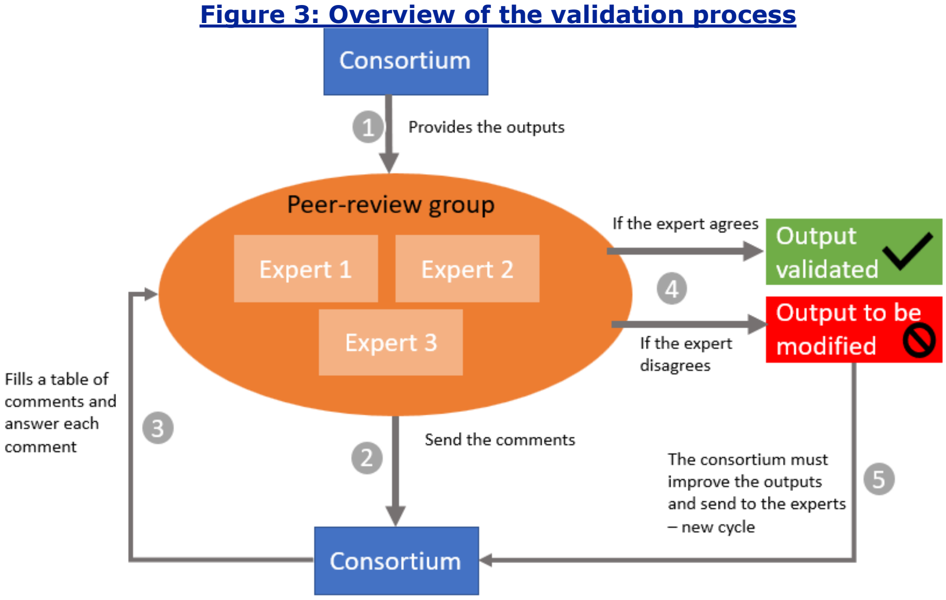
****Chosen among: conventional dairy cattle; conventional dairy goat; conventional pigmeat; conventional broiler, conventional beef*

The "organic laying hens" cluster was studied separately, since feed supply to organic animal farming sectors is specific and lacks any significant interaction with the supply of conventional feed materials.

1.1.3 Validation process

To ensure the soundness of the study methodology and the robustness of its results, the study team set up a validation process, with the same modalities of a peer-review process, which is common in the research sector. Three academics with proven expertise in animal farming and nutrition were selected as peer reviewers, upon approval by the European Commission. The functioning of the process is outlined in Figure 3.

Figure 3: Overview of the validation process



Source: Consortium

These peers reviewed the first interim report setting up the methodology of the study, and the draft final version of the report.

1.2 CASE STUDIES

One of the key components of the data collection and analysis strategy of the study was represented by **10 Case Studies, carried out in a total of 28 subclusters across 13 Member States**.

The **purpose of these case studies** was to *i)* describe the production system and context in each of these subclusters for all the actors of the studied value chain(s); *ii)* identify, test and discuss possible scenarios for feed diversification, taking into account the specificities of each livestock cluster and subcluster covered by the study; and *iii)* formulate recommendations at subcluster and cluster level.

1.2.1 Selection of case studies

The final choice of case studies was the result of combining a selection already included in the Terms of Reference (ToRs) with the Study Team's proposals and expertise. Case studies concern "clusters" that are a combination between an **animal species**, several **geographical areas** in the EU (across several Member States) and a **production system** (e.g., conventional, organic, etc.).

The following table illustrates the **final selection of Case Studies** carried out in the context of this study. Within each cluster, one Member State was chosen as subcluster to be studied more into detail, the focus of scenario selection and modelling (also called SSD, marked in **bold**). When multiple production systems were covered by the case study scope (e.g., in non-conventional productions: organic, non-GM and PDO/PGI) one system was analysed as a priority (e.g., non-GM for beef in non-conventional productions), but data on the others was also included and taken into account.

Table 3: List of case studies

Animal species	Region	Production systems
Pigmeat	**Germany**, Denmark, and France	Conventional – intensive
Pigmeat	**Spain** and Italy	Non-conventional (organic livestock, non-GM fed livestock and PDO/PGI)
Dairy cattle	**France**, Czech Republic, and Poland	Conventional – intensive and extensive
Dairy cattle	**Germany** and Austria	Non-conventional (organic livestock, non-GM fed livestock and PDO/PGI)
Laying hens	**France**, Germany, Denmark, and Sweden	Organic
Broiler	**Poland**, France, and Romania	Conventional – intensive and semi-intensive
Beef	**France**, Belgium, and the Netherlands	Conventional – heifer fattening and yearling male fattening
Beef	**Italy** and Spain	Non-conventional (organic livestock, non-GM fed livestock and PDO/PGI)
Dairy goat	**France**, the Netherlands, and Spain	Conventional – intensive and semi-intensive
Sheep meat	**Spain**, France, and Greece	Conventional – extensive and semi-extensive

Source: Consortium

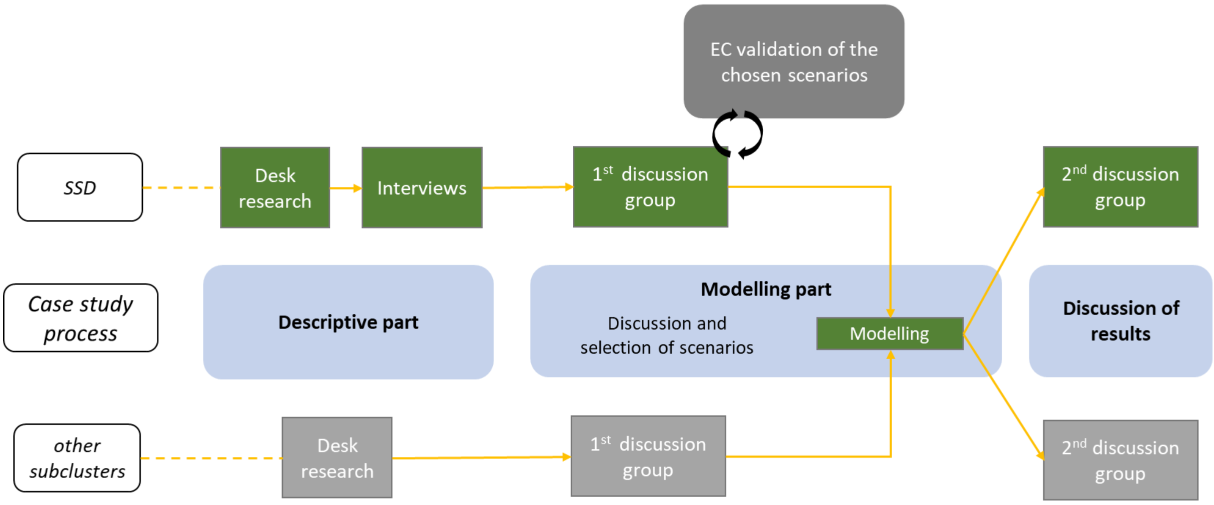
In **bold**, subcluster studied in detail (SSD); in red, non-conventional production systems analysed as a priority

Case studies were possible thanks to the close cooperation of the study team with a network of national experts in the MS involved in the field work, as well as with the European Commission.

1.2.2 Methodology for carrying out Case Studies

This section briefly describes how Case Studies were carried out, and the main data collection and analysis tools that were involved in case study work. Though each case study had a different scope and covered a varying number of MS, case study work followed a common process that is broadly summarized in the figure below. The work ran in parallel in the SSD and in the other subclusters, with the involvement of sectoral stakeholders and experts, and of the European Commission.

Figure 4: Summary of case study methodology and process



Source: Consortium

The **methodology** for carrying out case studies consisted in the **following steps**.

- Descriptive part
  This part had the goal of describing the subclusters covered by the case study (SSD and others), as well as of setting up a stakeholder group in each subcluster.
  1. Description of the SSD, via desk research, covering the main aspects of the production system of interest[5].
  2. Identification of the main stakeholders of the SSD to be interviewed → interviews carried out to refine the SSD description and identify areas potentially relevant for diversification of protein sources.
  3. Description of the other subclusters of the case study (via desk research) highlighting similarities and differences with the SSD.
  4. Identification of the main stakeholders of the other subclusters → contact established to inform them of the case study objectives and procedure.
- Modelling part
  This part represents the core of the case study: it aimed at selecting the diversifications scenarios to be tested and subsequently carrying out the actual modelling.
  1. Identification of scenarios to be tested in the SSD → up to five scenarios identified and ranked in cooperation with stakeholders of the SSD.
  2. Discussion with the European Commission and other subclusters on the suggested scenarios → scenarios are submitted to the European Commission and to stakeholder groups in the other subclusters covered by the case study. Differences, limitations and opportunities are discussed.
  3. Final design and selection of the two scenarios to be tested in the SSD → on the grounds of the above discussions and feedback.

[5] The following topics were addressed: access to feed; livestock production system and prevailing farm structure; demand of products of the studied segment; characteristics of the regions; feeding strategy of the studied segment including the subject of access to land; local production used by the studied segment; organisation of the supply chain(s) studied; legal provisions.

4. Modelling of the effects of the two scenarios in the SSD → following the methodology detailed in Section 1.1.2.3.

- Discussion Part
  The objective of this part was to share the modelling results to the stakeholders in order to discuss the feasibility of the scenarios, and the possible generalisation of the results at cluster level.

  1. Workshop or online meetings with the SSD's stakeholders to discuss the result of the scenarios' modelling → collection of stakeholders' feedback and recommendations.
  2. Workshops or online meetings with stakeholders in the other subclusters, to present the modelling results for the SSD → discussion of the possible generalisation of the results to their own subcluster and recommendations that can feed the study process.
  3. Drafting of a case study report with conclusions at cluster level (all subclusters + possible generalisation at EU level) and recommendations.

1.2.3 Scenarios modelled and discussed

As a result of the process and methodology just described, a total of 22 diversification scenarios were selected and modelled across the 10 case studies. Modelling results and discussions with stakeholders and experts in the different subclusters allowed to **assess the technical feasibility, economic viability, climate and environmental impacts, aptitude for generalisation beyond the subcluster of choice, and overall potential in terms of diversification of protein sources.**

The analysis carried out within each case study form part of the evidence base used to develop the broader analysis conducted for the study questions. An overview of all the diversification scenarios modelled[6] is provided here:

Pigmeat conventional (Germany):

1. Introduction of insect meal (black soldier fly meal, with varying levels of fat content
2. Increasing supply of legumes (peas, lupines, faba beans)

Pigmeat PDO/PGI (Spain):

1. Use of enzyme additives (NSPase)
2. Regional contractualisation for legume crops (peas and faba beans)
3. Diet with ideal protein

Dairy cattle conventional (France):

1. Increase roughage share and improve grassland quality and conservation
2. Increase the production of French soya beans and protein crops. Increase the availability of HP+ sunflower meal

Dairy cattle non-GM (Germany):

1. Increasing efficiency of forage through improving forage management regarding cultivation, preservation and feeding roughage
2. Increasing protein yield in field forage (by using small-seeded legumes like clover in forage crops or by cultivating alfalfa)

Beef conventional (France):

1. Increase the grass share in the ration and improve grassland quality through more grass or grass-legume mixes (meslin)
2. Increase the production of HP + sunflower meal

[6] In addition, for each diversification scenario mentioned, various hypotheses have been tested. In particular, some results of these variants are presented in SQ2 and SQ12 and the related hypothesis are presented there.

Beef non-GM (Italy):

1. Partial substitution of non-GM soya bean meal with an increased use of dried alfalfa in rations
2. Partial substitution of non-GM soya bean meal by increasing the protein content of fodder from meadows

Broiler conventional (Poland):

1. Introduction of legume crops (peas, lupines, faba beans)
2. Utilisation of industrial amino acids

Laying Hens organic (France):

1. Diversify the Raw Materials in the formula via minimal incorporation rate of local protein (shelled field beans, soymeal, sunflower meal)
2. Mixed scenario around methionine: insect meal and HP de-hulled sunflower meal

Sheep meat conventional (Spain):

1. Increased availability of dried alfalfa
2. Improved meadows (higher protein content, higher digestibility)

Dairy goat conventional (France):

1. Increase protein input through grass-based roughage
2. Increase the availability of HP rapeseed meal (45% vs. 37% protein)

The assessment of the potential for diversification of these scenarios and the limitations/opportunities deriving from their possible introduction vary significantly. In some cases, the results of the modelling were deemed both technically feasible and economically viable; in others, however, technical constraints and/or costs perceived as unsustainable, greatly limit the potential of a scenario. Case study conclusions and recommendations sometimes include an overall negative assessment, classifying a scenario as non-interesting for the purposes of increasing diversification of feed sources and ultimately improving resilience and self-sufficiency.

In light of the above, the analysis under the 12 study questions that follow will be based on scenarios whose modelling results brought forth either viable diversification solutions or useful insights for the production systems involved.

In order to better focus the analysis and provide a concise assessment under each SQ, a number of **selected scenarios will be further detailed showing the results but also the limitations**, while others will only be described to a limited extent or excluded for the purposes of the specific study question. This choice is made on the grounds of selection criteria detailed hereunder. These criteria allow to steer the analysis towards diversification scenarios that show some kind of potential in the EU context, in the short, medium or long term. Criteria and the indicators feeding them are illustrated in this section. The actual selection of scenarios may change within each study question and is therefore detailed at the beginning of the related analysis, when relevant.

Technical feasibility

Technical feasibility is preliminarily assessed on the grounds of the following indicators:

- The raw materials' *nutritional values* are relevant to diversify the diets without impairing the zootechnical performance;
- the *technologies* involved already exist, or the development path for their implementation has already been established and shows at least some preliminary results deemed promising (e.g., dehulling for the production of hi-pro sunflower meal);
- the *context* (economic, pedo-climatic, organisational) is suitable for the scenario to bring forth some meaningful changes (e.g., the cultivation of a certain crop is feasible in the subcluster, without the need for heavy recourse to irrigation in areas where water is already scarce);

- modelling results show that the scenario can actually *contribute to increasing protein self-sufficiency* to a non-negligible extent.

Economic viability

- the scenario involves diversification solutions whose costs for the involved operators are sustainable, or anyhow do not entail burdens that are off the scale compared to the current and historical situation in the sector. In this regard, modelling results show positive, stable or only mildly negative economic impacts;
- organisational changes required by the scenario can be carried out without heavy expenditures from operators at one or more levels of the supply chain.

Stakeholders' acceptance

- feedback from stakeholders and experts in one or more subclusters is positive, and scenario implementation is deemed desirable, acceptable or at least not unwelcome;
- discussions with stakeholders on modelling results did not uncover strong objections to core elements of the diversification strategy, that may lead to a full-out opposition to its implementation. Stakeholders objections might relate to technical feasibility or economic viability issues that would not have been identified during the desk analysis.

Adaptability, and generalisation to other contexts

- the scenario has some potential for application beyond the mere scope of the analysed subclusters;
- one or more elements of the diversification strategy can find an application either at EU level or in other subclusters not covered by the case study.

These preliminary selection criteria aim at guiding the reader of this report thorough the analysis and discussion of results. They can be used as reference when delving into the replies to the study questions, that can be found in the following chapter.

1.3 DESCRIPTIVE CHAPTER

1.3.1 The EU livestock sector

1.3.1.1 Importance of livestock in the European economy

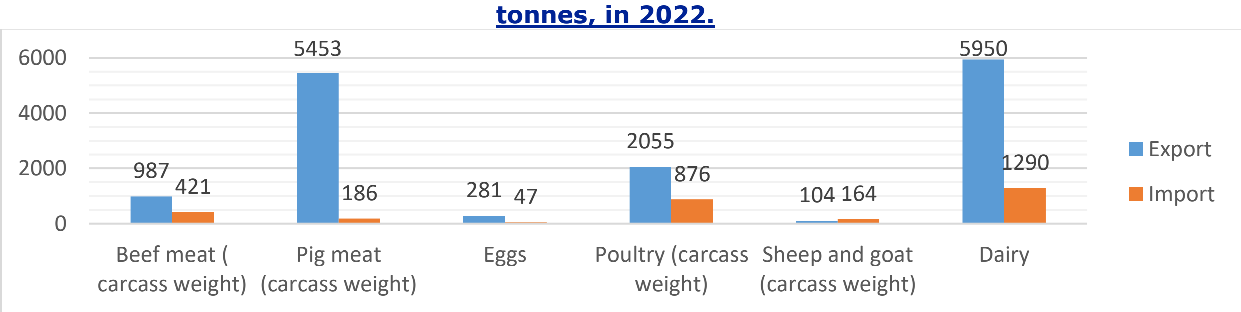
On average over the last ten years, **livestock production has contributed to 45% of the EU's final agricultural output**. In 2019, the value (EUR 161.4 billion) of farm animals and animal products, mainly milk and pigmeat, represented about two fifths (38.6%) of total output of agriculture (EUR 418 billion) in the EU[7].

The **EU livestock sector plays an important role at global level** as it provides 20% of the world milk production, 20% of the world pigmeat production (The EU ranked second, behind China), 12% of world poultry meat (ranking fourth behind the USA, China and Brazil) and 11% of world bovine meat production (ranking third behind the USA and Brazil for bovine meat production) (Chatellier, 2021).

In terms of production, in 2021 the pig sector represented 53% of the meat produced in the EU, followed by poultry meat (30%), beef (around 15%), and sheep and goat (a few percentage). The EU per capita meat consumption increased between 2020 and 2021 (reaching 67.5 kg per capita in 2020-2022), but is quite stable from this year and is set to decline by around 2,2% by 2032[8]. In 2021, the European milk market was highly dominated by the cow milk which represented 97% of the European milk market compared to sheep milk (2%) and goat milk the (1%)[9]. The total production of conventional eggs is close to 6.7 million tonnes (Mt) each year.

In terms of trade balance, as shown in the figure below, **the EU trade balance in animal production is largely positive**.

Figure 5: Trade of animal products from the EU with all Member States, thousand tonnes, in 2022.



Source: European Commission trade balance[10]

Regarding meat products, **pigmeat accounts for most of the exports** (5.4 million tonnes in 2022). The leading net exporters of pigmeat are Spain, Germany, Denmark, and the Netherlands[11]. The EU is also a net exporter of beef meat for which leading exporters are Ireland, the Netherlands, Poland, Spain, and France[12]. For non-conventional beef and non-conventional pigmeat, there is a prevalence of intra-EU trade. However, **the EU is not self-sufficient in terms of sheep and goat meat products**, imports especially come from the United Kingdom and New Zealand (64 130 and 40 679 tonnes, respectively)[13]. In addition, **the EU is a major exporter of dairy products and the world's largest exporter of cheese and skimmed milk powder**[14].

[7] Eurostat, 2020.
[8] EU Agricultural Outlook for markets, income and environment, 2022-2032.
[9] https://www.ahfesproject.com/app/uploads/2021/06/AHFES-A6.2_rapport-produits-laitiers_20210603.pdf
[10] https://agridata.ec.europa.eu/extensions/DataPortal/trade.html
[11] DG Agriculture and Rural Development - EU pig meat historical trade: https://agriculture.ec.europa.eu/document/download/2c37a3d2-2ade-4e9b-b205-422b5088eaa4_en?filename=trade-pig-historical-eu_en.pdf
[12] DG Agriculture and Rural Development - EU beef historical trade: https://agriculture.ec.europa.eu/system/files/2021-07/trade-history-beef_en_0.pdf
[13] Eurostat: https://ec.europa.eu/eurostat/databrowser/view/DS-045409__custom_4876961/default/table
[14] https://agriculture.ec.europa.eu/farming/animal-products/milk-and-dairy-products_en

The Netherlands (3 851million euro) has the highest balance, followed by France (2 511 million euro), Ireland (2 471 million euro) and Germany (2 051 million euro). **EU trade balance of eggs is also positive**, in 2021, the EU exported between 400 000 and 450 000 hatching eggs to Russia, Saudi Arabia and Iraq[15].

1.3.1.2 Specialisation, diversity, concentration of farms

Among the 9.1M farms in the EU in 2020, **21.6% were specialist livestock farms, and one fifth (19.3%) consisted of mixed livestock-crop farms**[16].

The EU livestock sector has a wide structural and economic diversity. The yield per stock head, the size of farms and number of animal heads varies a lot. France and Germany are the main milk producers while Denmark and the Netherlands have the biggest dairy farms, in terms of area and dairy cattle heads. Differences also exist in terms of economic value: for instance, the value of agricultural production on Danish granivore farms is eighty times higher than on Polish beef farms[17].

In places where the availability of land is limited, the growing season is short or where rainfall is a constraint, intensive livestock rearing prevails. In low animal densities areas, beef cattle prevail, and in mountain areas, extensive livestock farming is traditionally operated with sheep and goats (Babette, Lisett and Maren, 2019; Roguet *et al.*, 2015). Further information on the geographical distribution can be found in section 1.3.1.4.2. These concentration and specialisation phenomena have been explained by bio-physical conditions, comparative advantages, scale economies as well as by the industrial organisation of the supply chain. Environmental constraints and rural policies such as specific support to farmers in less-favoured farming areas were not effective in counterbalancing this concentration (Babette, Lisett and Maren, 2019).

1.3.1.3 Conventional vs. non-conventional livestock farming

All along the study, the conventional and non-conventional systems are defined as follow:

- **Conventional**: all livestock farming systems, except those listed under "non-conventional" livestock farming.
- **Non-conventional**: organic, non-GM fed livestock, and PDO/PGI labels.

1.3.1.3.1 EU legal framework on organic products

Organic animal productions have been increasing significantly over the last 10 years. However, they remain low, ranging from 0.9% (organic pig, heads) to 6.5% (organic goats, heads) of total animal population (Bio, 2021). Organic animal products are often driven by a bunch of Member States. Thus, in 2019, 61% of organic milk was produced in Germany, France, Denmark, and Austria; 44% of organic beef was produced in Spain, France, and Italy and 80% of organic pig is produced by four MS (DK, FR, DE, NL). Organic poultry meat is mainly produced in France (55% of EU organic broilers) as well as organic laying hens (28% in France, 20.7% in Germany. In France, organic eggs represented 37.2% of the total egg market.

Producing organically requires compliance with the rules of organic farming, detailed in Regulation (EU) 2018/848 of the European Parliament and of the Council on organic production and labelling of organic products. The main principles are:

- Prohibition of the use of GM feed;
- Limiting the use of artificial fertilisers, plant protection products;
- Prohibiting the use of hormones and restricting the use of antibiotics to only when necessary for animal health;
- Feeding with 100% organic feed[18];

[15] https://agriculture.ec.europa.eu/system/files/2022-11/eggs-dashboard_en_3.pdf
[16] Agri-environmental indicator - specialisation - Statistics Explained (europa.eu)
[17] CEREOPA, based on available data (Eurostat, FEFAC).
[18] Under Regulation (EU) 2018/848, competent authorities in the MS can authorise the use of up to 5% of non organic protein feed for young monogastrics (young poultry and piglets less than 35 kg under certain conditions; the end or prolongation of such derogations will be reviewed in 2026.

- The feed should primarily be obtained from the farm where the animals are kept or from farms in the same region;
- Non-organic feed materials from plant origin, feed materials from animal and mineral origin, feed additives, certain products used in animal nutrition and processing aids can only be used if they have been specifically authorised for use in organic production[19].

Those specification can have consequences on the alternatives to diversify protein feed (see SQ2, SQ5). For instance, synthetic amino acid that may adjust the ration are forbidden.

1.3.1.3.2 EU legal framework on non-GM products

For the needs of agriculture and to feed people, plants and animals with the most desirable characteristics have been, for centuries, selected. However, modern biotechnology techniques have made it possible to modify the genetic material of crops to give them new characteristics (e.g., tolerance to an herbicide, resistance to a disease, to an insect or to drought, yield or nutritional values improvement, etc.). **The cultivation of those genetically modified organisms (GMO) plants is prohibited in the EU**, with the exception of MON810 maize, which is mostly grown in Spain and Portugal, while several other Member States have requested a geographical exclusion to prohibit its cultivation[20].

For animal feed use, eight GMOs (four maize varieties, three rape varieties and one soya bean variety) are authorised under Directive 90/220/EEC. Although EU farmers cannot grow GMOs, the EU livestock can be fed with these GMO plants. This situation is regularly underlined by the EU agricultural sector (see SQ10). Recently, **new genomic techniques (e.g., targeted mutagenesis and cisgenesis) have revived the debate on GMOs.** The European Commission adopted on 5 July 2023 a proposal for a Regulation of the European Parliament and of the Council on plants obtained by certain new genomic techniques and their food and feed. According to this proposal, the NGT (new Genomic Techniques) plants considered as equivalent to conventional ones would not be subject to the EU GMO Regulation (authorisation process, traceability, labelling requirements, etc.). Nevertheless, they would be prohibited for the organic sector.

1.3.1.3.3 EU legal framework on PDO/PGI products: the example of Reblochon cheese and Iberian ham

Geographical indications allow consumers to recognise and trust quality products, while helping farmers to better market their products[21].
PDO products are those with the strongest link to the geographical area where they are made. PGI products emphasize the link between the geographic area and the name of the product if it has gained a particular quality or reputation that is attributable to this area.
PDO/PGI products usually come with specifications regarding the

Box 1: Examples of two PDO/PGI products

Reblochon cheese specifications (France, dairy cattle):
According to the specifications, the forages shall come from the geographical area of Reblochon (France), with the exception for farms located above 600m, which shall only use a minimum of 75% of forages that come from the geographical area of Reblochon PDO. Only hay can be purchased outside of the geographical area. The use of silages or GM feed is prohibited. Finally, only three breeds can be used to produce Reblochon: Abondance, Tarentaise and Montbéliarde (INAO, 2015)

[19] https://agriculture.ec.europa.eu/farming/organic-farming/organic-production-and-products_en
[20] Austria, Bulgaria, Croatia, Cyprus, Denmark, France, Germany, Greece, Hungary, Northern Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, the Netherlands, Poland, Slovenia, and Wallonia , more details here : https://food.ec.europa.eu/plants/genetically-modified-organisms/gmo-authorisation/gmo-authorisations-cultivation_en
[21] https://agriculture.ec.europa.eu/farming/geographical-indications-and-quality-schemes/geographical-indications-and-quality-schemes-explained_en

local origin of the feed, or the transformation process taking place in the geographical area. The specifications vary greatly between the various PDO/PGI certifications, but a geographical link to the specific territory is always specified. The specifications for two PDO products are detailed in the Box opposite.

Iberian ham specifications, PDO Dehesa Extremadura (Spain, pigmeat):
Iberian ham is made from acorn-fed pigs, from the Iberian breed. It can be either 100% Iberian or only 50% (minimum). The maximum number of pigs per ha depends on the number of oak trees on the grasslands (Dehesa system). The pigs shall stay on the farm for at least 60 days. (Ministerio de Agricultura, 2014)

Source: Consortium

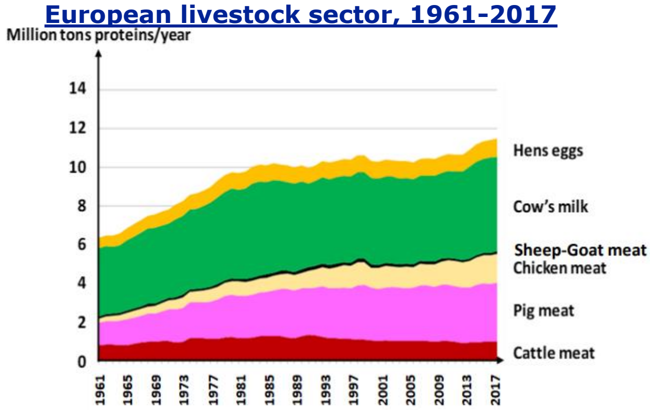
1.3.1.4 Livestock distribution in the EU

As the report concerns the feed requirements of animals, and in particular their protein coverage**, the calculation was made to reason in terms of Livestock Units (LU) according to definition by Céréopa's methodology throughout the study.** In fact, LUs by the Eurostat methodology only are particularly relevant in terms of the energy requirements of ruminants and could underestimate the protein needs of monogastric animals. The data used come from Céréopa's methodological work on Eurostat statistics (for the year 2021 when available) and FEFAC statistics, as well as from data collected during the case studies. They enable to count all the animals to be fed over a full year in each Member State and for each species. LUs by Eurostat methodology and heads may be used to define relevant indicators for extrapolating certain results to the European level at the end of the study.

1.3.1.4.1 Total herd

According to the ToRs, the number of livestock units increased from 1960 to 1990, decreased between 1991 and 2014, and has slightly increased again in recent years. In total, the EU today has far more pigs and poultry than in the early 1960s (+55% for pigs), but fewer ruminants (-6% for cattle, -17% for sheep). The Figure below shows the evolution of the protein output of the livestock sectors mentioned and shows the sharp increase between 1960 and 1990, due, among others, to an increase in productivity.

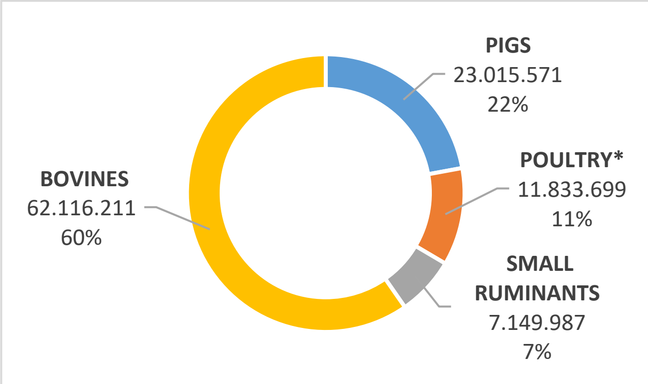
Figure 6: Evolution of the protein output of the European livestock sector, 1961-2017



Source: EU Animal Task Force, based on Food and Agriculture Organisation of the United Nation (FAO), 2020

In 2021, the total EU livestock amounts to more than 104 million LU. The bovine animals are the most numerous, as they represent more than half of the total herd with more than 62 million LU. Pigs come second with 23 million LU, representing 22%. Laying hens and broilers are less numerous, and the small ruminants (sheep and goats) are the less numerous, representing 7% of the LU.

Figure 7: Breakdown of LU in EU (2021=104 115 468)

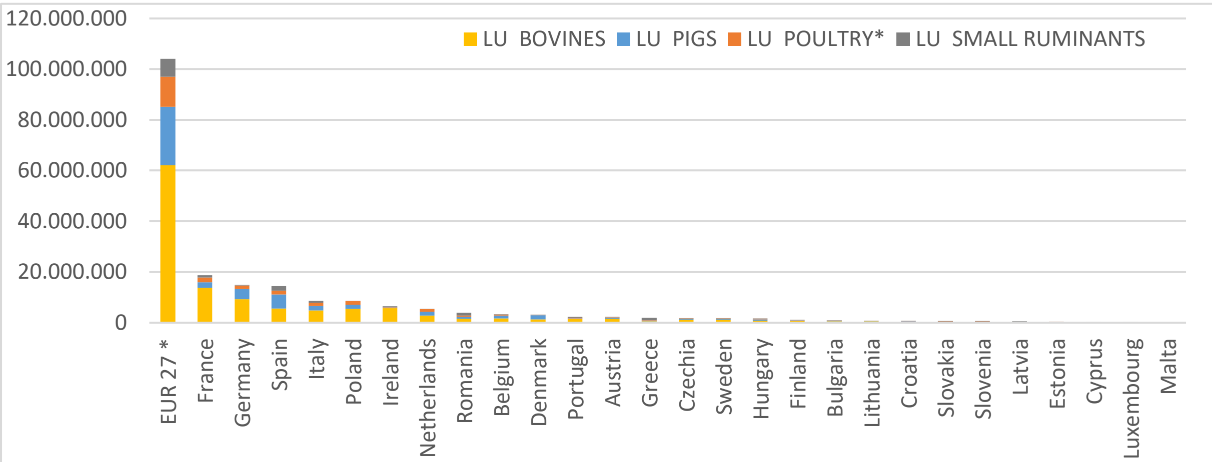


Source: CEREOPA, based on available data (Eurostat, FEFAC)
hens 2021 and broilers 2016

1.3.1.4.2 Geographical distribution of livestock sectors

The livestock sector in the EU is dominated by a small number of large Member States, which are mainly France, Germany, Spain, and Italy. France, Germany and Spain are the leading Member States in all clusters, except for conventional broilers (led by Poland) and non-conventional goats and sheep, led by Greece (see Figure below).

Figure 8: Types of livestock per Member State (LU, 2021)

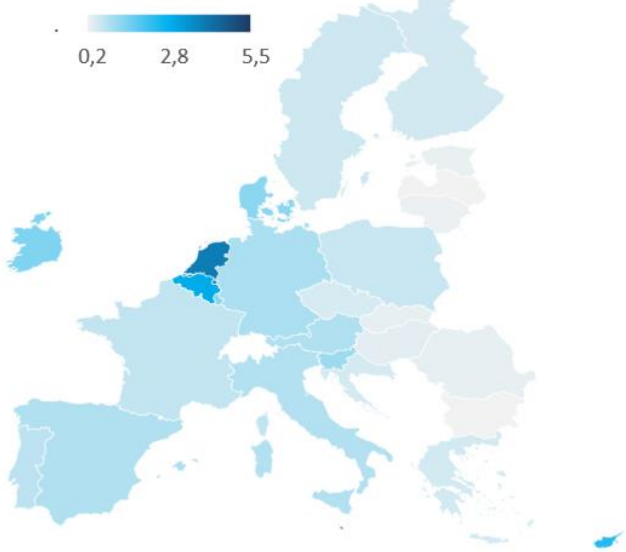


Source: CEREOPA, based on available data (Eurostat, FEFAC)
hens 2021 and broilers 2016

It appears quite natural that the biggest Member States have the most important livestock herd, however, the ratio of the LU per available feed areas, showed in the following maps, highlights the weight of livestock production among smaller Member States such as the Netherlands and Belgium.

The ratio of LU per UAA (Utilised Agricultural Area) is not homogeneous in the EU (between 0.2 and 5.5). Malta has the highest ratio (5.5 LU/ha), Netherlands comes in second (4), and then Belgium (2.9).

Map 1: Ratio total LU/UAA (excluding crops not used in the livestock feed*), EU-27 = 0.8



Source: CEREOPA, based on available data (Eurostat, FEFAC)
with Bing © GeoNames, Microsoft, OpenStreetMap, TomTom

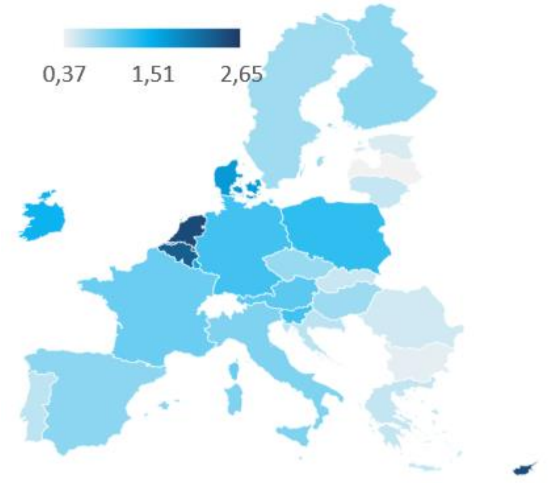
*Crops included : protein crops, oilseeds, harvested green plants, cereals, permanent grassland; crops excluded : root crops, fibre crop, fresh vegetables, permanent crops and others.

The stocking density (i.e. number of animals/hectare) varies throughout EU27 and is an interesting parameter to mark specific needs for feed supply.

Regarding ruminants, the ratio LU/forage areas is far to be homogeneous across the EU (between 0.37 and 2.65). Member States with large ratio include big Member States located in the Northern-East EU, like Germany and Belgium, but Malta and Cyprus also have a high ratio. The Member States with the lowest ratios are located in the Eastern EU.

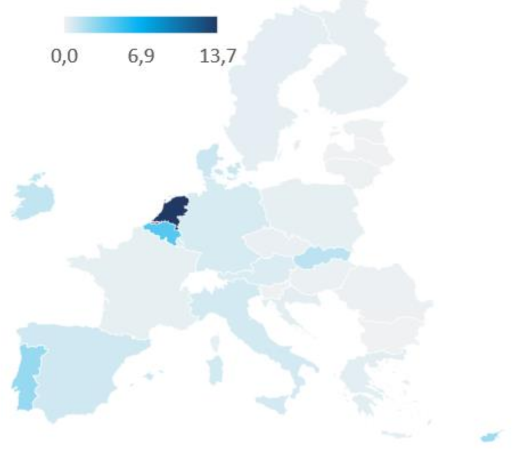
As for monogastric species, the ratio LU/area other than forage is far to be homogeneous in the EU (between 0 and 13.7). Most of the EU territory has a low ratio, but some Member States stand out. The Netherlands have the highest ratio (13.7), Belgium comes second, with a ratio amounts to 4.5, and then Portugal with 2.6. Member States located in the Eastern EU have lower ratio.

Map 2: Ratio total ruminant LU/forages areas, EU-27=0.99



Source: CEREOPA, based on available data (Eurostat, FEFAC)
with Bing © GeoNames, Microsoft, OpenStreetMap, TomTom

Map 3: Ratio total monogastric LU/areas other than forage, EU-27=0.5



Source: CEREOPA, based on available data (Eurostat, FEFAC)
with Bing © GeoNames, Microsoft, OpenStreetMap, TomTom

The geographical distribution of the different production system is also quite heterogenous across the EU. As a general trend, monogastric animals raised in Eastern and Southern Europe are more likely to be in conventional breeding systems. On the contrary, organic breeding systems for monogastric breeds are more widespread in Northern Europe and Austria. For monogastric and ruminants, non-GM breeding systems are more developed in Northern Europe, especially for dairy cattle. The organic breeding of ruminants is more developed in Central and North-eastern Europe, and in Member States with smaller herds. However, Greece has a significant share (around 10%-15%), of its sheep and goats raised in organic, whereas it has among the largest herds in the EU for these species. Dairy cattle is the only sector for which the data on PDO/PGI production systems are available, and organic production is mostly developed in Southern Europe.

In terms of total herd, the conventional sector is dominated by a small number of large Member States, mainly Spain and Romania for small ruminants, France and Ireland for ruminants, Spain, Poland and France for monogastrics. 16 Member States have more than 80% of conventional beef cattle and the lowest share of conventional beef is 53.5% (Lettonia). For the small ruminants (sheep and goat), the conventional production system is dominant, with 20 Member States having more than 80% of their herd in conventional system (19 Member States for sheep herd). The conventional broiler sector is very concentrated: Poland has the largest conventional flock, representing 97% of its total herd, and one fifth of the EU conventional flock (other largest producers are Spain, France, the Netherlands, and Germany); however, for laying hens, the conventional production system is very present in all Member States: 18 Member States have more than 90% of their hens in conventional system[22]. The conventional production system dominates also for the pig sector: 23 Member States have more than 90% of their herd with conventional pigs. Sweden and Finland are the two Member States with the lowest share of livestock in conventional production (1.8% and 51.9%).

In summary, the EU is one of the world's biggest producers of animal products especially for dairy products, and pigmeat, both sectors (combined) representing almost 40% of the total EU agriculture output (EUR 418 billion). The balance of trade is largely in surplus (give percentage), for both ruminant and monogastric products. The main meat product to be exported is pigmeat, and the EU is a major exported of dairy products (largest exporter of cheese). Only for goat and sheep productions, the self-sufficiency rate is below 100% (net import of 164 thousand tonnes in 2022). European livestock farms are concentrated and

[22] Although lack of data on the other production systems may explain this big share.

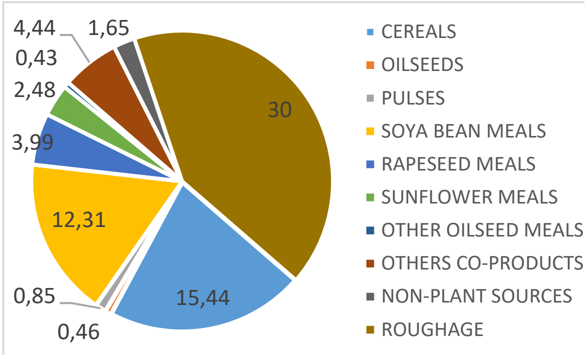
specialised, but production structures and conditions (soil/climate, agronomic, economic) vary greatly from one territory to another within the EU. The importance of the livestock at the EU scale, in terms of production and international trade requires sufficient and qualitative feed supply, especially in terms of protein.

1.3.2 Protein feed demand and supply by livestock sector in the EU

1.3.2.1 Plant protein consumption for livestock in the EU

The consumption of feedstuff (product weight) by the livestock sector was forecasted to reach 1,300 million tonnes in 2020-2021. **A large amount of feedstuff comes from roughage (80%)** such as grass and fodder crops grown and used on farms, **the remaining 20% comes from crops** (cereals (13%), oilseed meals (6%), mainly composed by soya bean, sunflower and rapeseed meals, and pulses). Each feedstuff has different protein content, and **the demand of crude proteins, in the EU-27, amounts to 72 million tons in 2020-2021**[23].

Figure 9: Breakdown of the EU-27 total Plant Protein use in million tonnes of crude protein (72 Mt) by taking all plant protein sources



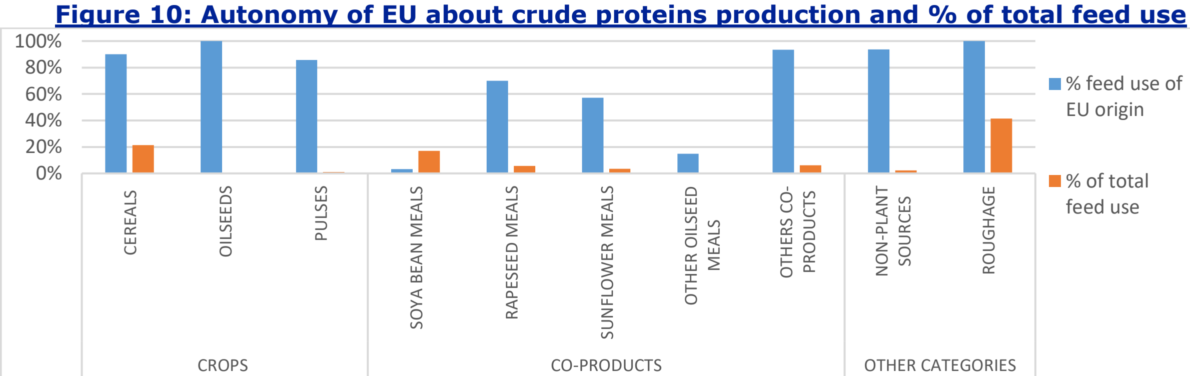
Source: EU Feed Protein Balance sheet (forecast), Campaign 2021/2022

Crude proteins mostly used in the EU feed in 2020/2021 mainly come from roughage (30 Mt), followed by cereals (15.44 Mt) and soya bean meals (12.31 Mt). Rapeseed and sunflower meals represent less used sources of proteins, just like the other co-products. The non-plant sources represent only 1.65 Mt, and the other sources like pulses are used to a lesser extent. Since 2007-2008, the consumption of meals other than soya meal has seen an increasing growth trend (see Source: Consortium based on Eurostat data).

1.3.2.2 The EU protein self-sufficiency

According to EU feed protein balance sheet (2021-2022), the EU's crude protein demand of 72 million tonnes is partly met with 55 million tonnes of crude proteins coming from the EU, representing around **77% of protein autonomy**. The EU feed marked is autonomous in roughage, 94% of non-plant sources feed and 90% of cereals feed are produced in the EU, but **only 37% of co-products (e.g., protein meals) are produced in the EU. Oilseed meals and more specifically soya bean meals account for a significant share of total feed used. Soya bean meal has a low self-sufficiency ratio of 3%.**

Figure 10: Autonomy of EU about crude proteins production and % of total feed use



Source: EU Feed Protein Balance sheet (forecast), December 2022

[23] EU feed protein balance 2021 – 2022.

The EU self-sufficiency in protein sources has slightly varied over the past decade between around 76% and 80%. This figure hides some differences among the different protein sources. Indeed, the EU is 97% self-sufficient on low protein sources (e.g., common wheat, etc.). Medium protein sources (e.g., broad beans, field peas, etc.) and super-protein sources (e.g., fish meal, processed animal proteins) ratio are also high - respectively 85% and 88%. **However, the self-sufficiency ratio is low (27%) for High Pro protein sources** such as oilseed meals.

Figure 11: EU self-sufficiency in protein sources

Source: FEFAC, based on EU feed protein balance sheets, 2022

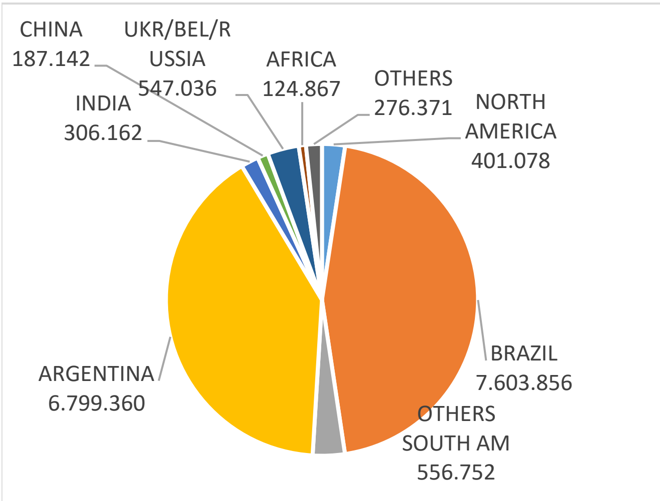
The EU relies on imports of soya bean meal (16.6 million tonnes in total in 2020) sunflower meal (2.7 Mt of which 47% from Ukraine in 2020), and in high protein by-products as Distillers Dried Grain with Solubles (DDGS) for 1.1 Mt[24]. Corn grain imports also rose from 5 to 20 Mt from 2010 to 2020.

1.3.2.3 Imports of feed products

For the 2021/2022 period, the net imports of the EU-27 amounted to almost 15 Mt of soya beans, 5.6 Mt of rapeseed as well as 16.8 Mt of soya bean meal24[24]. For grain corn, imports have increased from 5 to 20 Mt between 2010 and 2020[25].

Among the oilseeds and oilseeds meals for which the EU self-sufficiency is the lowest (i.e. soya bean meals, sunflower meal or rapeseed meal), the main regions of origin are western Europe and the Americas (but mainly South America). Ukraine and Russia collectively account for 40% of the imports of rapeseed meals (for which the EU is approximately 70% self-sufficient) and for 27% of the imports of the sunflower meals (for which the EU is approximately 57% self-sufficient). Soyabean meal, of which EU is approximately 3% self-sufficient, mainly comes from Brazil and Argentina. These two countries account for around 86% of soya meal's origin[26].

Figure 12: EU soya bean meals imports (2021-2022, total imports: 16.8 Mt)



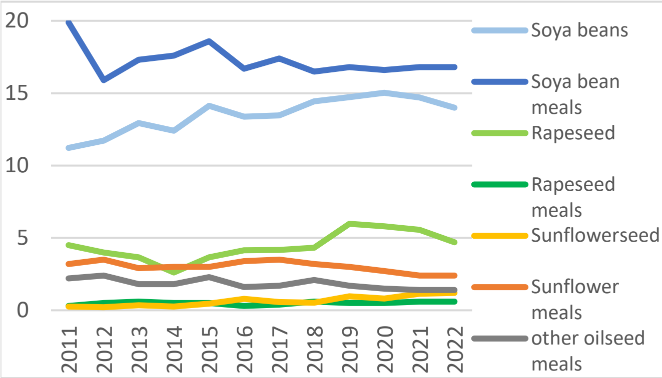
Source: Consortium based on Eurostat data

[24] EU feed protein balance sheet 2021-2022.
[25] https://agridata.ec.europa.eu/Reports/Cereals_Dashboard.pdf
[26] Consortium based on Eurostat data.

Among the protein feed products imported in the EU in the last decade, the soya beans and soya bean meals account for the highest share. Imports of soya bean meals amounted to 20 Mt in 2011, and have been quite stable in the last 3 years. Imports of soya beans have been increased from 2011 to 2020, and started decreasing in the last two years. Rapeseed and sunflower meals come second, fluctuating around 4 Mt in the period.

Even if high content protein products are highly used in animal production, it has to be mentioned that grass and roughage still represent a significant share of crude protein (see Figure 10).

Figure 13: Imports of feed products in the EU (millions of tonnes), 2011-2022



Source: EU Protein Balance Sheet

1.3.2.4 EU oilseed and dry pulses

1.3.2.4.1 Supply chain of soya bean in the EU

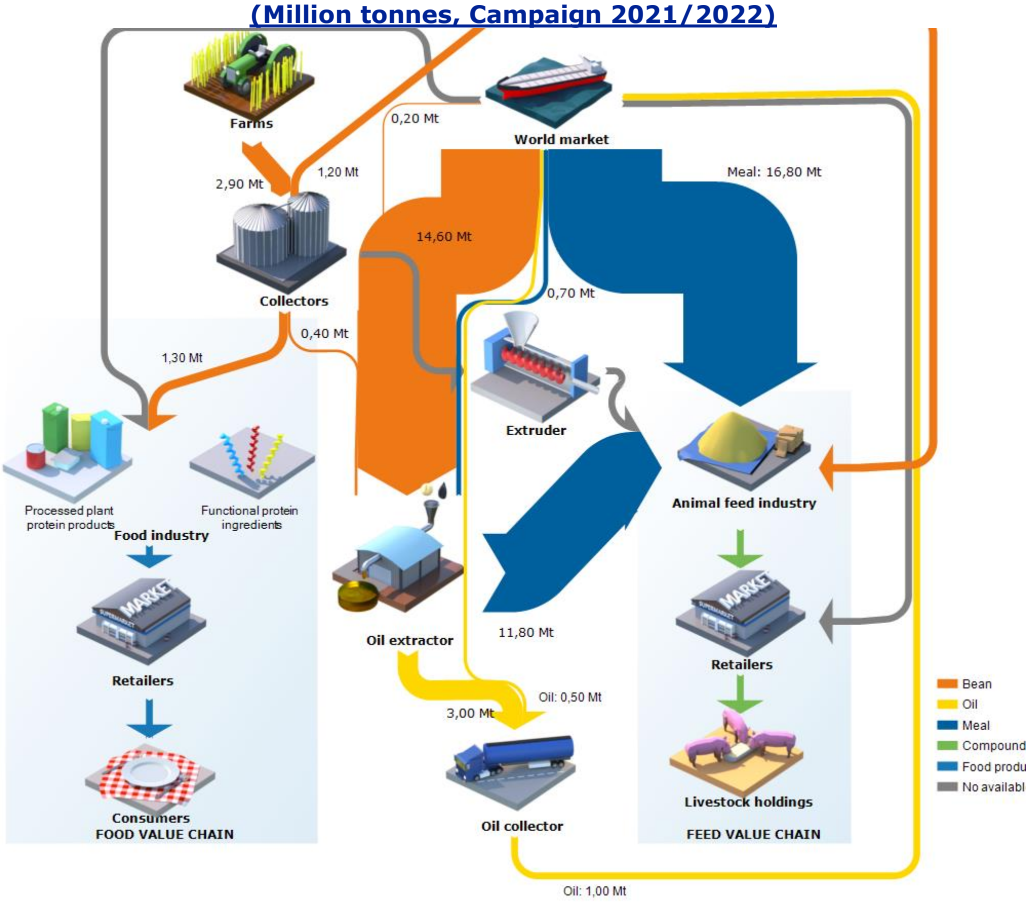
The EU farms produce 2.9 Mt of soya bean grain[27]. Collectors deliver soya beans to oil extractors, to the food and feed industry and to extruders. Oil extractors import 14.6 Mt of soya beans and transform it, with the grain from the collectors, into 11.8 Mt of crush mainly going to the feed industry and into 3 Mt of oil going to oil collectors[27]. The compound feed companies, also import 16.8 Mt of soya meal[27] and process it, with the incorporation of other raw materials into compound feed, sold to intermediaries and/or then to livestock farms.

The figure on next page gives a summary of this supply chain, the size of the arrows being proportional to flows.

[27] EU oilseeds balance sheet 2021-2022 https://agriculture.ec.europa.eu/data-and-analysis/markets/overviews/balance-sheets-sector/oilseeds-and-protein-crops_en

1.3.2.4.2 Total EU supply and demand for feed protein

Figure 14: Main flows of materials to sustain the demand in the soya bean sector (Million tonnes, Campaign 2021/2022)



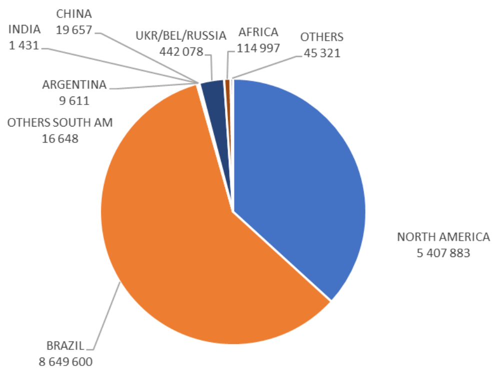
Source: own work based on previous work and several sources: EU Feed Protein Balance Sheet (EC), oilseeds, oilseed meals & vegetable oils supply & demand (EC), Eurostat. Campaign 2021-2022

For this supply chain, the most significant supply comes from imports and the largest demand is for feed (98% of volume).

1.3.2.4.3 Related tensions on soya bean global markets

EU imports of soya bean and soya meal, which are the main sources of EU imports of plant proteins, are dominated by 3 main producers: Argentina, Brazil, and the United States[28], where the production cost is unbeatable. Due to this oligopolistic situation, **the EU supply of soya bean (and soyabean meals) is very dependent on the production and policies in these exporting countries. As for organic soya beans, they come from West Africa and Asia.**

Figure 15: EU soya beans imports (2021-22, total imports: 14.7 Mt)

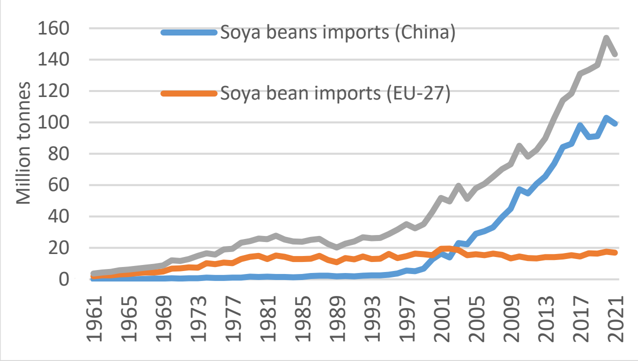


Source: Eurostat

[28] Comext.

Furthermore, world demand for proteins has drastically increased, mostly driven by the demographic boom and diet changes in Asia, especially in China. The figure below shows a major change in the imports of soya beans after 1995 in China. They represented nearly 100 million tonnes, that is around 62% of the soya beans traded on international markets in 2020/2021. This gives them considerable weight in the development of world prices. It has to be noted that the data for the EU include intra-trade, but given the low soya beans production in the EU, the intra-trade of this product is rather low. Hence, the stagnation over the period can be considered as representative.

Figure 16: Soya beans imports by China and EU-27* (Mt) and exports from Brazil/Argentina/USA (Mt)



Source: FAOStat 2021
**includes intra-trade*

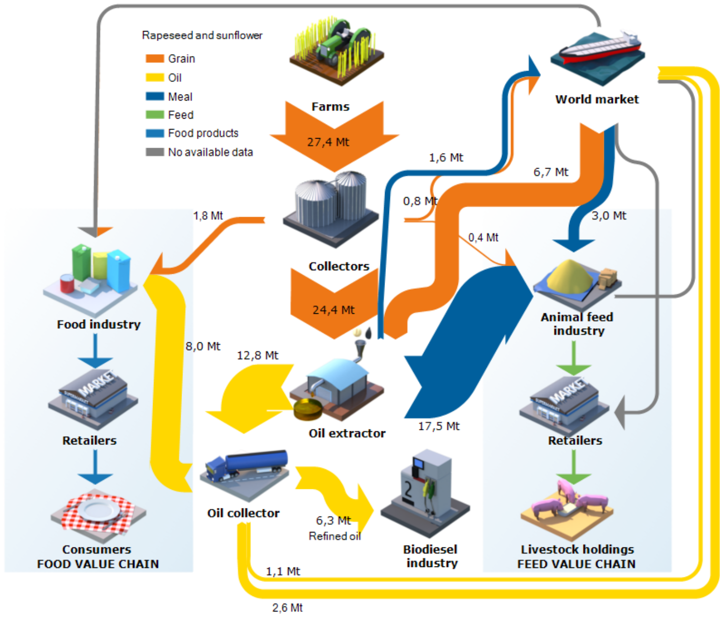
1.3.2.4.4 Other oilseed supply chains in the EU (mainly rapeseed and sunflower)

EU farms produce 27.4 million tonnes of oilseeds[29]. Collectors deliver oilseeds to oil extractors (around 24.4 Mt[30]), to the food industry and directly to the feed industry. Oil extractors also import an extra 6.7 Mt of grain and process EU produced and imported grains into 17.5 Mt of meal[29], mainly going to the feed industry and into 12.8 Mt of oil going to oil collectors[29]. Animal compound feed factories also import 3.0 Mt of oilseed meal[29], and process it into compound feed (incorporating other raw materials), sold to retailers and then to livestock holdings[31]. Oil collectors deliver 6.3 Mt of oil dedicated to the biodiesel sector[32], exports 1.1 Mt[29], to the world market and 8 Mt to the food industry[29].

[29] EU feed protein balance sheet 2021-2022.
[30] Own calculation based on the EU feed protein balance sheet 2021-2022 https://agriculture.ec.europa.eu/data-and-analysis/markets/overviews/balance-sheets-sector/oilseeds-and-protein-crops_en
[31] The compound feed arrows are not quantified, as they represent products composed of various materials and not only soya bean.
[32] Transport & Environment’s (T&E), 2022. https://www.transportenvironment.org/wp-content/uploads/2022/06/Food-vs-Fuel_-Part-2_Vegetable-oils-in-biofuels.pdf

Moreover, the food industry also imports oilseed grain and produces food products that are sold to retailers and then consumers[33] (see Figure 17). For this supply chain, the most significant supply comes from the EU itself and the demand is for food (for which oil is the main demand), the energy sector (oil for biodiesel) and feed (through meals). Both feed and food markets of rapeseed and sunflower include a specific organic premium market segment.

Figure 17: Main flows of material to sustain the demand in the other oilseeds (rapeseed and sunflower) sector (Million tonnes, Campaign 2021/2022)



Source: own work based on previous work and several sources: EU Feed Protein Balance Sheet (EC), oilseeds, oilseed meals & vegetable oils supply & demand (EC), Eurostat, Transport & Environment's (T&E). Campaign 2021-2022

1.3.2.4.5 Crushing capacities in the EU

Oilseed crushing plants in the EU are distributed between the production basins of protein-rich seeds (rapeseed and sunflower), and the sea and river ports that receive imported seeds (soya bean, sunflower, rapeseed). From 1995 to 2005, the European crushing capacity had stabilised at around 30 million tonnes. But the implementation of a proactive EU policy on biofuels since 2003 has increased this capacity. **In 2021/2022, the EU crushed 47.9 Mt[34] of oilseeds, among which soya beans (of which 95% that is crushed in the EU is imported), sunflower (of which 25% that is crushed in the EU is imported), rapeseed (of which 9% that is crushed in the EU is imported) and linseed (of which 115% that is crushed in the EU is imported), while at the same time supplying oilseed meal for animal feed.** The number of large plants now seems to stagnate, particularly following the cap on the incorporation of conventional biofuels at 7% of the energy contained in fuels decided in 2015 (Directive 2015/1513 concerning indirect land use change) and confirmed in 2018 (revision of the RE directive 2018/2001 called RED II).

[33] The food products arrows are not quantified, as they represent products composed of various materials and not only oilseeds.
[34] Oil World (2021/2022).

Three EU Member States accounted for 51% of European crushing of soya, rapeseed, sunflower seed and linseed, in 20/21: Germany (28%), France (13%) and Spain (10%). MS processing more than one million tonnes of seeds differ according to the oilseed (see Table 4). It can be noted that since the Russian war against Ukraine and subsequent cross-border flows of oilseeds between Ukraine and its EU neighbours, the market share of Bulgarian and Hungarian crushers has increased a little more.

Table 4: Main MS for oilseeds crushing (20/21)

Seeds	Main oilseed crushing
Soya	**Germany** (3.48Mt), **Spain** (3.31Mt), **the Netherlands** (3.26Mt), **Italy** (2.44Mt) **Portugal** (1.37Mt)
Rapeseed	**Germany** (9.54Mt), **France** (4.28Mt), **Poland** (3.1 Mt), **Belgium-Luxembourg** (1.4Mt), **Czechia** (1.23Mt)
Sunflower seed	**Hungary** (1.46Mt), **Bulgaria** (1.39Mt), **Spain** (1.15Mt), **France** (1.14Mt),
Linseed	**Belgium-Luxembourg**(0.38Mt), **Germany** (0.14Mt),

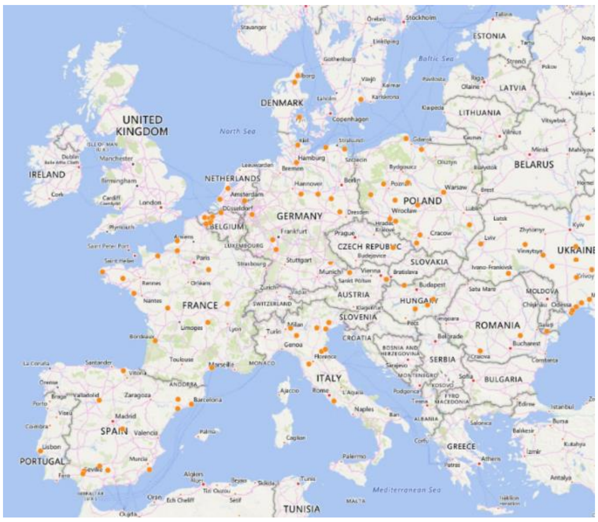
Source: Consortium, based on Oil World

Some Member States such as Austria, Denmark and Poland, primarily process their own production and therefore relatively little soya. Other Member States (NL, BE, DE, ES, PT) specialize in the processing of imported soya beans. Their main units, located in sea or river ports, are large-capacity plants because **soya beans, which are relatively low in oil, are faster to process than oil rich seeds**. MS (DE, IT), which in the past were more oriented towards the processing of imported soya beans as well, are now also crushing the production of seeds that they have developed at home.

Moreover, **the European crushing industry has experienced the phenomena of concentration and globalisation**. Nowadays, it is dominated by three large American groups: Bunge, Cargill and ADM (Archer Daniels Midland). There are also a few independent companies of a significant size. In addition, **over the past thirty years, industrial equipment has been modernized with the construction of very large capacity facilities at the expense of older units of smaller size or poorly located**. These large plants have a natural tendency, for economic reasons, to specialize in the crushing of massively available seeds, such as rapeseed or soya beans**. They leave to smaller units the specific and segmented markets, sources of added value** (high-oleic sunflower, erucic rapeseed, organic oils, etc.). A significant part of the EU crushing industry is supported by biodiesel plants. This is particularly the case for Northern Europe and Italy.

As said earlier, the share of seed imports in the production of soya bean meal in the EU was 95% in 2021/2022. Oilseed imports are therefore essential to the economic balance of European crushing capacities. Cutting off imports would generate a need to produce 22 to 23 million tonnes of additional oilseeds in the EU, just to run these plants. The fact remains that some plants are specialised on Biodiesel production and are not multi-purpose, that the crushing facilities are fairly concentrated in some areas (as described above) and not always in the places where the oilseed meal is used. **Increasing oilseed production in the EU to compensate for seed imports would need to be done in areas close to crushing facilities.**

Figure 18: Location of main crushing plants in the EU (straight vegetable oils)



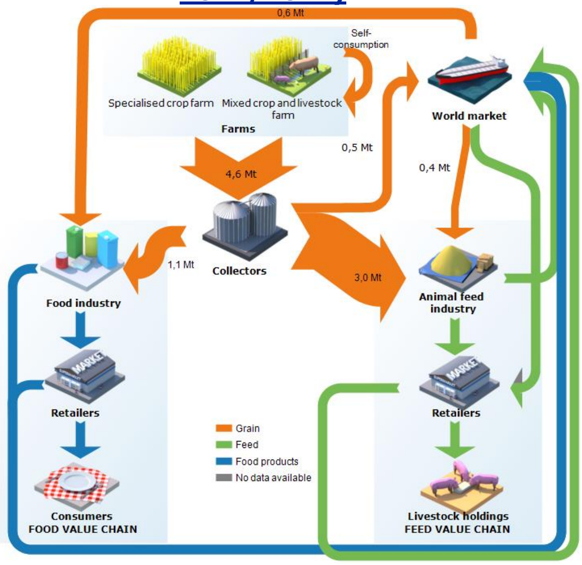
Source: BioplatEU (https://webgis.bioplat.eu/#/map)

But this will not necessarily correspond to the location of the farms and would risk accentuating livestock migration close to these areas, which in turn would risk concentrating them even more. In France, the current projects, linked to the development of soya local supply chains, are being developed on smaller plants, with a different technology (solvent free) where the output are "fatty" meal with different nutritional characteristics.

1.3.2.4.6 Pulse supply chains in the EU

Excluding self-consumption, EU farms produce 4.6 Mt[35] of pulse grains, and part of them also directly use pulses on-farm as feed (very little data can be found in this topic at EU level). Collectors deliver around 1.1 Mt pulses to the food industry and 3.0 Mt to the feed industry[36]. The sector also exports around 0.5 Mt of pulses[35]. In addition, compound feed factories import 0.4 Mt[36] of pulses and process it into compound feed (incorporated with other raw materials) which is sold to retailers or for export and then to livestock holdings[37]. On the food side, the food industry also imports pulses (0.6 Mt)[36] and produces food products sold to retailers or exported and eventually sold to consumers[38] (see Figure 19). For this supply chain, more than ¾ of the supply comes from the EU (82 %).

Figure 19: Main flows of materials to sustain the demand in the pulses sector (Million tonnes, Campaign 2021/2022)



Source: Consortium based on previous work and several sources: EU Feed Protein Balance Sheet (EC), oilseeds, oilseed meals & vegetable oils supply & demand (EC), Eurostat. Campaign 2021-2022

Feed demand is higher (around 1/2) than food demand. In value terms, the food sector has developed high-margin products going both to consumers (e.g., grain used as such) and the food industry for protein extraction (mainly with peas). Both feed and food markets of pulses include specific market premium for organic products.

1.3.2.4.7 Legume fodder supply chains in the EU

Forage legumes can be cultivated as pure stand or combined with other crops, mostly with other fodder grasses. Forages of legume plants are mostly self-consumed on farm under various conservation forms: hay, haylage, silage or sometimes directly grazed as such. Exchanges between farmers within a close territory are common but difficult to track because these are not reported in farming statistics and often informal. In some areas, legume fodder such as alfalfa (sometimes clover) is harvested green (undried or semi-sun-dried) to be dehydrated in a dehydration plant. For quality and handling reasons, traded legume fodders are essentially sundried (hay) and dehydrated fodder.

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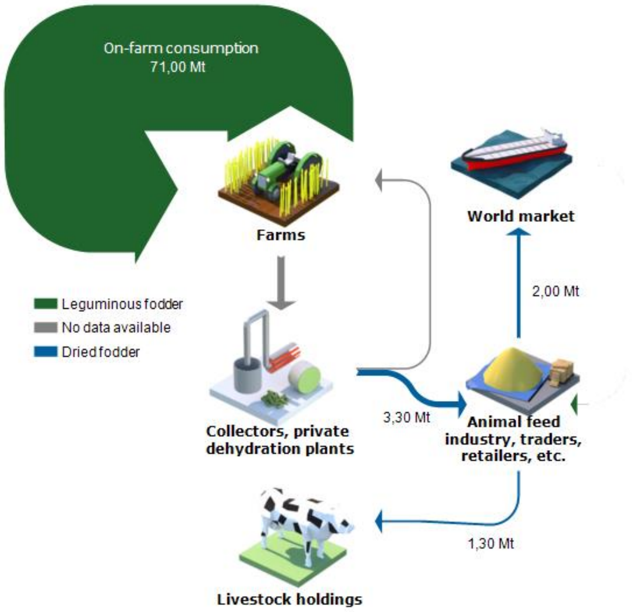
[35] EU oilseeds balance sheet 2021-2022.
[36] Own calculation based on EU oilseeds balance sheet 2021-2022.
[37] The compound feed arrows are not quantified, as they represent products composed of various materials and not only pulses.
[38] The food products arrows are not quantified, as they represent products composed of various materials and not only pulses.

After being dehydrated, fodder can be given back to the forage-producing farms to feed cattle (mixed farms) or sold to other farmers, animal feed producers, traders, and exporters. Plant processing allows forms of packaging (pellets, bales, compressed bales, small bales, meal) and allocation of harvests in drying plants enables segmenting the market with different quality products (levels of fibre, protein, energy, etc.).

The figure above shows the tremendous auto-consumption in livestock farms. There is nevertheless a market of dehydrated legume fodders and significant exports. It can be noted that certain schemes like organic or other quality schemes impose the use of grazing and feed produced on the farm to be used for livestock. In particular the obligation to have feed coming from the farms.

Figure 20: Legume fodder sector in the EU (Million tonnes, Campaign 2021/2022)



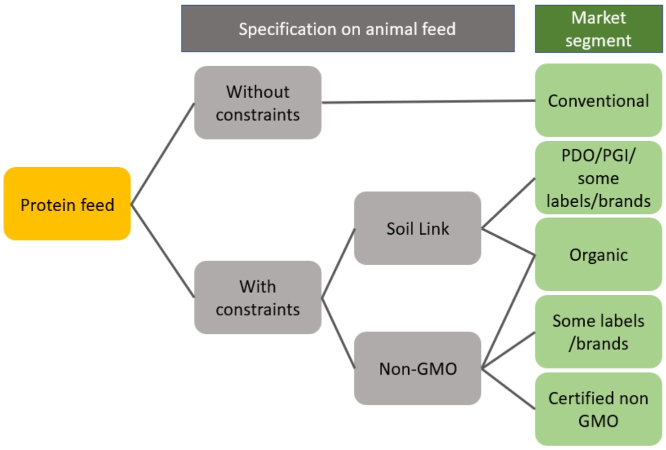
Source: own work based on previous work and several sources: EU Feed Protein Balance Sheet (EC). Campaign 2021-2022

1.3.2.5 Market segmentation

As shown on the figure below, regarding feed markets, different segments can be distinguished according to the constraints imposed (or not) on the animal feed. The four main feed market segments can be defined as follow:

- **Conventional feed segment:** farmers and compound feed manufacturers drive the protein feed demand in the conventional feed sector. Based on the market demand, livestock farmers decide how to feed their animals and how to source their feed (on-farm-produced or bought as compound feed). Compound feed manufacturers are using a wide spectrum of raw materials to supply livestock producers with compound feed fitted to their requirements. The conventional feed market seeks the most cost-effective, cheapest, and most convenient to use feeds (standardised quality and readily available).
- **Non-genetically modified (non-GM):** final consumers are the main economic agent driving this market of meat, dairy, and egg products, although choices of other economic agents can significantly impact the use of PRPs or not, like retailers or animal food manufacturers.
- **Organically produced animal products:** one of the main differences between the organic market segment and the conventional one is that the final consumers look specifically for organic meat, eggs, and dairy products and, in that sense, they are the main drivers of these markets. Legal obligations have to be respected for feeding animals: non-GMO, a minimum percentage produced on the farm, and grazing obligation for ruminants.
- **Production within** PDO-PGI areas with their own standards.

Figure 21: The main feed market segments in the EU



Source: Consortium

1.3.2.5.1 A dynamic toward non-GM segments

GM crop area is steadily increasing worldwide. In the EU, there is a strict regulation (see 1.3.1.3.2), but this does not preclude the presence of many other GM crops in food and feed. **GM feed is subject to GM labelling, but this is not the case of food products such as milk, meat, and eggs**, while significant amounts of GM soya, rapeseed and maize are imported for animal feed.

There is currently a strong consumer demand for non-GM or organic food orientation, driving the development of new markets. Although both segments are still niche markets, growth rates are positive (between 2015 and 2020, the retail sales of organic products doubled in the EU[39], and the European Non-GMO Industry Association (ENGA) clearly identifies shifts in the consumers habits[40] and also in the supply for non-GM soy to meet the demand[41]) and their role in sustainable food systems is increasing. **European brands or retailers demand non-GM fed products[42] and many EU MS value their GMO-free products as a quality standard**[43].

A study from (JRC *et al.*, 2016) had shown that among the 14 main importers (90% of total imports) "about 8.3% and 11.3% of the soya bean and soya bean meal, respectively, is imported as non-GM under segregation and identity-preservation schemes" representing about 2.7 million tonnes of soya bean meal equivalent yearly. These estimates suggest **the EU production of industrial compound feed certified as non-GM was clearly dependent on imports of non-GM soya bean products**. According to FEFAC (2021), the upward trend in EU production of GM-free feed which FEFAC estimated at around 15% of total feed production in 2020, was depressed during the COVID-19 pandemic, when it was very difficult to source non-GM protein sources outside the EU.

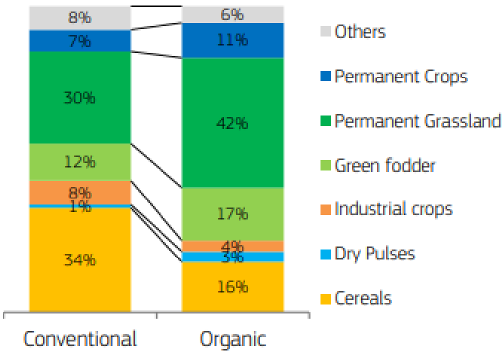
Due to the price inflation of the premium for non-gm soya beans**, demand from processors has decreased and could shift to a new segment that is non-deforesting soya beans**. This would match with European consumer demand regarding environmental concerns but at the expense of non-GM feed specifications.

[39] European Commission – DG Agi – Organic Farming in the EU – A decade of growth, 2023.
[40] The rise of sustainable diets and demand for plant-based foods: ENGA European Non-GMO Industry Association AISBL
[41] International Non-GMO Summit provides food for thought for a thriving market: ENGA European Non-GMO Industry Association AISBL
[42] https://www.gmo-free-regions.org/gmo-free-regions/gmo-free-retailers.html
[43] https://www.enga.org/non-gmo-production-in-europe

1.3.2.5.2 The organic market

In 2020, 9.1% of the EU's UAA was under organic farming representing 14.8M ha (compared to 5.9% in 2012). This situation is heterogenous among MS (see Figure 23), as the share of organic area ranges from 0.62% (Malta) to 22.97% (Estonia). In terms of land use, the share of permanent grasslands or green fodder are more important in the organic sector compared to the conventional one, and the share of cereals is less important (see Figure below).

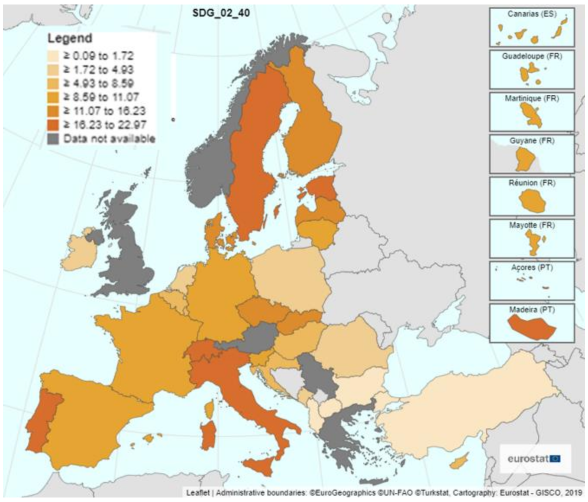
Figure 22: Land use of conventional and organic agriculture, 2020, by crop (%)



Source: DG AGRI calculation based on Eurostat (online data tables org_cropar and apro_cpsh1).

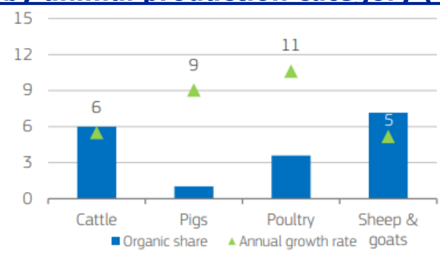
In 2019, organic oilseeds were grown on 339 000 ha, with France and Romania accounting for half of the total[44].

Figure 23: organic area in % of the total UAA (2021)



Source: Eurostat, SDG_02_40, 2021

Figure 24: Organic animal production, share in 2020 and annual growth rate 2014-2020, by animal production category (%)



Source: DG AGRI calculation based on Eurostat (online data tables org_lstspec, apro_mt_lscatl, apro_mt_lspig, apro_mt_lssheep, apro_mt_lsgoat, apro_mt_pann and ef_lsk_poultry). DG AGRI estimate for poultry and goats. The share of sheep and goats refers to 2019.

Source: Agricultural market brief, Organic farming in the EU (2023)

On the contrary, as shown in Figure 24, **organic animal production is less developed** ranging from 1% (pigs) to 7.2%% (sheep and goats). As explained in the EU agricultural economic brief, **organic conversion can be more difficult for grain-fed systems linked to monogastric species due to higher organic feed expenses, compared to extensive grass-fed systems adapted to ruminants** (European Commission, 2023).

Livestock farms that operate in organic production need to source at least 30% of their feed locally according to Regulation (EU) 2018/848 (30% pigs and poultry, 60 % (70% in 2024) ruminants). According to statistics from the Traces database, total EU imports of organic feed materials (for the most part oilseed meals) decreased from 302 000 to 234 000 tonnes between 2019 and 2020, which may be linked to the covid crisis. On the contrary, organic soya beans imports significantly rose in 2022 (+51%), mainly coming from Togo (63%), Ukraine (16%) and Benin (7%) (DG AGRI, 2023). More generally, in 2020, imports of organic oilseeds meals mainly come from China and India, and imports of organic oilseed grains from Togo, Ukraine, India and Kazakhstan (Ecozept and International, 2021).

As for animal products, organic milk represents 3.7% of total milk production in 2020, mainly produced by Germany, France, Denmark, Austria and Italy. **The organic market (feed and food) is clearly expanding in the EU. Retail sales of organic food and**

[44] https://www.agencebio.org/wp-content/uploads/2022/01/Organic-Sector-EU-2021.pdf

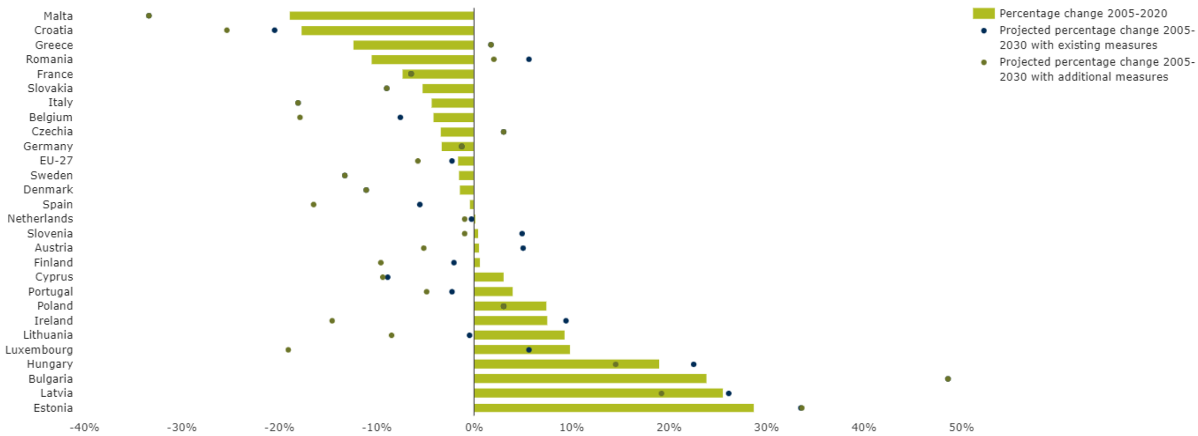
drink in the EU almost doubled between 2015 and 2020, reaching EUR 44.8 billion[45]. Although Germany and France heavily drive those sales (33.5% and 28.3% respectively), those figures show that the consumption of organic products is increasing, at least in Western Europe, which has also an influence on the GM-Free market since organic products are by definition GM-Free.

Finally, **the EU promotes organic farming through its various policies, such as the Farm to Fork strategy**, which aims to reach at least 25% of the EU's agricultural land under organic farming by 2030. The different policies implemented in the EU are detailed in Section 1.3.3.

1.3.2.6 Environmental challenges on feed demand and supply

Agriculture is both a carbon sink and an emitter of greenhouse gas (GHG) emissions. Excluding land use and land use change's emissions, the sector represents 11% of the EU total emissions (EEA, 2023), of which 70% come from the animal sector. CH_4, N_2O and CO_2 contributed respectively to 53.8%, 43.6% and 2.6% of total agricultural emissions. According to EEA, the EU's agricultural GHG emissions were lower in 2021 than in 2005, even if the trends are different among MS (see Figure below).

Figure 25: Agricultural GHG emissions and projected emissions by EU Member State



Source: EEA[46]

The livestock sector is one of the main sources of GHG emissions, and the different livestock categories have heterogenous impacts on the global warming: cattle are the main contributors, compared to pigs, poultry and small ruminants have lower share. **Enteric fermentation** dominates agricultural CH_4 emissions. In addition, both CH_4 and N_2O emissions from **manure management** (i.e., manure storage and application) and deposition on pasture, make livestock the main agricultural emissions source[47]. Direct emissions can be linked to growing feed crops (N_2O from fertilisers or CO_2 from loss of soil carbon), enteric fermentation, manure management and soil fertilisation. In addition, feed raw materials can have **indirect impacts related to LULUC (land use and land use change) issues**, and especially deforestation. Indeed, soya bean is one of the most imported protein-rich crops in the EU, although it mainly comes from Brazil, potentially participating to the deforestation. Against this backdrop, the EU recently adopted a Regulation on deforestation-free supply chains (see 2.11).

However, according to the study on Future of EU livestock (Commission *et al.*, 2020), some **practice changes in the feed production are identified to reduce the livestock emissions** and improve the feed quality, such as reducing the use of nitrogen and using more legumes (forage and gain) and grasslands, using feed additive, or precision feeding.

[45] European Commission, DG Agri - Organic Farming in the EU – a decade of organic growth, 2023.
[46] https://www.eea.europa.eu/ims/greenhouse-gas-emissions-from-agriculture
[47] https://www.ipcc.ch/report/ar6/wg3/downloads/report/IPCC_AR6_WGIII_FullReport.pdf

1.3.3 Policy context

1.3.3.1 EU policy context

The evident dependency of the EU production and consumption system for animal products on plant protein imports has become increasingly prominent on the political agenda. EU policymakers are aiming at reducing EU dependency on feed imports, given the possible risks of negative environmental impacts in third countries (deforestation[48] in particular) and the potential threats that it poses to EU food security[49]. However, replacing these imports is a challenging task, due to – among others - climatic constraints, limited availability / room for expansion of EU arable land, opportunity costs against other arable crops and strong price competition mainly from duty-free imported soya beans.

A key development in the process towards increased EU self-sufficiency for plant proteins was the adoption of the **Commission's Report on "The development of plant proteins in the EU"** (European Commission, 2018), which analysed the current supply and demand situation of plant proteins in the EU, highlighting the environmental and agronomic benefits of legumes. The report also presented a state of play in research and agricultural policy initiatives at EU and national level and defined a list of follow-up activities.

The Commission's **Farm to Fork Strategy**[50], elaborated in the broader framework of the European Green Deal[51], engages the Commission to evaluate the need for / promote the elaboration of legislation aimed at – among others - reducing the dependency on critical feed materials (e.g., soya beans grown on deforested land) by fostering production and use of EU-grown plant proteins, as well as alternative feed materials such as insects, marine feedstock (e.g., algae), by-products from biobased value-adding processes (e.g., fish waste from the so-called "blue bioeconomy" production processes) and a review of the current ban on the use of certain animal proteins as ingredients in animal feed production. The Farm to Fork Strategy also points to the need of moving towards a more plant-based diet, and of reducing excess nitrogen (and phosphorus) nutrients from farming activities. In this respect, the Commission has set the target of reducing nutrient losses by at least 50%, while ensuring that there is no deterioration in soil fertility, at the same time reducing the use of fertilisers by at least 20% by 2030. Among the goals set by the Farm to Fork Strategy that are particularly relevant for this study, we can find a revision of the animal welfare legislation and the objective of at least 25% of the EU's agricultural land under organic farming by 2030. Organic farming is also mentioned among the tools and drivers of the EU Biodiversity Strategy for 2030 (European Commission, 2020) to "bring nature back to agricultural land". The European Commission subsequently published an **Action Plan for the development of organic production (European Commission, 2021)**, based on three "Axes":

- Axis 1: stimulate demand and ensure consumer trust.
- Axis 2: stimulate conversion and reinforce the entire value chain (which includes a set of actions to *improve animal nutrition in accordance with organic rules*).
- Axis 3: organics leading by example: improve the contribution of organic farming to environmental sustainability.

The Covid-19 pandemic has posed additional challenges related to food security and the need for resilient food supply chains. While global protein supply chains have not been affected by major disruptions during the crisis, the still substantial EU import dependency for high- protein feed and the concentration of global supply for plant proteins in few leading producing and exporting countries raise serious concerns. The ***NextGenerationEU* stimulus package[52]**, through its comprehensive combination of intervention areas and

[48] For the future, the risk of deforestation due to soya is addressed through the new EU deforestation regulation.
[49] Reliance on imports is not a necessarily threat to food security, provided that the sources of imports are well diversified.
[50] https://ec.europa.eu/food/horizontal-topics/farm-fork-strategy_en
[51] https://ec.europa.eu/info/strategy/priorities-2019-2024/european-green-deal_en
[52] https://ec.europa.eu/info/strategy/recovery-plan-europe_en

unprecedented availability of financial means, is providing and will provide both enhanced and new instruments to address the related challenges.

Russia's invasion of Ukraine in February 2022 has further aggravated those challenges, with particular regard to the supply of fodder grains and oilseeds, of which Ukraine is a major exporter, including to a number of EU Member States.

The following sections will address more into detail two key policy measure at EU level: the Common Agricultura Policy (CAP) and research funding under the Horizon Europe programme.

1.3.3.1.1 The Common Agricultural Policy

The **CAP ending in 2022** provided several instruments directly or indirectly recognising legume benefits from an environmental standpoint, or maintaining and supporting the production of protein crops in the EU (European Commission, 2018); these included:

- The so-called "greening," through the possibility to grow certain nitrogen-fixing crops that are beneficial for biodiversity on Ecological Focus Areas (EFA), as well as a crop diversification requirement.
- Rural development programmes (RDPs), through the Agri-Environment-Climate Measures (AECM), and measures supporting knowledge transfer, advisory services, cooperation and innovation, and investments.
- Voluntary Coupled Support (VCS), which Member States could decide to grant to a list of sectors and productions (including protein crops and grain legumes) where specific types of farming or specific agricultural sectors particularly important for economic, social, or environmental reasons undergo certain difficulties. For claim year 2021, 16 Member States opted to grant VCS to protein crops, for a total earmarked amount of EUR 472.4 million (protein crops were the 4th biggest VCS beneficiary after the animal-based sectors, and the biggest area-based VCS beneficiary) (European Commission DG AGRI, 2021).

The **new CAP for the period 2023-2027** has introduced new support measures that may be relevant to the sectors at hand, when purposely tailored to do so in the National Strategic Plans of Member States (EU, 2021).

- Income Support measures

The EU provides farmers with income support to:

- function as a safety net and make farming more profitable;
- guarantee food security in Europe;
- assist them in the production of safe, healthy and affordable food;
- reward farmers for delivering public goods not normally paid for by markets, such as taking care of the countryside and the environment.

The main income support measure is the provision of direct payments, primarily based on the farm's size in hectares or LU reared, but also on the provision of other services or on specific characteristics (e.g., young farmers).

The **budget envelope for income support** allocated to each MS (financed by the European Agricultural Guarantee Fund), is detailed in Annex IX of **Regulation (EU) 2021/2115**. Within the EU's multiannual financial framework (MFF) for 2021-27, up to EUR 270 billion are earmarked for income support schemes.[53]

- Conditionality

Receiving full income support under the new CAP requires the farmer to comply with a number of rules (conditionality) related to farm's management and agricultural practices. Conditionality rules are classed as Statutory management requirements (SMR) and

[53] https://agriculture.ec.europa.eu/common-agricultural-policy/financing-cap/cap-funds_en

Standards for good agricultural and environmental condition of land (GAEC), and are listed in Annex III to Regulation (EU) 2021/2115.

Among conditionality rules relevant for the purposes of this study we can find: GAEC 1 (Maintenance of permanent grassland) and GAEC 7 (Crop rotation in arable land).

- Eco-schemes

The new measure of "Eco-schemes" can provide - if activated through national CAP strategic plans - incentives for farmers to adopt a wide range of practices that can help in reducing the EU's protein dependency, such as the inclusion of leguminous crops in the rotation, transition to low-intensity grass-based livestock systems, establishment and maintenance of permanent grassland, etc (European Commission, 2021b)

These schemes "for the climate, the environment and animal welfare" should cover a number of areas of action listed in the Regulation, among which *climate change adaptation, including actions to improve resilience of food production systems and animal and plant diversity for stronger resistance to diseases and climate change*.

To the financing of eco-schemed are devoted **25% of the allocations** each MS has for income support[54].

- Coupled income support

A number of crops also used in livestock feed are theoretically eligible for coupled income support under the new CAP, if included by Member States in their CAP Strategic Plans. Among these crops are: cereals, oilseeds, protein crops (including legumes and mixtures of legumes and grasses), starch potatoes and dried fodder. Animal products under the scope of this study eligible for coupled income support are: milk and dairy products, sheep meat and goat meat, beef and veal.

Within the National Strategic Plans of Member States, financial allocations for coupled income support interventions had to be limited to a **maximum of 13%** of the amount available for income support measures[55].

- Sectoral interventions

One of the main novelties of the new CAP (Reg. EU 2021/2115 – Art. 42) is the possible extension of financial support to producer organisations via the tool of Operational Programmes (OPs) to the sector of protein crops (among "other sectors"[56]). Operational programmes presented by recognised producer organisations (and/or associations of producer organisations) may allow such groupings of operators to fund specific activities and support their medium to long-term planning, thus boosting a structured development of the sector.

EU financial assistance is limited to 50% of the actual expenditure incurred for the activities included in the OP and up to 6% of the value of marketed production of the producer organisation (or association of producer organisations). The actual uptake of this tool is linked to its inclusion in the National Strategic Plans of EU MSs.

- Rural development measures

The CAP contributes to the sustainable development of rural areas through three long-term objectives:

- Fostering the competitiveness of agriculture and forestry;
- Ensuring the sustainable management of natural resources and climate action;
- Achieving a balanced territorial development of rural economies and communities including the creation and maintenance of employment.

[54] Art. 97 of Reg. (EU) 2021/2115.
[55] Art. 96 of Reg. (EU) 2021/2115.
[56] i.e., sectors other than fresh and processed fruit and vegetables, wine, apiculture, hops and olive oil and table olives.

Rural Development measures are funded by the European Agricultural Fund for Rural Development (EAFRD), with the aim of reinforcing the 'first pillar' of income support and market measures by strengthening the social, environmental and economic sustainability of rural areas. **EAFRD funding to Rural Development measures for 2023-27 amounts to EUR60.5 billion in total**[57], distributed through rural development programmes (RDPs), where national and regional authorities handle the selection of the projects and the granting of payments.

The types of intervention for rural development are shaped around national needs and capabilities.

RDPs provide various types of intervention, in payments or support, with regards to eight main subjects: climate, environment, risks management and knowledge exchange, as well as other related themes. In the context of this study, the most relevant type of intervention concerns environmental, climate-related and other management commitments from farmers. Only farmers or other beneficiaries who voluntary undertake management and improvement commitments in these regards are eligible for RDP grants from their Member State. Commitments may include, for example, going beyond the relevant minimum requirements for the use of fertilisers and plant protection products or for animal welfare. Funds are also granted to manage production and income risks through financial contributions for income stabilisation and to promote cooperation supporting (e.g., producer groups, producer organisations or interbranch organisations).

1.3.3.1.2 EU-funded Research and Innovation: Horizon Europe

The new EU research programme **Horizon Europe**[58], with particular regard to its Cluster 6 "Food, Bioeconomy, Natural Resources, Agriculture and Environment"[59], also reflects the need for improved EU self-sufficiency in feed proteins in its priorities. The following table provides a list of the 9 EU projects funded by the Horizon programme, whose objectives are most in line with the aims of this study. Taking into account these 9 Horizon Europe projects, EU contribution amounted at almost 59.2 million EUR in total, destined to research on topics concerning animal nutrition and protein crops. In particular, the Valpro Path and FarmInsect projects, (total contribution from the EU of 11 million EUR), have as main objective to decrease Europe's dependence on imported proteins and to replace current proteins used for animal feed with alternative proteins (e.g., insects). Moreover, particular attention is given to the study of the positive effects of crop rotation (LegumeLegacy, LEGUMINOSE, IntercropValuES and Root2Res), feed quality (WHEATBIOME and CARINA) and the reuse of residues for new bio-products (AgriLoop).

Table 5: Horizon Europe: research projects with a focus on protein and feed sources

Name *Start and end dates*	Title	Description	EU contribution (EUR)
AgriLoop *Start: 01/12/2022* *End: 30/11/2026*	**AgriLoop: Pushing the frontier of circular agriculture by converting residues into novel economic, social and environmental opportunities**	The EU-funded AgriLoop project will extend the agricultural production value of the EU and China by eco-efficiently upgrading underexploited residues into a portfolio of high-added-value bio-products able to generate new bio-based markets. The project will develop safe-and-sustainable-by-design (SSbD) bioconversion processes and integrate them into a cascading biorefinery approach, to convert agri-residues from tomato, soya, straw, potato, brewery, oil, winery and livestock sectors, among others, into plant and microbial proteins, polyesters and other bio-based chemicals.	7 825 297
CARINA	**CARinata and CamelINA to boost**	The EU-funded CARINA project will focus on innovative farming systems for oilseed crops,	7 512 996

[57] Regulation (EU) 2021/2015, Annex XI.

[58]https://ec.europa.eu/info/research-and-innovation/funding/funding-opportunities/funding-programmes-and-open-calls/horizon-europe_en

[59]https://ec.europa.eu/info/research-and-innovation/funding/funding-opportunities/funding-programmes-and-open-calls/horizon-europe/cluster-6-food-bioeconomy-natural-resources-agriculture-and-environment_en

Name ***Start and end dates***	**Title**	**Description**	**EU contribution (EUR)**
Start: 01/11/2022 End: 31/10/2026	**the sustainable diversification in EU farming systems**	carinata and camelina, which can grow almost everywhere in Europe and Northern Africa. The co-product from oil extraction from these crops is a protein-rich cake that can be used as animal feed.	
FarmInsect *Start: 01/01/2023 End: 31/12/2024*	**Automated turnkey insect rearing farm. Enabling farmers to produce their own sustainable insect protein feed**	FarmInsect responds to the global need for alternative protein sources for animal feed in a sustainable and efficient way, putting farmers in the centre of the solution. Utilizing BSF larvae in a full closed loop system, farmers feed the larvae on organic sidestreams.	2 499 999
LegumeLegacy *Start: 01/02/2023 End: 31/01/2027*	**LegumeLegacy – Optimising multiple benefits of grass, legume and herb mixtures in crop rotations: modelling mechanisms and legacy effects**	LegumeLegacy will bring together 10 doctoral researchers to develop a model system of crop rotation, in the common experiment grassland plots of two grasses, two legumes, and two herbs. The findings will be useful for the design of grassland leys within crop rotations that optimise agronomic and environmental performance.	2 224 461
LEGUMINOSE *Start: 01/11/2022 End: 31/10/2026*	**Legume-cereal intercropping for sustainable agriculture across Europe**	Growing two or more crops in proximity is a way to produce a greater yield on a given piece of land. This intercropping practice is also more sustainable compared to traditional cropping systems. The EU-funded LEGUMINOSE project will identify the obstacles to intercropping and boost awareness and acceptance among farmers by providing knowledge and demonstrations that promote economic, environmental, and social benefits of legume-cereal intercropping. The project will establish a network of six field trials and farm labs across Europe and in Egypt and Pakistan.	7 188 013
IntercropValuES *Start: 01/11/2022 End: 31/10/2026*	**Developing Intercropping for agrifood Value chains and Ecosystem Services delivery in Europe and Southern countries**	A growing number of farmers are opting for intercropping practices, cultivating two or more crops on the same field at the same time. The EU-funded IntercropValueES project will design and develop intercropping systems that can be managed in ways that ensure productivity and profitability along the entire agrifood chain.	7 419 463
Root2Res *Start: 01/09/2022 End: 31/08/2027*	**Root2Resilience: Root phenotyping and genetic improvement for rotational crops resilient to environmental change**	Climate change is a growing pressure on the agricultural industry. Aiming to deliver crops adapted to changing environments, the EU-funded Root2Res project will enhance the resilience of rotational cropping systems. Innovations include phenotyping, genetic and modelling tools that will help breeders evaluate novel and existing genotypes of a range of crops (cereals, potatoes, legumes) as root ideotypes for different soil and climatic environments across Europe. It will also investigate the potential role of emerging crops (sweet potato, lentil) to enhance resilience to environmental change.	6 367 651
VALPRO Path *Start: 01/09/2022 End: 31/08/2026*	**new VALue landscapes for plant PROtein Pathways**	Due to an absence of premium supply chains for protein and feed crops in the EU, farmers miss out on added-value opportunities that exist for the crops they already grow across Europe. The goal of VALPRO Path is to design, validate and deliver sustainable and competitive plant protein crop systems and value chains. Sustainable diversification of rotations with grain legumes will support the transition to more environmentally sustainable farming.	8 662 360
WHEATBIOME *Start: 01/01/2023*	**Unravelling the potential of the wheat microbiome for the development of healthier, more**	The EU-funded WHEATBIOME project will study the role of microbial fermentation in food/feed quality and reduce food waste by recirculating wheat by-products. Another aspect of the research will be explaining the interactions between wheat	5 060 547

Name *Start and end dates*	Title	Description	EU contribution (EUR)
End: 31/12/2026	**sustainable and resilient wheat-derived food & feed products**	(prebiotics, probiotics, bioactive compounds and immunogenic proteins) and the human/animal microbiota, and their effect on human and animal health.	

Source: CORDIS – List projects by framework programme. https://cordis.europa.eu/projects

1.3.3.2 Member States' national policies or strategies

At national or regional level, several EU Member States have elaborated and implemented policies or strategies related to the topic and products covered by this study. These national strategies are usually quite recent and may have a quite diverse array of objectives, often with an integrated approach. Among others:

- Increase the area and the production of protein crops;
- Improve the relations between business operators of the supply chain;
- Improve the sustainability and quality of protein sources for animal feed;
- Develop new protein sources for food and feed;
- Ensure the feed autonomy of the livestock farmers;
- Reduce the dependency on plant proteins from other countries.

Initiatives and strategies covered by this section are summarised in the table below; key takeaways from each document are provided in the following sub-sections, by Member State.

Table 6: National strategies to develop plant proteins

Member State or region	Name of the strategy	Promoted by	
		Sectoral stakeholders	Competent Authorities
Belgium-Wallonia	Development of plant proteins in Wallonia	✓	✓
Belgium-Flanders	Flemish protein strategy (2021-2030)		✓
Denmark	Proteins for the future		✓
Finland	Implementation plan to increase Finland's protein self-sufficiency	✓	✓
France	Plant protein plan		✓
Germany	BMEL's Protein Crops Strategy		✓
Netherlands	Dutch national protein strategy		✓

Source: Consortium summary

1.3.3.2.1 Belgium-Wallonia: Développement des Protéines Végétales en Wallonie

The "Plan for the development of protein plants in Wallonia (strategic development plan to 2030)" (Wagralim, 2019) was drafted by the operational support services for the *Collège des Producteurs*, in close cooperation with WAGRALIM, Cepicop and the Association for the Promotion of Protein and Oilseed Crops (APPO). The Plan aims to:

- Achieve an increase of 15,000 ha of the area sown with protein crops by 2030;
- Ensure structured supply chain relations between the industry, niche markets and producers for at least 75% of this increase in production;
- Ensure a minimum of 25% of this increase in production thanks to the work of crop associations;
- Ensure an increase in the protein profile of fodder and crops intended for monogastric feed and food (for human consumption).

The identified priority crops with the most potential for increase are: peas, field beans, rape, lupines, alfalfa and soya beans.

1.3.3.2.2 Belgium-Flanders: Flemish protein strategy (2021-2030)

The Flemish Protein Strategy (Vlandeeren, 2021) represents an initiative promoted by the regional government of the Flanders, with a broad group of stakeholders in the agri-food chain and research institutions, to realise a more sustainable, diverse and forward-looking protein supply by 2030. The strategy is meant to cover the entire value chain from production through to consumption.

The Strategy sets out 6 key working themes and goals:

1. Sustainable animal feed: making protein sources for animal feed more sustainable;
2. Sustainable animal production: making animal production more sustainable;
3. More vegetable proteins: increasing vegetable protein production;
4. More novel proteins: developing innovative protein sources;
5. Greater product diversity: diversity in processing for diversity in supply;
6. Sustainable protein consumption: "balanced, healthy, diverse, environmentally responsible and local".

All types of proteins and protein products (animal and vegetable, innovative and conventional) are taken into account within the Flemish strategy, given the emphasis put on a comprehensive approach to protein diversification. The goal of the Flemish protein strategy is to meet the FEFAC guidelines for 100% of soya used for animal feed by 2030 (with 60% already achieved in 2022 and 75% is expected in 2025). By 2030, all soya used by Belgian animal feed manufacturers will have to bear a sustainability label and half of the raw materials used for animal feed must consist of co-products from the food industry and biofuels.

1.3.3.2.3 Denmark: Proteins for the future

The Danish National Bioeconomy Panel (Ministry of Environment and Food) is established by the Danish government with the aim to providing recommendations on a variety of different aspects of the bio-economy. Its members are scientists from leading universities, with the contribution of representatives from different stakeholder groups. In 2018, the Panel presented its "Recommendations to the Danish Government for the proteins of the future"(The Danish National Bioeconomy Panel, 2018), a document listing 15 recommendations on the topic of protein sources from the perspective of bio-economy. Recommendations were made as regards different fields:

- Raw materials (including research and development measures);
- Processing and technology (on the topic of biorefining);
- Market (including measures on improved traceability systems and funding for studies on the nutritional profile for feed);

as well as general recommendations on setting up joint forums of relevant stakeholders, training and new skills, in the context of a defined strategy with clear political targets.

1.3.3.2.4 Finland: Implementation plan to increase Finland's protein self-sufficiency

In Finland, VTT (a research institution on sustainable growth owned by the Finnish Government) presented its first roadmap to increase protein availability in the Member State already in 2015. In 2018, VYR (the Finnish Cereal Committee) organised a series of workshops with experts and operators to examine the state of the art in Finland's protein sector, and to develop a plan to increase Finland's protein self-sufficiency[60]. The workshops aimed to identify measures to increase self-sufficiency, taking into account cereals, oilseeds, grassland, water management (with a focus on fisheries), insects and cellular agriculture.

[60] https://www.vttresearch.com/en/about-us/what-vtt

On the grounds of evidence collected through these workshops, VTT and VYR published an action plan for using these protein sources more efficiently in the production of both food and feed. A working group on protein was subsequently set up to share information and promote cooperation among operators. A number of "Innovation paths" (VTT, 2019) were identified" by the working group, namely:

1. Developing new tools for primary production (i.e., improving cultivation technologies and practices, introducing smart crop rotation practices, breeding better quality and more tolerant plants);
2. Developing ingredients and food technologies for plant-based food;
3. Improving production technologies for protein production (e.g., for turning former foodstuffs or insects into feed).

1.3.3.2.5 France: Plan protéines végétales

The "Plan protéines 2030"[61] was launched in 2020 by the French Government with a budget of EUR 150 million: the stated end-goal is to double the area (from 1 million/ha to 2 million/ha) under protein-rich plants and turn France into a leader in plant protein for human consumption by 2030. The Plan's three key priorities are to:

1. Reduce the country's dependence on imports of protein-rich materials (especially soya imported from non-EU countries);
2. Improve the feed autonomy of livestock farms;
3. Develop a local product offer for pulses and encourage French consumers to increase their consumption of plant proteins.

The Plant protein plan involves the following main actions:

- Support for research and innovation, to develop relevant solutions from an economic, environmental and nutritional point of view;
- Support for the investments required by both arable crops and livestock farmers;
- Support for the structuring of plant protein sectors and downstream investments;
- Support for the promotion of pulses consumption towards the general population.

A few calls for projects will also be financed within the framework of France Relance 2030[62], with the aim of maintaining oilseed areas, in particular. Moreover, the *compte d'affectation spécial pour le développement agricole et rural* (CasDAR)[63] calls for projects will also be oriented towards the development of protein autonomy.

1.3.3.2.6 Germany: BMEL's Protein Crops Strategy

The German Federal Ministry of Food and Agriculture (BMEL) published its first Protein Crops Strategy[64] in 2012, renewing and adapting it in the course of the years. BMEL's strategy is aimed at reducing the competitive disadvantage domestic protein crops may have, by addressing gaps in research, and testing and implementing a number of measures in practice. The German federal budget has earmarked EUR 4.8 million for the Protein Crop Strategy in 2021 alone.

[61] https://agriculture.gouv.fr/batir-notre-souverainete-alimentaire-en-proteines-vegetales
[62] The France Relance is an exceptional plan of 100 EUR billion launched by the French Government to relaunch the economy and obtain results in terms of decarbonization, industrial recovery, and strengthening of skills and qualifications throughout the country. This plan is financially supported by the European Union for approximately EUR 40 billion. https://www.economie.gouv.fr/plan-de-relance
[63] The *Programme National de Développement Agricole et Rural* (PNDAR) defines for the period 2022-2027 the priorities of actions financially supported by the *compte d'affectation spécial pour le développement agricole et rural* (CasDAR). https://chambres-agriculture.fr/recherche-innovation/programmes-rd/programmes-casdar/
[64] https://www.bmel.de/EN/topics/farming/plant-production/protein-crop-strategy.html

The Strategy, focused especially on pulses, mainly pursues the following key objectives:

1. improving ecosystem services and resource conservation, i.e., improving environmental protection and climate change mitigation, improving biodiversity in agricultural landscapes, reducing mineral nitrogen fertilisation, improving soil fertility;
2. strengthening regional value chains;
3. increasing the protein supply from domestic productions and improving the protein supply through non-GMO protein crops;
4. increasing production and strengthen supply and demand for domestically produced pulses;

The key elements of the protein crop strategy are funding of research and development projects from the cultivation to the utilisation of protein crops along the whole value chain as well as transfer of knowledge into practice with a special focus on networks for soya bean, peas and beans, fodder legumes and a new cross-crop network for grain legumes ("LeguNet") (FEED Magazine/Kraftfutter, 2021).

1.3.3.2.7 The Netherlands: National Protein Strategy

In December 2020 the Dutch Ministry of Agriculture, Nature and Food Quality (MANFQ) launched its National Protein Strategy[65], that aims to: *i)* increase the level of self-sufficiency of new and existing vegetable proteins in a sustainable way by 2025: and *ii)* ensure a healthy balance in the ratio of animal to vegetable proteins in consumer diets. The Dutch government also intends to invest in research into new protein-rich sources for both humans and animals, and stimulate the extraction of proteins from co-products and by-products from other value chain. The Dutch Strategy proposes five key elements to support the advancement of a protein transition:

1. A focus on the cultivation of typical Dutch protein-rich crops (i.e., potatoes, grass and legumes, including field beans).
2. Stimulating the development of alternative protein sources for humans and animals, such as microbial proteins and cultured meat.
3. Production of insects for animal feed and food.
4. Valorisation of "residual flows" (co-products and by-products)
5. Increase the share of vegetable consumption and sustainable diets by offering sustainable choices and by educating consumers about healthy diets.

[65] https://www.rijksoverheid.nl/documenten/kamerstukken/2020/12/22/nationale-eiwitstrategie

2 ANALYTICAL CHAPTER

2.1 SQ1: Which are the dominant feeding strategies observed in the typical livestock production systems in the EU, and what are the main drivers behind?

SQ1 describes the feeding strategies existing within the EU. The answer to this question is based on a literature review, statistical analysis, CEREOPA methodology and consortium expertise. In addition, the information was crosschecked with data collected in the case studies or with interviews at EU level. The first step describes the typical livestock systems in the EU and helps identify the dominant feeding strategies for step two. The final step on the drivers of the dominant feeding strategies relies on the two previous steps.

2.1.1 Defining 'typical livestock production systems' in the EU by cluster

2.1.1.1 Overall description of the 'typical livestock production systems' in the EU

The overall description of the EU-27 livestock sectors focuses on dairy cattle, beef cattle, sheep meat and goat, pigmeat, laying hen and broiler production. Where possible, data are given according to conventional and non-conventional (non-GMO, organic, PDO/PGI) production systems. The figures have been developed based on the CEREOPA methodology and reporting data from December 2021.

Beef cattle are the ruminants with the highest number of LU in the EU, at around 34 million LU; dairy cattle follow with 28 million LU and sheep with 6 million LU. Goats are the least represented, with only 1 million LU. Regarding monogastric animals, pigs clearly lead at around 23 million LU, followed by broilers at around 6 million LU. Laying hens are last with around 5 million LU[66].

At EU level, the share of non-conventional breeding systems is different depending on the animal species, ranging from 5 %–10 % (for pigs, beef, sheep, and goats) to 40 % (for dairy cattle, led by non-GM feeding). As for broilers and laying hens, around 20 % of flocks of both types are raised in non-conventional production systems including organic farming.

2.1.1.2 Farm characteristics according to livestock production system

2.1.1.2.1 Farm size

Even though non-conventional systems are generally bigger than conventional ones in terms of hectares[67], the stocking density on conventional farm is generally higher than the that on non-conventional farms, and the proportion differs between clusters. The conventional beef and pig sectors are very concentrated in the largest farms (from 100 to 500 LU[68]); 59.5 % of beef cattle are reared on 11.4 % of farms, while 92.5 % of the herd is concentrated in 5.6 % of the farms for the pig sector. The non-conventional systems are less concentrated. Goat herds can range from 850 goats/farm in the Netherlands in the conventional system to 197 goats/farm in PDO/PGI systems in France. The dairy sector is more varied: even if less than 2 % of dairy farms in the EU-27 have 100 or more cows in the conventional system, the average LU/farm can vary from 17 (Austria) to 169 (Denmark) in non-conventional systems. Conventional and non-GM broilers are raised on very large farms with high densities (up to 42 kg/m^2, i.e. around 22 broilers/m^2 for conventional production[69]). On the other hand, organic or PDO/PGI farms have specifications requiring access to outdoors and a certain space per animal such as less than 12 broilers/m^2 in a closed building during the growing phase for the PDO/PGI 'Poulet de

[66] The CEREOPA data are higher than the Eurostat data because they take into account the number of slaughters over the year. This figure is therefore consistent with the feed produced.
[67] EU Agricultural Economic briefs (europa.eu)
[68] See cluster sheets.
[69] Council Directive 2007/43/EC of 28 June 2007 laying down minimum rules for the protection of chickens kept for meat production (text with EEA relevance).

Bresse', and up to 4m^2 for one bird according to Regulation (EU) 2018/848 for organic production.

2.1.1.2.2 Farm specialisation and other activities

There is a lack of data at EU level on the degree of specialisation of livestock farms, especially for non-conventional systems and small ruminants. However, it can be noted that specialisation seems more common for conventional systems. Specialist farms in cattle-rearing and fattening[70] accounted for 32 % of bovines reared in the EU-27 in 2020. This share is particularly high in Spain (61 %) but very low in Romania (7 %). The farms range from free-range farms in the Alpine regions to large and specialised dairy farms in northwest and central EU. The same statement can be made for pigs: specialist farms account for 82.7 % of the pigs reared in the EU-27. Romania is an exception, with 56 % of the total herd reared on specialist farms.

On the other hand, a typical conventional EU broiler farm cultivates 50 ha of crops (mostly cereals) and manages a 2 000-m² broiler unit growing 40 000 broilers every two months. All the manure is spread on the cultivated areas where cash crops are grown (Menghi et al., 2014). No average data are available at EU level for the specialisation of farms breeding laying hens. However, in France in 2017, the 13 % largest farms bred 30 % of organic laying hens. This was their main activity on the farms, which kept 9 000 hens on average. Twenty-four percent were middle-size farms and raised more than 58 % of organic hens, with 6 000 birds on average per farm. They were not specialised in laying hens and grew other productions[71].

2.1.1.3 Yields according to livestock production system

Non-conventional production systems have lower productivity than conventional ones (van Wagenberg et al., 2017) and were an estimated 12 % lower overall for organic farming (Gaudaré et al., 2021). Several factors can influence productivity in different production systems: feed (e.g. antinutritional factors (ANF) reduce yields for monogastrics), climate (e.g. species reduce their consumption under high temperatures) and breeds (e.g. slower growth strains), etc.

Other factors that can explain the difference in productivity between conventional and non-conventional systems are the breeds used, the feed ration composition, and higher vulnerability to animal diseases and parasites. Intensive and conventional production systems in fact use mostly a few highly selected breeds, while extensive and non-conventional systems tend to use less productive breeds, often associated with local and traditional niche markets in the EU (Bovo et al., 2020). Some breeds can also be associated with some PDO/PGI productions. Productivity differences are also significantly driven by feeding strategies. For dairy cattle, lower milk production can come from longer and more regulated pasture seasons and from feeding strategies with lower levels of concentrate supplementation or conserved forage (van Wagenberg et al., 2017). For ruminants, organic farmers use a higher share of fodder because organic concentrates feed is less available and limited by regulation, thereby explaining the productivity gap (Gaudaré et al., 2021). Among all livestock types, dairy cattle is the only one that presents a significant productivity difference between organic and conventional farming, at around 14 % (Gaudaré et al., 2021). Additionally, it has been proved that pasture feeding has a positive impact on the nutrient profile of the milk, by increasing the content of some beneficial nutrients (Alothman et al., 2019).

[70] Eurostat/FADN database.
[71] https://www.produire-bio.fr/articles-pratiques/les-elevages-de-poules-pondeuses-bio-en-france/

Box 2: Use of breeds in the EU in the dairy and pigmeat sectors

For pigmeat, the commercial breeds (Italian Large White, Italian Duroc and Italian Landrace) have been subject to intensive selection programmes since the early 1990s. Under specific conditions, these breeds perform better than the autochthonous breeds[72], which are usually raised in extensive or semi-extensive production systems and in more marginal areas. Autochthonous breeds are characterised by good adaptation to local agroclimatic and environmental conditions, high level of hardiness, slower growth rate and high adipogenic potential.

For dairy breeds, Holstein-Friesian cows are predominantly selected in conventional systems. Non-conventional systems might use other breeds, such as Normande, Montbéliarde, Swiss Brown, Jersey, Simmental, and Ayrshire (Rodríguez-Bermúdez et al., 2019).

Source: Consortium

2.1.1.4 Main type of organisation

The feed supply chain is characterised by the difference, in economic size, between farmers, processors and distributors. Bargaining power tends to concentrate towards the last links in the chain[73]. Such long supply chains[74] are the most common today, but shorter supply chains that directly link producers and consumers are being developed to deal with this asymmetry of bargaining power.

In the dairy cattle and dairy goat sector, the supply chain structure is mainly composed of private dairies and cooperatives. Cooperatives have a sizeable market share: in 2015, about 64 % of all EU cow's milk deliveries were handled by cooperatives. In addition, on-farm cheese processing and direct selling are more likely to be found for non-conventional dairy goats than for the conventional sector. For instance, in France (2020), the 5 000 goat farmers, almost all in family farming, are split into two types of supply chains. Half are in the dairy industry, with five dairy companies**Erreur ! Signet non défini.** representing 80 % of national milk collection. Because they can negotiate with big distribution companies, their products are mainly sold through national distribution channels and for export (Jenot et al., 2021). The other half are traditional goat farms producing cheese on-farm or delivering to artisanal dairies as well as refiners. They produce 20 % or 20,000 tonnes of French goat cheese per year. They mainly sell their products through local distribution channels (Jenot et al., 2021). Sheep milk production in the EU presents a lack of structured supply chain organisational patterns, and is characterised by low competitiveness and productivity.

For meat, some sectors have a high degree of vertical integration. Part of the pork industry is completely integrated (overseen by a single entity for breeding, slaughtering and sometimes processing into consumer products) (Bellini, 2021). For broilers, there are companies operating upstream and downstream of the production level (hatcheries, feed mills, slaughterhouses, and processing facilities), which may negotiate contracts directly with individual farmers or producers' organisations. There are also large and specialised operators focused on one level of the chain (horizontal integration). On the other hand, sheep meat and milk production shows a lack of structured supply-chain organisational patterns (European Commission et al., 2017). There are only four interbranch organisations in the EU for sheep meat (one in Spain and three in France). In the beef sector a consolidation is emerging, with a decreasing number of companies producing increasing volumes of meat (on the 2012-2019 period). There are ten recognised interbranch organisations in the mainland EU beef and veal sector (among 5 are in France).

[72] i.e., Alentejana, Bísara, Majorcan Black, Basque, Gascon, Apulo-Calabrese, Casertana, Cinta Senese, Mora Romagnola, Nero Siciliano, Sarda, Krškopolje pig, Black Slavonian, Turopolje, Moravka, Swallow-Bellied Mangalitsa, Schwäbisch-Hällisches Schwein, Lithuanian indigenous wattle and Lithuanian White old type.

[73] http://www.eurodetachement-travail.eu/datas/files/EUR/chaine%20fr1].pdf

[74] https://www.eufic.org/fr/production-alimentaire/article/chaines-dapprovisionnement-alimentaire-courtes-relier-les-producteurs-et-les-consommateurs/

The EU system relies on a number of market measures to stabilise the beef and veal market when necessary.

For eggs, in the upstream supply chain, intra-EU trade in one-day-old pullets is very specialised and highly concentrated. There are few genetic firms and hatcheries. On the downstream side, packaging and ovo-products facilities are parts of international groups. In the non-conventional sector, the integration level depends on the sector. For example, the 'Oeuf de Loué' PGI is highly integrated, while small organic holdings are not integrated.

The supply-chain structures of non-conventional production systems can be subject to stricter regulations than conventional systems. For example, for organic cattle, sheep and goats, according to Regulation (EU) 2018/848[75] *'at least 60 % of the feed shall come from the farm itself or, if this is not feasible or such feed is not available, shall be produced in cooperation with other organic or in-conversion production units and feed operators using feed and feed material from the same region'*. For pigs and poultry, the regulation is the same, but the percentage of local feed is 30 %.

2.1.2 Describing 'dominant feed strategies' by typical livestock system

2.1.2.1 Overall description of the 'dominant feed strategies'

The dominant feed strategies are described in this part by typical livestock system. While the range of feeding strategies is quite wide, two main categories can be distinguished: ruminant and monogastric animals[76]. The livestock needs and the detailed nutritional values are available in SQ2 (see Section 2.2).

Ruminants' rations rely on forage[77], which makes up between 60 % and 100 % of their diet depending on the production system. This percentage is higher in non-conventional systems. The rest of the ration is made up of concentrates, co-products and by-products[78], supplied either by feed manufacturers (in the case of dairy cattle and conventionally fed goats) or made on the farm, mostly in the case of beef. There are no data on sheep concentrates. The share of concentrates may lead to dependency on imports (especially soya bean meal imports) for the conventional dairy-cattle and goat sectors (see Section 2.1.2.3).

The diet of monogastric animals is essentially made of cereals (around 60 % to 70 %) and oilseeds meals, especially for laying hens for which soya bean meal is incorporated into the rations up to 25 %. This figure is only 15 % for broilers' rations. The feed for monogastric animals mainly comes from feed manufacturers, at between 30 % and 95 %. Cereals are extensively produced in the EU, but the oilseeds and oilseeds meals mainly come from imports, creating a dependency on this feed.

The table below provides a summary of the average rations at EU level:

Table 7: Summary of the average ration for livestock at EU level (crude protein, tonnes)

Crude protein (tonnes)	Bovines	Sheep and goats	Pigs	Poultry	Total
Grass	**25 (52 %)**	**4 (64 %)**	0	0	**29.1**
Fodder maize	4 (9 %)	0	0	0	**4.7**
Other roughage crops	10 (21 %)	1 (18 %)	0	0	**11.2**
Cereals	3 (6 %)	0	**7 (58 %)**	**5 (57 %)**	**15.2**
Pulses and oilseeds	0	0	1 (5 %)	0	**0.9**
By-products	6 (12 %)	1 (9 %)	5 (36 %)	3 (37 %)	**14.2**
Other feed	0	0	0	0	**0.6**

[75] Regulation (EU) 2018/848 of the European Parliament and of the Council of 30 May 2018 on organic production and labelling of organic products and repealing Council Regulation (EC) 834/2007.
[76] More detailed information is available by cluster and subcluster in the case-study reports.
[77] Forages include grass, preserved grass, and plants harvested green (fodder crops).
[78] Concentrates are everything that is not grass.

Crude protein (tonnes)	Bovines	Sheep and goats	Pigs	Poultry	Total
Soya bean meal	0	0	0	0	**0.8**
Total	**49.32**	**6**	**12.56**	**9.03**	**77**

Source: data from CAPRI modelling[79]

For a single species, feeding strategies can also vary between production systems (Gaudaré et al., 2021). Conventional dairy cattle in the EU consume on average 71 % forage, whereas organic dairy cattle consume 86 % forage and PDO/PGI dairy cattle consume 78 to 100 % forage.

2.1.2.2 Access to feed materials and on-farm feed production

In the EU, the biggest livestock farms are mostly located where the supply of feed is easier: farms with ruminants are more likely to be in areas with a high share of grassland in the UAA. Goats and sheep are more likely to be located where there are shrubs not consumed by other animals, especially in marginal areas of grasslands and shrublands. Farms rearing monogastric animals tend to be located in areas close to where the share of arable land, cereals, oilseeds and protein crops is higher (see figures below), or where access to imported raw materials is facilitated by favourable location factors like ports or internal transport systems (e.g. the Netherlands).

Figure 26: Agricultural land use in the EU

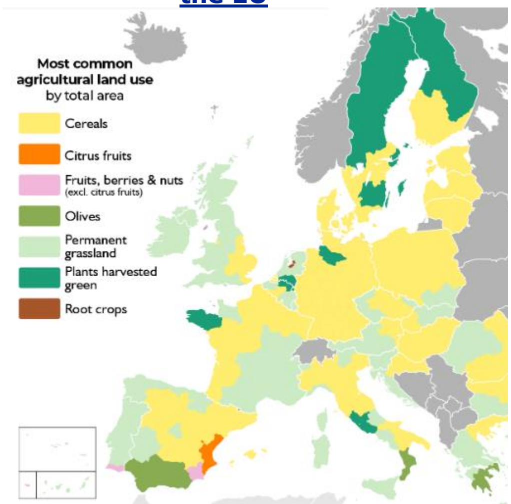
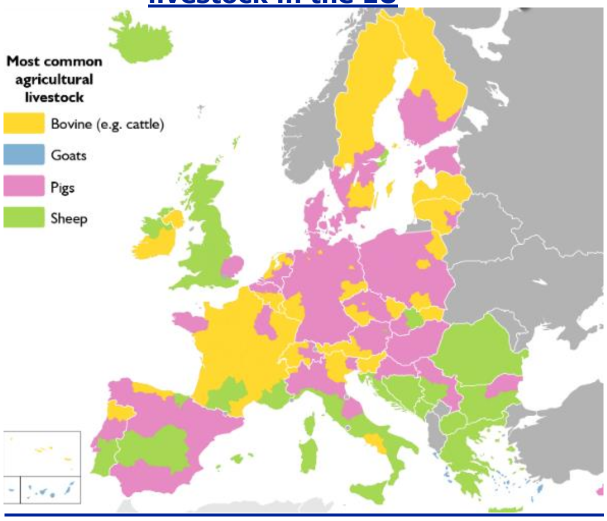


Figure 27: Most common agricultural livestock in the EU



Source: (Landgeist, 2021) [80]

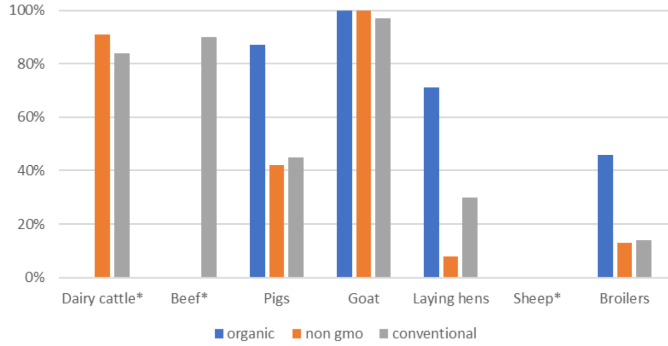
The production of on-farm feed can either fulfil all the needs of the farm or be mixed with a commercial feed that complements the ration[81]. For all types of livestock, the feed produced on-farm is higher for organic production systems; this is due to organic regulations (see 1.3.1.3). According to the feed manufacturer survey, 56 % of ruminant farms have more than 40 % self-consumption of feedstuff (like cereals, co-products, but excluding fodder), 10 % of pig and poultry farms produce no feed at all, 42.5 % produce less than 20 % of their feed, and 17.5 % produce over 40 % of their feed.

[79] Common Agricultural Policy Regional Impact (CAPRI) is an economic partial equilibrium model designed to evaluate the effects of EU agricultural policy. The model's database is filled with agricultural accounts and trade data mainly sourced from Eurostat and FAOSTAT. Feed rations are based on 11 feed groups, which can be detailed into 45 feed items. For further details see what_is_capri [CAPRI Online Manual (update)] (capri-model.org)

[80] https://landgeist.com/2021/09/02/europes-most-common-livestock/

[81] https://www.bretagne.synagri.com/synagri/fabrication-d-aliments-a-la-ferme#:~:text=La%20fabrication%20d'aliment%20%C3%A0%20la%20ferme&text=Deux%20modes%20de%20fabrication%20existent,qu'un%20peu%20de%20c%C3%A9r%C3%A9ales.

Figure 28 : Share of feed produced on-farm (forages and home concentrates) by type of animal



Source: CEREOPA own calculation

*Data for organic dairy cattle, organic and non-GMO beef, and sheep are not available.

2.1.2.3 Dependency on imports according to main feeding strategy

While the specificity of each production system makes it difficult to determine a dominant feeding strategy by livestock type at EU level, some sectors are more or less dependent on extra-EU imports. In the table below, it can be noted that monogastrics rely more on imports than ruminants. Indeed, as their diet is composed mainly of cereals and rounded out by oilseeds meals (especially soya bean meals, rapeseed meals and sunflower meals), the demand for these kinds of feed are met through extra-EU imports. On the other hand, as ruminants are mainly fed by forage, they are less dependent on imports and rely more on on-farm produced feed (e.g. grassland) (see 2.1.2.3).

Regarding distinction by raw material origin, the most imported one is soya bean meals, coming mostly from South America for the conventional production systems, and from West Africa or Asia for organic production. Soya bean availability in the EU is still too low to meet the demand, and the EU stakeholders interviewed emphasised that it is not the most competitive crop, as it enters into competition with more profitable crops such as cereals, although soya bean production can bring agronomic advantages in crop rotations. Still, the EU has a comparative advantage over non-GM production of soya beans. Moreover, the various clusters rely on Eastern European countries, and especially Ukraine and Russia, for sunflower meal.

Table 8: Main origin of the raw materials

Sector	**Laying hen**	**Pigmeat**	**Pigmeat**	**Dairy cattle**	**Dairy cattle**	**Broiler**	**Beef**	**Beef**	**Dairy goat**	**Sheep meat**
Production systems	Org	Conv	Non-conv	Conv	Non-conv	Conv	Conv	Non-conv	Conv	Conv
SSD	FR	DE	ES	FR	DE	PL	FR	IT	FR	ES
Cereals (maize excluded)	++	++	++	+		++	+	+		
Maize		++			+	++		+		
Peas / field bean										Not used
Soya bean meal	+	+	+		+	+			+	+
Sunflower seed meal			+							Not used
Rapeseed meal		+	+							Not used

Sector	Laying hen	Pigmeat	Pigmeat	Dairy cattle	Dairy cattle	Broiler	Beef	Beef	Dairy goat	Sheep meat
Forage	Not used	Not used	Not used	++	++	Not used	++	++	++	++

Source: case studies

(green)	EU-grown product
(yellow)	Partly EU-grown (<50 % of total supply)
(red)	Mainly imported from outside the EU (>50 % of supply)
(grey)	Missing data
++	Main feed component (>50 % of the ration)
+	Other significant feed components

Box 3: Feed price volatility and futures markets in the EU

Two categories of protein crop raw materials must be distinguished: those which have a futures market and those which do not.

Three of the four major raw materials used in animal feed in the EU are highly correlated with the world market: corn, wheat and soya bean meal. All three have fluid Chicago futures markets (Chicago Board of Trade (CBOT)). On the EU side, Euronext is more active and representative in wheat and in corn. Soya is not listed there. Livestock feed manufacturers arbitrate their purchases either through futures contracts or through options (a type of insurance that is less expensive to operate than futures). This helps reduce their exposure to price volatility.

Other techniques have developed (Against Actuals) around these futures, in order to decorrelate the act of purchasing and selling by the two commercial partners (the supplier and the food manufacturer), allowing for a win-win situation. Soya bean meal can only be arbitraged in Chicago with a significant 'currency' risk, and not on 100 % of its European quotation, which results from an equation with four unknowns: Chicago futures market + prime FOB South America + freight and insurance + EUR/USD parity.

Certain raw materials are not directly 'arbitrable' but can be linked to a futures market via a premium (this is the case for wheat co-products, for example). All others are finally not 'arbitrable' and are therefore riskier. Rapeseed meal has a futures market (Euronext), but it is not very fluid (not enough participants and contracts exchanged). Sunflower and rapeseed meals are subject to the volatility of soya bean meal but also of the oil market. The pea price equation takes into account not only the prices of wheat and of soya bean meal, but also the volume of protein crops available. The market visibility of these three raw materials is therefore reduced, which may limit their interest compared to soya beans, whose market is easier to anticipate.

The European cereals market is affected by globalisation, and storage organisations set their prices according to the global context. Producers/breeders who sell/buy wheat or maize on the European market do not have this culture of the futures market as do their American counterparts and are undoubtedly more subject to price volatility. A mixed farmer-breeder most often uses harvested crops, regardless of changes in the market price. They are then less linked to volatility, but undoubtedly they sometimes miss certain opportunities.

To encourage the production of peas or soya, contracts are put in place between growers and commercial structures which want to secure volumes (often to supply a profitable niche market). In this case, operators agree on volumes and set price targets linked to futures markets when possible (fixed plus premium, price tunnel, etc.).

Source: Consortium

2.1.3 Analysing drivers of feeding strategies (financial, economic, regulatory, logistics, etc.) by type of operator

Drivers of feeding strategies have common points for all different clusters but can differ according to the type of stakeholders (arable crop farmers, livestock farmers, raw material suppliers, feed manufacturers, retailers, etc.).

2.1.3.1 Drivers for livestock farmers

One of the most important costs for livestock farmers is feed. In the monogastric case studies, feed represents at least 60% of the production costs (see SQ6). According to the stakeholders in all case studies, this cost, determined on the global market, is one of the main drivers influencing farmers' choice. It is influenced by several factors:

- The **price of the raw material or the feed** must not be too expensive to be integrated in the ration;
- The **price ratio between cereals, feed/raw material and animal product**. If the price of cereals is very high, livestock farmers with cropland usually grow cereals to sell them and buy the feed. On the contrary, if the price of protein is high and the price of cereals is low, farmers tend to grow their own protein crops to use it as feed.
- The **ratio between the price of the raw material/feed and their nutritional quality**. Crops and forages must be of good nutritional quality to be aligned with the needs of the animals. Some types of animals need specific diets in terms of nutritional profile, taking into account the intake capacity and preferences of the species.

Box 4: Examples of prices for protein alternatives

Scenario modelling has shown that **when a feed is competitive, it is integrated into the ration at the expense of other feeds.** For example (see Table 9), for the cluster Beef conventional in France, the price of sunflower meal HP 40 is 294 EUR/tonnes, whereas it would be integrated in the ration at a price of 255 EUR/tonnes. For the cluster Pig conventional in Germany, the price of insects is 2.000 EUR/tonnes on the market, while it should be 10 times cheaper to be integrated in the ration. For lupines in the cluster broiler conventional in Poland, the price is 224-253 EUR/tonnes, while it would be integrated at 165 EUR/tonnes. For dried alfalfa, in the cluster beef non-conventional in Italy, it is 158 EUR/tonnes, while it would be integrated at 127.5 EUR/tonnes.

Table 9: Example of protein fed that have a price too high on the market to be integrated in the ration.

Cluster	Scenario	Price on the market	Price for protein alternative fed to be integrated in the ration
Beef conventional in France	Introduction of sunflower meal HP40	294 EUR/t	255 EUR /t
Pig conventional in Germany	Introduction of insect meal - black soldier fly pupae (BSF)	2.000 EUR/t	200 EUR /t
Broiler conventional in Poland	Introduction of lupines	224-253 EUR/t	165 EUR /t
Beef non-conventional in Italy	Introduction of alfalfa dried in the Charolais diet	158 EUR /t	127.5 EUR /t

Source: Case Studies

Source: Agrosynergie

Moreover, in integrated supply chains, contracts are implemented between farmers and the other stakeholders (e.g., buyers, collectors, slaughterhouses). This may constrain the integration of alternative feeding strategies. In other supply chains, the feed can also be sold by farmers without any contractual relationship on spot markets, at current day price on a reference market, or on informal markets. Finally**, tradition is often important among farmers**: today's feeding strategies are a direct consequence of the strategies adopted by their parents or grandparents.

2.1.3.2 Drivers for suppliers of feed materials

A relevant share of raw materials is supplied to feed manufacturers and livestock farmers by intermediate processors and industrial producers. Traders of commodities also play a major role in the supply chain of ingredients used in the feed production.

The main driver identified by these players is **price**: as the strategy of feed manufacturers is to find the most cost-effective way to produce feed products with the desired nutritional qualities, suppliers of feed ingredients primarily adapt their offer on the grounds of the relative prices of feed materials on the market. The point is to strike a balance between the value of the proteins and their price, also minding the trade-off between growth time and cost of the most effective proteins. The **relative price** of the different protein sources for feed *compared to soya* is thus a key parameter in the market for feed ingredients and the change in incorporation rates of these ingredients within the ration (pull component).

For some protein-rich raw materials, the feed sector competes with other, more profitable, value chains. Such markets are often able to pay higher prices for some ingredients also used in feed, thus reducing the quantities ultimately available to the livestock sector. This can reportedly be the case for the following raw materials:

- Starch co-products used in pet food, specialised human nutrition, but also insect farming;
- Insect meals, whose price is still too high for the livestock sectors to be a viable feed ingredient on a large scale (see SQ3 and SQ5). Outlets such as pet food or aquaculture can better value them;
- Processed Animal Proteins (PAPs), which have found in pet-food a profitable market outlet after the Bovine spongiform encephalopathy (BSE) crisis led to their ban from livestock feed (see SQ5);
- Soya bean and pulses that are often firstly dedicated to human consumption.

For a number of key protein sources such as oilseed meals (but also starch co-products, and all co-products from other industries in general) it should be highlighted that **the main driver for feed suppliers is actually the market demand for their core production**, i.e., vegetable oil, starch, meat, etc. As far as prices for vegetable oils remain high and demand thrives, oilseed meals will be readily available on the market, and it will be economically relevant to use them in feed.

Regulatory requirements also play a major role in influencing the choices of suppliers of feed materials. This is particularly true in the case of **PAPs**: since their re-authorisation for feed use (for *monogastric species* only), the requirements in place have been particularly stringent, with a control system deemed burdensome and of limited efficiency by consulted stakeholders. In this policy context, so far, only a limited number of PAPs suppliers have chosen to make the organisational changes and investments needed to access the feed market. **Responsible soya** imports entail a change in the operational and sourcing practices of traders and crushers, who foresee an increase in costs to comply with traceability requirements. On the one hand, these operators have already been working in third countries to improve farming practices and address deforestation issues in their supply chain (as reported by interviewed organisations); on the other hand, legal requirements regarding imported deforestation such as **Regulation (EU) 2023/1115**[82] are expected to have a non-negligible impact on the imports of raw materials for feed use, thanks to better traceability.

2.1.3.3 Drivers for feed manufacturers

The **main drivers for feed manufacturers are nutritional quality, price, and availability** (of feed materials and feed additives), the latter also including the aspect of *consistency* in the supply (stable quality and satisfactory quantity). **Sustainability** is also

[82] REGULATION (EU) 2023/1115 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 31 May 2023 on the making available on the Union market and the export from the Union of certain commodities and products associated with deforestation and forest degradation and repealing Regulation (EU) No 995/201.

an increasingly relevant driver, according to the consulted stakeholders. According to the feed manufacturers surveyed, 62% of them tried to include more EU-grown feed in their production. The main reasons were, inter alia, to respond to customers demand (37%), decrease imports dependency (22%) and increase the crop rotation sustainability (20% each).

In terms of nutritional quality, the key aspect is the overall composition of feed as a source of nutrients (proteins, amino acids, fats, minerals, etc.): the type of feed material itself is less relevant as long as it is available, cost effective and provides the right nutrients needed by the animal species supplied. In this regard, it should also be underlined that in the ***poultry and pig segments***, the diet is rather standard and usually undergoes relatively limited changes unless the prices of raw materials change dramatically. Whilst *monogastric species* are **protein-intensive animals and rely heavily on soya bean meal**, mid-protein products (i.e., sunflower meal and rapeseed meal) can be interesting feed materials for **bovines**, due to the type of rearing, the lower protein intensity required (also related to the size of the stomach) and the higher importance of fibre in the diet. Another variable for feed manufacturers supplying *ruminants* is the availability of natural proteins from grazing/forage/silage crops: in case of droughts, for example, there is usually an increase in demand for compound feed integration.

Soya is still deemed to be a crucial source of feed proteins by most business stakeholders consulted for the study, which consider it to be rather difficult to substitute from a protein content and cost perspective. According to the results of the survey carried out for this study, **purchases of soya bean meal by feed manufacturers are predominantly driven by the quality/price ratio** (56% of survey replies) but are also linked to the share of *poultry* feed in the manufacturer's production and to a limited availability of other types of oilseed meal. 67.6% of respondents hedge their soya purchases with futures and/or options.

Box 5: Feed price volatility and futures markets in the EU

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- All others are finally not "arbitrable" and are therefore riskier. Rapeseed meal has a futures market (Euronext) but it is not very liquid (not enough participants and contracts exchanged). Sunflower and rapeseed meals are subject to the volatility of soya bean meal but also of the oil market. The pea price equation takes into account the price of wheat and that of soya bean meal, but also the volumes of protein crops available. The market visibility of these three raw materials is therefore reduced, which may limit their interest face to soya bean, on which anticipations are "easier".

European cereals live in global times, and storage organisations set their prices according to the global context. Producers/breeders who sell/buy wheat or corn on the European market do not have this culture of the futures market, like their American counterparts and are undoubtedly more subject to price volatility. A mixed farmer-breeder most often uses harvested crops, regardless of changes in the market price. It is then less linked to volatility, but undoubtedly sometimes he misses certain opportunities.

To encourage the production of peas or soya, contracts are put in place between growers and commercial structures which want to secure volumes (often to supply a profitable niche market). In this case, operators agree on volumes and set price targets, more or less linked to futures markets when possible (fixed plus premium, price tunnel, etc.).

Source: Consortium

2.1.3.4 Drivers for other operators in the supply chain (food producers and retailers)

Operators in the downstream stages of the animal products value chains reported **food (and thus feed) safety as a primary concern**, with an emphasis on the need of ensuring traceability throughout the supply chain. **Food processors** are interested in feeding strategies also in terms of the **final characteristics of the animal products they use**. This is particularly true, for example, in the case of eggs, where the colour of the yolk is tightly linked to the nutritional characteristics of feed used for laying hens. As the yellow colour of the yolk is an important feature for many industries (e.g., pasta, mayonnaise, etc.), egg processors welcome the possibility of using feed ingredients and additives that allow for such natural colouring, whilst preserving animal health and welfare.

Retailers in particular, from their position at the end of the supply chain, are driven by consumer demand: requirements on elements linked to animal welfare, climate issues, health and nutrition, for example, are based on consumption trends and can be included in specifications for suppliers. Some key topics in this regard involve, e.g., GM-free products[83], deforestation-free products and organic products. More details on drivers for retailers are available in the main findings of SQ8 (see Section 2.8.3).

Consumer perception on the main problems related to raw materials used in animal farming mostly involves deforestation-related crops (mainly soya) and issues related to animal health and welfare, but also the use of proteins of animal origin (PAPs). After the BSE crisis, perception surrounding such proteins is still rather negative (albeit with differences among MSs), and their use is complicated to explain to consumers, from the retailers' standpoint. However, some change was reported in the attitude of retailers towards PAPs used in feed, resulting in a slow phasing out of the exclusions related to animal proteins in some instances. In particular, sector organisations expressed the interest among retailers in building a circular food system and collaborating with farmers to ensure availability and supply of sustainable and locally produced feed ingredients.

Other strong drivers are **legislation** (determining the allowed feeding practices) and the **spending capacity of consumers**. Due to the current economic context (inflation, energy crisis), consumers are very price sensitive, showing a polarisation between higher and lower income households, with the latter less inclined to purchase higher quality products. In light of this, it should be considered that some feeding strategies leading to premium quality and pricing might not lead to an increased consumption of the derived animal products if the final prices are perceived by consumers as unaffordable.

2.1.4 Main findings

Feeding strategies can be divided between monogastric and ruminant species. The former is much more dependent on cereals that often represent more than 60 % of their diet, while ruminants rely on grasslands or fodder, representing around 80 % of their diet. These feeding strategies largely explain the locations of the different livestock sectors, i.e., next to production basins of grains or grass. As protein sources are essential for

[83] Different levels of interest for non-GMO products are registered among consumers across the EU (very strong demand in some MSs, but not everywhere), linked to media attention, specific campaigns, societal expectations, etc.

livestock productivity, both categories depend on meals and especially on soya bean meal, which is mainly imported (from the Americas for the conventional sector, and from Africa or Asia for the organic sector). For a single species, feeding strategies may be different according to the production system (conventional or organic). This is especially the case for dairy cattle, for which non-conventional farming is less reliant on concentrates.

As for non-conventional feeding strategies, they can also be partly influenced by their respective specifications or requirements (e.g. percentage of local production for the organic sector). At EU level, **non-conventional systems (non-GM, organic, PDO/PGI) are more developed for ruminants** than for monogastrics. Indeed, for the organic sector, as ruminants can be fed with grasslands or fodder, they are less dependent on concentrates or grains, which are a major expenditure and in addition are subject to availability issues. The situation is variable between Member States, some of which are already very developed (e.g. almost 100 % of dairy cattle in Germany are non-GM fed).

Due to these diets' compositions and availability of feed components, **both conventional and non-conventional systems of monogastric farming tends to be more dependent on imports than is ruminant farming**. However, the latter remains linked to imports, and no significant difference is noted between the two production systems.

The feeding strategies are mainly driven by **economic reasons**. Farmers, raw material suppliers and feed manufacturers make their decision based on the **prices** of raw materials and, more precisely, on the **price ratios** of crops/feed (farmers)[84], crops/soya beans (suppliers)[85] and quality/price (farmers, feed manufacturers)[86].

Nevertheless, there are additional drivers to explain feeding strategies. Farmers are influenced by **contractual arrangement** and **traditional practices**[87]. Suppliers of raw materials are also dependent on **regulatory requirements** that can prevent them from supplying types of raw materials (e.g. PAP, non-deforesting soya, etc.). They are also driven by **other markets**, since there is competition for some raw materials with other sectors (e.g. pet food, human consumption, etc., and even among livestock sectors that are willing to pay higher prices, thereby reducing availability for feed use. Likewise, some raw materials such as meals are dependent on **demand for core production** (e.g. oils and starch). Beyond prices, feed manufacturers have to strike the right balance between **nutritional quality, availability** and prices. Last but not least, **sustainability** considerations such as deforestation-free soya are growing among all stakeholders, encouraged by **regulations** and **consumer demand**. The latter is very price sensitive and drives retailers' choices.

[84] If the price of cereals is too high, livestock farmers with cropland usually grow cereals to sell them and then buy feed. On the contrary, if the price of protein is high and the price of cereals is low, farmers tend to grow their own protein crops to use for feed (see Section 2.1.3.1).
[85] As soya beans are a competitive protein source (protein content/price), suppliers usually compare the relative price of the other different protein sources for feed to soya (see Section 2.1.3.2).
[86] For farmers, the protein sources must be of good nutritional quality to satisfy animal needs, palatability and specificities of the species (see Section 2.1.3.1).
[87] i.e. practices based on family heritage and on the most common practices used by farmers at the local scale.

2.2 SQ2: How could the typical feed composition be diversified to include more EU-grown feed taking into account the impact of possible feed alternatives on nutrition values of different feed sources (energy, protein content digestibility, and other nutrients characteristics)?

Determining the composition of livestock feeds requires optimal provision of energy and nutrients, by creating a balanced diet that both meets the biological requirements of the animal for a given level of performance and minimises the cost of the diet. In particular, the formulation of compound feeds typically uses this least-cost optimisation approach. Given the nutritional quality of the available raw materials, the biological requirements of the animals and other constraints (e.g. limits on how much of a material can be included into a diet, availability, etc.), and the prices at which the raw materials are supplied, the composition of the final feed/ration is that which meets all the requirements and constraints, at the lowest cost.

This strategy has led to the widespread use of maize and of soya bean meals worldwide. These have ideal as well as well-known and quite stable characteristics in terms of energy (maize) and protein (soya bean meal), and they have few constraints (low fibre). Although hundreds of raw materials are available, including those grown in the EU, it remains difficult to replace these two main staples of livestock diets. Compared to soya bean meal, alternative protein sources may be deficient in essential or semi-essential amino acids, may contain excess fibre or harmful anti-nutritional factors (ANF) that require costly processing to remove[88]. Diversification therefore turns difficult because the alternative feeds do not meet quality or economic requirements. However, research has been and is still carried out, such as the Horizon Europe programme[89], to find alternative raw materials that could be grown in the EU and that would maintain the right nutritional balance.

In addition to this approach dedicated to compound feed, this study also analyses the role that grass, and enriched roughage could play in the ruminants' systems. On the other hand, some alternative strategies focus on improving the quality of existing alternative products, by improving genetics or processes (e.g. fractioning, green protein, etc.). These strategies are presented in SQ5. The objective of SQ2 is to explore these EU-grown feed candidates for the diversification of EU livestock diets (including cereals, forage/roughage, and protein crops) and to see how they can meet the nutritional needs of livestock in a way that can be technically[90] and economically feasible.

2.2.1 Definition of the feed composition elements of each cluster

2.2.1.1 Needs and typical diets of the studied species

Many factors can influence the needs of species, such as production systems, climate, breed, and others. These needs are met by diversifying the diets of each species with feed that provides energy, proteins, fibres, or nutrients, etc. Formulation consists in optimising a mixture of raw materials to satisfy the 'needs' and to meet performance and product quality objectives as well as specifications that correspond to the target market (conventional, non-GMO, organic, PDO/PGI, etc.). The production challenges concern zootechnical performance as well as sensory characteristics and the technological aptitudes of the products for cutting or processing. It is therefore a question of adapting a production scheme (genetic choice, breeding model) and optimising the feed to satisfy all the constraints at the lowest cost (economic, environmental).

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[88] The processes mentioned in the case studies concerned cooking, dehulling or extruding protein crops.

[89] Additional details on the various research programmes undertaken as part of Horizon Europe are available in Section 1.3.3 (see Table 5).

[90] In this report, technical feasibility implies the following aspects: i) no impact on animal performances, ii) technology already exists or the development path for implementation has been established and shows at least some promising results, even if preliminary, iii) a suitable context (economic, pedo-climatic, and organizational), and iv) a positive impact on improving protein self-sufficiency in the EU.

As stated above, the **type of species** can require specific needs and diets (see also Section 2.5.3). But the feeding strategies can also vary greatly for the same species between Member States, depending on the **availabilities of raw materials and the price ratio**. In the case study on the 'Organic Laying Hens' cluster for instance, while northern Member States (Sweden, Denmark) were used to incorporating fish meal within the diet, this is not a usual practice in France. Moreover, the range of a diet for a same species within a Member State can also significantly change (see the box opposite on the dairy goat cluster). Finally, **diet also changes along the lifecycle** of a species to meet as precisely as possible their needs.

Box 6: Feeding systems of the goat sector in France

In France, a study described nine goat feeding systems whose main characteristics are described below:

- Dominant legume hay: More than 80 % of fodder is hay, and more than 70 % is legume hay.
- Hay of grasses and legumes: More than 80 % of fodder is hay and less than 70 % is legume hay.
- Grazing: More than 90 days of grazing.
- Maize silage: More than 20 % of fodder is maize silage.
- Pastoral system focusing on distributed feed: 30 % to 75 % of annual ration is from rough grazing and grassland grazing. At least 500 kg of hay per goat per year is bought.
- Pastoral system relying on grazing: More than 75 % of the annual ration comes from rough grazing and grassland grazing. Less than 300 kg of hay is bought per goat per year.
- Feeding in green fodder: More than 30 % of fodder is fresh grass distributed mechanically.
- Wrapping: More than 20 % of fodder is distributed wrapping.
- Dehydrated and concentrated dry rations: Concentrates and dehydrates represent more than 50 % of the ration, or more than 600 kg per year per goat.

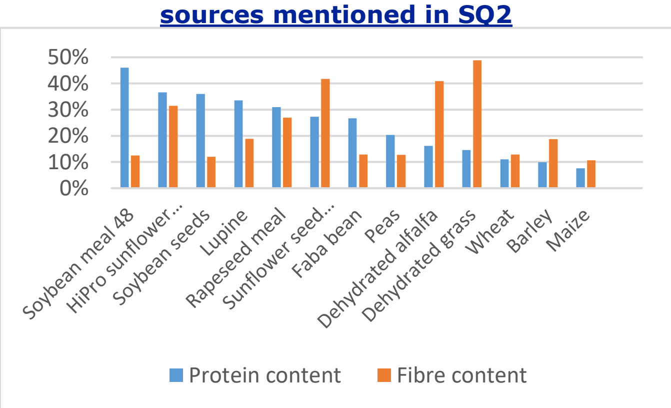
Source:(GEB, 2022)

Therefore, making a generalisation about a typical diet requires a rough estimate that cannot consider every specificity in each production system**. The general diets and raw material origin are described in SQ1.** For each scenario of diversification modelled for the case-study clusters (see 1.2), the diet changes were modelled. **All modelling work was run to test different EU-grown feed, assuming that the species needs are fully met, implying no impact on animal productivity.**

2.2.1.1.1 Nutritional values of the raw materials

The diets are not only determined according to crude protein needs but also based on other nutritional values such as fat, starch, etc. The protein and fibre contents of the main raw materials discussed in the SQ are presented in the opposite figure. A distinction may exist between conventional and organic raw materials, especially for meals (see Box 7). Moreover, fodder nutritional values are highly dependent on the crop used.

Figure 29: Protein and fibre content (% as fed) of the conventional alternative protein sources mentioned in SQ2



Source : https://www.feedtables.com/content/tables

2.2.1.1.2 Limits for the inclusion of feed materials into the different diets

The first limiting factor for feed distribution to consider is the **ingestion capacity of the animals** due to the physical volume taken in the rumen or in the stomach. It is even more relevant to consider for ruminants, since **forages occupy a lot of space and may have low nutritional values**. Thus, special attention must be taken to avoid deconcentrating too much energy and protein intake (e.g. alfalfa fed to lambs or goats, which has a high protein content but a low energy value and a high fibre content). Although some raw materials seem promising based on their nutritional values, there may be limitations on their incorporation into diets, due to the biological process that can alter animals' health and productivity. This issue mainly concerns monogastric species that are more sensitive to it. Thus, laying hens and poultry can suffer from legumes ANF such as vicine and convicine from fava beans, which are haemolytic agents. Even if ruminant species are less sensitive to ANF, because they are degraded in the rumen, they can trigger ruminal acidosis due to their high starch content.

From a nutritional point of view, one other factor that limits **legume seeds use is their amino acid profile.** It was an issue particularly raised in the monogastric case studies (conventional broilers in Poland and organic laying hens in France) as well as in the interviews conducted at EU level. Indeed, as these species are required to attain high production levels, their needs for amino acids – and particularly methionine in the case of laying hens – is notably high. Thus, some raw materials with interesting crude protein content **may not provide the right content in specific amino acids**. In the case of ruminant animals, amino acid profile is less relevant due to the protein degradation in the rumen and to microbial synthesis, as mentioned in the case studies on ruminants and in Pathak et al. (Pathak, 2008)[91].Thus, amino acids need to be protected from the rumen to supplement the animal, otherwise they are degraded and transformed into microbial protein.

Moreover, some **raw materials are not palatable** for the species. Therefore, even if their share is increased in the ration, the animals will not eat more of them. The inclusion rates of some meals are also limited by **some specifications**[92].

Some solutions exist to overcome those limits, although they may increase the feed cost. These include:

- **Genetic solution and breeding: selection** of low-ANF varieties or varieties that do not produce those ANF (e.g. zero alkaloid genes of lupines). This option can nevertheless be accompanied by lower yields, and the availability of the products on the market remains low (e.g. zero vicine/convicine fava beans (Khazaei et al., 2019)).
- **Detoxification methods** based on the transformation of the raw material (e.g. heating of soya beans to eliminate antitrypsic factors, or heating fava beans with beta-glucosidase to eliminate vicine and convicine (Khazaei et al., 2019)). However, those technologies can alter the quality of the raw materials and the amino acid's digestibility.
- **Processing of the raw material** makes it possible to concentrate the proteins from various materials, such as grass and legume grass. The fibres are removed in the process, making it possible to feed monogastric animals with the protein

[91] This study showed that microbial protein amounted to two thirds of protein intake and that the rumen enabled production of around 13 g of microbial protein for 100 g of digested organic matter.

[92] The case study on non-conventional beef in Italy highlighted that rapeseed meal was forbidden in some PDO, PGI and by some retailers due to its meat-darkening effects. Alfalfa inclusion is also limited due to its darkening effect on meat colour and yellowing effect on fat colour. Siloed material use (and especially grass and maize silage) is also limited in PDO/PGI raw-milk cheese production for sanitary reasons, to avoid the risk of food poisoning due to the microorganisms present in the silage that can be transferred to milk, as mentioned in non-conventional dairy cattle and conventional dairy goat case studies.

concentrates obtained. However, this process is still expensive and requires heavy infrastructure. (Santamaría-Fernández and Lübeck, 2020)

- Parasitism can be overcome through **green fodder feeding** (the grass is cut and given fresh to the animals), but this technique requires heavy investments for specific material, as mentioned in the case study on conventional goats in France.

2.2.2 Alternative feeds by species

To diversify the sources of proteins within the diet of animal species, some alternative feeds were identified through the literature review and the case studies for each subcluster. These feeds can be either existing ones that are produced in the EU or new feeds already produced in the EU that are not yet widely available. Besides EU-grown alternative feed, SQ2 also deals with the quality improvement of meals with a higher protein rate (see box below).

Box 7: improving meal quality, a promising strategy.

To produce oilseed meals with higher content of crude protein, there are **technological processes to remove the hull of oilseeds** (e.g. sunflower), to decrease the fibre content and thus increase the protein content by concentrating them (Univia, 2022a). Legume seeds can also undergo **physical dehulling processes** to increase their digestibility by decreasing the ANF and tannin content (e.g. dehulled fava beans suited for poultry feeding). It is often put to good use in the non-GM feeding sector because of its high energy and protein content. (Univia, 2015). Moreover, **traditional genetic selection** is in progress to produce HiPro rapeseed meal that could be available on the market in the coming years. **These strategies would make it possible to reduce the pressure on the needs of cultivated areas by improving the quality of the meals issued from those crops, provided they are economically viable – which is not obvious (see 2.2.3).**

The organic sector is so far less concerned by this progress. Indeed, to compensate the costs of the process, conventional by-products (hulls) are sold to generate energy. But the added value of an organic hull is not taken advantage of.

Moreover, it is noteworthy that **organic meals are less concentrated in proteins** than conventional ones, because meals are produced using an expeller, by crushing and pressing only, as the use of synthetic solvent is forbidden by Regulation EU 2018/848 (see table below). Their inclusion rates are thus limited by the amount of fat they contain.

Table 10: Protein rate of meals

Meal	% crude protein – Conventional	% crude protein – Organic	% crude protein – Conv HiPro
Soya bean	47 %	46 %	48 %
Sunflower seed	28 %	26 %	37 %
Rapeseed	34 %	31 %	40 %

Source: (Univia, 2022; Feedpedia, 2020)

Seven case-study scenarios considered the use of HiPro meals as a **lever**.

Source: Consortium

Table 11: Levers to diversify the species' diets

Action levers for the scenarios (examples)	Species							Production systems			
	PIG-MEAT	BROILE	LAYING HENS	DAIRY CATTLE	BEEF	DAIRY GOATS	SHEEP MEAT	Conv	Organic	Non-GM	PDO/ PGI
Raw materials											
Improve quality and protein density											
Plant breeding											
High protein rapeseed meal	X			X	X	X	X	X	X	X	Depends on the specifications
Methionine rich raw materials (e.g. maize)	X		X					X			
Raw materials with fewer anti-nutritional factors	X	X	X			X		X	X	X	
Technological path											
Dehull field beans	X	X	X			X		X	X	X	X
HiPro sunflower seed or rapeseed meal		X	X	X	X			X		X	X
Improve organic meal	X	X	X	X	X	X	X		X		
Defatted rapeseed meal	X			X		X		X		X	
Agronomic path											
Introduce more legumes in meadows				X	X	X	X	X	X	X	X
Early cut grass silage				X	X	X	X	X	X	X	
Increase in availability/Supply of EU-grown feed											
Soya bean/ Soya bean meal	X	X	X	X	X	X	X	X	X	X	X
Pulses (fava bean, pea)	X	X	X	X				X	X	X	X
Meslin development (seeds, harvesting tools, conservation)				X	X	X	X	X	X	X	X
Meadows (legumes, grazing techniques, etc.)				X	X	X	X	X	X	X	X
Improvement and diversification of free-range/pasture areas		X	X						X	X	X
Roughage / fodder			X	X	X	X	X	X	X	X	X
Dried (but not dehydrated) alfalfa				X	X	X	X	X	X	X	X

Source: Case studies, literature review

	Scenario modelled
X	Scenario identified by case-study stakeholders but not modelled

The main levers identified through the case-study clusters and literature review are presented in the table above. The methodology explaining the selection of scenarios to be presented is described in the descriptive part (see Section 1.2).

2.2.2.1 Alternative EU-grown feeds for monogastric species

Monogastric species (e.g. laying hens, broilers, pigs) are species whose nutrition has been deeply studied, going beyond the crude protein content of raw materials. This can be partly explained by the significant role that feed manufacturers play in those sectors. Thus, for industrial markets, the **nutritional requirements of those species are often detailed at the amino acid level.**

2.2.2.1.1 Organic laying hens

Within the diet, **the methionine amino acid is paramount** since its absence is a limiting factor for laying hens. Among the alternatives identified, the **increase of organic soya bean production** to provide more soya bean meal is the most promising one, as this is the most imported raw material of the cluster. Other meals are considered to have interesting amino acid profiles, such as hemp meal (Malomo, He and Aluko, 2014) and sesame meal, but the volumes are far from the needs of feed manufacturers, or they are produced outside the EU (sesame meal). Some research projects show that the increase of fava beans as a replacement for maize, wheat and soya bean meal led to lower performance due to ANF[93].

Box 8: Limitations due to organic specifications

The range of raw materials that could be used to diversify the sources of proteins is limited in the organic sector due to:

- **Unavailability of protein-rich raw materials** (e.g. conventional maize gluten feed, HiPro sunflower meal)
- **Prohibition of technological processes** concentrating the protein, such as chemical solvents used for conventional meals
- Prohibition of synthetic amino acid (see SQ 5)

Moreover, **the shift from 95 % to 100 % organic feed for organic species,** implemented from 2022, has led to significant changes in the diet of organic laying hens. According to the case study in France, the 5 % conventional protein-rich raw material (maize (corn) gluten feed) was mainly replaced by imported soya bean meals at the expense of other protein crops. To strike the right amino acid profile, the protein content of the diet increased following this regulation[94], which could have caused health and environmental issues.

Source: Consortium

Moreover, the Horizon 2020 research project 'OK-net Ecofeed' has identified alternative feeds such as **roughage** to fulfil some hen requirements for protein and amino acids that give acceptable egg production. In addition, as organic laying hens have access to outdoor areas, one innovative option would be to exploit the **range/pasture area with protein-rich grass**. This requires making the range area attractive for the laying hens (Díaz-Gaona et al., 2021). Other raw materials were quoted by stakeholders, such as **lupines**, but they are not widespread in the EU. **The availability of organic raw materials** is the main obstacle to diversifying protein sources. Moreover, to increase the EU-source feed supply**,** the **pedoclimatic conditions** could be a limit for northern Member States, as soya beans and sunflower seeds, which are rich in methionine, do not grow well in those climatic conditions, and pastures there are not relevant either (the grass season is from May to September in Denmark). Hence, these scenarios are not applicable in northern Member States, but they could resort to imports from other EU Member States producing those crops. Moreover, other alternatives could be **silage, peas,** or dehulled fava beans, and there is already use of dehulled oats in Denmark and Sweden and of rapeseed meal in Germany. The production of rapeseed can face challenges due to agronomic constraints, given its susceptibility to pests and diseases. **Protein grass concentrate** could also be an option (see SQ5), albeit accompanied by a higher price tag compared to other available alternatives[95]. So far, even if the models showed interesting results (see box below),

[93] http://www.itab.asso.fr/downloads/actes-volailles/6_resultats_station_poules_pondeuses.pdf

[94] The Secalibio project showed that it is possible maintain the same performance with a 100 % organic feed by increasing soya bean and sunflower seed meal, but at a higher cost.

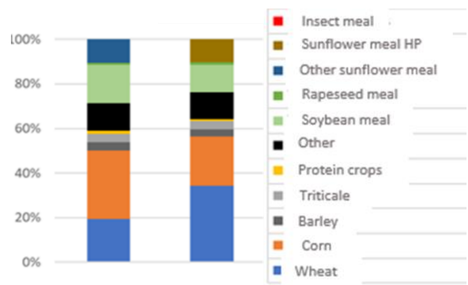
[95] https://www.wur.nl/upload_mm/a/6/8/af0ed21c-c784-46b0-ba47-feff2e26f448_8412102802_WFBR_Eiwittechnologie_boek_LR.pdf

organic HiPro sunflower production does not exist yet and requires more R&D. Finally, the main obstacle for those alternatives is their lower economic competitiveness compared to soya bean meal.

Box 9: Modelling of HiPro sunflower meal for organic laying hens

The scenario modelled the introduction of organic HiPro sunflower[96]. It is not commercially available in the organic sector yet, but its production is considered as possible according to studies and trials. It was supposed that all the current sunflower meal would shift to HiPro sunflower meal. The introduction of HiPro sunflower seed meal **enables a 4 %-point decrease in soya bean meal use. This entails changes in the cereals, with more wheat replacing maize**. The other raw materials of the laying hens diet barely change. As the dehulling process leads to a loss of 43 % of the volume of meal produced, it is necessary to set it at a higher price than standard sunflower seed meal. The outlet for the oil produced is also a major driver of increased use of this meal.

Figure 30: Evolution of organic laying hens diets with the introduction of HiPro sunflower seed meal



Source: Consortium, based on PA model

Source: Consortium

Box 10: Developing soya bean production in the EU: an encouraging perspective

The development of soya beans has not been modelled in this study, as it was not one of the scenarios chosen by stakeholders in the studies clusters. Nevertheless, as this oilseed has one of the best nutritional values for feed and is the most imported one in the EU, the development of its cultivation appears to be one of the most promising alternatives to its import.

Hence, encouraging domestic soya bean production remains a promising option for the EU to reduce its import dependency, narrow the protein gap and improve food security. While 80 % of the demand for this crop is still met by imports (European Commission, 2022), domestic soya bean production is on the rise, albeit from a low base. As such, soya been production has expanded by almost 120 % over the past decade, up to 2.7 million tonnes, with the area under cultivation having grown from 0.4 million hectares in 2011 to 0.9 million hectares in 2021. However, soya bean cultivation remains limited, accounting for less than 1 % of the total European cultivated area (FAOSTAT, 2023).

Yet, local soya bean cultivation is set to grow; available forecasts estimate that EU soya bean production will expand by 33.3 % over the next decade, driven by the implementation of supportive EU policies for protein crops, changes in farming practices to encourage crop rotation, feed demand for the still expanding organic dairy herd, the increase in labelled soya products (GM-free) as well as the push for deforestation-free soya beans (European Commission, 2022).

In addition, available research suggests strong potential for improving Europe's soya bean self-sufficiency, given the constant need for it. The results of a study conducted by INRAE and AgroParisTech suggest that soya bean self-sufficiency of 50–100 % is achievable in Europe under current and future climatic conditions if 4–11 % of the cultivated area were devoted to soya beans (Guilpart et al., 2022). These scenarios aim to offer an approximate estimation of the land scale necessary for the EU to achieve self-sufficiency in soya bean production. However, they do not account

[96] Protein content of HiPro sunflower seed meal: 45%, and a methionine content of up to 13g/kg.

for any potential impact on other crops, particularly those designated for food purposes, regarding potential substitution effects.

Source: Consortium

2.2.2.1.2 Conventional broilers

Poland is the main producer of broilers in the EU. Generally, feed mixes for chicken broilers are based mainly on cereals–maize, wheat, triticale, barley, and oats. Compound feed mixes for broiler chickens also contain by-products of cereal milling–fodder flour, maize gluten meal, maize germ meal and wheat sprouts, DDGS as well as feed fats (vegetable oils), pork, fish, and beef fat. The feed ration also contains oilseeds, in practice soya bean meal and rapeseed meal. In Poland, the poultry sector is the top consumer of soya bean meal, making it very dependent on imports given the negligeable domestic production of soya beans. Soya bean meal presents several advantages for broilers: high concentration of proteins, good amino acid profile, low-ANF content and highly digestible proteins. Even with the development of alternatives to increase other protein sources in the rations, the poultry sector remains dependent on soya beans, and the local production should increase sharply to meet the demand. Among the alternatives in terms of EU-grown feed, **increased production of local protein-rich crops is considered as the most plausible one, provided it is competitive economically.** About the question of reducing the needs for imported soya beans, stakeholders from France and Romania fear that the transition to **less intensive breeding systems would reduce production volumes** and lead to increased imports, thereby increasing the cost of meat.

Regarding the **increased use of legume seeds**, the stakeholders from Poland, France and Romania agreed that these alternative shows promising results in decreasing soya bean use (see box below). Thus far, in some Member States, such as Poland, the introduction of legume seeds has been dependent on competitive prices for farmers, reliable supply for feed manufacturers and good profitability for broiler breeders**. Another obstacle to legume seeds is their ANF content, their limited availability, and their variable quality**.

2.2.2.1.3 Conventional pigmeat

As with laying hens, and broilers, the needs of pigs vary according to their lifecycle. In Germany, conventional fattening pigs are mainly fed with cereal grain (rye, barley, wheat, oats, maize, triticale) and by-products. The main protein sources are soya and rapeseed meals, accounting for 15 % of the ration. In Germany, the availability of grain legumes is low, as they are either used directly on farms or directed to poultry feed. Increasing the supply of legumes appears to be a paramount issue. A study found that replacing soya bean meal with peas in the diets of growing and finishing pigs does not negatively affect the organoleptic characteristics of the meat (Stein et al., 2006). **Fava beans, field peas and lupines** (low-alkaloid varieties) are potential candidates for diversifying rations. From a nutritional point of view, **pea is generally the best legume of the three (see box below), due to it having fewer ANFs, less fibre, and more starch, even though it has lower protein content or may reduce feed intake**. Lupine is richer in protein and fat but has more fibre and contains almost no starch. However, the current prices are not competitive enough to make them significantly enter the diet. These feed sources can be produced in the EU, like faba beans and peas in Denmark, but would need to be rounded out with imports because of insufficient availability (low production, low yields, and low profitability for the farmers).

Box 11: Modelling of increased use of legume seeds for conventional pigmeat

This scenario aims at improving legume yields and imposes a minimum percentage of protein crop incorporation in the ration. Compared to a baseline scenario (only peas included) when lupines and fava beans are included in the model without a global limit the amount of legume seeds in diets more than doubles. However, with a limit to prevent performance issues due to ANF, the model reflects **the preference of the model for peas over the other two legumes and shows how difficult it is to increase legume use without modifying the inclusion rates. The scenarios that most favour the**

inclusion of legume seeds are those that make it possible to raise the limits on inclusion rates. There are several ways to do so, by using cultivars with low amounts of antinutritional factors, or through suitable processing. The 'optimistic' scenario, which includes processed legume seeds with higher energy values, higher limits for inclusion and higher prices, makes it possible to reduce the amount of soya bean meal by almost 50 %**. Pea remains technically the most interesting legume**, while **lupine is poorly competitive.**

Stakeholders from the three Member States agreed that this scenario is interesting and falls in line with the current research in pig nutrition. Indeed, legumes are already used in the rations, peas especially because their nutritional values suit the needs of the pigs. The share of legumes in the rations is determined by the shadow price and the availability of legume seeds, which is still too low and leads to higher logistical costs. Volatile yields and legume/grain competition do not encourage farmers to adopt them.

Source: Consortium

2.2.2.1.4 Non-conventional pigmeat

PDO/PGI productions are limited by their specifications (e.g. geographic constraints, limitations to the inclusion of legume crops, etc.), and feeding can vary greatly according to PDO/PGI, leaving little room for diet changes. Thus, in Spain, in the case of PDO Iberian ham, pigs can only pasture graze via *montanera*, which is an animal feeding regime based on the use of the acorn and pasture resources of the *dehesa*. The denomination differs according to the complement they eat (cereals, pulses, etc.)[97] (INAO, 2006; Ministerio de Agricultura, 2014). The Iberian pig is an animal that needs more time to develop its genetic potential, and **its protein intake, although necessary, is not as high as in other conventional pigs**. In contrast, in Italy feeding strategies for pigs reared for the two Italian PDO hams make no use of acorns as diet components and very rarely involve free-range fattening. Compared to Iberian PDO hams, grain maize (and cob mix) and soya bean meal has much greater importance in the typical diet of pigs reared for the two leading Italian PDO hams. As for organic pigmeat, this sector is very limited in Spain, and in Italy where only 58 000 organic pigs were reared in 2021, it accounts for just 0.7 % of the national pig herd.

To diversify protein sources, two main alternatives linked to EU-grown feed were identified during the case studies. The first is **greater inclusion of legume crops**, which could be furthered by **regional contractualisation of the crops**. However, until now their production has decreased because of a lack of profitability, problems of availability of suitable seeds adapted to the climatic conditions, and unstable yields. Meanwhile, it seems that there are no major hurdles to an increased use of peas in the diet of pigs used for PDO/PGI production. Some trials and studies have been conducted with inclusion rates between 5 % and up to 20–30 % of the ration's dry weight (Prandini, 2011), without significant negative influence on the quality of the final product (PDO ham). **Contractualisation of such legume crops may be a prerequisite for guaranteeing profitability for the crop producer**, but some obstacles need to be overcome (see box below). Legume seeds are also limited by their amino acid profiles and ANF content. Although they are deficient in methionine and cystine and have a low content of tryptophan, they are an excellent source of lysine and are highly digestible. Sunflower meal is usually also added to diets that include peas and a limited volume of soya. Thus, one option could be the use of **HiPro sunflower seed meal,** which has a good amino acid profile for pigs (poor in lysine, but beneficial content in sulfur, tryptophan, and arginine) as well as good palatability despite its fibre content. Although it is mainly recommended for fattening pigs and sows in gestation and lactation, very good quality meal could also

[97] Pigs must eat exclusively acorns during the final fattening stage to be called *'De bellota'*. If cereals or pulses are added, the denomination becomes *'De cebo de campo'* and if the pigs are raised in intensive systems with rations containing mainly cereals and pulses, the denomination then becomes *'De cebo'*.

be considered for piglets in transition. Such meal is in fact already used and can be increased if the **PDO specifications evolve in Italy to include more in the diets**.

Box 12: Modelling of contractual arrangements for legume crops for non-conventional pigmeat

Because pulses are not included in the Iberian pig diet to date, the model accounted for peas and fava beans. Due to their energy content (starch), **they seem to compete more directly with cereals that are the main components (more than 70–80 %) of the diet**, with modest effects on soya bean meal. However, this is not viable from an economic and environmental point of view (linked to the process of fava beans). Although contractualisation allows stability in prices, stakeholders pointed out some limitations: • They are a small economic entity in the sector, with no specific organisations established for dialogue and negotiation of the contract models. • **Market prices are currently very variable**, and contracts would suffer from breaches and complaints depending on the prices.

Source: Consortium

2.2.2.2 EU-grown feed alternatives for ruminants

Contrary to monogastric species, ruminant feeding strategies rely heavily on forage and grasslands. Thus, among the alternatives identified during the case studies, some are identical between species, especially regarding the quality of grassland or the increased use of roughage in the ration.

Among the forage protein crops, Alfalfa is one of the most widespread in the EU, as it is grown on 8 million hectares in the EU. It is a good protein source, with a protein content of 16 % in the stems and 35 % in the leaves. It also has a high fibre content, between 30 and 40 %, which makes it more suitable for ruminants (Popovic et al., 2001). The inclusion of alfalfa in the rations of some beef cattle destined for PDO/PGI meat production is restricted, due to the darkening of the meat and the change of fat colour, as mentioned in the Italian case study on non-conventional beef. Moreover, clover and sainfoin are also forage protein crops but are less widespread than alfalfa. Sainfoin has interesting nutritional properties: it is rich in proteins and reduces enteric methane emissions in in-vitro experiments thanks to the condensed tannins that it contains (Guglielmelli et al., 2011). The tannins also exhibit a protective effect on proteins, allowing better protein availability after the rumen. Clover contains Polyphenols oxidase, which exhibits protein protection activity in the rumen, thus increasing feed efficiency in ruminants (Hart et al., 2016).

Proteins from grass containing clover, alfalfa or sainfoin can be extracted and concentrated. The protein concentrate obtained is suitable for monogastric feed and the 'grass cake' is suitable for ruminant feeding. However, such processing plants require high levels of technicity and investments (Santamaria-Fernandez *et al.*, 2019). More details are provided in SQ5.

Grassland importance was underlined in the interviews conducted at EU level, taking the example of the Irish model, which is based on grass to reduce the dependency on imports. However, the stakeholders stated that this model was probably not replicable throughout the EU due to the increasing droughts in the summer in southern Member States, which sharply decrease the productivity and quality of grasslands. For some producers, implementing some of the identified options might prove challenging due to the scarcity of available land, especially for smaller farms.

2.2.2.2.1 Conventional dairy cattle

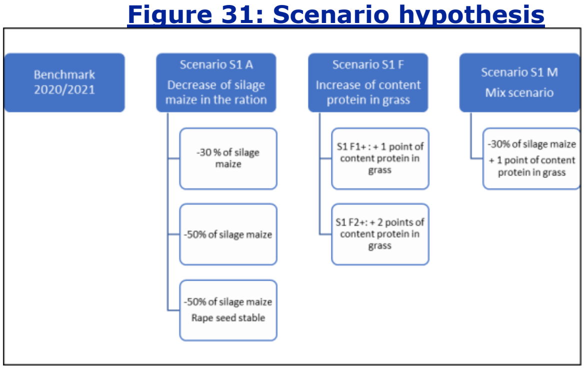
Grass is a major lever to diversify protein sources, either by increasing the share of grass in the rations or by improving the protein content in the grass. Besides sowing **legume forages** to improve the protein content of the forages, it is also possible to improve the protein content of grass through agronomical or preservation techniques (e.g. grass silage). A Norwegian study found that **very early cut grass silage** could be fed to dairy cows without the addition of concentrates, and without impairing the performances (Randby et al., 2012). The cows fed with early cut grass silage ate more but showed a better feed-conversion ratio than those fed with late cut grass silage (Pang et al., 2018). It was also found that feeding **hemp seed meal** to animals increased performances for dairy cattle, dairy goats, and laying hens, thereby increasing the quality of the animal products (Klir, Novoselec and Antunović, 2019).

The scenarios identified by stakeholder include grassland quality and conservation; increased roughage shares in the diet; and increased production of protein crops (peas, fava beans and lupines), soya bean or HiPro rapeseed. This would require additional area dedicated to cereals to compensate the decrease of maize silage in the ration to cover energy needs[98], which might not be a feasible solution for producers with limited land resources. The modelling results clearly show positive trends despite some limitations (see Box 13 below). In addition to roughage, increased use of high-protein sunflower meal and rapeseed meal could be an EU-grown lever to include richer oilseed meals. The modelling of increased production of French soya beans and protein crops, as well as of increased availability of HiPro sunflower seed meal, showed that, in the end, the Protein Rich Raw Materials (PRRM) basket benefits monogastric animals more than ruminants. However, this scenario seems to be more realistic for case-study stakeholders, as they think that it would have fewer negative economic effects on production compared to the modelled scenario, even if it requires more support (financial, awareness-raising) and good climatic conditions (lupine produced in PL instead of sunflower).

Box 13: Modelling of an increase of the grass in the ration and improved quality for conventional dairy cows

The share of fodder is on average 70 % for dairy cows in France. This scenario aims to increase roughage share in the ration (>75 %), with more grass instead of silage maize, and to look at the effect of higher-quality grass (especially a higher protein content). Regardless of the type of scenario, the impacts on the supply of imported raw materials are significant:

Figure 31: Scenario hypothesis



Source: Consortium

- Decrease in imported soya bean meal (up to 7 percentage points).
- Decrease in imported sunflower seed meal (up to 3 points).
- Decrease in imported rape meal (up to 6 points) with the need to lower its price to keep it constant in the model.
- Increase in cereals use by 3–5 points but shift from wheat to other cereals (barley, maize, triticale).
- Increase in wheat co-products by 4 to 6 points.

Thus, the different strategies (increasing the share of grass in the ration or improving the quality of grass) both result in a decrease in the consumption of imported raw materials in dairy feeds. However, **the results are more significant due to the decrease in maize silage than due to the increase in grass quality**. At best, the consumption of soya bean meal dairy cattle could decrease by 41 %.

[98] Maize silage replacement in diets also requires an extra source of starch to fuel rumen activity. It has been approached by an extra supply of cereals (considered as wheat, but could be triticale/barley), to supply nutritional needs of dairy cows (energy, protein, fibres, dry matter, etc.).

Despite these interesting results, case-study stakeholders warned of various obstacles:

- **Reluctance of farmers to switch from maize to meadows** (higher risks and maize make it possible to secure mass autonomy for farmers and require less work for a greater production), which would require a complete change in the production system of the Member State (CZ).
- Risk of production loss during summer droughts and during winter.
- **Fears of significant economic impacts** due to a decrease in the competitiveness of the region, a decrease in milk production and dependence on milk and milk product imports.

Source: Consortium

2.2.2.2.2 Non-conventional dairy cattle

In Germany, non-GM fed dairy cattle rely on forages, like all ruminants, and on concentrates containing cereals (54 %) and oilseed meals (21 %), with rapeseed meal being the most used, representing up to 16 % of the meals and mainly imported from other EU Member States[99]. Soya bean meal is mainly imported from the USA. The meals provide the proteins needed to sustain high milk production levels. The levers to diversify the feed are mainly centred on **increases in forage management, in efficiency and quality, and in legume seed production**. However, stakeholders were less interested in the latter because of their low yields and the competition with other crops and field forage, which already has a high protein content. Yet, it's important to acknowledge that certain options requiring expansion of crop area dedicated to animal feed might not be feasible for smaller farms with no available land. In Germany, increase of forages protein contents could be achieved thanks to sowing small seed legumes (e.g., clover), provided it is accompanied by counselling to implement these practices. And the increase of forage energy content should not occur at the expense of protein content, because it would otherwise not reduce the protein gap. In Austria, where increased protein yield in grasslands has already been achieved, the following limitations were pointed out:

- Reseeding grasslands would reduce biodiversity and resilience.
- Farmers usually prefer growing high-yield forages to ensure that they have enough mass autonomy, because transporting forages is much more expensive than transporting concentrated feeds.
- Mechanisation is difficult in the mountainous Austrian context, silage is not very widespread, and existing silos are not simple to change.

Improvement of forage can also be achieved through **improvement of the drying process**, which could help reduce protein losses, but investment in new machines is limited by the small size of farms and the constraints posed by the mountainous areas.

2.2.2.2.3 Conventional beef (heifers and yearling males)

The feeding strategy targeting young cattle is a special case because there are **several stages with different feeds**[100]. Forages (maize silage, beet pulp, good-quality grass) represent more than 50 % of the ration of a young beef fattened in France (IDELE, 2008). The ration is supplemented with cereals (often wheat), protein supplements in the form of oil cakes, and straw. Soya bean meal remains the most significant and preferred source of high-quality vegetable protein for animal feed manufacturers. Among the alternatives identified during the case study in France, the most promising ones are **protein-rich crops** (through an increase in the production of protein crops including soya bean and rapeseed) and **grass** (through an increase of grass in the ration and improvement of its quality). In the Netherlands, stakeholders consider grass quality is already very high, and further application would be limited by Dutch manure legislation. The use of **meslin** was modelled

[99] Germany mainly imports from the Netherlands which, is the main entry gate for organic raw materials. Traceability is lost afterwards.

[100] Grass and milk before the weaning, at the 8th month, and then forages and energy-rich concentrates before slaughtering around the 18th month.

(see box below), as it presents several agronomic and environmental advantages over pure cereals or pure protein crops: fewer inputs are required; better resistance to diseases; nitrogen fixation; longer crop rotation; and well balanced in terms of energy (due to the cereal[101]), protein (due to the legumes[102]), and fibre. Meslin is typically distributed as silage or in wrapped bales, although it can also be given as hay or via pasturing.

Two major drawbacks of meslin highlighted by a stakeholder include **the high volatility of meslin nutritional values[103] and the potential negative effects on the duration of the fattening**. Within the cluster, in Belgium maize silage is better suited to the Belgian Blue breed, which needs an energy-dense diet; in the Netherlands the climate has fewer droughts and is more suited to the production of high-quality maize silage; and in France clover, alfalfa and grass silage usually provided better results and had more stable nutritional values.

Box 14: Modelling of increased grass share in the ration and improved grassland quality through more grass or grass-legume mixes (meslin) (S1) and increased production of HiPro sunflower seed meal for conventional beef (S2)

The objective of Scenario 1 is to test the inclusion of **meslin silage** (mixture of cereal forage and legume forage) to assess its effect on the reference diet, which is usually made of maize silage, soya bean meal, wheat, and grass hay. Three forage meslins of different crude protein (CP) levels were tested: 5–10 % CP, 10–15 % CP and 15–20 % CP. The tests were modelled for different breeds (Limousin, Charolais, Normand and Montbéliard).

The same trends occur for the different breeds. Thus, low-protein meslin (5–10 %) can enter the diets when its production cost is slightly lowered compared to the default value, but it has generally no effect on the use of soya bean meal or even maize silage. **Middle-range protein meslin (10–15 %) always enters the diets, usually replacing part or all the maize silage, usually reducing the soya bean meal, or even eliminating it. As for high-protein meslin (15–20 %), it always eliminates soya bean meal and usually eliminates maize silage.** Therefore, high protein-meslin is a good alternative for both soya bean meal and maize silage, and it is theoretically possible to provide diets containing only this meslin and a cereal (plus minerals and vitamins).

Moreover, two HiPro sunflower seed meals were tested with 40 % or 48 % CP in dry matter.

Regarding the traditional HiPro sunflower seed meal 40, it can fully replace soya bean meal when combined with wheat and maize silage in the reference diets, provided its price is lowered significantly. As for the HiPro sunflower seed meal 48, it always eliminates the need for soya bean meal, while at the same time not requiring too much of a reduction in its price. However, it is likely that such a high-quality product would have a higher price than regular HiPro sunflower seed meal.

Source: Consortium

On the contrary, the second scenario (increasing the use of HiPro sunflower seed meal) is less popular with stakeholders because sunflowers are not produced in Belgium and the Netherlands due to climatic conditions. In France, beef fattening can already be done without soya bean meal.

2.2.2.2.4 Non-conventional beef

PDO/PGI specifications can limit or prohibit the inclusion of oilseed meals (especially defatted rapeseed meal) in some PDO/PGI meat products because they affect the meat colour. Among the levers identified, **field peas could be used for fattening beef feed** (Anderson, Lardy and Ilse, 2007). Moreover, **fava beans** can be introduced in the ration

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[101] e.g., wheat, triticale, barley, rye or spelt.
[102] Fava, pea, and vetch.
[103] The nutritive value of meslins is highly variable due to their wide range of botanical composition, harvest periods (maturity), and ensiling methods.

of dairy or beef cattle, replacing soya bean meal without impacting the performance (Cherif et al., 2018) or the quality of the meat (Keller et al., 2021). For PDO/PGI, studies showed that for Parmigianino Reggiano-producing cows, within the authorised limit set by the PDO organisation, **fava bean could represent a way of totally substituting soya bean meal in association with field peas** (Volpelli et al., 2012; Volpelli et al., 2010). In Italy, the scenarios discussed during the case study concern the **increased availabilities of EU soya beans and dried alfalfa (although the latter is a lot less easy to digest than soya bean).** So far, Spain and Italy are major exporters of dehydrated alfalfa to Middle East countries, which are more profitable markets than the national ones. Soya bean is considered as the most advantageous protein-rich crop for beef fattening, so increasing local production would be a major lever to reduce importations. However, soya beans face a **need for irrigation and lack of available irrigated land**, which is dedicated to highly profitable crops such as industry tomatoes. The improvement of nutrient density in sunflower seed meal is a potential option, as standard sunflower seed meals constitute up to 15 % of the diet. But sunflower seed meal and alfalfa can colour the meat, potentially limiting its outlets. Although sunflower is already produced extensively in Italy and used in beef feed, the Italian sunflower seed meal is not as rich in proteins as soya bean, and up to now HiPro sunflower seed meal has been imported from Hungary, Serbia, and Ukraine.

Moreover, **annual meadows are preferred to multi-annual meadows (e.g. alfalfa)** because farmers can adapt their crop rotation according to market opportunities. Although protein-rich meadows modelling (see box below) shows promising results, non-GM beef stakeholders in Italy consider them as not adapted to the current intensive production model and unlikely to be adopted. However, annual meadows may be applicable to other non-conventional sectors that are less intensive (organic or PDO/PGI), or to other EU Member States where breeds are more suitable to this feed.

Box 15: Modelling of the introduction of dried alfalfa and protein-rich meadows for non-conventional beef

The introduction of dried alfalfa was modelled but the **market price of dried alfalfa was too high** to enter the formula. When reducing the price to EUR 127/tonne, the introduction of dried alfalfa into Charolais diets results in halving soya bean meal inclusion and in doubling or tripling grain maize use. As alfalfa is already grown and used and the sector is already established, stakeholders considered this option as realistic. However, Italian stakeholders mentioned the meat-darkening effect of alfalfa, as well as the yellowing of the fat. They also emphasised that farmers prefer to grow maize and buy alfalfa. In Spain, **water availability is the major constraint, along with the lack of processing facilities**. Italian stakeholders also highlighted that alfalfa had a relatively low protein content and has lower energy values than that of maize silage.

Moreover, the pastures with 18 % and 22 % protein result in the complete elimination of soya bean meal and of maize silage and grain maize. However, according to Italian stakeholders, only a sharp decrease in meat consumption could allow for the implementation of this scenario. The reason is that the current beef sector is very intensive and due to farm structure and low availability of land, it is not possible to use it extensively and fattening time would be longer. Increasing the protein content of fodder from meadows would be a possible solution to be implemented in selected value chains, as intensive fattening systems need fodder with high energy values. In addition, the breeds used require energy-dense feed, and deconcentrating the diets would increase the fattening time. In Spain, however, this is considered to increase the sustainability and competitiveness of the sector, although there are some limitations, such as water availability and the cost of grassland management material.

Source: Consortium

2.2.2.2.5 Conventional dairy goats

Conventional dairy goat feed is mainly composed of roughage, for more than half of the dry matter intake. Roughage is either hay, grass silage, green fodder (i.e. cut grass) or maize silage. Grazing is not common in conventional goat-rearing systems; concentrates are used to sustain high production levels. Concentrates are mainly made from cereals, cereal by-products, and meals, especially soya bean meal. However, small ruminants do not represent the biggest consumers of soya bean meal, as it is estimated that goats and sheep consume around 2 % of the soya meal in France (Idele, 2022). Legume seeds are also used, but to a lesser extent due to their low availability and to their starch content, which can trigger ruminal acidosis and anti-nutritional factors, to which goats are more sensitive than cattle.

Box 16: The very mixed goat sector in the EU

With about 530 000 tonnes of goat milk produced in 2021 (Eurostat, 2023), France is the top goat milk producer in the EU. The goat sector is deeply rooted across the country, leading to a wide diversity of production systems. These range from highly intensive and technologically advanced operations in the western regions, where a substantial portion of the national production is concentrated, to more traditional farming in the southern and eastern areas (Dubeuf, 2004; IDELE and CNE, 2021). This geographical diversity significantly influences the various feeding strategies employed, as exemplified in Box 13.

In goat farms, protein autonomy is very variable and lower than in other ruminant production. This disparity is largely attributed to reduced reliance on grazing, put into effect to mitigate the risk of parasitism. One proposed approach to enhance feed diversity and elevate the quality of raw materials involves the utilisation of green fodder. This method would ensure a consistent supply of fresh grass in the diet, even when the pasture is distant from the farm or during extended periods. However, it would require additional investments. Another viable option would be to facilitate agreements between cereal producers and goat farmers for the exchange of alfalfa hay and manure. In Spain, turning fruit and vegetable waste into feed was deemed as a feasible alternative to a greater degree.

Source: Consortium

Several scenarios of diversification were identified by case-study subclusters. They concern the **increased production of pulses, soya bean, rapeseed, and sunflower seed meals** (HiPro or not) although it may be limited by agronomical and logistical constraints according to stakeholders (e.g. unstable yields, goats more sensitive to ANF such as tannins than cows, need of irrigation for soya bean meal, lack of varieties early enough for Northern regions). Breeding allowed the creation of low-tannins varieties, and **goats tend to have a preference for low-tannins fava bean** (Wegi, 2016). Moreover, **pea integration into the diets of goats was found to improve performance** (Antunović et al., 2013). Although sunflower meal represents some advantages (it requires fewer inputs and is less sensitive to droughts, and HiPro sunflower seed meal is also more palatable for dairy goats than rapeseed meal), stakeholders estimate that, generally, **protein-rich feed goes primarily to the dairy cattle sector**. This was confirmed by the model showing that, with increased availability of HiPro rapeseed meal (45 % of crude protein instead of 37 %), **HiPro rapeseed meal is valued much better for other species than goats**, which is its last outlet when its consumption is not mandatory in goat feed. Moreover, in Spain rapeseed oil is rarely consumed so cannot draw the market of rapeseed meal.

The use of **grass-based roughage to increase protein input through different levers** (increase in grass share in rations; increase in surface of alfalfa, clover, sainfoin; feeding green fodder; increase in fodder quality) is the most promising and praised scenario. However, several limits remain, such as the technicity level to increase the protein content (mentioned by French stakeholders), the regulation on grassland and meadow fertilisation (mentioned by Dutch stakeholders) and the lack of water. Expanding the surface of on-farm crop area dedicated to feed might also be challenging for smaller farms with limited land availability. Other alternatives to improve better assimilation of the ingested feed (essential oils, extensification, algae, genetics, amino acid) are discussed in SQ5.

Box 17: Modelling of increased protein input through grass-based roughage for dairy goats

Increased protein input through grass-based roughage was modelled using three sub-scenarios: (i) more forage in diet share, (ii) better forage in the diet (alfalfa instead of grass hay), (iii) more better-quality forage in the diet. All the scenarios entail a **drastic decrease of concentrate use**. Regarding diet, the share of cereals increases at the expense of cereal co-products and oilcake. Maize replaces part of wheat. Moreover, **there is a decline in sunflower seed meal and an increase in rapeseed and imported soya beans meals.** Increasing the protein content of the fodder can be applied to case-study Member States, but with some reserves.

Table 12: Diet change (% point) according to three scenarios

	Baseline 20/21	S For +	S Prot+	S Mix
Wheat	9 %	-4	-4	-4
Maize	11 %	+8	+8	+9
TOTAL Cereals	25 %	+4	+4	+4
Maize DDGS	3 %	-3	-3	-3
Protein crops	0 %	=	=	=
Imported soya bean meal	10 %	+2	+2	+2
FR soya bean meal	0 %	=	=	=
Rapeseed meal	12 %	+2 '	+2	+2
Sunflower meal	13 %	-6	-6	-6
Others (mainly Cereal co-products, Beet co-products (1 %), Amino Acids, Minerals & Vitamins)	37 %	+1	+1	+1

Source: Consortium

Indeed, in Spain there is a trend towards a more intensive model with more concentrates and less fodder, and alfalfa has become very expensive. In the Netherlands, the stakeholders have already increased their use of grass. In France, they consider the scenario feasible and ongoing, but with various implementations depending on the systems, which are particularly diverse.

Source: Case study based on PA model

2.2.2.2.6 Conventional sheepmeat

In intensive sheep meat production systems, there is little to no on-farm feed production. However, around half of the dry matter intake is fodder. Concentrates are also used, mainly containing cereals (barley, wheat bran, grain maize), cereal by-products, and oilseed meals. The sector is dependent on imports, especially on protein-rich raw materials such as soya bean meal. Nevertheless, as mentioned for dairy goats, **small ruminants do not represent the biggest consumers of soya bean meal**. Legume seed use is increasing to replace soya bean meal, to increase the sustainability of the sector. The nutrition approach in Greece is different because sheep are mainly bred for milk. Therefore, concentrates are not formulated for fattening sheep, as they are intended to provide ewes with sufficient energy and protein levels to sustain the production of milk and not fat.

Several scenarios were identified to diversify the protein sources used in sheep feeding. The most promising ones involved raw materials that are already produced in Spain, such as **sunflower seed meal and alfalfa**, because they are tolerant to droughts. Further, the quality of these products can be improved through processes like the harvesting technique for alfalfa (to preserve the leaves) and dehulling for sunflower seed meal (to decrease fibre content). Alfalfa use would increase sustainability and profitability of sheep farms. Stakeholders from the three Member States mentioned several limitations such as: irrigation needed in Spain or Greece, high production costs (prices have increased due to droughts and the high demand for dehydrated alfalfa from the Middle East), and lack of awareness about this crop. Contractualisation between crop producers and breeders would help in resolving some of these constraints.

HiPro sunflower seed meal was also considered interesting, as sunflower is already produced in Spain. However, the Spanish stakeholders reported that it could only replace soya bean meal in limited proportions. Meanwhile, production of rapeseed is very limited in Spain due to limited consumption and agronomic conditions.

Box 18: Modelling of increased protein intake from dried alfalfa for conventional sheep meat

This scenario looks at the impact of the introduction of dried alfalfa in the diet. It focuses only on fattening diets that are exclusively based on concentrate feed with or without straw. **The integration of dried alfalfa (at a constant volume of feeds), results in a significant decrease in other feeds, notably cereals (by 7 %) and oilseed meals (by 30–38 %). Soya bean meal decreases by 17–20 % of volume.** However, because the tonnages remain small, those decreases represent only several tens of thousands of tonnes. The inclusion rate of dried alfalfa (8 %) is consistent with those used by the NANTA company for those diets until 2005 (Huws et al., 2018).

Table 13: Diet change (% point) according to two scenarios

	Baseline	Alfalfa 15 (15 % crude protein, 26.6 % fibre)	Alfalfa 17.5 (17.5 % CP, 24.3 % fibre)
Cereals (%)	43 %	-3	-3
Oil meals (%)	19 %	-5	-7
Soya bean meal (%)	14 %	-2	-3
Alfalfa (%)	0 %	+8	+8

Source: Consortium based on FeedMod

In France, stakeholders pointed out that without proper equipment (automated mixing machines), it was difficult to precisely measure the various compounds of the ration and, according to the same stakeholders, sheep farms usually don't have this kind of equipment. Also in France, measuring 8 % of the ration (i.e. the quantity of alfalfa given to ewes in the scenario) was not possible.

Source: Consortium

Increasing the protein content of meadows also showed interesting modelling results (see box below) and the **development of meslins** was deemed promising but limited by their highly variable nutritional values. To improve their meadows and meslins, farmers would **need support to improve the agronomic practices** and the quality of the meadow. Natural constraints such as droughts are the major limitations. Other, more local scenarios such as the use of fruit processing by-products were deemed too local to be implemented in Spain, and the **improvement of wheat quality is limited**, because if the protein content increases, priority is given to using wheat in food applications.

Box 19: Modelling of increased protein intake from high-quality pastures for conventional sheep meat

This scenario looks at **the impact of different pasture qualities (see table below) on the diet.** It focuses on reproductive sheep herds. Thus, the use of pasture with a higher protein and energy content has a direct positive effect on the reduction of the need for protein supplements. Switching from a pasture containing 7 % to 11 % and then 17 % crude protein results in the **reduction and even elimination of soya bean meal** in the diet for gestating and lactating ewes (early lactation) and in a significant reduction of this protein source in lactating ewes (late lactation).

Table 14: Different types of pasture

Type of pasture	Crude protein in %	Crude fibre %	UFL per kg	UEM per kg DM	PDI g/kg	BPR g/kg
Low quality	7.0	29.3	0.83	1.24	57	-30
Medium quality	11.2	23.0	0.96	1.14	70	-6
High quality	16.8	18.8	1.07	0.98	78	38

Source: ETSIAM pasture database

In all cases, the concentrate proportion of the diet goes down. Although all stakeholders agreed that it was interesting and feasible. This strategy **depends on the type of actions that can be taken to increase the nutritional value of the pastures** (management, species, etc.), notably when sheep are at their lowest productive time, especially during summertime in Spain, and whether the cost of these efforts can offset the expected decrease in compound feed. As grass is already a major component of the rations, the protein content improvement is a major lever. Greek stakeholders mentioned the fragmentation of land and the lack of cooperation between farmers. Those in Spain mentioned sustainability constraints[104] that limited the productivity of meadows. Those in France mentioned counter-season parturition to overcome the dry season, but this means that these lambs will not graze.

Source: Consortium

2.2.3 Testing scenarios for three French subclusters in the global French situation to provide a systemic view

The different modelling results presented in the previous parts concern single specific clusters and the relevant raw materials for their diets. However, as livestock sectors and raw materials are intertwined, if the results show an increase of sunflower meal in one species' diet, this can be made at the expense of the other species. To have a more systemic view, an additional model was run in France for the conventional clusters, considering all species[105].

Table 15: Scenarios and species modelled

Scenarios retained (from the fastest to the slowest to be implemented)[106]
• S1: More protein through roughage • S2: More protein crops • S3: HiPro sunflower seed meals • S4: HiPro rapeseed meal

Source: Consortium

Among the four scenarios modelled (see table above), two scenarios emerge in terms of positive impact on the diversification of supply for French livestock, with an increase of protein self-sufficiency at feed manufacturer level:

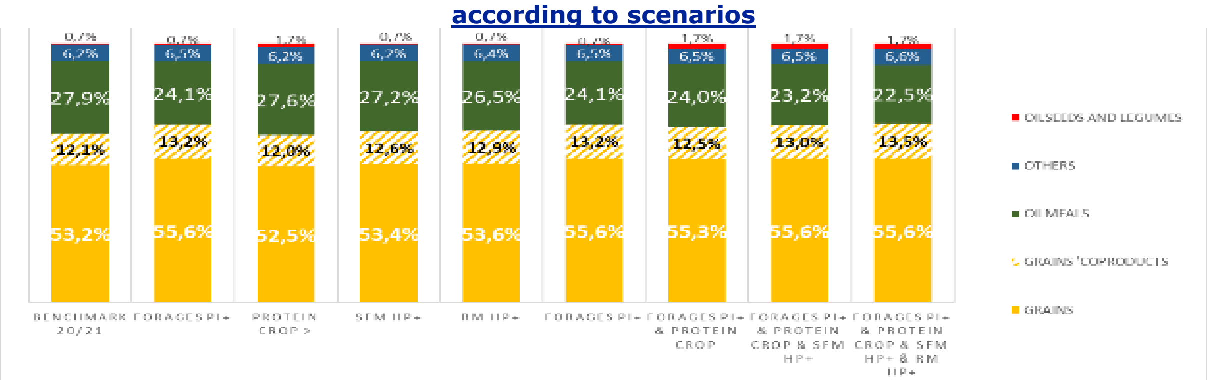
- Scenario 1 (S1), linked to forages share in ruminant diets (in quantity and quality), allows for a decrease in commercial feeds dedicated to ruminants. This is especially significant in beef but much less so in dairy cows and goats. This scenario allows for a decrease in both soya bean meal and imported sunflower seed meal, which is

[104] Limitation of fertilisation and pesticides used on pastures under EU regulations.
[105] Dairy cattle, beef cattle, goats, sheep, poultry, pigs and rabbits.
[106] Each animal sector will have more choices to find the optimal solution to meet its needs than in case study, while being in a more competitive environment to capture a raw material that may be suitable for several sectors.

not the case for other scenarios. This work on ruminants allows for a reallocation of certain raw materials in the monogastric sectors, also allowing them – but to a lesser extent – to improve their protein independence.

- Scenario 4 (S4) also has a major impact on all sectors. It concerns the replacement of standard rapeseed meal by HiPro rapeseed meal from varietal selection. This meal is very versatile and is well positioned in bovines, which makes it possible to anticipate that it can also replace soya meal purchased directly by dairy and beef farmers. Switching to protein-enriched rapeseed (varietal selection) increases the value of the meal by 23 % compared to standard rapeseed meal, which corresponds to a price ratio of 88 % compared to imported soya bean meal (compared to 73 % for standard rapeseed in the 20/21 price context). The use of this raw material is very effective in reducing soymeal imports but slightly increases dependence on imported HiPro sunflower seed meal.

Figure 32: Breakdown of raw materials used by feed manufacturers (all species) according to scenarios



Source: Consortium based on PA model

Across various scenarios, the decline in imported meals – specifically soya bean and sunflower seed meals – is primarily driven by the protein content of the substitute employed, rather than solely by the quantity of the substitute. In essence, the decrease in imported meals is more significantly affected by the protein concentration of the substitute rather than by its sheer volume. As such, reducing soybean imports could be achieved by substituting them with rich, easily digestible proteins. The availability of protein crops (fairly intermediate in terms of proteins) has no effect on the volumes of imported oilseed meals. The scenario for protein crops (S2) is disappointing and confirms many studies that point out the need for significantly **lowering their price** if they are to be incorporated in large quantities, due to the nutritional profile of peas and field beans. Promoting them would require very high compensations to farmers.

Likewise, the **HiPro sunflower seed meal scenario also seems to be more difficult to implement**. First, technological costs must be compensated by the market, and the cellulosic fraction generated by the sifting of the oilseed meal (shells and LP-cake) would have to be valuated. In a 2020/21 price context, its valuation is 99 % of the price of imported soya beans, which corresponds to a premium of 29 % compared to HiPro sunflower seed meal currently produced in France (about EUR 88/tonne). But in a context of lower imported soya bean prices, the price would decrease. This **meal appears interesting for the egg industry** but disadvantageous to other industries. In the end, **it does not seem to be very versatile**, which could be a disadvantage in feed manufacturers' plants with limited storage capacity. Moreover, looking at the cumulative scenarios, the protein self-sufficiency of French feed manufacturers improves by 19 points. Scenario combinations are very positive for hens (+28 points), dairy cows and poultry (+22 points) followed by beef (+18 points) and pigs (+13 points).

2.2.4 Main findings

Most of the EU-grown feeds identified by case-study stakeholders are raw materials **already produced in the EU. The main challenge is to increase their competitiveness to raise their production or availability** within the region, considering existing constraints such as soil, pedoclimatic conditions etc. While various alternatives have been taken into consideration for the distinct production clusters, two dominant feeding strategies have emerged as the most promising ones. The first is to **improve the quality and the quantity of grass and forage in the ration**, which is more relevant for ruminants. The second, to **diversify diets using additional protein crops**, appears to hold the most potential for monogastrics.

The diets of monogastrics are already well optimised to meet their nutritional requirements. Introducing more EU-grown feed would require finding the right balance between the nutritional content of various raw materials and any potential constraints on their inclusion. **Introducing legume seeds** such as peas or fava beans appears to be a promising option in decreasing the reliance on soya beans in monogastric diets. However, this may lead to reduced performances for poultry and pigs due to ANFs. Proper processing such as cooking, extruding or dehulling is therefore required before incorporating them into animal diets, which thereby adds to their overall cost. **Peas show promises for pig nutrition**, while lupines are less competitive. Thus, further research is needed to identify crops with lower ANF or breeds with better resistance to them (see SQ5). Additional limitations for pulses include fluctuating yields and prices, as well as competition between grains and protein crops, resulting in a low availability. **Contractualisation between operators along the value chain**[107] could help overcome some obstacles, but this requires a well-organised sector. Moreover, **enhancing the quality of meals (such as HiPro sunflower or rapeseed meals) or protein crops (such as dehulled fava beans) can reduce dependency on other protein-rich crops** (e.g. soya bean meals), albeit with accompanying economic and technical challenges.

In the organic segment in particular, the sector is struggling to find the right diet following the stronger implementation of the regulation on 100 % organic feed. Specifically, in the laying hen sector, this has led to a greater reliance on imported soya bean meal at the expense of pulses. While these alternatives have high protein content, they **do not always contain the right amino acid profile required for a production system that cannot use synthetic amino acids, due to the organic specifications** (see SQ 5). Some crops like hemp or sesame meals were identified with very good amino acid profiles for monogastric species, but production levels in the EU are currently quite limited. The use of protein-rich pasture or roughage, while more experimental and dealing with smaller volumes, could help reduce the use of soya bean meal. In the case of PDO/PGI production, diversification might be limited by specifications on the inclusion rate of certain crops or their geographical origin.

As for ruminants, **enhancing the quality of forage or increasing the share of fodder in the ration** has been identified as a highly effective strategy. Indeed, since fodder accounts for approximately half of the dry matter consumed by ruminants, the protein content in fodder sources like grazed grass, hay, green fodder, and grass silage can significantly contribute to meeting their protein needs.

Modelling results for all the ruminants clearly show that such strategies as improving meadows, incorporating dried alfalfa, utilising protein-rich meslin and enhancing protein

[107] The operational programmes of producers' organisations, which are in the new CAP and are open to all sectors, could be a relevant instrument to be explored by the operators of value chains to improve these relationships and reach contractualisation.

content in grass make it possible to decrease the needs for concentrate and protein-rich raw materials, especially soya bean meals. This approach also promotes greater use of wheat in on-farm feed. Yet, it's important to acknowledge that certain options may encounter constraints in specific production systems, especially in terms of farm size and land availability when this latest approach does not necessarily allow for an expansion in the crop area dedicated to animal feed. As such, for ruminants such as goats, for which on-farm sourcing is significant, options considering an increase in on-farm production might not be viable in the case of small farms with limited land availability. **Dried alfalfa can be a viable option, provided its price is competitive**.

The different alternatives modelled show diet adjustments related to the utilisation of protein crops or oilseed meals, as well as shifts between maize and wheat. Wheat with its higher protein content and distinct amino acid profile can help in balancing the diet when incorporating alternative protein sources grown in the EU.

Encouraging the production of domestically grown soya beans in the EU could contribute to reducing its imports. Available forecasts estimate that the EU production of soya beans will expand over the next decade, driven by the implementation of supportive EU policies for protein crops, changes in farming practices to encourage crop rotation, feed demand for the still expanding organic dairy herd, the increase in labelled soya products (GM-free) as well as the push for deforestation-free soya beans. However, further development of this crop in the EU is limited by a series of factors such as climatic conditions, including water availability for irrigation.

In conclusion, although some alternatives are very promising in some Member States, they cannot be brought into widespread use in the EU-27. This is the case for sunflower seeds and soya beans, which grow well in the south of the EU but not in the north, due to the climate and varietal constraints. **Should these Member States be capable of generating a substantial surplus and engaging in inter-member exchanges, it would become imperative to have suitable infrastructure in place to facilitate the smooth flow of these raw materials.**

On the other hand, increasing the share of grass in the rations or the use of pasture for ruminant species may be riskier in southern Europe because of summer droughts, which can significantly impact grassland productivity and the protein content of the grass. Doing so would **require sound management of grass and of livestock to address these challenges.** Lately, the feed market has remained competitive, and the **feasibility of switching between different feed options is determined by the ability to pay for those options specific to each species**. This is the case, for example, of HiPro rapeseed meal, whose availability will be entirely captured by the poultry sector, since its capacity to pay for this raw material is higher than for the other species. This specific point will be discussed in SQ6.

Overall, while many alternative protein sources already exist in the EU and can be grown all over the EU in the case of protein crops, a series of obstacles still limit their widespread use. This includes their **overall low availability, stemming from factors like lower profitability, variable yields, lack of availabilities of standardised and significant production lots and reduced competitiveness compared to imported soya bean meal.** Additionally, the EU-grown alternatives may have differing and sometimes more fluctuating nutritional values, requiring dietary adjustments to meet animal needs. The use of amino acids or enzymes can be explored to enhance nutrition value and digestibility. These options will be discussed in SQ5.

2.3 SQ3: What would be the main drivers for livestock producers and feed manufacturers to use more EU grown feed sources?

2.3.1 Main drivers for feed manufacturers and livestock farmers to use more EU grown feed materials

It was possible to identify a number of **drivers that can influence the decision of supply chain stakeholders to use more EU-produced feed sources**; they can be broadly classified as: technical, economic, related to the organisation of the supply chain or policy-related. These drivers were collected via the extensive stakeholder consultation carried out for the study and were assessed against the evidence available from literature and Case studies.

From such assessment, **two core drivers** emerged as being at the forefront of the decisions of feed manufacturers and livestock farmers in terms of sourcing: price and availability. They are analysed together in the following section.

Related to these, **further drivers** were identified as having a **positive and/or negative effect (to different degrees)** on the willingness and possibility for operators to use more feed materials grown or produced in the EU. This extended list of drivers is provided in table form in Section 2.3.1.2 below.

Some **preliminary caveats** should be pointed out to complement the analysis:

- A number of stakeholders highlighted how a shift towards "EU supply" only for feed would not be a real diversification, as a higher number of supply channels are needed to achieve supply chain resilience. Trade includes both import and exports: limiting one of these would not be conducive to food security. While reducing import dependency is indeed perceived as a positive tool to reduce exposure to market volatility, imports are deemed crucial to maintain a sufficient production level in the EU (see also SQ4 in this regard).
- A key driver for protein autonomy might derive from consumer preferences and (possibly) policy choices, via the promotion and adoption of **dietary changes that reduce consumption of animal products**.

2.3.1.1 Two core drivers: price and availability

The **two key drivers identified for feed manufacturers and livestock farmers** are:

1. **availability**, i.e., in perspective, satisfactory availability of protein sources produced in the EU – in terms of both quantity and quality (nutritional composition, amino acid profile); and
2. **price**, i.e., looking at protein autonomy, a competitive price of EU-produced feed materials compared to imported ones[108].

As regards **availability**, it should be noted that *for livestock farmers* the **nutritional value** of raw materials, their amino acid ratio, their digestibility, and their energy value, are key in order to meet the needs of the animals. This is one of the reasons why soya bean meal is very popular with farmers: its nutrient profile, combined with its price, makes it a very competitive raw material.

In terms of **price**, it is interesting to highlight that the drivers for *feed manufacturers* for choosing European, protein-rich, raw materials can be different depending on their market positioning. The two main positions are summarised in the following table.

[108] According to the survey of feed manufacturers carried out in the context of this study, 33% of respondents indicated an attractive price (quality, transport) as the main driver for increasing the use of EU-grown raw materials, 14% an increase in subsidies to compensate for competition from imports (which reinforces the first choice), 13% the use of amino acids to lower the protein content of feed, and 13% their CSR approach; only 7% mentioned contractualization of crops (to be noted: 1/3 of the feed manufacturers who responded to the survey are also involved in the collection and storage of crops).

Table 16: Feed manufacturers' market positioning - in brief

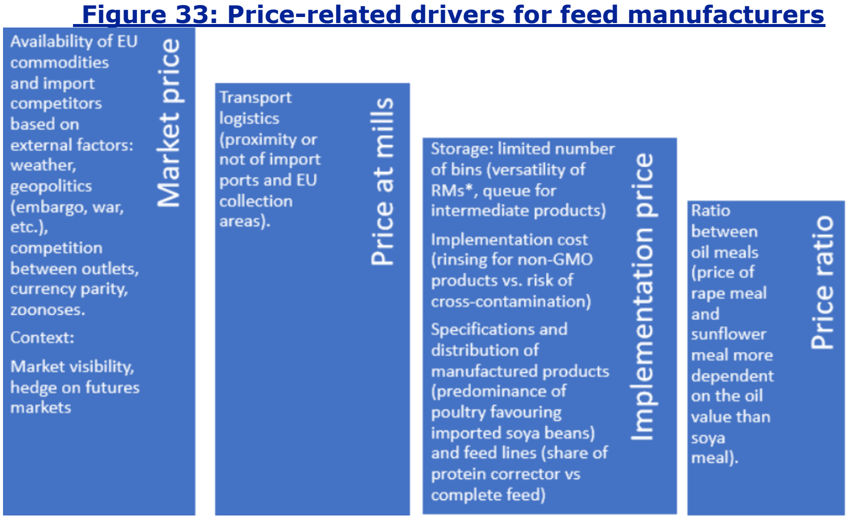
Feed manufacturers who need to meet a set of specifications	Feed manufacturers who need to meet a demand for competitiveness (best quality/price ratio)
Commercial, i.e., from retailers (private labels), food industry brands, processors and in particular slaughterhouses, food service (e.g., restaurants, canteens, prisons, etc.), in line with consumer expectations or the company's image (marketing). *Regulatory*, e.g., organic, non-deforestation, prohibition/authorisation of the use of certain raw materials, etc. *Company-related*; e.g., their CSR approach, use of raw materials collected by the group, contracting with farmers, etc.	If the feed manufacturer is part of a vertically integrated group, it is a cost centre to be minimised. If the feed manufacturer is "independent", it must be a profit centre to be maximised.
Full economic optimisation is limited by the formulation constraints resulting from the specifications (e.g., % mandatory incorporation rates, ban of certain feed ingredients, etc.).	They face no specific constraints other than legislation in force, technical constraints of the factories, and availability of supplies. An example of this case is the "low cost" production of Spanish pork fed with imported feed materials (corn, soymeal).

Source: Consortium

Similar considerations can also be made for livestock farmers, which can have different operating positions in the value chain, according to their market outlets and level of vertical integration (if any). Requirements related to feed, or lack thereof, are in most cases related to requirements placed on the animal product that will be ultimately marketed.

The market price is only the tip of the iceberg: supply and use costs and, finally, price ratios between raw materials are factors that can be positive or negative for EU production. Hedging purchases on futures markets is complicated for European proteins (nothing on protein crops and sunflower meal, limited rapeseed meal trade on Euronext, entailing a lack of market liquidity). The following figure summarises the main price-related drivers and highlights the different elements at play when discussing this driver.

Figure 33: Price-related drivers for feed manufacturers



Source: Consortium

(*) RMs: Raw Materials

Considering the relevance of **price ratios between raw materials**, it is interesting to provide a summary of the views of consulted feed manufacturers on the prices of feed ingredients of EU origin, outlined in the following Table. The main competitors for each feed source are also included, both in terms of *competing raw materials* and in terms of other *market outlets* that compete with feed manufacturing for the supply of a certain ingredient. Such an overview allows to grasp in a concrete way the multi-faceted aspects of the price dynamics that drive purchasing decisions of operators.

Table 17: Views on the prices of EU-grown feed ingredients

Processed animal proteins	Insect meal	Non GM soybean meal	Rapeseed meal	Sunflower meal	Peas/field beans	Cereals coproducts, beet pulp	Dehydrated alfalfa	Super Pro products (>55% Pi, derived from peas, soya, etc.)
• Too high (low availability) • Administrative cost (legislation) • Pet food and export are more remunerative outlets. • reintroduced in The Netherlands and Spain (mostly used for animal products to export markets).	• Too high for 45% of survey respondents (38% are not aware of the price) • Outlets: pet food, aquaculture, human food	• Higher than imported non GM soybean meal • Expensive road transportation • Rinsing costs (cross contamination) • Non GM soybean meal import	• Depends on the price ratio vs soybean meal • Road transportation costs depend on the feed manufacturing plant's proximity to crushing facilities (favours or not import vs EU product) • Share of poultry feed produced in the plant, share of correctors in production • Imported soybean meal: lower impact of energy prices (high gas prices in Europe only)	• Depends on the price ratio vs soybean meal • Road transportation costs depend on the feed manufacturing plant's proximity to crushing facilities (favours or not import vs EU product) • Imported soybean meal: lower impact of energy prices (high gas prices in Europe)	• The price ratio vs wheat and soybean meal is often too high • Raw materials with a more liquid market and better market visibility (protein crops do not have a futures market, volumes are limited, with a smaller pool of sellers, etc.) • Raw materials more concentrated in proteins	• 79% of survey respondents think that cereal co-products, DDGS, beet pulp will be less available and therefore more expensive, in the future. • Competition with other outlets: insects, methanization. • Direct farm: sale in wet to limit drying costs	• Rising prices (energy costs) • Export markets outside the EU, where prices paid are higher.	• Prices are too high for their use in livestock farming others than young animals. • Piglets, calves, aquafeed, human nutrition

Table legend: Market Price - Price at feed mills - Implementation price - Competitors

Source: Consortium

2.3.1.2 Other drivers: technical, economic, organisation and policy-related

Besides the key elements of price and availability, a number of other drivers (technical, economic, organisational and policy-related) contribute to determining the sourcing decisions of feed manufacturers and livestock farmers in the EU. Such drivers are listed, summarised and assessed in the Table that follows. Drivers are classified into **5 categories**:

1. Technical;
2. Economic – supply side;
3. Economic – demand side;
4. Supply chain organisation; and
5. Policy.

For each driver, **key content points** are provided and, when relevant, *elements from the assessment made by stakeholders and from success stories*. It is important to notice that **drivers are often interlinked and can amplify or limit the effects of other drivers**: such significant connections are made explicit in two columns of the table. Finally, a synthetic overall assessment is made of the overall effect each driver can have on protein autonomy. Summary judgements are based on the analysis of each driver and are coded as follows:

+ + +	Strong positive effect	+/-	Mixed effect (can be both positive and negative)
+ +	Significant positive effect	-	Mild negative effect
+	Mild positive effect	- -	Significant negative effect

Table 18: Summary assessment of drivers to use more EU grown feed sources

Groups of categories of drivers ***Categories of drivers***	**Key points** ***Specific assessment of stakeholders; success cases***	**Links to other drivers** Amplifying/concurring drivers	Limiting/opposing drivers	**Overall effect on protein autonomy**
Technical				
Availability of genetically improved feed crop varieties	Varietal improvement of protein crops, grain legumes and/or forage legumes to get new varieties adapted to EU pedoclimatic conditions as soon as possible. NGTs as a way to obtain quicker results than traditional breeding techniques (+ agronomic advantages and nutritional characteristics).	*Clear policy framework and policy priorities:* breeding research requires long-term planning and resources	*Price dynamics of feed materials:* competitiveness of imported feed materials (e.g., GM soya) *Limitations in the use/availability of inputs for agricultural production:* improved seeds are expensive; profitability depends on the use of effective defence techniques	+ +
Technological innovation in feed production and processing of feed materials	Processing as way to enhance the nutritional value of protein plants and coproducts, and as well as their use (e.g., advances made in the production of hi-pro oilseed meals, high quality coproducts of distillery (DDGS) or of starch industry).	*Support to R&D and new technologies*.		+ +
Advances in animal nutrition and feeding technologies (precision feeding and additives)	Better characterisation of feeds would help identifying gaps or surpluses of nutrients: help in providing the right types of feed, in the right amount. Changes in formulation habits: e.g., shift from the use of ME (Metabolisable energy) to NE (Net Energy) could decrease the use of soya bean in monogastrics; taking the starch content into consideration for formulation purposes could improve the interest for peas in poultry feed and ruminant feeds. EU production of feed additives such as amino acids (e.g., tryptophan, isoleucine and arginine promising for the reduction of soya bean meal in the diet of pigs) and enzymes (removal of antinutritional factors; extraction of the maximum nutritive value from suboptimal feed ingredients).	*Support to R&D and new technologies:* align marketing authorisations of additives to even out competition from imported products.		+
Pedoclimatic factors - varying climates and productions	Climate specificities of the various regions as a lever to use different EU-grown protein sources, according to the pedoclimatic conditions of the region / favour the crops most fit to these conditions. EU-wide perspective on production: the diversity of climates and soil conditions could be a lever for the production of different protein sources, adapted to the soil and climate conditions of each region.	*Technological innovation + investments in arable crop farming techniques/equipment* *Improved storage facilities + logistics and transport within the EU:* allow raw materials to reach the areas where they are in demand		+

Technological innovation + investments in arable crop farming techniques/equipment	Investing in: agricultural tools for cultivating and harvesting legumes or grasslands; storage equipment; green forage harvest and distribution machines; to overcome the limited availability of large-scale collection, sorting and storage infrastructures for grain legumes cultivated in the EU.	*Improved storage facilities + logistics and transport within the EU*		+
Economic – supply side				
Development of bioenergy market – vegetable oils	Oil meals are co-products of the vegetable oil industry, whose expansion was fostered by the support to and market of biofuels. Increased production of rapeseed and sunflower oil = increased availability of the related meals.		*Arable crops – competition for land use*	+ + +
Market liquidity and visibility (or lack thereof)	Protein crops with no futures market: no hedging. Small volumes: a minimal change in supply can have a strong impact on prices.			+
Risk management practices	Limit volatility by reducing dependence on imports in connection with geopolitical and sanitary uncertainty. Reliability of EU-produced materials *vs.* risk of contamination and fraud related to imports from third countries (e.g., organic ingredients).		*Price dynamics of feed materials:* competitiveness of imported feed materials	+
Company guidelines	A company's CSR approach, use of raw materials collected by the group (if vertically integrated to some extent), contracting with farmers, etc.			+
Price dynamics of feed materials	Price competitiveness of each feed material *vs.* the available substitutes. Price competitiveness of EU *vs.* imported products. *Survey of feed manufacturers: for 33% of respondents an attractive price (quality, transport) is the main driver for increasing the use of EU-grown raw materials.*			+/-
Arable crops – competition for land use	Overall limited availability of arable land in the EU: competition in terms of profitability and margins vis-à-vis other main crops cultivated in the EU (e.g., cereals). *Consulted stakeholders: other areas of the world are currently more efficient than the EU in the production of oilseeds; a shift towards such crops in the EU might not be an economically sensible choice, considering the relevance of other crops currently produced in the EU instead.*		*Increased intensity of support to the crops of interest in the EU*	-
Competition between feed sector and other outlet markets	Outlet markets with more appealing prices for producers can limit availability of certain raw materials for feed purposes. For example: pet food for PAPs, export to third countries for dried alfalfa, human consumption for hi-pro specialised ingredients.	*Development of bioenergy market – biogas / methanisation*		- -
Development of bioenergy market – biogas / methanisation	Biogas production may subtract raw materials to the feed sector (e.g., silage maize, former foodstuffs, by-products of the food industry)		*Clear policy framework and policy priorities:* if food/feed uses are prioritised and a hierarchy of uses for these raw materials is set	- -
Economic – demand side				

Requirements/specifications for the supply of live animals / animal products set out by downstream operators	Requirements concerning animal nutrition in the related arrangements as a possible incentive to the use of feed materials produced in the EU. This may be the case for: PDO/PGI (if providing feed-related specifications); Organic (to some extent); Other voluntary certifications and premiumisation efforts.	*Consumer preferences – quality, niche markets / environmentally friendly products*	*EU Regulations on organic farming*	+ +
Consumer preferences – quality, niche markets / environmentally friendly products	Increasing consumer demand for products complying with specific sets of characteristics (e.g., local, environmentally friendly, non-deforestation, PDO, organic, etc.) *can* encourage farmers to find alternatives to imported raw materials. *Example of success case: Austria. Organic soya bean area and production have significantly increased in the last decade due to an increase in the demand for organic eggs and poultry, leading to a near-self-sufficiency in the supply for the organic poultry sector.*	*Requirements for the supply of live animals / animal products set out by downstream operators.* *Promotion of the demand for animal products fed with EU-produced.*	*Consumer preferences – Cost of living*	+ +
Consumer preferences – Cost of living	In MSs and circumstances where a low purchasing power is prevailing (e.g., inflationary tendencies / cost of living crisis) higher requirements in terms of feeding practices – if more expensive – may be overlooked in favour of cheaper options: usually imported feed materials.			- -
Supply chain organisation				
Improved storage facilities + logistics and transport within the EU	A limited number of storage bins favours the most multi-purpose raw materials. By increasing the number and size-range of bins, a broader range of feed materials could be handled. More efficient intra-EU transportation networks and support facilities (e.g., promote water transport and assist in the maintenance of waterways).		*Requirements for the supply of live animals / animal products set out by downstream operators:* Increased segmentation entails more complex storage needs in terms of segregation of supplies.	+
Linkages with agriculture, food & energy industries	Such linkage could bring more coproducts and new feed materials to the sector; e.g., larger use of co-products; crop residues; PAPs; former foodstuffs. Circular economy approach as a way to keep nutrients within the food & feed system.	*Development of bioenergy market – vegetable oils* *Advances in animal nutrition and feeding technologies:* use of enzymes to enhance nutritional value of coproducts.	*Competition between feed sector and other outlet markets.* *Development of bioenergy market – biogas / methanisation.*	+
Collective approach to food and feed certification	Quality certifications affecting (also) feed appear to be more successful in involving operators when they are based on a collective approach (associations of operators in the value chain), rather than commercial ones.			+

	Example of success case: VLOG[109] (Non-GMO collective approach) in Germany federates more and makes the demand less volatile than, e.g., the similar commercial certifications that are common in France.			
Policy				
Clear policy framework and policy priorities	Need for long-term, coherent priorities and goals to invest in long-term planning and solutions. *Consistent feedback from stakeholders on the need to make decisions in a policy environment informed by clear and consistent policies for the sector.* *Perceived inconsistency between rules for internal operators vs imported products: i) importing GM soya beans is allowed, while growing them is prohibited; ii) different marketing authorisations for feed additives developed in Europe and for imported ones.*		*Competition between feed sector and other outlet markets*	+ + +
Increased intensity of support to the crops of interest in the EU	CAP tools, e.g.: coupled income support for farmers who grow protein crops and/or feed animals with local plants; Eco-schemes with stronger incentives to promote plant proteins; Operational Programmes for Producers Organisations in the sector.			++
Policy-related limitations to feed and/or commodity imports from (specific) non-EU countries	Rules that would apply "mirror clauses"[110]. Those restrictions could indirectly lead to a reduction in the use of imported soya beans to the benefit of the use of local plants. Potential challenges à compliance with WTO commitments, response measures by the affected non-EU commercial partners.		*Price dynamics of feed materials:* economic viability of feed production	+
Support to R&D and new technologies	Fostering research and innovation on the production and processing of raw materials through the European Innovation Partnership (EIP-Agri).	*Technological innovation in production processes related to feed production.* *Clear policy framework and policy priorities.*		+
Promotion of the demand for animal products fed with EU-produced materials	Strengthened promotion of the consumption of animal products from production systems that do not rely extensively on non-EU feed imports.	*Consumer preferences – quality, niche markets /*	*Consumer preferences – Cost of living*	+

[109] The German Association for Food without Genetic Engineering (VLOG) represents around 760 food producers and retailers as well as the upstream and downstream sectors of food production. It issues licenses for the use of the seal "Ohne GenTechnik" for food produced without genetic engineering.

[110] As clarified in a Report from the Commission to the European Parliament and the Council on the application of EU health and environmental standards to imported agricultural and agri-food products, COM(2022) 226 final, the EU can, in certain circumstances, adopt unilateral legislation in which it is requested that imported products comply with the EU's production in order to achieve its policy objectives in terms of a high level of sustainability. However, this must be done in full compliance with WTO rules. In order to be WTO-compatible, certain conditions must be respected: measures could be taken where they concern the protection of the global environment or in the case of major ethical concerns. Such measures have to be designed in a way that they are not discriminatory and no more trade restrictive than necessary to achieve the intended objective. This requires a case-by-case assessment. In any event, the purpose of such policies can never be justified by competitiveness concerns, protectionist stances or level playing field considerations.

		environmentally friendly products		
EU Regulations on organic farming	Requirements related to feed and a "minimum link" to the soil: a share of the feed must come from the farm itself or from the nearby region. At the same time, the stricter implementation to 100% organic feed for all animals in this segment, as provided for in the regulations, puts the use of local protein crops at a disadvantage in favour of imported organic soya beans and soymeal (see SQ4, Section 2.4.1.2.1).			+/-
EU policy framework on non-deforestation	Even though the objectives of the non-deforestation legislation are environmental, it can have, as a side effect, a positive impact for the development of EU-grown soya, even if the supply chain of non-deforesting imports is already organising and prices of imports could remain competitive.	*Linkages with agriculture, food & energy industries*	*Price dynamics of feed materials*	+/-
Limitations in the use/availability of inputs for agricultural production (fertilisers, pesticides)	Concerns regarding stronger competition from feed products coming from non-EU countries in light of the application of environmental practices at EU level that might make EU feed products *more* expensive. Considering more carefully the side effects of some environment-related regulations: the banning of pesticides on some plants could limit the availability of high protein coproducts (e.g., rapeseed meal).			-

Source: Consortium

2.3.2 Main findings

The assessment carried out under this study question allows to focus on the drivers that can promote the use of more EU grown feed sources among the two key operators in the supply chain: livestock farmers and feed manufacturers. The **two core drivers identified** are:

1. **availability**, i.e., in perspective, satisfactory availability of protein sources produced in the EU – in terms of **both quantity and quality** (nutritional composition, amino acid profile, digestibility, energy value); and
2. **price**, i.e., looking at protein autonomy, a competitive price of EU-produced feed materials compared to imported ones.

Economic drivers appear to be the most important determinants in the choice of feed materials for both farmers and feed manufacturers. This is the case also for suppliers of feed materials, who select the market outlets for their products based on profitability. As can be expected, this causes competition between different sectors for the supply of certain raw materials, and the feed sector is not always on the winning side. Additionally, the **availability of sufficient quantities of EU-produced feed materials** is not guaranteed in several cases: e.g., a general lack of organic oilseed meals and organic feed ingredients was reported at EU level (albeit with differences across different MSs).

The other drivers that contribute to determining the two core drivers of availability and price and that can have the strongest positive effect on protein autonomy are the following[111].

Table 19: Drivers with a strong positive overall effect on protein autonomy

Name of the driver	Key elements	Category
Development of bioenergy market for vegetable oils	*Oil meals are co-products of the vegetable oil industry: increased production of rapeseed and sunflower oil entails an increased availability of the related meals.*	**Economic – supply side**
Clear policy framework and policy priorities	*Need for long-term, coherent priorities and goals to invest in long-term planning and solutions.*	**Policy**

Table 20: Drivers with a significant positive overall effect on protein autonomy

Name of the driver	Key elements	Category
Availability of genetically improved feed crop varieties	*Varietal improvement of protein crops, grain legumes and/or forage legumes to get new varieties adapted to EU pedoclimatic conditions as soon as possible (NGTs as a key technology).*	**Technical**
Technological innovation in feed production and processing of feed materials	*Processing as way to enhance the nutritional value of protein plants and coproducts, and as well as their use.*	**Technical**
Requirements/specifications for the supply of live animals /animal products set out by downstream operators	*Requirements concerning animal nutrition in the related arrangements as a possible incentive to the use of feed materials produced in the EU (e.g., PDO products; voluntary certifications).*	**Economic – demand side**
Consumer preferences – quality, niche markets/ environmentally friendly products	*Increasing consumer demand for products complying with specific sets of characteristics (e.g., local, environmentally friendly, non-deforestation, PDO, organic, etc.) can encourage farmers to find alternatives to imported raw materials.*	**Economic – demand side**
Increased intensity of support to the crops of interest in the EU	*CAP tools, e.g.: coupled income support for farmers who grow protein crops and/or feed animals with local plants; Eco-schemes with stronger incentives to promote plant proteins; Operational Programmes for POs in the sector.*	**Policy**

[111] Drivers assessed as having a "strong positive effect (+ + +)" or "significant positive effect (+ +)" in Section 2.3.1.2 are highlighted here.

2.4 SQ4: What is the potential of diversifying feedstuff and sources through other imported feed sources, e.g. labelled under recognized sustainability schemes, in order to increase supply chain resilience and public acceptance of feed sources?

2.4.1 Diversification of imported feed sources

2.4.1.1 Protein crops

Protein crops have a real agronomic interest and a good image among consumers. It can therefore be estimated that if demand were to arise, the already existing imports could increase. We import from third countries mainly peas (0.55 Mt in 21/22) and a little lupin (0.18 Mt in 20/21). The flow of field beans from third countries is marginal.

Lupins - Lupin consumption by livestock in the EU rose from 0.22 to 0.52 Mt (+136%) between 2010/11 and 2020/21. Over these 11 years, the EU 27 doubled imports from third countries to reach 0.20 Mt in 21/22. However, thanks to the increase in local production (+0.2 Mt), the share of imports in the supply of European livestock fell from 39% to 35%[112]. **In 21/22, lupins imported into the EU come almost exclusively from Australia (98%)**, with 80 % entering through the Netherlands and 16% through Belgium. Because of a less optimal amino acid profile for monogastric species, the majority of Australian lupin exports are used in feed for *ruminants*, followed by pigs and poultry.

Peas - The EU imported 0.55 Mt of peas in 2021/22 from third countries, mainly from Russia (75%) and Ukraine (15%). It should be noted that Russia's market share increased from 62% to 75% compared to the previous season, at the expense of Ukraine (from 24% to 15%). Italy, Spain, Belgium and Latvia importing the most of peas from third countries.

In a forward-looking perspective, it should be noted that production increases each season in Russia, estimated at 2.6 Mt in 2022. Ukraine is a much smaller player by comparison, with a production of 0.5 Mt. Russian pea exports do not seem to be impacted by the Russian invasion of Ukraine and ongoing conflict; EU sanctions towards Russia explicitly exclude food and feed products. The opening to Russia of the Chinese market (ongoing work of the Russian authorities on phytosanitary agreements for the access of Russian agricultural products to Chinese buyers) could change the dynamics on the world market for peas[113].

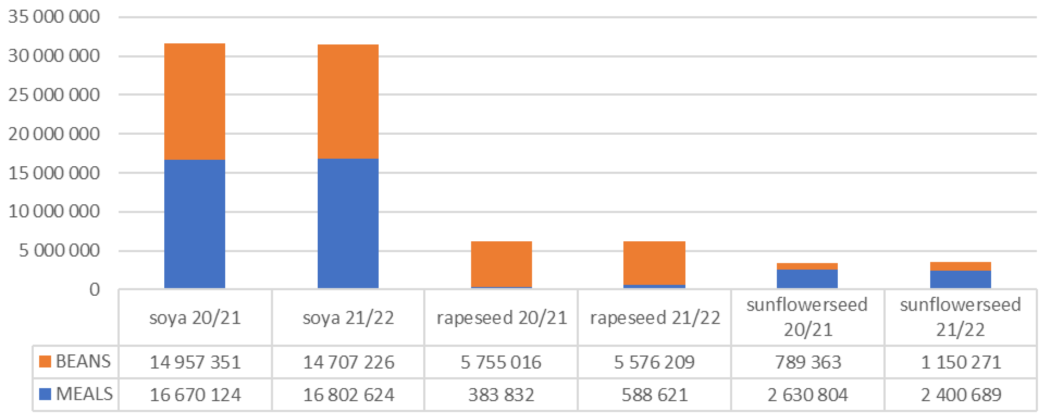
2.4.1.2 Oilseeds and oilseed meals

EU Member States import from third countries oilseeds, which are subsequently crushed to meet their needs in oils for food, feed, and industrial purposes (including biofuels). Soya bean is the most imported oilseed, followed by rapeseed and sunflower.

[112] data from EU-feed-protein-balance-sheet.

[113] China is an exporter of pea proteins that is challenging the international competitiveness of the North American pea protein sector (see for instance: https://agfundernews.com/the-future-of-the-us-pea-protein-industry-in-grave-peril-says-puris-as-us-investigates-flood-of-cheap-imports-from-china).

Figure 34: EU imports of oilseeds and meals (2020-21 and 2021-22, tons)



Source: Eurostat

In parallel to the imports of seeds, and in order to satisfy the protein needs of livestock, EU MSs also import oilseed meals. Soya bean meal takes the lion's share, followed by sunflower. The volume of imported rapeseed meal is smaller. It should be noted that the prices of oilseeds and of the related oilseed meals may not be systematically correlated, so at times it may prove more favourable to import seeds rather than meal (or vice versa).

Table 21: Oilseeds imports and crushing (EU)

	crushing			imports			% imports/crushing		
source oil world (1000 t)	16/17	20/21	21/22	16/17	20/21	21/22	16/17	20/21	21/22
soybeans	13 874	15 630	15 479	13 357	15 205	14 714	96%	97%	95%
rapeseed	22 659	22 858	22 310	5 363	6 235	5 470	24%	27%	25%
sunflowerseeds	7 756	8 111	9 560	635	817	897	8%	10%	9%
linseeds	661	658	638	731	745	735	111%	113%	115%
total 4 seeds	44 950	47 257	47 987	20 086	23 002	21 816	45%	49%	45%

Source: Oilworld

The share of seed imports in the production of soya bean meal in the EU was 95% in 2021/2022, compared to 25% for rapeseed and 9% for sunflower. Oilseed imports are therefore essential to the economic balance of European crushing capacities. Cutting off imports would generate a need to produce 22 to 23 Mt of additional oilseeds in the EU, just to run these plants. I more. The increase in oilseed production in the EU to offset seed imports should take place in areas close to crushing facilities, to avoid excessive internal flows. However, some of these plants are located close to ports, rather than to potential production areas. This would create flows of both seeds to the plants and oil meals to the farming areas, which would most likely be larger than current ones.

2.4.1.2.1 Soya beans / soya bean meals

In 2000, following the ban on PAPs in animal feed, imports of soya bean meal exploded (up to 24 Mt in 2007). In more recent years, with the availability of rapeseed meal, co-product from the biodiesel production the availability of imported High Pro sunflower meal, and the increased use of synthetic amino acids, soya bean imports slightly declined in some MS. However, after the low point of 2017 (18.4 Mt), imports of **soya bean meal** have increased again, up to **18.6 Mt in 2021/22**[114]. The main countries of origin are Brazil, Argentina and other South American countries, together accounting for 89% of EU imports of this feed material. At the same time, oilseed imports, which peaked at 18 Mt in 2003, fell until 2012, before rising again and stabilizing at around 15 Mt for the past eight seasons. The level of meals and oilseeds imports depends on the level of the crushing margin[115].

[114] Oil world, Eurostat.
[115] which is given by the difference between the purchase price of the seed and the sale price of the co-products (oil cake, oil and hulls).

Three main elements explain the volumes of soya beans meal imported in the different Member States:

- The nutritional quality of soya bean meal (its concentration and amino acid profile makes it the ideal and multi-purpose raw material for the animal sector);
- Feed demand. A decrease in the number of animals (epizootics, decapitalisation) can lead to a decrease in imports;
- The price ratio with other available raw materials, that could be different in each MS.

It is interesting to note that before the Russian invasion of Ukraine, only a minority of surveyed feed manufacturers (27% of 71 respondents) used to purchase soya bean meal from former USSR countries (Russia and Ukraine in particular). This suggests that the conflict has had relatively limited impacts on EU imports of sustainable soya *bean products as a whole.*

Non-GM soya beans / soya bean meals

The demand for non-GM fed animal products developed from 2005 onwards under the impulse of consumers. The non-GM premium compared to the price of standard (GM) soya bean meal steadily increased since then, from around 4% to around 30% in 2022/2023, with a peak in 2021.

During the course of 2021, several non-GM soya bean sources dried up for different reasons:

- Brazil: the physical commodity exists but is no longer segmented. Producers do not get the premium (captured by traders) and prefer to reduce costs because the price of "standard", GM soya beans is sufficiently remunerative on the world market;
- India: lack of manpower (Covid-19);
- Nigeria: insecurity of supplies, small and expensive;
- EU: a variable production and high road transport costs (post Covid-19).

Faced with this rise in costs, and at a time when consumers' purchasing power is at a low ebb, **demand for non-GM fed meat is falling**. This is causing some shifts in the uptake on non-GM among operators: in a rather schematic way, MS in the northern areas of the EU are taking very limited step backs in the non-GM sub-sector (constant poultry, VLOG scheme), whereas southern Europe has largely disappeared from this market. European soya beans, which took advantage of this non-GM character to seek value, could see their price decrease.

Among the surveyed feed manufacturers operating in the "non-GM" segment, the majority (59% of respondents) deemed that their use of non-GM soya bean meal would decrease in the future, due to prohibitive costs and/or the switch to non-deforestation soya. However, the premium of non-GM soya has fallen sharply since, in the absence of demand, so monitoring user positioning also in the future remains key.

Non-deforestation soya beans / soya bean meals

The European Commission has defined targets in terms of imported deforestation, that by 2025 will oblige sellers of soya to guarantee their non-deforesting nature in order to sell them in the EU (Regulation on deforestation-free products[116]). Under the Regulation, any operator or trader who places these commodities on the EU market, or exports from it, must be able to prove that the products do not originate from recently deforested land or have contributed to forest degradation.

This will require the purchase of segregated soya, i.e., soya bean/meals that are traced from start to finish (at least up to the feed manufacturer). In the first half of 2023, the premium for segregated soya (with respect to standard soya bean meal) was

[116] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32023R1115&qid=1687867231461

of 35/40 EUR/tonnes[117]. The deadline set by the European Commission for the entry into force of the Regulation (1 January 2025) entails that soya importers and their customers should prepare their forward purchases and their respective schedules. It would appear that competition between suppliers will eventually reduce the premium for this segregated soya.

The premium for non-deforesting segregated soya bean meal could be between 35 EUR/tonnes and 20 EUR/tonnes by 2025, depending on the level of competition between importers (which are in most cases large multinational companies that source raw materials from several non-EU countries) in the various Member States. Despite the recent reduction in the non-GMO premium, the non-deforestation premium remains two times cheaper and explains why some specifications quickly switch from one to the other. This also reinforces the competition with European soya beans for which the non-deforestation advantage is disappearing.

The majority of the surveyed feed manufacturers (62% of 71 respondents) already purchase soya bean meal (or soya beans) under "deforestation free" and/or "responsible soya" certification schemes. The prevailing typology of certification among survey respondents is based on mass balance (52% of 44 replies); certification based on credits has significant diffusion (32%), whereas certification based on segregation is less common (16%). From 2025, all soya products will have to be segregated, which will make them more expensive than they are now (an additional cost of €35/tonne compared to €3/tonne for certifications based on mass balance). However, this will still be cheaper than buying non-GM or organic soya beans.

<u>*Organic soya beans / soya bean meals*</u>

The growth of organic livestock farming in the EU, especially for poultry, would not have been possible without the increase in imports of organic soya bean and soya bean meal. Main exporters are located in Africa (Togo, Benin, Burkina Faso, etc.), China and India[118].

European production levels for organic soya are far from being able to satisfy internal needs. Considering the low availability of other organic meals, this leaves operators no other choice than to resort to imports. The stricter implementation to 100% organic livestock feed increases the pressure on these imports, since conventional maize gluten meal (a maize co-product) and conventional potato concentrate will no longer be accepted except for young animals (derogations to be reassessed). Numerous studies carried out in the EU[119] (AlterAgri, 2012; Knowledge; Céréopa, 2014; ITAB, 2013) have shown the risk of a shift from local proteins to imported soya when these regulations come into force. In fact, the use of 5% conventional raw materials (possible under derogations) made it possible to use conventional products that were very rich in protein (Super-Pro: over 50% protein content). This left room for local raw materials with a lower protein content, such as protein crops. Under the stricter rules for derogations, more organic soya bean meal (mainly imported) will be needed to meet the animals' amino acid requirements. There is no organic offer for corn gluten meal or potato protein concentrate (market too small to be segmented). Eggs are the most dynamic organic segment (together with milk, which has fodder as an alternative). Imports of organic soya beans and soymeal are thus essential to the development of the organic *monogastric* livestock.

Future imports depend more on the **evolution of the demand within the EU** than on the world availability. In this regard, some consulted stakeholders reported that imports of organic soya bean products are currently declining, mainly due to economic considerations (high cost vs. shrinking price).

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[117] DURALIM Observatory, https://www.duralim.org/

[118] A reported issue concerning imported organic feed materials (including soya bean products) from certain origins is the reportedly limited reliability and trustworthiness of the related certifications.

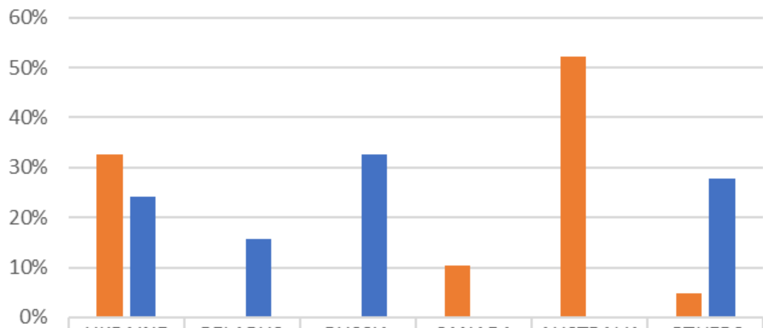
[119] https://organic-farmknowledge.org/discussion/theme/21

2.4.1.2.2 Rapeseed / rapeseed meals

The European rapeseed crushing reach 23 Mt (compared to 13 Mt for soya bean and 8 Mt for sunflower - source: Oil World) has been driven by the use of rapeseed oil as a base for biodiesel. It makes available nearly 12 Mt of rapeseed meal of which 25% from imported seeds (see Figure 35 for the main origins). This meal is less multi-purpose in its use than soya meal considering its amino-acid profile and its fibre content. Its consumption is therefore limited.

In 20/21, imports of rapeseed meal used in the EU come mainly from Russia (231 000 t), supplemented by Belarus (90 000 t) and Ukraine (91 000 t). This meal is non-GM, unlike Canadian GM canola meal, which flows mainly to China and is not exported to the EU. China is importing more and more rapeseed meal, increasing world prices and competition between recipients, trend expected to continue in the coming years.

Figure 35: Origin of rapeseeds (5.6 Mt) and rapeseed meal (0.6 Mt) imports to the EU (2021-22)



	UKRAINE	BELARUS	RUSSIA	CANADA	AUSTRALIA	OTHERS
RAPE SEED	33%	0,00%	0,1%	10%	52%	5%
RAPE MEAL	24%	16%	32%	0%	0%	28%

Source Eurostat

In a forward looking perspective, the evolution of the EU car fleet could also play a role in the future availability of rapeseed meal: if a drop in demand for biodiesel occurred over the next 10 years, a reduced availability of rapeseed meal produced in the EU[120] could increase its price and reduce its appeal for feed uses. This, in turn, could then create a demand for imported rapeseed meal (or soya bean meal) from non-EU countries. However, in a comparable timeframe (5/8 years), we can expect to see a supply of **protein-rich rapeseed meal** resulting from varietal research marketed in the EU. There is real potential for these new varieties of seed, which could provide an economic advantage, as well as a clear improvement in our protein sovereignty. As the meal is more concentrated, less is used than standard meal, while at the same time reducing soya imports. It would not require any additional investment in existing crushing plants.

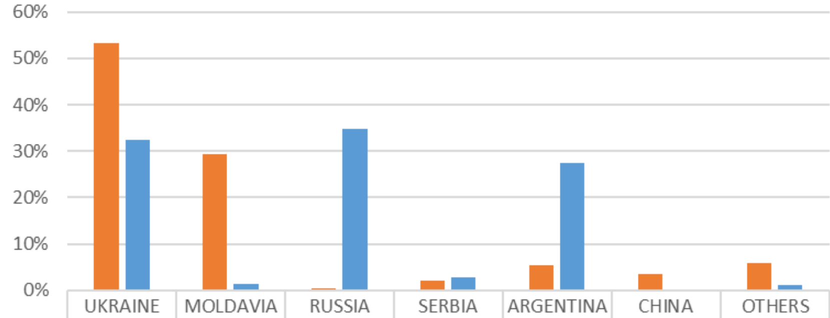
2.4.1.2.3 Sunflower seed / sunflower seed meals

In 2021/2022, EU imports of sunflower meal reached 2.4 Mt (against 1.1 Mt for sunflower seeds). Ukraine shared the first place as key exporter to the EU with Russia (both ca. 0.8 Mt of flows). It should be noted that imports of sunflower seeds from Russia dried up in 21/22, whereas the flows of Ukrainian seeds increased (imported for

[120] The impact of phasing out high indirect land-use change (ILUC) biofuels, and particularly palm oil, could mitigate this decline (see on the matter the European Commission's *Report on the status of production expansion of relevant food and feed crops worldwide*, COM(2019) 142 final, Brussels, 13.3.2019).

crushing in the East of the EU)[121]. The main importers of sunflower seed meals are Netherlands, France, Italy and Poland. France and Italy are also big crushers of this oilseed, while Poland does not crush sunflower seeds.

Figure 36: Origin of sunflower seeds (1.1 Mt) and sunflower meal (2.4 Mt) imports to the EU (21-22)



	UKRAINE	MOLDAVIA	RUSSIA	SERBIA	ARGENTINA	CHINA	OTHERS
SUNFLOWER SEED	53%	29%	0%	2%	6%	3%	6%
SUNFLOWER MEAL	32%	1%	35%	3%	27%	0%	1%

Source: Eurostat

Sunflower seed and meals are of particular interest for stakeholders as non-conventional protein sources because they are non-GM by default.

High-Pro sunflower seed meal, notably from the Black Sea area but also from Argentina, is also an interesting source of protein feed (non-GM and not linked to deforestation). A limitation in the global growth of palm oil[122] – which might be envisaged in the future (mainly due to climate change and efforts to combat deforestation) - could further push the global cultivation of sunflower (as an oil-rich seed). It should be noted, however, that China's significant imports of this feed material could limit its overall availability worldwide.

2.4.1.3 DDGS (Dried Distillers Grains with Solubles)

The wheat and maize co-products protein content depends on the base cereal and the extraction process adopted. About 0.5 Mt come from third countries such as the USA, Canada, Russia, Vietnam or the UK. The European Commission estimates that the 27 EU MS consume 3.3 Mt of DDGS, which entails a 15% dependence for these products. Some origins do not guarantee that these raw materials are non-GMO (notably of North American origin).

It is difficult to imagine the evolution of this type of import. In the USA, support to the biofuel industry is very strong and it is possible that the local market will not be able to absorb the future surplus of DDGS. However, on the one hand, China is buying more and more cereals and their co-products; on the other hand, the development of insect production, may represent a more profitable market outlet for cereal co-products than feed.

Some consulted stakeholders observed that increased use of DDGS in the diets of animals would very likely entail increased use of amino acids, since DDGS have a sub-optimal aminoacidic profile compared to soya bean products. Another consulted stakeholder observed that in some Member States DDGS are increasingly used as feedstock for biogas production, which could reduce their availability for feed use.

[121] Due to energy shortages caused by the conflict, Ukraine crushed only 72% of its sunflower seed production in 2021/22, compared to 98% in 2020/21. In 2022/23 it crushed 106% of its production, mainly by using up stocks from the previous campaign. In 2023/24, it returned to a 92% share. Reduced crushing in Ukraine translated into exceptional imports of Ukrainian sunflower seeds for crushing by some Member States, especially Bulgaria.

[122] If this were to happen, the price relationship between oils would change, and could encourage the production of oil-rich seeds instead of other crops in certain countries.

The GM nature of DDGS imported from certain third countries and more remunerative outlets are likely to remain disincentives to further imports of these raw materials into the EU.

2.4.1.4 Views of stakeholders

The **current potential for diversification of imported feed sources** was perceived as "medium" (i.e., a certain diversification is possible, but some challenges exist) by the vast majority of surveyed downstream operators (73% of 64 replies); however, a significant minority of respondents (20%) perceived such potential as limited or absent. The most important **limitations to a diversification of imported protein sources** were identified in: i) current cost of organic/GM-free protein sources vs. the actual possibility to add value to animal products from livestock fed with such types of protein sources (29% of 55 replies); ii) limited consumer interest/demand for animal products from livestock fed with GM-free protein sources, with other certified protein sources (e.g., certified non-deforesting) or with organic protein sources (between 18% and 13% of replies). The same limitations were also identified by the surveyed National Competent Authorities, especially as regards the gap between the current cost of organic/non-GM protein sources and the added value of the final products.

Some consulted stakeholders (representing business interests in animal farming, commodity trading and retail distribution) underlined that they **do not consider improved EU self-sufficiency for protein sources as a goal in itself**, to be pursued at any cost: **price competitiveness** of EU protein sources versus imported protein sources is a key factor in the business decisions of most operators. Other consulted business stakeholders (representing interests in arable crop farming and commodity trading), by contrast, attach a strategic importance to the improvement of EU self-sufficiency for protein sources, and actively pursue that goal. The consulted European Commission services acknowledged that the objective of improved EU self-sufficiency for protein sources can only be pursued by considering the relative competitiveness of domestic production vis-à-vis imports: if the latter are significantly cheaper, operators will clearly favour them. An important consideration made by a consulted stakeholder representing business interests in feed manufacturing is that diversification in terms of <u>type of protein sources</u> should not be the only goal to pursue: **diversification of the <u>origins of protein sources</u> would even be more important**, since the EU mostly relies on just 2-3 exporting third countries to source high protein feed ingredients. One consulted stakeholder made an interesting point by observing that the **import of products obtained from sustainably-fed animals reared in third countries** could be a **realistic alternative scenario** to importing sustainable protein sources from third countries to rear animals in the EU.

Among the **non-conventional protein sources of particular interest** for the surveyed stakeholders, "certified non-deforesting protein sources" and "certified local protein sources" stood out.

A consulted EU level **organisation representing consumers** noted that most consumers are unaware of the absence of GM free requirements for feed in the specifications for most PDO/PGI animal products. The organisation deems problematic that animals used in the production of PDO/PGI products are fed with GM feed (but also with algae or insects), as their marketing relies heavily on the idea of local traditions, which appears to be in contrast with the use of such feedstuffs. The consulted **European Commission services** observed that the demand for non-GM or locally produced feed sources is increasing only in few high-income Member States (Germany and Austria in particular), where consumers' willingness to pay for the related animal products is higher: these segments are unlikely to grow in all Member States, unless the consumption of the related products is dictated by public policies (e.g., sourcing requirements for public food counters).

2.4.2 Alternative/innovative protein sources

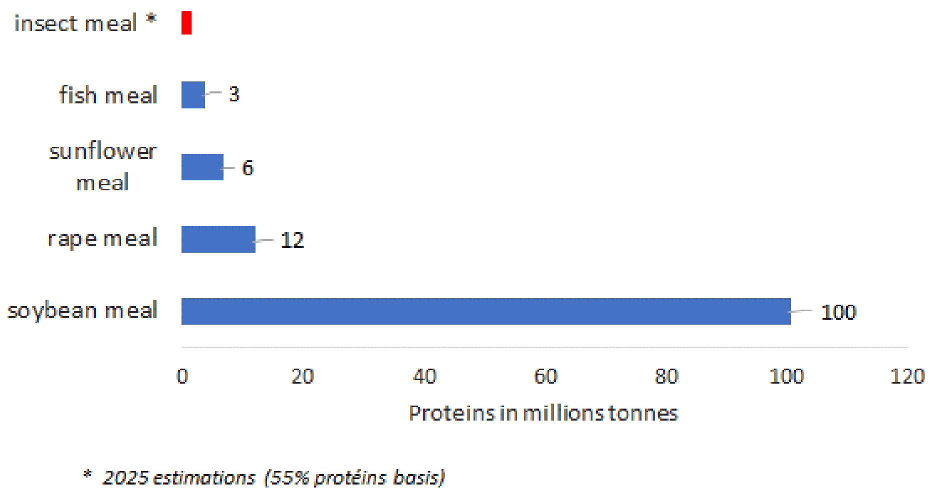
2.4.2.1 Insect meals

Insect meals mobilise many funds but are of **little interest to livestock farming, at present**. Despite a high protein content (>60%), their cost is prohibitive, especially as a feed ingredient for *monogastric* animals, which are the most likely candidates for insect meal use. The price of insect meal (currently over 3 000 EUR/tonne) *de facto* limits its use to pet food and aquaculture (with exports notably to Norway). The insect production model based on large, energy-intensive structures (Thévenot *et al.*, 2018) is not without issues and the reduction of production costs is slow.

In the EU, where regulations are more restrictive than in the rest of the world regarding the substrate on which insects feed (the use of food waste is not possible in the EU) insects compete with other livestock animals for feed resources. Insects need to be fed: their use would imply additional activities in the chain (loss of efficiency), and large-scale production of insect meals for feed use would require substantial volumes of nutrients, also because the feed conversion rates of insects are rather poor. For example, in France (where fundraising totals 1 billion EUR for insect farming start-ups), substrates based on grain co-products (wheat feed, bran, beet pulp) are used, that potentially remove protein sources from the poultry and ruminant feed sectors. Additionally, the aminoacidic profile of insect meals may be ill-suited for certain animal species.

The following graph shows how marginal the supply of insect proteins is expected to remain by 2025 at global level, compared to other sources already available.

Figure 37: Global proteins production (Mt) - 2016



Source: Céréopa

Several consulted stakeholders raised doubts on the technical feasibility, economic sustainability and acceptability for final consumers and retailers of the use of insect meals in animal farming.

One consulted stakeholder in the feed manufacturing industry observed that insect meals are part of a range of various “super-pro” feed materials (crude protein content above 55%), together with single-cell proteins, yeast, potato proteins, whey proteins, non-ruminant PAP, or algae meal. According to that stakeholder, the supply of super-pro feed materials in the EU is currently sufficient; the main problem is improving self-sufficiency for “high-pro” feed materials (35–55% crude protein content), and oilseed meals in particular.

The consulted consumer organisation deems that the use of insect meals as feed might be more acceptable for *poultry*, as it would be more in line with the animals’ natural behaviour. However, it is not favourable to the use of insect meals as feed for animals reared for PDO/PGI productions.

2.4.2.2 Marine feed ingredients

Krill, algae and other marine feed ingredients are seen by some stakeholders as promising feed materials (they are easy to collect and process, and do not suffer from significant risks of resource depletion), but **scaling up their production would require large investments, and their main potential use would be in the aquaculture sector**.

From a nutritional point of view, algae biomass is considered an important and sustainable protein source. Microalgae's protein content is typically high and can go up to 70%; seaweeds' content is usually lower (9–22%) – though this is compensated by their high availability – reaching up to 47% in specific red seaweed species (Bleakley and Hayes, 2017). However, the exact protein content of algae can vary remarkably.

There is little reliable data in terms of quantities/volumes on the use of algal biomass in Europe. Most of the seaweed companies in the EU direct their biomass production to food (36%), food- related uses (15%) i.e., food supplements, nutraceuticals and hydrocolloid production and, to feed (10%), accounting for 61% of the total uses[123.]

Currently, the **cost and scale of producing seaweed-based protein** for fish feed is not yet competitive with other protein sources with a high environmental footprint such as soya. The upscaling of the production and optimisation of the processing methods is expected to place seaweed biomass in a better market position for feed applications in the future (Emblemsvåg *et al.*, 2020). However, the production of algae as an alternative source of protein is an industry in its infancy and has not yet had a significant impact on animal feed.

According to FAO data, of the 36.23 million tonnes of seaweed produced in 2021, only 0.0912 million tonnes (0.25 % of global production) were produced in the EU. Because of this very low production, **the EU is today a top importer worldwide of seaweed products both in terms of value and of volumes**. Seaweed for Europe estimated that in 2016 EU seaweed imports amounted to EUR 554 million. According to EUMOFA data, in 2022 the EU-27 imported in total 153.9 thousand tonnes of seaweed products (measured in net product weight) and exported up to 56.0 thousand tonnes (in respective evolution of +7 % and -8 % compared to 2020)124. **There is no information on the proportion dedicated to feed**, but it must be very limited given the breakdown of the European market and the species imported.

2.4.2.3 Processed Animal Proteins (PAPs)

PAPs are authorised again by EU legislation for use in pet food and aquaculture feed as well as, more recently, in pig and poultry feed, but they remain underused due to **limited market acceptance** (albeit with a more favourable attitude than in the past by certain operators and competent authorities in a number of Member States) and high costs linked to compliance with regulatory requirements at feed mill and transportation level. The main strengths of PAP as feed materials are linked to their **environmental sustainability** and their **efficient use of natural resources** (no need for arable land, limited carbon footprint, promotion of circular economy, deforestation-free and non-GM by default).

Intra-EU flows of PAP exist, enabling suppliers who cannot find outlets in their own Member State to sell their co-products elsewhere. It should be noted that, in any case, European supplies are lower than they were before 2000, with some sourcing having been banned and incinerated and others having found outlets outside animal feed. The

[123] Please note that these results are based on the share in the number of companies (not by volume). Bioeconomy, Current Status of the Algae Production Industry in Europe: An Emerging Sector of the blue Bioeconomy. Published: 27 January 2021.

[124]https://urldefense.com/v3/__https://www.eumofa.eu/bulkdownload__;!!DOxrgLBm!ElOPXFRQSPghE3NZOUqI6F8OkyTo7w2ZAZis_1FQXvLN_-Sr9WAMw15uNRxNaF1lW1uaHSnMrORWWNE_6NyKQR111klq$

use of this raw material remains a definite advantage in meat-producing countries exporting to the EU (Brazil, USA, etc.).

The consulted **consumer organisation** is against the use of animal proteins to feed *ruminants*, and would oppose a hypothetical relaxation of the rules in this regard. As regards the use of animal proteins to feed *monogastric* animals, the organisation observed that most consumers are likely to be unaware of it, but if they knew, they would probably see it unfavourably. It also observed that the use of animal proteins to feed monogastric animals also poses some issues to religious consumers, especially in case pig proteins are fed to *poultry*.

2.4.2.4 Amino acids

The most used amino acids in feed diets are methionine, lysine, threonine, tryptophane and valine. The market for more recent amino acids such as arginine, isoleucine and leucine is also increasing, as a response to sustainability market drivers such as the need to reduce nitrogen pollution and the need to reduce imported deforestation through soya bean meal. With the exception of methionine, which is chemically produced, all amino acids used in feed are produced by fermentation.

The size of the **EU market** for the most used amino acids is estimated by a key operator in the field (interviewed in the context of this study) at around **1 million tonnes**, with more than half of this market being allocated to lysine. The global lysine market is estimated above 2.5 million tonnes, i.e. about 5 times the size of the EU market. About 70% of the global lysine production is controlled by China. Only a limited number of operators produce amino acids in the EU: two operators for methionine and one operator for the amino acids produced by fermentation. Besides domestic production, **the EU amino acids supply is largely dominated by China** and overall ensured by a rather limited number of other countries (Indonesia, South Korea, United States).

The competitiveness of the EU amino acids production (or lack thereof) is mainly determined by the costs of raw materials (such as sugar used in fermentation and ammonia) and energy, since the process is energy intensive[125]. **Structural measures** are required to secure the competitiveness of EU amino acids production to avoid increased dependency on imports. As an example, since the stop of threonine production in the EU in 2018, the EU is 100% dependent on China for its threonine supply.

Amino acids are widely perceived as **a solution to include in the diets EU-produced feed materials whose aminoacidic profile is suboptimal** compared to soya bean products.

2.4.2.5 Other feed sources

Some potential **alternative plant protein sources**, like jatropha, tend to suffer from strong nutritional limitations. Genetic breeding and innovation in processing technologies might help in addressing such limitations: however, in the EU there may be some resistance in that regard from the civil society and policy makers.

Finally, the **use of former foodstuffs (FFS) as feed materials** was highlighted by some consulted stakeholders as an alternative option with significant potential, even though substantial technical, organisational and regulatory hurdles in this regard remain largely unaddressed.

[125] EU plants producing amino acids are handicapped by sharply rising energy costs (for natural gas and electricity) since the start of the Russian invasion of Ukraine, and by a rise in the cost of raw materials (ammonia and sugar), which are themselves strongly affected by the rise in energy costs. The price of sugar in the EU, which has increased remarkably after a prolonged depression in the first years that followed the termination of quotas, is now well above the international price. The situation has further worsened due to a fall in demand on the feed markets caused by the outbreak of avian influenza and by the restructuring of the pig sector in the EU. Finally, low-priced Chinese imports of amino acids (due to production overcapacity in China) are also contributing to undermine the competitiveness of EU-based amino acid producers.

2.4.2.6 Views of stakeholders

The **overall attitude of the surveyed downstream operators towards "alternative feeding strategies"** (e.g., organic, GM-free, environmentally friendly, sustainable, locally sourced, sources of non-agricultural origin like insects and algae, etc.) was **mostly neutral** (17 out of 32 replies – 53%): operators saw some interesting opportunities in them, but deemed that certain issues should be solved to fully exploit them. A significant share of respondents (10 out of 32 – 31%) believed that the importance of alternative feeding strategies will increase in the coming years, and were willing to promote them. By comparison, the overall **attitude of the surveyed NCAs (National Competent Authorities) is more positive than that of downstream business operators**: 13 out of a total of 23 surveyed NCAs (56%) deemed that alternative feeding strategies will increase in the coming years, and are willing to promote them. The attitude of the other surveyed NCAs (44%) is neutral.

Surveyed downstream operators identified the most important **elements that are influencing or will influence a shift towards alternative feeding strategies** in: i) possibility to reduce dependency from third countries and to promote the development of supply chains that use more feedstock produced in the EU (27% of a total of 79 replies); ii) consumer demand/attention towards certain certification schemes (e.g., organic, GM-free, locally sourced, non-deforestation, animal welfare) covering the whole supply chain of animal products (25% of replies); iii) possibility to reduce feeding costs and thus increase the competitiveness of the supply chains (19% of replies). In this respect, surveyed NCAs also indicated the role of opportunities offered by policy changes aimed at incentivising the use of alternative protein sources (20% of 59 replies).

As for the most important **issues and challenges surrounding a potential shift towards alternative feeding strategies**, the surveyed downstream operators highlighted: i) the availability of an adequate supply of alternative protein sources in the medium/long term (29% of a total of 52 replies); ii) consumers' willingness to pay premium prices for animal products from livestock fed with alternative protein sources (e.g., organic, GM-free) (25% of replies); iii) consumers' acceptance of animal products from livestock fed with alternative sources of protein (e.g., insects and algae) (15% of replies). The same issues and challenges were also identified by the surveyed **NCAs**. The importance of market demand in the relevant segments in the EU in influencing the uptake of alternative feeding strategies was underlined by the consulted European Commission services.

2.4.3 Main findings

In the light of the elements emerged from the assessment, the main **strengths, weaknesses, opportunities and threats to the EU animal products supply chains** that are related to imported/innovative protein sources are the ones presented in the SWOT (Strengths, Weaknesses, Opportunities and Threats matrix) (see Table 22).

Table 22: Imported/innovative protein sources: SWOT matrix

The attitude of both supply chain actors and other stakeholders towards alternative feeding strategies is moderately positive ***EU imports of sustainable protein sources (non-GM, non-deforestation, organic) are a well-established reality, in particular for soya bean products***[126]	***The development potential of alternative feed sources (insect meals, processed animal proteins, amino acids, former foodstuffs) is perceived as limited, due to different constraints and challenges (regulatory constraints, technical drawbacks, limited cost competitiveness, unfavourable consumer attitude, etc.)***
Opportunities *The development potential of feed use of processed animal proteins, amino acids, and former foodstuffs could improve once the main constraints and challenges are addressed*	**Threats** ***Declining consumer interest for animal products fed with non-GM and organic feed materials*** *The import of products obtained from sustainably-fed animals reared in third countries could be a realistic alternative scenario to importing sustainable protein sources from third countries to rear animals in the EU*

Source: Consortium

In ***bold italics***: elements backed by wide convergence of multiple stakeholders and/or by concrete evidence

The previous analysis and SWOT matrix allow to draw a number of conclusions on which **feed sources show some potential in terms of increased supply chain resilience and public acceptance**. In terms of **alternative/non-conventional protein sources**, availability of sufficient quantities in the medium/long term and consumers' actual willingness to pay premium prices for animal products from livestock fed with alternative protein sources emerged as the main issues and challenges surrounding a potential shift towards alternative feeding strategies.

The main findings are summarised hereunder and classified in terms of potential, following the technical and stakeholder-based assessment above.

Sources showing higher potential

Also in light of the standards recently introduced by Regulation (EU) 2023/1115, which will be applicable from 30 December 2024, **non-deforestation protein sources**, and soya bean products in particular, emerged as the imported/alternative feed sources that are bound to record the most remarkable development.

Imports of organic soya beans and soya meal (in combination with an increased domestic production of the same feed materials) are deemed essential to the development of the organic segment, especially for monogastric species.

In terms of innovative protein sources, there is real potential in the development of new varieties of **protein-rich rapeseed** (in the next 5/8 years), resulting from varietal research and grown in the EU. As the meal is more concentrated, less is used than

[126] Organic soya is not grown on deforested land. As for non-GM soya, the difference in yield between it and conventional soya may automatically make non-GM soya less sustainable. However, this approach should also take into account the impact on biodiversity, which would make organic, non-GM and non-deforestation soya more sustainable than standard GM soya.

standard meal, while at the same time reducing imports of soya. Protein-rich rapeseed meal could provide an economic advantage, as well as an improvement in protein sovereignty in the EU.

Finally, it should be noted that for a number of imported raw materials, the EU relies on a relatively limited number of supplying countries, e.g., Australia for lupines, Brazil and Argentina for soya products, Russia and Ukraine for sunflower, China for amino acids. This is of course due to the overall functioning of the global market for these commodities and to the competitive advantage some countries have gained over time. However, to the extent possible, **diversification of the origins of protein sources would be an important goal to pursue**. Shifting from imports to EU production for some protein sources may not be a viable or economically sound strategy, but a diversification of the origins of these imports may indeed contribute to increased resilience.

Sources showing potential, but with some limitations

Protein crops have a real agronomic interest and a good image among consumers. The global market of lupines and peas is smaller than that of oilseeds and cereals, but – for peas especially – cultivated areas in the key exporting countries are increasing, providing room for growth. In turn, a possible opening up of the Chinese market for Russia peas might reduce availability of this supply.

High-Pro sunflower seed meal, notably from the Black Sea area but also from Argentina, is also an interesting source of protein feed showing some potential (also being non-GM and not linked to deforestation). Depending on developments in the oil market (and in particular a potential slowdown in the growth of marketed volumes of palm oil[127]), the production of oil-rich seeds, including sunflower, could be of interest compared to other crops. However, China has very quickly become the main importer of high-pro sunflower seed meal and could limit its overall availability worldwide.

Amino acids are widely perceived as a solution to include in the diets EU-produced feed materials (rapeseed meal, sunflower meal, DDGS, etc.) whose aminoacidic profile is suboptimal compared to soya bean products. However, the heavy dependence of the EU livestock sector on import of amino acids, especially from China is cause for concern. Structural measures are required to secure the competitiveness of EU amino acids production, due to the energy-intensive nature of the related processes[128], to avoid increased dependency on imports.

A **circular economy approach** could allow to keep nutrients within the food/feed system, by valorising e.g., **PAP** and **former foodstuffs**. For such sources, however, the feed sector suffers competition from other outlets (e.g., pet food, biogas production) and reports some difficulties in adjusting to regulatory requirements or in overcoming existing technical hurdles. A clear policy framework prioritising the use of these materials for feed purposes could be beneficial in this regard. *For PAP consumer acceptance is still low*; however, other supply chain actors are more open to their use than in the past (e.g., retailers), especially for monogastric species.

Sources showing low potential

The assessment revealed **widespread scepticism about the potential of insect meals for feed use** in the supply chains of interest, due to a number of technical and economic limitations, as well as a perceived low acceptance by final consumers and retailers.

[127] Growth in palm oil production could be slowed by the fight against deforestation and climate change. An increasing proportion of palm oil is also used for biofuel production in producing countries, thus limiting exports.

[128] EU plants producing amino acids are handicapped by sharply rising energy costs (for natural gas and electricity) since the start of the Russian invasion of Ukraine, and by a rise in the cost of raw materials (ammonia and sugar), which are themselves strongly affected by the rise in energy costs.

2.5 SQ5: WHICH OTHER STRATEGIES COULD FACILITATE THE DIVERSIFICATION OF EU FEED SOURCES, SUCH AS ADAPTING ANIMAL BREEDS, CHANGING PRODUCTION METHODS, USE OF FEED ADDITIVES IN VIEW OF OPTIMIZING PROTEIN SHARES AND FEED RATIO COMPOSITIONS, ETC?

SQ5 focuses on identifying and defining the strategies that would act as promoting/enabling factors towards greater diversification of feed sources within the EU.

Against this backdrop, SQ5 focuses on sector-specific strategies, in the sense that they should be devised and implemented mainly by livestock producers and/or feed manufacturers. In addition to promoting strategies, enabling strategies also target the removal or reduction of current barriers that hinder the diversification of feed sources in the sector. These strategies should meet criteria of current (or at least potential, in the view of sectoral stakeholders) technical feasibility and economic sustainability. Research at EU level is also ongoing to identify the impact, identify knowledge gaps and investment needs of these alternative strategies[129].

To this end, the investigation draws on key insights from SQ1 (identification of constraints/barriers), SQ2 (technical feasibility and economic sustainability) and SQ4 (environmental sustainability and social acceptability). Ideally, the strategies for promotion and enablement should also uphold environmental sustainability and garner social acceptance.

2.5.1 Identification of theoretically relevant categories of promoting/enabling strategies: definition and classification

Many strategies have the potential to enhance the diversification of EU feed sources and improve the EU's protein self-sufficiency. These strategies can be broadly sorted into three main categories:

- Farm level (production methods),
- Animal level (nutrition, genetics),
- Feed raw materials (improvement in quality and availability).

Figure 38: Scope of strategies

Source: Consortium

Strategies related to the supply or improvement potential of EU-grown feed have already been discussed in SQ2. The different levers identified within the case study are presented in the table below. In terms of raw materials, SQ5 exclusively addresses more experimental options such as insects feed.

This section is organised using a lever approach. For information relating to a specific cluster, the table below should be consulted to pinpoint the options that have been examined for that specific cluster.

[129] A list of research projects implemented at EU level is available here: https://hal.inrae.fr/hal-02917639/document

Table 23: Alternative protein sources identified that are grown or produced in the EU

Action levers for the scenarios	Species							Production systems			
	PIGMEAT	**BROILERS**	**LAYING HENS**	**DAIRY CATTLE**	**BEEF**	**DAIRY GOATS**	**SHEEP MEAT**	**Conv**	**Organic**	**Non-GM**	**PDO/PGI**
Raw materials											
Develop new raw materials for feed											
Algae	X	X	X	X	X	X	X	X	X	X	**Depends on the Specific-ations**
Insect meal	X	X	X					X		X	
Fish meal	X	X	X					X		X	
Processed Animal Proteins (PAP)	X	X	X					X		X	
Protein concentrates (e.g. from grass clover)	X	X	X		X			X	X	X	
Single cell protein	X	X	X		X			X		X	
Animal											
Animal nutrition											
Ideal protein: better understanding the needs to adapt the feed	X	X	X	X	X	X	X	X	X	X	X
European amino acids	X	X	X	X	X	X	X	X		X	X
Enzymes	X	X	X					X	X	X	X
Essential oils	X	X	X	X	X	X	X	X	X	X	X
Decrease the energy content / protein level	X		X		X		X	X	X	X	X
Animal breeding											
Animals with a lower nutritional requirement (slower growth)	X	X			X			X	X		X
Animals more resilient to ANF (genetic) / Rustic breeds	X	X	X			X		X	X	X	X
Production methods											
Dairy extensification				X		X		X	X	X	X
Date of calving / Age at first calving				X	X	X	X	X	X	X	X
Precision feeding: personalisation of diets (sensors, agritech).	X	X	X	X	X	X	X	X	X	X	X

Source: Case studies, literature review

	Scenario modelled
X	Scenario identified by case-study stakeholders but not modelled

2.5.2 Animal nutrition

Research in animal nutrition is relevant for all types of species and production systems and has significantly contributed to a **better understanding and characterisation of the needs of animals, for developing tailored diets and reducing overfeeding**. Overfeeding leads to higher environmental impacts, as it necessitates larger quantities of feed and leads to excessive nutrient excretion. Additionally, it incurs higher costs and diminished animal performance. For instance, for laying hens, excess proteins in the diet can trigger digestive issues which reduce growth and egg-laying rates.

Approaches to animal nutrition can involve the **development of new EU-produced feeds** that are better suited to the specific needs of the animals. Alternatively, it can entail **developing feed additives** such as enzymes or amino acids, **to improve the digestibility and complement the existing resources grown in the EU**. These developments could be further improved with precision feeding techniques including the use of scales and precision feeder, to further reduce overfeeding.

2.5.2.1 Better knowledge of species needs and of raw materials values – Precision feeding

Better knowledge of animal needs and of the raw materials' nutritional values is key to achieving production objectives while optimising resources. This not only positively influences the profitability of livestock operations (Pomar, Van Milgen and Remus, 2019), (Remus, Pomar and Warner, 2021), but also has beneficial effects on the environment (Remus, Pomar and Warner, 2021) (Commission *et al.*, 2020). Many stakeholders in the market contribute their expertise to enhance feed efficiency, including research organisations, technical institutes, additive suppliers, and feed consultancy firms.

Nutritional modelling is key to studying the response of the species to different nutritional regimes, including to new raw materials. It also plays a crucial role in providing on-farm management support and assisting in decision-making to achieve desirable and cost-effective animal production. While several models are available, only a limited number of them are readily accessible for users (Halas, Gerrits and Van Milgen, 2018). For every species, the needs requirements also evolve rapidly over time, depending on the physiological stages such as the starting, growing, and finishing stages. It's thus necessary to design and supply different diets to guarantee efficient nutrient utilisation, as illustrated in the **multiphase feeding approach** mentioned in Section 2.5.5 This approach is exemplified by broilers, laying hens and pigs, demonstrating how feed can be tailored to suit the requirements of the animal's growth phase. For instance, for laying hens, studies[130] on the implementation of a five-step feed supply approach showed constant animal performance while leading to a reduction in protein usage and costs.

In the case of both ruminant and monogastric species, precision feeding is also a promising tool, as it can adjust feeding rations precisely to individual feeding requirements based on real time. Studies assessing the impact of precision feeding on pigs, for example, show positive results in terms of environmental impact without influencing growth (Gaillard, Brossard and Dourmad, 2020). Looking for the **ideal protein** is an example of a way to achieve precision feeding (see 2.5.2.2).

[130] cf. the Secalibio research project implemented in France.

Once the needs are correctly characterised, **understanding the feed's nutritional values is equally important**. This is particularly relevant for ruminant species since the grass or roughage is not always subjected to a thorough analysis. Better analysis of forage and ration quality may be in this sector despite being considered as a good lever in dairy cattle clusters, to complement the ration better with necessary nutrients or suitable amino acids. In the case of monogastric species, for which diets are generally already well optimised, better identification of the alternative feed's nutritional values could support further diet diversification.

Box 20: Real-time determination of nutritional values through NIR

For the past 15 years, NIR (Near Infra-Red) or 'near infrared spectroscopy' has revolutionised the methods of analysis in animal feed. It makes it possible to rapidly find out the nutritional values of a raw material (protein, moisture, fat, micro-components including amino acids, vitamins, harmful components, etc.) received in the feed manufacturer plant. It allows sorting of deliveries, for example by separating soya bean meal according to protein content and facilitates the adjustment of feed formulas.

However, the acquisition of this type of equipment is far from being advanced in many Member States that apply very high safety margins in the use of raw materials (higher incorporation rates). This is the case in Poland for conventional poultry, for instance, where the share of soya bean meal is higher to guarantee the broilers' growth performance.

Source: Consortium

The **implementation of precision feeding tools on production farms** has been increasing significantly in recent years, although their adoption rates across the EU still exhibit a high degree of variation that depends on prevailing regional production intensity and operational structures. While the availability of recent data[131] on the adoption rate of precision feeding tools remains limited, figures on the adoption rate of other digital technologies used in the livestock industry can be used as a proxy to provide valuable insights into the broader trends and development within the sector: for example, in 2019, the adoption rate of automated milking systems was already at 30 % in Iceland and Sweden and at more than 20 % in the Benelux countries (Vik et al., 2019). Progress is also being made in other clusters, and certain large operators are starting to equip farmers. For instance, in France, cooperatives are experimenting precision feeding and monitoring in turkey and pig breeding; precision forage analysis to adjust concentrates volumes given to dairy cows; and individual precision monitoring of each sow, to ensure that they are fed according to their needs. The adoption of cutting-edge technologies may lead to disparities between those who have access and those who do not, which could manifest itself in several ways including between farms with small and large agricultural operations. Therefore, **it is key for sectoral stakeholders to collaborate in providing training, resources, and incentives to help farmers adopt these technologies, ensuring inclusive access for all**.

2.5.2.2 Fine-tuning the diet with feed additives

A feed additive is a product used in animal nutrition to improve the quality of a given feed and thus the quality of not only the final product, but also animals' health and performance. The use of feed additives in animal diets can also reduce the environmental impact of livestock[132]: in intensive ruminant livestock, it could decrease their enteric methane emissions by up to 10 % (Guyomard et al. 2020). Feed additives are regulated by the Feed Additives Regulation (Regulation (EC) No 1831/2003). Three

[131] Previous research on the adoption rate of precision feeding tools in the EU was conducted by Banhazi et al. in 2012.

[132] https://www.wur.nl/en/research-results/research-institutes/livestock-research/show-wlr/new-feed-additive-significantly-reduces-methane-emissions-from-dairy-cows.htm

types of feed additives are of particular interest here: i) amino acids, ii) enzymes, and iii) essential oils.

2.5.2.2.1 Amino acid and the concept of ideal protein

Amino acids provide animals with **essential building blocks for protein synthesis**, ensuring they receive the precise amino acids they require for growth, reproduction, and maintenance. **Supplementing the feed with synthetic amino acids not only improves the balance of the feed, but also reduces its protein content** (Beski, Swick and Iji, 2015) **and improves the performance of the farm** in terms of animal production performance (IFIP, 2011) and welfare as well as environmental releases.

Knowledge about amino acid digestibility has been largely disseminated, first in **pigs** since the 2000s and in **poultry** since the 2010s, resulting in a common solution adopted in both these sectors. However, the lack of reliable information on the quality of grass and forage as well as technical factors linked to the ability of amino acids to bypass rumen degradation still limits its adoption for ruminants.

Obtaining the ideal protein is made possible by the contribution of raw materials often supplemented using synthetic or fermented amino acids such as DL-methionine, lysine HCl, L-threonine, L-tryptophan, and L-valine. Others are now available (tyrosine, arginine, isoleucine) but are not yet widely used. According to the latest EU regulation, 73 amino acids are currently authorised as feed additives[133], with a positive impact on EU feed manufacturers' supply diversification capacity. According to a survey conducted for this study, the increased availability of amino acids has helped 66 % of them to diversify their supply.

In terms of availability, the EU remains dependent on imports for the supply of amino acids. While there is potential to scale up domestic production, investments should be made to further develop the sector. In addition, developing further EU amino acids would require regulatory adjustments, as highlighted by Spanish stakeholders. As such, the development of EU amino acids is seen more as a medium- to long-term strategy.

Box 21: Concept of ideal protein

The concept of ideal protein is used to represent an amino acid profile which allows the set performance criteria (live weight, feed conversion ratio, etc.) to be maximised, by containing the minimum amino acids necessary to support maintenance and production (van Milgen and Dourmad, 2015), while limiting the amount of excreted nitrogen. When the formulation no longer respects the ideal protein profile, a decrease in performance can be observed[134].

Source: Consortium

Box 22: Amino acid in the organic market

The use of **synthetic amino acid is forbidden for organic production** according to EU Regulation 2018/848. Thus, this has not been an available lever to date to fine-tune the amino acid profile of the ration in this sector. According to many case-study stakeholders, the existence on the market of an amino acid such as methionine issued from non-GM organisms would be a good breakthrough in the field of organic animal nutrition.

Source: Consortium

Supplementing amino acids in the ratio shows potential to substitute the reliance on soya bean meals in monogastric diets; the results of the modelling procedure carried out as part of this study suggest that doubling or more the share of industrial amino acids makes it possible to cap the inclusion of soya bean meal to 25 % or less in the case of conventional broilers. However, this would not lead to reduction of the overall volumes of feed needed, since the use of amino acids changes the profile of the raw material used but not the quantities. The magnitude of the impact might also be more limited in lower-value markets (such as intensive broiler production for low-cost

[133] Considering the authorised products under the category '3c) Nutritional additives – amino acids, their salt and analogues'. https://ec.europa.eu/food/food-feed-portal/screen/feed-additives/search

[134] Some amino acid may be limiting factors (e.g., methionine for laying hens), and the protein synthesis can be restrained by their level of availability.

catering) or when the use of soya bean meals in the diet is limited (such as for non-conventional pigs).

Formulation according to the concept of ideal protein varies across Member States, and amino acid vendors report that there are still big differences in the way such systems and commercial amino acid supplementation have been taken up by feed professionals throughout the EU, suggesting room for improvement. In France, for instance, partnerships between private companies and research organisations have made computerised feed tables available to nutritionists[135], to develop pig and poultry feeds using amino acid digestibility values. On the other hand, these practices are less common in countries such as Germany, the Netherlands and Italy. Poland also does not seem to have adopted this progress at all, especially for poultry.

Box 23: The amino acid market

There is a risk of moving from one dependency (soya bean) to another (amino acids). Regarding lysine, the EU is a producer but not self-sufficient. For methionine, there are several production units, and the EU is an exporter. An increase in its use would not pose a problem of supply (current exports would switch to the local market). For other amino acids (threonine, tryptophan, etc.) EU dependence is more problematic, although production know-how for amino acids exists in the EU. They are imported from China and the USA. Although it helps mitigate certain environmental concerns, it's important to note that amino acid production still relies on energy-intensive processes.

European amino acids produced by fermentation (of beet molasses) have an environmental advantage (in terms of GHG emissions) compared to Asian or North American amino acids (mainly produced from maize fermentation in the USA). Investments in this sector are undoubtedly desirable and would also have the advantage of strengthening the European sugar sector.

In terms of impact, optimising amino acid requirements has a positive effect on global warming, a lower positive effect on land use, and a negative effect on energy demand, partly due to the production process of amino acids (see SQ11 for additional details).

Source: Consortium

2.5.2.2.2 Enzymes

The role of enzymes is to fully exploit all the components of the feed. They can either **reduce the effects of some antinutritional factors[136] or increase the digestibility of feed and release the maximum amount of nutrients and amino acid** in the digestive part of the animals, with **significant impact on feed efficiency and thus on reducing production costs and environmental footprint** (FAO, 2019).

Enzymes can be used in all livestock species considered in the study. Xylanases and glucanases are now widely used in diets containing wheat, barley, rye and triticale for pigs and poultry to stabilise or even improve the energy and protein value of the diet. However, the high cost[137] of certain enzymes is a limit for further adoption. Despite positive impact on pig growth performances (De Cuyper et al., 2020), **proteases are not widely adopted by the different livestock sectors**.

Some stakeholders can also be reluctant to use enzymes due to the balance between the cost and the **variability in the experiments' results**, since the effectiveness can vary according to certain parameters such as the physiological and physical state of the animal or the microbial activity in the digestive tract (Beckers and Piron, 2009). For the organic segment, enzymes must be generated by non-GM organisms. As for amino

[135] AmiPig in 2000, EvaPig since 2010, FeedTables.com since 2017.
[136] For example, the 'cage effect'[136] of hemicelluloses for pigs or poultry.
[137] According to stakeholders, the latest prices for enzymes in Spain were: lysine: EUR 1 400/tonne, methionine: EUR 2 350 /tonne, creatine EUR 1 600/tonne.

acids, the development of enzymes will require alignment of marketing authorisation with market needs, a process which could take a certain amount of time.

Box 24: Modelling of the use of NSPase in the diet

For the non-conventional pigmeat cluster, the use of enzymes was modelled for the Iberic pig (ES). Since phytases are already included in the case-study diets, only the effect of NSPases was tested. According to literature (Cozannet, Preynat and Noblet, 2012; Maliwong et al.) NSPases increase the energy value of the diet. The main effects occurred for growing pigs (20–60 kg) and lactating sows. As the diets are already well optimised, the modelling results showed limited changes in the diet composition in raw materials. Lesser energy is obtained by redistribution of the energy sources (less fat), with a little less soya bean meal for diets. Stakeholders from both subclusters agreed that enzymes were very expensive, so that it would be worthwhile in the early stages of animal development only. **In addition, they highlighted that NSPase are mostly used to increase energy digestibility and not proteins.**

Source: Case study in Spain and Italy

2.5.2.2.3 Essential oil

Essential oils are aromatic components extracted from plants with various properties depending on their composition. In animal production, essential oils are mainly used to **improve zootechnical performance** such as growth rate, feed conversion ratio, intake levels, feed digestibility and animal health status. Their effects on animals may depend on their biological targets and method of absorption, itself impacted by various factors such as the diet chemical composition, their form of presentation or their dose level (FAO). Certain **mixtures of essential oils would reduce the rate of degradation of complementary feed and nitrogen in the rumen** by limiting the activity of certain bacteria. Incorporating essential oils into animal nutrition provides additional benefits, including positive impacts on the digestive microbiota, animal tissues, immunity and inflammation, digestion, metabolism, nervous system and behaviour (Alleman et al., 2013).

Interest in essential oils as additives in animal feed has surged due to the phasing out of antibiotic growth promoters. Essential oils are now **commonly used in pigs and poultry**, where they enhance the digestive action of specific enzymes. Research studies on supplementing piglet feed with essential oils have demonstrated positive effects on growth performance and digestion (Peng *et al.*, 2022). In the poultry sector, much of the research has concentrated on the impact of thyme, oregano, and rosemary essential oils, with results varying depending on the variability in the composition of active ingredients in the products tested (INRAE, 2013). Further research would be necessary to determine the appropriate dosage.

In the case of ruminants, various essential oils can **enhance the efficiency of energy and protein utilisation from forage in the rumen**. They achieve this by regulating the competition among different populations of microorganisms, thanks to their selective antimicrobial properties (Fernand *et al.*, 2018). Stakeholders interviewed suggested that essential oils can lead to **improved assimilation of ingested proteins** in conventional dairy cattle, conventional dairy goat, and conventional beef cattle. This observation was corroborated by researchers and feed manufacturers who participated in this study. They found that the use of essential oils for assimilating fodder proteins yielded positive results, particularly in the conventional dairy goat sector. The use of essential oil could also be explored as an option to mitigate the impact of heat stress of milk productivity in southern Member States (Kalaitsidis *et al.*, 2021).

2.5.3 Animal breeding

Improved animal genetics for livestock may have two interesting features in the pursuit of achieving greater protein independency:

- Selection of slow-growing strains that need fewer concentrated feeds.
- Selection of more efficient animals that better use the feed consumed.

Animal breeding is a viable option for both ruminants and monogastric animals, though with more advanced developments seen in the latter. It was identified as a potential strategy in four case studies. Nevertheless, altering genetic traits necessitates a long-term outlook, and specific PDO/PGI specifications may restrict the utilisation of certain new breeds.

2.5.3.1 Slow-growing strains

The principle of slow-growing strains is to **lengthen the period of raising, so that it is less necessary to resort to highly concentrated proteins** such as soya bean meals, which are paramount for the start-up and growth phases.

Box 25: Conventional intermediate-growth chickens in the Netherlands

Chicken production for the fresh market in the Netherlands has undergone a change since 2015 that has resulted in 100 % intermediate-growth chickens on the shelves by the end of 2023. This trend is driven by animal welfare label requirements (Beter Leven). Thus, instead of being raised 42 days, the chicken is raised in 56 days. This longer life involves more energy and more feed, but the current diet for the 'Better Life' chicken contains less soya bean than the fast-growing chicken. Better Life Chickens farming reduces the overall demand for soya products, thereby limiting the pressure to convert land to arable land.

Source: Consortium, based on Five questions about chicken meat in supermarkets–WUR

Slow-growing strains in livestock farming enjoy several benefits in terms of improved animal welfare (Rayner *et al.*, 2020); (Ritchie and Roser, 2023) and a reduction in the incidence of health issues (Bessei, 2006). However, this comes with economic drawbacks because production cycles are longer, leading to increased volumes and higher feed costs. According to a study conducted by Wageningen, transitioning from a conventional system to one with slow-growing broilers would result in an increase in costs ranging between 15–19 % (Van Horne, 2020) and financial incentives would be needed to encourage adoption among farmers. In addition, **the zootechnical performances are not always optimal, requiring a more intensive follow-up of the breeding process.**

The use of slow-growing strains is increasing, as part of efforts to balance animal welfare, economics and environmental impacts. In the case of broilers, over 330 companies operating in the EU have signed on to the European Chicken Commitment[138]. Slow-growing animals are also raised as part of non-conventional production (PDO/PGI, organic, etc.), with **the specifications and regulations influencing practices**. For instance, within the framework of the French 'Label Rouge', chickens are slaughtered at 84 days, and there is a minimum of 75 % of cereals and cereal co-products in the diet as well as a maximum incorporation rate for soya bean and soya bean meal set at 10 % and 35 %[139] by weight of the formula. In the case of Label Rouge, the rearing period duration increases feed consumption. Additionally, specific products like animal meal and growth promoters are prohibited. Moreover, stringent quality control measures are applied to all raw materials (INRA, 1997).

2.5.3.2 Selection of efficient and adaptable animals (new traits for performance and feed efficiency)

Research on better understanding of protein digestion mechanisms and on the genetic selection of more efficient animals is underway to improve target action levers at both feed and animal levels. In this context, new traits related to performance and feed

[138] https://www.eurogroupforanimals.org/library/economics-slow-growing-broilers
[139] Label Rouge specifications No. LA 08/87 'Free-range white chicken, whole and cuts, fresh' is available via the following link: https://info.agriculture.gouv.fr/gedei/site/bo-agri/document_administratif-2894302e-8ffb-4a7f-8bdc-d7bc196fa221/telechargement

efficiency were investigated in different monogastric species and experimental settings during the European programme Feed-a-Gene. This project also tested approaches that could be used to improve the accuracy of selecting feed efficiency for production farms. Several traits were found to be promising for further improvement of feed efficiency by genetic selection in different production environments (Feed-a-Gene, 2015[140]).

2.5.3.2.1 Monogastric species

High-yielding commercial breeds of chickens have been developed in recent decades to meet growing global demand for animal-source foods. These chickens are bred specifically either for meat or egg production and require **health and intensive nutritional management** to reach their genetic potential, with maize and soya bean-based feeds standardly used as feed source, thereby not allowing for optimal exploitation of EU raw materials (De Verdal et al., 2013). These breeds have also contributed to a reduction in genetic diversity and to biodiversity losses.

In an effort to bolster the EU's self-sufficiency in protein sources by diversifying feed ingredients, research focusing on the identification of species with a higher tolerance for new feedstuff, such as species with more **rustic strains**, is a promising option and a potential opportunity for smaller farmers[141]. This alternative was mentioned by conventional and organic stakeholders interviewed for the case studies. Native breeds also enjoy advantages in being better adapted to local conditions, as they provide a more robust response to environmental and climatic variations (di Rosa et al., 2020). Nonetheless, such a shift would represent a **substantial departure from current production trends, particularly within the conventional sector**. Stimulating this transition would require comprehensive measures, including investments, effective knowledge dissemination and proactive efforts to raise farmer awareness.

Several studies demonstrate the potential to improve feed efficiency by selecting animals on heritable criteria such as growth, feed conversion and feed intake (Prakash, Saxena and Singh, 2020). The ability of an animal to digest its diet can also be a selection criterion. Animals can be categorised into good and poor digesters, with differences in feed intake and anatomical characteristics of the digestive tract accounting for these distinctions (Rougière *et al.*, 2009; De Verdal *et al.*, 2010). This underscores the potential for genetic selection to enhance digestive efficiency within animal populations.

In the pig sector, enhancing protein efficiency through selective breeding presents an opportunity to lower production costs and enhance environmental sustainability. Estimating genetic parameters related to protein and nitrogen efficiency is thus required, along with determining their heritability. Results from Feed-a-Gene have demonstrated the heritability of digestive efficiency concerning energy, organic matter, and nitrogen in pigs. Studies have also shown positive phenotypic correlations with phosphorus efficiency. Moreover, it has been shown (Ewaoluwagbemiga, G. and C., 2022) that protein efficiency is heritable in Large White pigs and does not change the meat quality (except its redness). Likewise, having animals more resilient to fibre content is considered as a potential lever.

2.5.3.2.2 Ruminants

Interest in selection for improved feed efficiency is increasing for ruminants, but some economic issues must be quantified before selecting for feed efficiency. Some studies in Ireland suggest that **selection for improved feed efficiency has no deleterious effect on dairy cow performance** (Connor, 2015). On beef production there can be two types of rations used for feeding cattle: a cellulose-based ration (grass silage plus beet pulp) for breeding females and a starch-based ration (maize silage plus wheat) for fattening animals. Depending on the objectives pursued by the farmer, the ration

[140] Digestibility measurements (pigs), biomarkers for digestion (broilers), number of head hits received (pigs), Blom's rank score from feeding behaviour traits (pigs), blood counts (pigs). https://www.feed-a-gene.eu/sites/default/files/documents/Feed-a-Gene_D5.2_New_traits_to_select_for_feed_efficiency_.pdf
[141] https://zootecnicainternational.com/featured/label-rouge-supply-chain-model-markets/

received by the animal is different throughout its life. The optimum would therefore be to select animals that are efficient in both situations. For this reason, the BEEFALIM2020 research programme (2015–2020) aimed at understanding the genetic and nutritional determinisms to be able to integrate feed efficiency into the genomic selection of beef cattle. Genetic analysis of feed efficiency in sheep or goats remain less prolific. However, a recent study showed that, to improve feed efficiency without influencing other production traits in meat sheep, the residual feed intake (RFI) should be taken into account in selection schemes (Tortereau et al., 2020).

2.5.4 Plant breeding

While the extension of crop areas is not always technically feasible due to several constraints (climate, trade-off with other crops, etc.), as explained in SQ2, SQ11 and SQ12, one option to overcome the issue is to carry out plant breeding to:

- Overexpress nutrients and amino acid profiles of the plants.
- Reduce anti nutritional factors.
- Improve yields and enlarge crop areas.

Plant breeding can play a crucial role in improving EU protein self-sufficiency and was mentioned as a relevant strategy in four case studies. By developing varieties of crops like peas, lupins, and maize that are richer in essential amino acids, particularly methionine, plant breeding can enhance the nutritional value of these crops for livestock feed and reduce the needs for other raw materials such as for laying hens (van Krimpen et al., 2016). Research can also support the development of meal of improved quality such as high-protein rapeseed meal. Current research conducted on Corteva's ProPound rapeseed meal indicated that it has 20 % more protein-contains than usual rapeseed and is adapted to the livestock needs.

As previously mentioned, there is room for developing pulse varieties with lower ANF such as vicine and convicine (v-c), since their negative impact on production performance is a factor limiting the adoption of this promising alternative for monogastric species. Varieties with reduced v-c content, such as the *Fabelle* variety, already exist but are not yet widely available on the market.

However, as mentioned by stakeholders from case studies, plant breeding faces several difficulties, especially the **length of the breeding process**. The potential lack of interest of plant breeders in protein crops, which remains a small market, is an obstacle as well (Ferreira, Pinto and Vasconcelos, 2021; CERESCO, 2021). For non-conventional and especially organic raw materials, this is all the more challenging given that the volumes are much lower. Additional challenges may emerge due to the likely **growing impact of climate change on the prevalence of pests and diseases**. Research efforts should be oriented towards addressing these issues (refer to the bow below for more details).

Box 26: Options to address the rising risk of crop pests and diseases due to climate change

The expected impacts of climate change on ecosystems and global agricultural production systems are set to reshape the dynamics of international trade in agricultural products and alter the prevalence, intensity, and global distribution of pests. Indeed, the increased globalisation of global markets in recent years, combined with rising temperatures, has created an environment highly conducive to the spread and establishment of pests (Deutsch et al., 2018; Savary et al., 2019).

Over the past decade, the EU has been confronted with several major outbreaks of new plant pests that have had a significant impact. On example is the recent outbreak of *Xylella fastidiosa* affecting olive trees[1], whose cost for the EU was estimated at over EUR 5.5 billion per year in production losses, with potential annual export losses of EUR 0.7 billion (European Commission, 2019).

Implementing preventive, mitigative and adaptive strategies is key to curb the global spread of pests facilitated by trade and travel. These encompass initiatives ranging from the use of disease-resistant seeds and high-quality planting materials to cutting-

edge technologies for more efficient pesticide application. For short- and medium-term solutions, the use of resistant crop varieties and the modification of microclimates are crucial measures. Further research is also needed to fill the existing knowledge gap on the impact of climate change on both pests and plant health, including its potential to affect the effectiveness of management strategies. Strong collaboration is also essential to ensure the implementation of effective systems for pest risk analysis, surveillance, and monitoring (FAO, 2021).

Source: Consortium

2.5.5 Production methods

Farm management should promote efficient resource utilisation to avoid wastage. This chapter provides a selected number of examples for precise ration adjustment tailored to specific animal species. However, changes in production methods should not compromise economic outcomes for livestock farmers. While reducing the size of the livestock herd could enhance on-farm feed self-sufficiency, this might lead to a decrease the EU's animal protein independence if consumption levels remain unchanged. Nevertheless, the strategies of changing the production methods face many obstacles including **investment costs (e.g. monitoring equipment), data management, or limited access to pasture**, which may limit their adoptions. Moreover, these techniques could be time-intensive and require greater **skills and knowledge** for implementation. More extensive production methods may require specific animal breeds adapted to a certain type of diet (see 2.5.3).

2.5.5.1 Ruminants

It is possible to adapt the herd management to align animal needs to the time when resources, especially grass, are more abundant, to favour forages at the expense of concentrates. As highlighted in SQ2, **resorting to more grassland and fodder in the ruminant's diet, as well as the improvement of their quality** through better management is essential to improve EU proteins self-sufficiency level. Among the many initiatives to increase the mass and protein autonomy of the farm the Interreg AUTOPROT[142] project identified three levers concerning herd management, based on innovations encountered on farms in the cross-border area (FR, BE, LU, DE).

Table 24: Production methods for cattle to increase protein autonomy.

Strategy	Description
Spring calving	Grouping calving at spring (March in the EU) allows the peak of lactation and the growth of grass to be synchronised. This requires the presence of grassy areas close to the farm and enough space in the barns to accommodate all the calves at the same time, which could limit the adoption of such practice in farms with more limited land availability.
Implementing efficient rearing practices that optimise protein utilisation by feeding less while sustaining herd production	Practices could be reducing the age at first calving, shortening the dry period, lengthening the lactation period, and extending the career of the cow. **On average, the adoption of all these measures 8.5 % of the protein requirement**. Opting for a breed better suited to the system is a lever in achieving these objectives. Reducing the age at calving frees up hectares, buildings' space, and work time since there are fewer animals for the dairy workshop, but this requires precision feeding and monitoring of fertility.
Reducing the protein content of the ration	Adjusting the protein content to the real needs of the cow allows for a reduction in nitrogen losses and improves protein efficiency and protein autonomy, as well as the CO_2 balance. When aiming for a reduced protein content in the diet, incorporating bypass proteins (tanned meals) and balancing proteins with protected amino acids, which won't be degraded in the rumen, can fine-tune the diet and adjust the amino acid profile to the animal's needs, without the constraints of ruminal protein degradation. However, this approach requires comprehensive knowledge of each animal's needs and the nutritional content of the raw materials.

Source: Autoprot project

[142] https://www.autoprot.eu/fr/

For beef production, the fattening stage is the most crucial part regarding protein component of rations. **Limiting needs means first adjusting protein supplements to the strict minimum**. According to the French Livestock Institute, over supplementing proteins inputs on feed has no effect[143]. Reducing the share of maize silage in favour of better-quality forages such as meslin or alfalfa silage, also appears to be an interesting way to change the share of protein provided by meal (see SQ2). **The precise management of the feeding programmes of fattening animals is key for farmers to improve protein efficiency**.

Likewise, during the milking period of the ewes, farmers are confronted with the heterogeneity of the production levels and the stages of lactation. Generally, the feeding of young females and late ewes is differentiated from the rest of the flock, by overfeeding them in the milking parlour. Working on a **better adjustment of feed intake by homogeneous batches**, to avoid waste caused by excessive coverage of the needs of the least productive ewes seems to be an interesting approach. Depending on the production system, the area, and the breeding objectives, it appears necessary to always define the levels of coverage of the needs.

2.5.5.2 Monogastric species

Multiphase feeding can be a significant lever for pig feeding, with implication in terms of reducing feed costs and environmental impact without compromising growth (Pomar et al., 2014). It consists in segmenting the feeding according to the needs of the animal. It can be achieved either by separating the input of energy or protein, or by dividing the number of phases. As mentioned in the conventional pigmeat case study for Germany, up to six phases are mobilised (two initial, middle, final, lactating sows, pregnant sows).

Multiphase feeding can also be used in the laying hens or broiler sectors. In France, the Secalibio research project showed that the five steps feed supply (instead of three steps usually used) does not degrade technical performance and enables proteins and cost savings. This strategy can be a solution in a context of tight availability and high price of soya bean meal, but it may engender some logistical constraints (increase the stock volume in the feed manufacturers, group the feed supply etc.). Moreover, **an extensive management of monogastric may be accompanied by animals with slower growth**, needing fewer protein-rich diet (see 2.5.3.1). **The use of the pasture** was also mentioned in the case study (and explored in the Secalibio project) to compensate a feed less rich in protein. The pasture must, however, be maintained to provide a young cover and propose attractive plants for the animals. Moreover, by diluting the diet of laying hens, the digestible methionine content can be reduced (van Krimpen et al., 2016). Thus, the intake of this low–energy feed will increase but using fewer protein-rich raw materials.

Both for ruminants and monogastric species, these production methods heavily rely on precise qualification and quantification of the raw material composition, as well as understanding the nutritional requirements of the animals. This faces similar advantages and constraints as precision feeding.

2.5.6 Innovative feeds

2.5.6.1 Insects

Insects fall into Regulation (EU) 2015/2283 on novel food, which applied from 1 January 2018. Only five species are authorised in the EU[144], and the authorisation only started in 2021. The authorisations concern **processed insects, such as defatted meals, fats, frozen and dried insects, but usually not whole insects.** Ruminants are to be fed hydrolysed proteins only. (IPIFF, 2023). Their protein content is high,

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[143] On rations based on corn silage combined with wheat and soya bean meal, going from 115 g of PDI/UFV to 100 g of PDI/UFV allows a saving of 600 g of soya bean meal per day and per animal, i.e., 180 kg per animal over 300 days of fattening.

[144] Yellow mealworm (*Tenebrio molitor*) in 2021, migratory locust (*Locusta migratoria*) in 2021, house cricket (*Acheta domesticus*) in 2021, and finally lesser mealworm (*Alphitobius diaperinus*) in 2023 and Black soldier fly larva (*Hermetia illucens*).

between 30 and 80 % depending on the species, with a high digestibility and a good palatability. Insect meal can constitute a good alternative to soya bean and fishmeal, replacing from 25 to 100 % of these depending on the animal species. (Sánchez-Muros, Barroso and Manzano-Agugliaro, 2014; Makkar et al., 2014). But, in the case studies, surveys and interviews, most stakeholders assess that **the sector is not mature yet**, and that insect proteins were still far **too expensive to enter in the feed chain**. This was confirmed by two modelling results (see box below).

According to the surveys conducted among feed manufacturers, only 16 % of the respondents think that insects will become affordable in the next five years, and 45 % think it won't. This is mainly due to high production costs, especially because insect breeding is an energy-intensive process. There is still a gap between research and industrial application. The respondents think that it will be used initially in high-value products, such as food, pet food and fish feed.

Box 27: Modelling of insect meal scenarios

Introduction of insect meals in the diet was modelled for two case-study clusters. For the **organic laying hens case study** (FR), the introduction of 10 000 tonnes (insect+) of insect meal represents at best only 2.6 % of the laying feed. It allows the entry of fava beans into the formulas and reduces the use of soya beans meal, while there is a clear shift from maize to wheat. Roughly, **one tonne of insects saves one tonne of soya beans imported for layers**, but this requires lower prices to be realistic. It should be positioned between 114 % and 120 % of the price of imported soya beans, depending on the scenario. In 21/22 it was worth at least 195 % of the price of imported organic soya beans.

For the conventional pig cluster (DE), the model looked at the integration of the Black Solider Fly (BSF) insect meal according to different prices. The inclusion rate of BSF32 at national level, even when free, barely exceeds 3 %, and sharply decreases once the price is over EUR 200/tonnes. Its use was rejected by all stakeholders, who considered it unrealistic because of the gap between the interest price[145] and the market price.

Source: Consortium

The other major issue raised by the stakeholders is that the insects are fed with feed materials that can be fed directly to animals, reducing efficiency, and increasing competition over resources. Insect production typically requires less land use compared to traditional feed and food production. However, the environmental impact in terms of energy use is often higher for insect production when compared to conventional products (Oonincx and Finke, 2021).

Stakeholders also pointed out that the **current regulation on organic insect** rearing and feeding conditions is not set yet. The question of feeding insects with waste products has been raised, especially on the compliance with food safety and traceability schemes. Additionally, there is a knowledge gap on the optimal utilisation of insects as feed. This includes understanding the insect's nutritional requirements, determining the appropriate inclusion levels of insects in feed, and establishing standardised practices (Gligorescu *et al.*, 2020).

2.5.6.2 Processed animal proteins (PAPs)

Since the 2001 ban of PAPs in animal feed, the main outlet for these products has been pet food and fertiliser production. In 2021, Regulation (EU) 2021/1372 partially lifted the feed ban on PAPs **for poultry and pigs[146]. However, their use in ruminant feed remains prohibited in the EU.** The **new production, transport and usage conditions are extremely strict**: they require the physical segregation of facilities based on species type along the value chain to avoid cross-contamination with ruminant

[145] The interest price corresponds to the price at which the first tonne of the alternative feed tested is used by the manufacturer without changes in the cost of the manufactured feed. This implies that, to be introduced in the composition of manufactured feed/of the ration, the market price must match the interest price.
[146] PAP are still used and widespread in Asia, South and North America, and Africa. Compound feeders still have expertise in the matter.

PAPs that are fully prohibited in feed for food-producing animals. This also aligns with the 'cannibalism ban', which aims to prevent contamination of pig feed with porcine PAP and poultry feed with avian PAP.

The PAPs are a source of **highly digestible and high-quality proteins for pigs and poultry**. The protein digestibility rate ranges between 60 and 90 % in the case of poultry-based PAPs incorporated into pig diets (Van Horne, 2020). They are also a source of energy, minerals, and vitamins, which might not be present in feed materials of vegetable origins (FEFAC, 2021[147]). Studies on the use of PAPs in broiler feed show no impact on production performance (Krimpen et al., 2018). However, unlike biological contaminations, inorganic contaminations are less monitored, which can lead to heavy metals contaminations (Pederiva et al., 2022). Moreover, the rendering process can decrease protein digestibility by altering amino acids. This may lead to a reduction in digestibility from nearly 90 % to a range of 75 % to 80 % due to racemisation and cross-linkage between amino acids (Bellagamba *et al.*, 2015).

According to the stakeholders interviewed at EU level, developing the use of PAPs would allow the animal sector to achieve **greater circularity**, since it would reduce wastes and provide a source of local proteins. However, all stakeholders underline the huge challenges of **social and political acceptance** of this feed, which has been banned for 20 years due to health crises. In addition, complying with legal requirements, in particular monitoring, will add to the production cost and limit the potential economic gains for operators using PAPs (FEFAC, 2021). Moreover, some operators now require **100 % plant-based-fed animals** for their markets. Finally, according to the stakeholders interviewed at EU level, despite the reauthorisation there is **little PAP production** because rendering plants do not have sufficient volumes to process.

2.5.6.3 Marine products (fish meal, mussel meal, etc.)

Fish meal is a source of **high quality and digestible protein.** It also provides a relatively high protein content, from 62 % to more than 70 % (Sauvant, Perez and Tran, 2004), as well as a wide range of micronutrients including the amino acid profile, and the vitamin and mineral composition (Zeng *et al.*, 2014). While **fish meal is used significantly in monogastric sectors**[148] that require concentrated proteins, its predominant applications continue to be in aquaculture and pet food due to its relatively high price[149].

The EU produces annually between 400 000 to over 600 000 tonnes of fish meal, accounting for 10–15 % of the global production (EUMOFA, 2021). Most commercial fish meal is derived from small, bony, and oily fish that are typically unsuitable for human consumption. In addition, certain fish meals are produced from the by-products of seafood-processing industries. **A 5 % or less inclusion (dry weight basis) is typical in terrestrial livestock feeds**.

Research indicates a favourable effect of incorporating fish meal in pig nutrition, leading to enhanced growth performance and overall health (Yang *et al.*, 2022). The EIP-AGRI focus group and the ProjetOK Net Ecofeed have also investigated the **utilisation of mussel and starfish meal in poultry nutrition**, and results from the Ecofeed project show positive results in terms of preservation resulting from the fermentation of these meals (Díaz-Gaona *et al.*, 2019). The Danish case study on organic laying hens similarly highlighted the inclusion of mussels in their nutrition.

The quality of fish meal can significantly differ depending on the fish species, freshness of the raw materials, and processing method, all of which can influence production performance (Kim and Easter, 2001); (Jones *et al.*, 2010). Moreover, there is rising apprehension regarding the **presence of dioxins, PCBs and other chemicals in fish**

[147] https://fefac.eu/wp-content/uploads/2021/08/21_EU_18_Q_A_lifting-feed-ban.pdf
[148] The pig industry is the second largest consumer of fishmeal, accounting for 14% of total consumption in 2019. Fishmeal in poultry feed accounted for 5% of total consumption in 2019 (EC, 2021).
[149] According to the data collected for Germany in the context of this study, the average fish meal price for 2020–2021 was EUR 1 243/tonne compared to EUR 530/tonne for soya bean meal 50.

meals and fish oils (Suominen *et al.*, 2011). The case study on organic laying hens in Sweden addressed this issue, noting that discontinuing the use of fish meal has led to a reduction in dioxin pollution.

Despite the potential nutritional benefits, the **commercial production of fish meal poses sustainability concerns**, such as the depletion of fish stocks[150], which could hamper its expansion. Additionally, the high cost and limited availability of these products may restrict their potential for further development in sectors with less remunerative outlets.

2.5.6.4 Algae

The utilisation of algae as a feed supplement is not a novel concept, and its application is progressively gaining traction on a global scale. Currently, **approximately 30 % of the world's microalgal biomass production is being marketed for animal feed applications** (Saadaoui *et al.*, 2021).

According to a study from the European Parliament, the EU accounts for around 1 % of the total algae production worldwide in 2023. In 2018, macroalgae represented 99.88 % of the algae biomass produced in the EU, equivalent to about 290 000 tonnes. Harvesting from wild stocks is predominant (accounting for 68 % of the macroalgae production). Microalgae represent 0.12 % of the algae biomass produced in the EU (about 345 tonnes) with *Chlorella sp*. being the most cultivated strain. The EIP-AGRI Focus Group suggests that microalgae can be included in animals' drinking water to avoid high drying costs. Around 10 % of macroalgae and 19 % of microalgae are allocated for feed applications, serving as a source of beneficial compounds, particularly proteins and lipids (Kuech, Breuer and Popescu, 2023); (Vigani *et al.*, 2015)).

Using algae as a source of livestock feed shows several benefits for both monogastric species and ruminants. In poultry feed, the use of algae has demonstrated potential for partially replacing proteins. Up to an inclusion level of approximately 5–10 %, algae can be safely incorporated as partial substitutes for conventional protein sources in the poultry diet. However, providing higher concentrations may lead to adverse effects, such as less efficient feed conversion and decreased protein and energy efficiency. Similar experiments were conducted with laying hens, for which diets containing 12 % Chlorella showed no significant impact on egg production, egg quality or feed conversion ratio. In the case of pigs, algae can serve as a valuable nutritional supplement. Studies have indicated that dietary supplementation of Chlorella and Scenedesmus, replacing soya bean meal and cottonseed up to a concentration of 10 %, did not have any detrimental effects on feed conversion ratios. For ruminants, incorporating spirulina into the diet resulted in a notable 7.6 % increase in average milk yield compared to cows fed the control diet (Spruijt, van der Weide and Van Krimpen, 2016).

Despite encouraging results, the sector still faces many challenges, as outlined in the European Parliament study. These include the need to **scale up production to ensure a sufficient supply and reduce costs**, **as well as a knowledge gap on algae cultivation**. Surveying feed manufacturers revealed that 48 % of respondents believe algae will not be cost-effective within the next five years, while 42 % did not express a definitive opinion. The majority indicated that production and drying costs remain prohibitively high, and availability is still limited. Algae is primarily viewed as an additive in high-value feed products (such as milk replacement and young animal feed), or as an ingredient for food products. While identified in four case studies, its application in livestock feed, both for monogastric and ruminant animals, appears to be constrained by the aforementioned factors.

2.5.6.5 Single Cell Proteins (SCPs)

Single Cell Proteins are essentially bacterial cultures, so their advantages and disadvantages are close to those of algae. They can be produced from various microorganisms including bacteria, fungi, yeast, or microalgae, resulting in **high**

[150] https://www.eitfood.eu/blog/why-sustainable-fish-feeds-are-needed

protein contents ranging from 40 % to over 60 % (Raziq *et al.*, 2020). SCPs are **rich in essential amino acids** like methionine and lysine (Bhandari *et al.*, 2022). They offer additional benefits such as rapid generation turnover (algae, 2–6 h; yeast, 1–3 h; bacteria, 0.5–2 h), wide substrate availability (carbon sources), consistent quality through continuous production, resilience to environmental variations, **low land requirements and ecological advantages (Voudouris *et al.*, 2017);** (Gerhard, Neil and Irina, 2023).

As highlighted by the European Focus Group EIP-AGRI, the most interesting aspect lies in the ability of these microorganisms to **thrive on by-products that do not compete with the food/feed chain**, such as waste waters from starch production or maize cobs (Group, 2020). Poultry wastes and slaughterhouse by-products can also be used, although they have to be treated appropriately before killing the pathogens (Spalvins, Ivanovs and Blumberga, 2018). **SCPs can be used for monogastric species or ruminants** (e.g. calves). However, SCP production requires a significant amount of energy(Gerhard, Neil and Irina, 2023), and their usage is constrained by the need for a comprehensive microbiological set-up to prevent cross-contaminations, **potential risks of heightened immune response, and limited public acceptance**. Moreover, due to the relative immaturity of the SCP production platform, comprehensive sustainability assessments are still lacking in available data (Gligorescu *et al.*, 2020).

2.5.6.6 Protein concentrates

Proteins from grass containing clover, alfalfa or sainfoin can be extracted and concentrated. The protein concentrate obtained is suitable for monogastric feed and, the ‘grass cake’ is suitable for ruminant feeding. Green biomass provides good nutrition as feed, although the protein content is low: the protein concentrates contain around 33.5 % of crude protein, but ranges between 18 % and 89 % of dry matter, depending on the protein precipitation method used (Santamaría-Fernández and Lübeck, 2020). The Danish case study on organic laying hens has mentioned grass protein concentrates as a source of commercially available protein. However, the sector is not mature yet, and such processing plants require high levels of technicity and investments (Santamaria-Fernandez *et al.*, 2019).

According to the interviews conducted with EU-level organisations, starch production also makes it possible to make concentrated proteins from potato, maize, peas, etc. The EU-level stakeholder interviewed insisted on the necessity of supporting starch production in the EU, to allow farmers to source proteins that are GM-free, deforestation-free and produced under EU quality standards**.** Existing EU research projects such as SuperGrassPork[151] and OrganoFine[152] should provide additional information on the potential of green biomass for protein feeds.

2.5.7 Main findings

Besides diversification of diets with EU-grown feed discussed in SQ2, many other strategies enable feed composition diversification or at least reduce the requirements in protein-rich crops. **First, improved characterisation of the livestock needs would avoid oversupplying some nutrients** and guarantee good performance. Finding the ideal protein for each animal species is paramount to being able to fine-tune the diets. The segmentation of the feed according to the species lifecycle is hence a way to supply the protein needs when it is the most necessary, but this requires access to precision feeding technologies. As such, a collaborative effort including training, resources and incentives is needed for inclusive technology adoption, to prevent some farmers from being left behind. Moreover, to meet these needs, it is also necessary to **characterise the nutritional values of the raw materials** used in the ration better.

In a long-term perspective, breeding new crop varieties that are less rich in ANF or richer in specific amino acids, could overcome some obstacles to diet diversification (see

[151] https://icrofs.dk/en/research/danish-research/organic-rdd-3/supergrasspork/
[152] https://icrofs.dk/en/research/danish-research/organic-rdd-2/organofinery/

SQ2 Section 2.2). Moreover, the availability of raw materials being a significant issue, the breeding of crops that can ensure stable yields in various pedoclimatic regions across the EU as well as show resistance to pests and diseases would benefit protein diversification in the long term. Likewise, selection of more robust animal species that are less sensitive to ANF and more adapted to diversified diets would make it possible to expand the range of raw materials included in the diets. These two options require investments from companies that often operate at an international level as well as the guarantee that the market is willing to embrace and pay for new varieties or new breeds. For the organic sector, lower volumes are often an obstacle in the path of reaching significant positive traits.

Some experimental feeds that could be complementary to EU-grown feed, as discussed in SQ2, seem to be relevant in terms of nutritional values. While they show promising results, their current stage of development and available market price classify them as niche products: some products are specific to regions (e.g. fish meal is more available in the Nordic Member States), others have proven to be far from economic reality (e.g. insects), and public acceptance could be a hindrance for others becoming widespread (e.g. PAP, SCP). The adoption of alternative feed sources in the non-conventional sector might face limitations due to existing regulatory frameworks and standards. These regulations, which may determine the types of feed allowed, as well as the quality and safety standards that must be met (ex: PDO, PGI), could be revised in the future to allow the use of these alternative feed options. Overall, it is highly likely that more remunerative outlets such as pet food or aquaculture would enhance their value better. Moreover, the sustainability of some innovative alternatives is questioned, as their production also requires its own feed (e.g. insects) or can have an environmental impact (e.g. depletion of fish stocks). On the contrary, PAPs could enable greater circularity.

Furthermore, the diversification of feed sources can be facilitated by inputs such as **amino acid and enzymes**, which allow optimisation of nutrients included in the raw materials or decrease the needs of some raw materials such as soya bean meal. So far, these strategies are not evenly used across the EU, although they show positive effects on the rations and performance. However, their higher rate of use remains dependant on imports, and these alternatives are limited for the organic sector as it is forbidden to use synthetic amino acids. **While the know-how is available in the EU, the development of these options would require investment to scale up production along with regulatory adjustments**. Consequently, these options are viewed as medium- to long-term strategies.

Finally, at farmer level, different **nutritional management practices** can reduce the needs for certain high-protein feeds for the livestock (e.g. multiphase feeding). However, this requires ensuring high efficiency in production, availability of land and/or capacity building for farmers and/or new equipment. Many of these strategies mainly focus on the optimisation of diets with **high precision feeding, which remains more difficult to implement for ruminants** whose feed, grass and fodder are variable and less standardised than monogastric species.

2.6 SQ6: How would different replacement scenarios impact the competitiveness and economic viability of the livestock production system analysed at economic operator level (livestock producers, arable crops producers and feed manufacturers)?

In theory, none of the operators of the livestock supply chain would change their practices if their competitiveness and economic viability were impacted negatively. Indeed, manufacturers would only include alternatives in their concentrates if their price were inferior or equal to the price of interest[153] of their feed composition, and arable crop producers would only grow alternative crops for feed if their profitability was not impacted given the market price determined at global level.

In all subclusters but French ones, the scenarios modelled were based on the FeedMod model, i.e. on the mandatory incorporation of feed alternatives by manufacturers, and they provided estimations of the potential changes impacting feed cost. These are taken into account to conclude on economically viable diversification strategies at EU level (SQ7). On the other hand, the Prospective Aliment model, available only for French subclusters, is based on the determination of the price of interest of feed alternatives, i.e. the price that would allow their use in feed manufacturing without significantly increasing the cost of the feed, in a context where all subclusters can use any raw material available.

In order to examine the potential economic impact at livestock producer level, we thus focused on systemic scenarios (i.e. run for all clusters together) based on four levers:

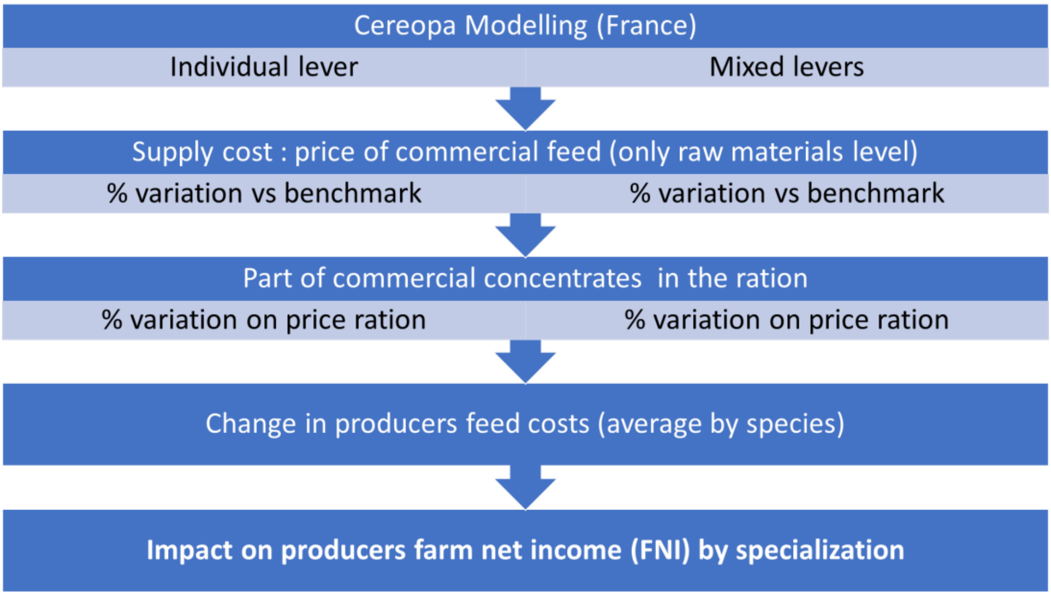
- Development of forages with high protein content;
- Increased use of protein crops for feed;
- Increased use of HiPro sunflower meal (SFM HiPro);
- Increased use of HiPro rapeseed meal (RM HiPro).

The Prospective Aliment model makes it possible to determine, for each lever individually and for all levers together, (1) how the price of manufactured feed would evolve, (2) how the share of commercial feed in the ration would evolve, and (3) what the impact of these changes would be in commercial feed price and quantity on the Farm Net Income (FNI)[154] of livestock producers, simulated using the FADN data. This process is described in the following figure. Commercial feed here relates to manufactured feed that is bought on the market and not self-produced.

[153] Feed manufacturers incorporate the raw materials tested at the price required to consume the volume (realistic over a 5-year horizon) of these materials proposed in the assumptions (the more you have, the cheaper they are). By definition, the price of interest obtained corresponds to an equivalence in terms of the total cost of the feed.

[154] The FNI represents remuneration of fixed factors of production of the family (work, land and capital) and remuneration of the entrepreneur's risks. It includes all the aids received by the farm and provides information on the economic viability of the farm activity.

Figure 39: Logic of the Prospective Aliment model used for French subclusters



Source: consortium

2.6.1 Assessing the impact on livestock producers' economic viability by cluster and subcluster

2.6.1.1 Analysis of the sensitivity of the cost structure to changes in feed costs

Table 25: Share of specific feed costs in the farm cost structure (%) –2017, 2018, 2019

			% specific feed costs* in crops and livestock inputs		% specific feed costs in total intermediate consumption (incl. farming overhead**)		% of specific feed costs in farm costs (incl. wages, rent and interests)	
MS	**Farms**	**Sample size**	**Average**	**CV**	**Average**	**CV**	**Average**	**CV**
DE	Pig conv	2 098	**75 %**	2 %	**56 %**	3 %	**49 %**	3 %
ES	Pig non-conv	29	**37 %**	45 %	**33 %**	40 %	**32 %**	40 %
PL	Broilers conv	139	**89 %**	1 %	**80 %**	2 %	**76 %**	2 %
FR	Organic laying hens	21	**54 %**	44 %	**48 %**	39 %	**46 %**	38 %
FR	Beef conv	1.968	**54 %**	5 %	**24 %**	5 %	**21 %**	4 %
IT	Beef non-conv	258	**74 %**	4 %	**48 %**	8 %	**40 %**	8 %
FR	Dairy cattle conv	2.458	**61 %**	3 %	**29 %**	2 %	**26 %**	2 %
DE	Dairy cattle non-conv	694	**52 %**	8 %	**22 %**	7 %	**19 %**	7 %
ES	Sheep meat conv	1.920	**78 %**	3 %	**58 %**	4 %	**51 %**	5 %
FR	Dairy goat conv	288	**53 %**	13 %	**32 %**	8 %	**29 %**	7 %

*Specific feed costs: depending on the type of farm, herbivorous livestock feed costs / pig feed costs / poultry feed costs; **Farming overhead: supply costs linked to production activity but not linked to specific lines of production.

Source: consortium based on FADN data

Table 25 presents the weight of animal feed in farmers' costs at different levels of expense. Although it is specific to Member States' subclusters, it highlights the sectors where it is most important to activate the levers of economic competitiveness. This is particularly the case in the broiler poultry sector, where feed costs account for 76 % of total farm costs. Feed costs are also significant, but to a lesser extent, in the sheep meat (51 %), pigmeat (49 %), organic laying hens (46 %) and non-conventional beef (40 %) sectors.

2.6.1.2 Change in the share of concentrates in rations and impact on income per cluster

The Prospective Aliment model, for which data are only available for France, makes it possible to take into account the fact that the share of commercial feed declines for ruminants as the share of forage increases. The nature of concentrates supplied by manufacturers may also change (e.g. less need for protein). Thus, under the assumptions adopted, there are no longer any sales of nitrogen correctors in the beef segment, but only production of feeds that provide less protein and energy.

The following Table 26 summarises the changes in the price of commercial feed share for each cluster and each lever. For the scenario mixing the four levers together, the results presented in the two last columns correspond to the lowest and the highest variation along with the progressive introduction of each additional lever.

Table 26: Change in commercial concentrates price from the systemic modelling for all subclusters (FR)

Change vs benchmark 20/21	Forages Pi+	Protein crops >	SFM HiPro	RM HiPro	MIXED (range)	
Dairy cattle	**-5.88 %**	-0.14 %	0.15 %	-0.03 %	**-5.88 %**	-5.57 %
Beef	**-9.97 %**	-0.15 %	0.56 %	0.60 %	**-11.08 %**	-9.91 %
Small ruminants	-0.23 %	-0.13 %	-0.16 %	1.41 %	-0.86 %	0.34 %
Pigs	0.26 %	0.15 %	0.06 %	0.52 %	0.34 %	0.84 %
Poultry	-0.12 %	0.05 %	-0.19 %	-0.61 %	-0.50 %	0.00 %
Hens	0.09 %	0.04 %	-0.71 %	-0.09 %	-0.80 %	0.10 %

Source: consortium based on PA model

In systemic modelling (i.e. all clusters together), shifts in raw materials between species can change the price of feed for an animal sector to a limited extent (+/- 1 %), as shown in the previous table. However, the main change in the price of commercial feed concerns the case of improved forage protein value or an improved percentage of forage in the ration. The commercial feed profile is then less demanding and can lead to a drop of 5 % to 10 % in the price of concentrates for beef or dairy cattle.

Table 27: Change in the need for manufactured feed in the ration in France

	PART OF FEED MANUFACTURERS CONCENTRATES IN THE RATION		
FRANCE	BENCHMARK 20/21	CHANGES IN SCENARIOS	NEW
DAIRY CATTLE	9.7%	-1%	9.6%
BEEF	4.6%	-30%	3%
SMALL RUMINANTS	11.2%	-13%	9.7%
PIGS	60%	0%	60%
POULTRY	99%	0%	99%
HENS	88%	0%	88%

Source: Prospective Aliment

In addition, the systemic modelling makes it possible to assess the change in the quantity of manufactured concentrates in the ration in scenarios based on forage (Table 27Table 27). These scenarios would result in a decrease of 30 % in concentrates use in the beef cluster and of 13 % in the small ruminant clusters, but only 1 % in the dairy cattle cluster. However, given the low share of manufactured feed in the total ration of ruminant subclusters, there is no significant change overall in total feed costs due to the various scenarios.

The change in commercial feed costs calculated is then applied to FADN data to simulate the potential change in the Farm Net Income (Table 28 below) for the various subclusters.

Table 28: Change in FNI obtained from the systemic modelling (%, France)

Sector	Sample size	Forages Pi+	Protein crop	SFM HiPro	RM HiPro	Mixed range 1	Mixed range 2
Dairy	2 458	0.59 %	0.01 %	-0.01 %	0.00 %	0.60 %	0.53 %
Beef	1 968	0.32 %	0.00 %	-0.02 %	-0.02 %	0.36 %	0.30 %
Sheep and goat	1 203	0.02 %	0.01 %	0.02 %	-0.13 %	0.11 %	0.01 %
Pig	697	-0.56 %	-0.33 %	-0.11 %	-1.15 %	-0.56 %	-1.86 %
Poultry	753	0.40 %	-0.17 %	0.64 %	2.01 %	1.64 %	0.00 %
Laying hen	82	-0.18 %	-0.09 %	1.45 %	0.18 %	1.62 %	-0.21 %

Source: Consortium based on Prospective Aliment and FADN

Overall, Table 28 shows that variations in the FNI due to the introduction of feed alternatives are relatively low (-/+2 %). Results from the cumulative scenarios remain within the same range of income variation (-/+2 %). As seen above, even if changes in costs seem to be marginal in the commercial feed sector, this can have a greater or lesser impact depending on the weight of feed in the farmer's total costs. Consequently, granivore subclusters are the most impacted in absolute value according to the hypotheses of the systemic modelling, positively for poultry and negatively for pigs.

The individual scenario with the greatest impact is the one involving the availability of rapeseed meal with a higher protein concentration: when the model is forced to incorporate HiPro rapeseed meal, it improves the income of poultry farmers but, paradoxically, reduces that of pig farmers. This is due to existing competition between species for raw materials with limited availabilities. Modelling all the clusters together, and thus the existing competition for resources, shows that at national level a lever can involve winners and losers. In this case, the poultry industry has a strong economic interest in accessing HiPro rapeseed meals (which are limitedly available), while the benchmark situation allocated rapeseed meals for swine feed production. In this simulation, factories will save costs by allocating HiPro rapeseed meals to poultry feed, while using more expensive feedstuffs for swine feed production, resulting in an increase in pig feed prices, though poultry feed prices are lower.

In the case of ruminants, where on-farm sourcing is significant and will increase (self-consumption or external purchases), the increase in certain costs (production costs, storage, labour costs, etc.) should be considered in parallel. The change in the cost structure is particularly unpredictable in the case of scenarios based on forage. The models used only partially estimate the change in the price of feed but not the other types of costs.

2.6.2 Assessing the impact on feed manufacturers' competitiveness and economic viability

The simulations run for each scenario considered in the different sub-clusters compute an optimal composition of the feed content for each sub-cluster, taking account of actual market prices. To assess the related impacts on the competitiveness and economic viability of feed manufacturers, an investigation of the impacts of the necessary adaptations of the feed production process has been made[155]. Since quantitative databases containing data on the economic results of feed manufacturers are not available, the expected changes have been discussed with national and EU-level associations of those operators. The evidence base has been completed by the outcomes

[155] To the extent allowed by the available evidence, the following key components defining competitiveness and economic viability have been considered in the assessment: i) price of ingredients (i.e., feed materials) used in feed production; ii) quality of ingredients used in feed production; iii) availability of specific ingredients; iv) change in the quantity of feed produced and ability to supply the market; v) quality of feed produced; vi) processing costs (including the possibility of achieving scale economies at plant and/or company level) ➔ feed production costs ➔ selling price of feed; vii) organisational and/or logistic constraints (including those related to the location of manufacturing plants), and their possible influence on the quality of service; viii) other costs (e.g., logistic costs, marketing costs, etc.); ix) feed selling prices.

of the modelling exercise and the qualitative conclusions obtained from the cluster workshops implemented to discuss the results of the model.

2.6.2.1 Definition of the impact mechanisms

Theoretically speaking, different impact mechanisms can be defined for the scenarios considered in the sub-clusters and the key components of the competitiveness and economic viability of feed manufacturers. The main distinction can be made between:

- **Direct** impact mechanisms, i.e., those that have a direct influence on the components of manufactured feed (e.g., inclusion of new feed materials in the formula, or change in the price and/or quantity of feed materials already included in the formula) and/or on its production process (e.g., due to the need of additional steps in the process to include new feed materials in the formula, or to obtain specific quality features).
- **Indirect** impact mechanisms, i.e., those that have a direct impact on the components of the diet other than manufactured feed (e.g., forages, concentrates produced on the farm, etc.) and, through that, an indirect impact on the components of manufactured feed (e.g., increased protein content of forages may reduce the quantity of manufactured feed in the diet, and/or change the composition of its formula) and/or on the production process of manufactured feed (e.g., in terms of additional steps in the process to obtain specific quality features of manufactured feed that are needed to enable changes in the other components of the diet).

Besides impacts on manufactured feed, the scenarios considered in the sub-clusters can have impacts also on **other manufactured components of the diet**, such as **integrators, enzymes,** and **feed additives**. In the EU, these components are supplied by both specialist producers and diversified feed manufacturers: for this reason, also integrators, enzymes, and feed additives have been considered in the assessment, to the extent allowed by the availability of specific evidence.

2.6.2.2 Impacts on the competitiveness and economic viability of feed manufacturers

From the relevant bibliography (FEFAC, 2021a; FEFAC, 2021b; FEFAC, 2022a; FEFAC, 2022b) and the interviews with sectoral stakeholders, it emerged that the EU feed manufacturing sector has operated in extremely difficult and unstable conditions since the outbreak of the Covid-19 pandemic. The Russian invasion of Ukraine and global market dynamics for agricultural raw materials and, especially, energy products and bulk freight rates have aggravated the situation further. All these factors have made the sourcing of feed materials (oilseeds and cereals in particular) challenging and more costly than in the pre-Covid period until rather recently, when the prices of oilseeds and cereals for feed use in the EU have reverted to pre-Covid levels. This implies that the prospective impacts of the different scenarios would be experienced in a sector that has been coping with challenging operational conditions since 2020.

2.6.2.2.1 Stakeholders' perceptions on the expected impacts

Generally speaking, the consulted sectoral stakeholders made it clear that they do not consider the diversification of protein sources (especially in terms of the inclusion in the formulas of protein sources that currently see limited/no use), and increased production of feed proteins in the EU as objectives to pursue in themselves: the economic sustainability of any alternative feeding strategy is a critical aspect in their assessment of the scenarios of change, together with technical feasibility. This implies:

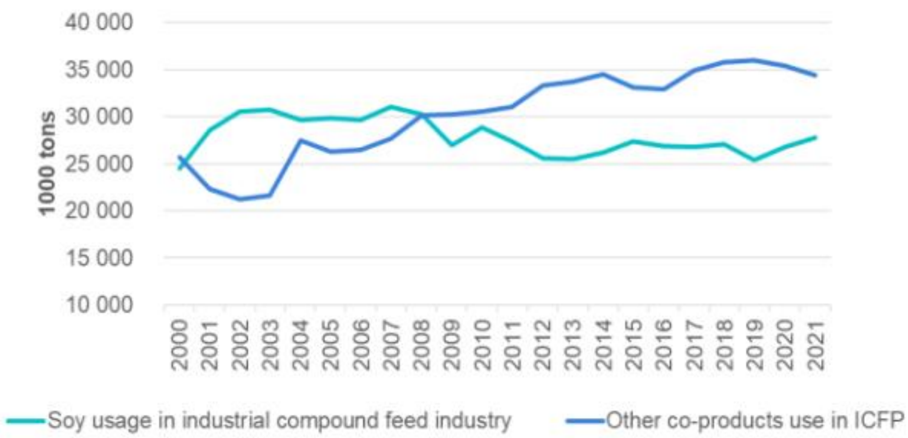
- that scenarios which would determine a significant increase in feed production costs are bound to be deemed economically unsustainable by manufacturers; and
- that scenarios where the inclusion of specific feed materials in the formulas would only occur at significantly lower prices than the ones recently observed on the market, cannot be deemed realistic by manufacturers in the absence of substantial changes in the relative prices of feed materials.

Sectoral stakeholders have clearly indicated (in interviews and in (FEFAC, 2022a; FEFAC, 2022b) that geographical diversification of protein sources (together with other feed materials, cereals in particular, and energy products) is a top priority for strengthening the competitiveness and the resilience of the EU feed manufacturing sector against the perturbating effects of external factors over which manufacturers basically have no control. **Reliance on a too limited number of non-EU main suppliers** of feed materials (soya beans and oilseeds in particular, but also amino acids) and energy products, combined with a marked polarisation towards 1-2 leading suppliers (e.g., Brazil and USA for soya beans; Brazil and Argentina for soya bean meal; China, South Korea and USA -depending on the amino acid involved- for industrial amino acids), **has been identified as a serious weakness in procurement strategies**, at sectoral level and also considering the EU agribusiness system as a whole.

The **key trend** in feed material procurement that has had the most significant implications on cost competitiveness for feed manufacturers **has been the replacement of soya products with co-products, a process that has been ongoing since the mid-2000s** (FEFAC, 2022b); however, the trends show that total soya bean products use by the EU feed manufacturing sector has never fallen below the 25 million tonnes threshold since the early 2000s, and sectoral stakeholders believe that pursuing very limited dependency on soya bean product imports from non-EU origins is an unrealistic goal. The other notable trend, i.e., booming use of "responsible soya" (mostly made of environmentally sustainable and deforestation free soya beans) by the EU feed manufacturing sector[156], is mainly related to regulatory developments (in particular the policymaking process that led to Regulation (EU) 2023/1115 on commodities and products associated with deforestation and forest degradation), to increasing attention to Corporate Social Responsibility (CSR) by feed manufacturers, as well as to the growth in the final demand for sustainably-produced animal products. This trend also has clear implications on (cost) competitiveness, since "responsible soya" is generally sold at a premium over conventional soya: the extent of this premium has been increasing and is expected to increase further[157].

Figure 40: Evolution of total soya bean product use* by the EU feed manufacturing sector (1 000 tonnes, EU-28)

* ICFP = industrial compound feed products

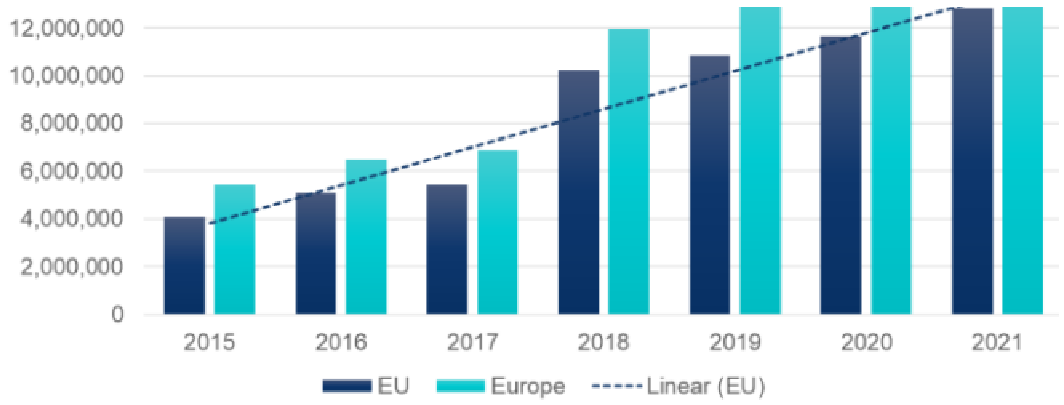


Source: FEFAC (2022a)

[156] According to FEFAC (2022b) *Feed Sustainability Charter – Progress Report 2022*. Available at: https://fefac.eu/wp-content/uploads/2022/09/Final_Feed-sustainability-charter-annual-progress-report-2022_WEB-1.pdf. the use of "responsible soy" by EU feed manufacturers grew from around 4 million tonnes in 2015 to nearly 12 million tonnes in 2021.

[157] The assessment under SQ 4 revealed that in the first half of 2023 the premium for segregated soya (with respect to standard soya bean meal) was in the 35/40 EUR/tonnes range.

Figure 41: Evolution of "responsible soya" use by the EU feed manufacturing sector (tonnes)



Source: FEFAC (2022a)

2.6.2.2.2 Impact assessment

The impacts of the different scenarios considered for the study on the competitiveness and economic viability of feed manufacturers mainly depend on:

1. the impact mechanisms defined above (direct/indirect impacts);
2. the direction (increase/decrease) and the magnitude of the variations that the changes characterising each scenario induce in the key components defining competitiveness and economic viability.

The assessment of the impacts of the alternative scenarios on the competitiveness and economic viability of feed manufacturers is mostly based on the results of the case studies, and in particular on the outcomes of the discussion of the modelled scenarios with sectoral stakeholders.

The effects stemming from several of the considered scenarios would probably affect adversely – albeit to a varying extent – the competitiveness and economic viability of EU feed manufacturers. This is especially true:

- for all the scenarios which are based on increased importance of forages as protein source in the diets[158], since forages are agricultural products that can directly be included in the rations without industrial processing;
- for all the scenarios where on-farm production, or supply of feed materials by operators other than EU feed manufacturers, could play a more or less important role[159].

In both situations, a larger portion of the protein needs of farmed animals would be covered through on-farm production, or in any case by sources other than manufactured feed. This would translate into reduced demand for manufactured feed (to an extent that is not quantifiable, but that will most likely vary in the different scenarios), and hence in more or less serious adverse impacts on the economic viability of feed manufacturers.

An equally significant number of scenarios would probably result in mixed combinations of favourable and adverse effects, whose final balance (positive, negative, neutral) is however impossible to predict with sufficient reliability, mainly because the extent of the induced changes remains basically undetermined for a number of critical aspects.

Only two scenarios, both developed for organic laying hens, would translate into a prevalence of positive effects for EU feed manufacturers, provided that the related

[158] Such scenarios were tested for all the species of ruminants covered by the assessment: dairy cattle (conventional and non-conventional); beef cattle (conventional and non-conventional); dairy goats; meat sheep.

[159] Such scenarios were tested for conventional pig farming and for conventional broiler farming, and were both based on increased use of legume seeds in the diets.

assumptions (that are extremely hypothetical and/or rather far from the current situation) materialise in practice.

Two scenarios based on the use of insect meal, tested for conventional pig farming and for organic laying hens farming, revealed that at current insect meal prices production costs and selling price of feed would be too high to be sustainable for manufacturers[160].

In conclusion, the effects of most of the considered scenarios are unlikely to be beneficial for the competitiveness and economic viability of EU feed manufacturers, even though the severity of the adverse effects might prove to be relatively limited. In particular, the extent of the reduced need for manufactured feed as a protein source in most forage-centred scenarios is likely to be constrained by the relatively limited scope for improvements in protein content/availability and in aminoacidic profile that would be achieved in the concerned forages. In the case of the scenarios for dairy goats and sheep meat, the concerned volumes of manufactured feed are in any case rather limited. A noteworthy exception in terms of positive effects on the competitiveness and economic viability of feed manufacturers is the use of high-protein (HP) rapeseed meal, which emerged as an interesting diversification strategy for conventional broiler farming from a simulation considering all the feed materials and all the species in France.

2.6.2.3 Gap between interest price and market price

For alternative raw materials to be introduced in the composition of manufactured feed, their interest price must match the market price. For peas, in the systemic scenario presented above, this corresponds to a 16% drop of the current price ratio peas/wheat. In the context studied, this is equivalent to 54 EUR/tonne or 148 EUR/ha (based on the 2020 French yield).

While it is possible to make this comparison for protein crops like peas, field beans or lupines vs. wheat, the exercise is more complicated for the co-products tested (French soya bean meal, HP rapeseed and sunflower meal) vs. imported soya bean meal.

High-Protein Rape meal (44% vs 33% for standard rape meal): switching to protein-enriched rapeseed (thanks to varietal selection) increases the value of the meal by 23% compared to standard rape meal, which corresponds to a price ratio of 88% compared to imported soya bean meal (compared to 73% for standard rapeseed in the 20/21 price context). This premium must cover the additional cost of seeds and a possible variation in yield. It would appear that these variations may be minimal. This scenario has the advantage of not impacting industrial yield or cost. If we based our calculations on current de-oiled rapeseed industrial yield, we could improve the price of seed by 13%.

Unfortunately, **the market price of oilseeds depends to a large extent on the price of oil, which in turn depends on the world market for other oils**. It is conceivable that the share of meal in the added value of the seed will increase, but this does not give any indication of the market price of the seed, and therefore of its competitiveness in relation to other crops.

For **HP+ sunflower meal** (46% vs 37% for standard HP sunflower meal), the protein concentration depends on an industrial process that limits quantities (especially cake/shell yield) and raises the question of how to valorise the cellulosic fraction (shells and LP-cake). In the 2020/21 price context, its valuation is 99% of the price of imported soya beans, which corresponds to a premium of 29%. In this case, we are talking about 88 EUR/tonnes. But in the context of lower imported soya bean prices, this would decrease. If we based our calculations on this industrial yield, we could improve the

[160] Information collected for the case study on conventional pig farming sets the current price of black soldier fly meal at 2.000 EUR/tonnes and beyond. In the case study on organic laying hens, current (2023) insect meal price is estimated at 2.500 EUR/tonnes. As for forward-looking considerations on the production cost, and hence the selling price, of insect meal, a study by OECD (2022) suggests that there is important scope for reducing production costs through industrial-scale production techniques, as well as the use of lower cost feed for insects, and more efficient breeding techniques. However, several consulted stakeholders deem it unlikely that the price of insect meal will decrease to levels that would allow for its inclusion in the diets of most conventional monogastric animals (around 300 EUR/tonnes).

price of seed by 11%. But the technological cost must be remunerated by the market. It is also necessary to be able to valorise the cellulosic fraction generated by the sifting of the oilseed meal.

Table 29: Oilseeds complex prices (France) 20/21

EUR/T France	Soya	Rape	Sunflower
Seed	469	426	480
Oil	948	980	1 040
Meal	401	290	275
Meal/Seed	86%	68%	57%
Oil/Seed	202%	230%	217%
Meal/Oil	42%	30%	26%

Source: Terres Univia

2.6.3 Assessing the impact on arable crops producers' competitiveness

Under the diversification scenarios modelled, arable crop producers will still be able to sell their products at market price, since it is determined at global level and since they are price-taking agents. In other words, analysing the impact of replacement scenarios on the competitiveness of arable crop producers consists instead in assessing if they have financial incentives to switch to growing alternative arable crops.

Expected margins are not the only parameters taken into account by farmers in their production decisions. They also consider local soil and climate constraints, agronomic constraints and the possible introduction of the crop in the rotation, the low mobility of the capital when relevant, relations with manufacturers, etc. These drivers are detailed in SQ11 see 2.11. However, during the case studies, profitability was always the first driver to be mentioned.

We focused the analysis on the gross margin (Gm) of the crops, given that economic results at farm level make it difficult to compare the different farming systems. We calculated the margin over operational costs of the crops (without any coupled support). This includes neither farming overhead nor amortisation and therefore is only a rough *proxy* of crop profitability. It is calculated as:

Crop Gross Margin = Total Crop Output (sales+ farm use + change in stocks) – the crop operating costs (Seeds and plants + Fertilisers + Crop protection + Other crop Specific Costs)[161,162].

Given that FADN data provide only production costs at the level of the farm activity and do not detail them per type of crop, we compared the crop gross margin per hectare of farms specialised in the given crop (i.e. a crop that provides more than 60 % of the farm total output).

First, the average gross margin per hectare of farms specialised in alternative crops that can potentially replace wheat (rapeseed and protein crops) has been compared for the main Member States that provide raw material for feed (see Table 30). Then similar comparisons are made between farms specialised in maize compared to soy and sunflower.

[161] FADN variables: SE135–(SE285 +SE290+SE295S+SE300+SE305).
[162] For each FADN variable, the weighted average and the coefficient of Variation (CV) were computed. In order to maximise the size of the sample, we merged 2017, 2018 and 2019 FADN databases together. This also makes it possible to smooth the economic results of farms that can vary significantly from one year to another depending on external factors (such as climatic conditions or crop pests for instance).

Table 30: Crop gross margin for specialists in wheat, rapeseed and protein crops (EUR/ha) –2017, 2018, 2019

Cell colour keys: Maximum ratio 1 Minimum ratio

Member State/ region	Wheat		Rapeseed		Ratio Gm Rapeseed/ Wheat	Protein Crops (PC)		Ratio Gm PC/Wheat
	Gross margin	CV	Gross margin	CV		Gross margin	CV	
Germany	747	37 %	591	*40 %	0.79	697	*50 %	0.93
France	585	52 %	586	*35 %	1.00	602	*50 %	1.03
Hungary	406	53 %	761	41 %	1.87	309	84 %	0.76
Italy	832	47 %	849	*49 %	1.02	880	90 %	1.06
Poland	512	48 %	552	44 %	1.08	313	204 %	0.61
Romania	455	38 %	499	98 %	1.10	638	69 %	1.40
Spain	443	53 %	382	27 %	0.86	729	75 %	1.65

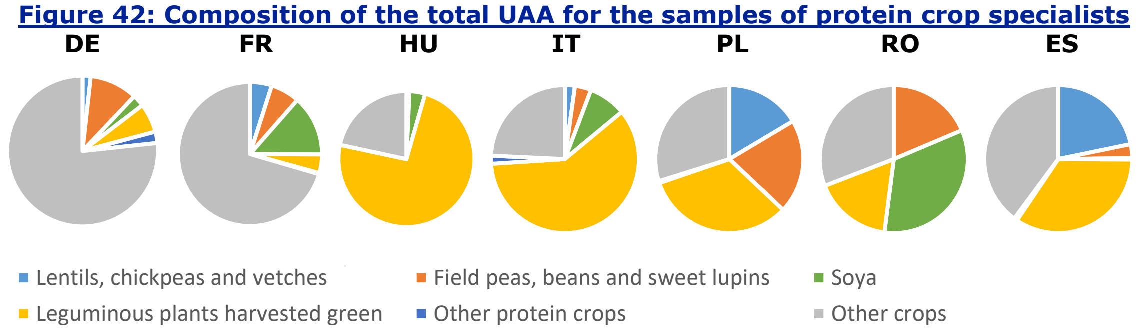
* When the specialist sample was not sufficient, we selected the 100 farms where the studied crop type stands for the highest share in the crop output

Source: Consortium based on FADN

When comparing gross margin for rapeseed to gross margin for wheat: it emerges that these are comparable in most Member States studied (FR, IT, PL, RO). Exceptions are in Germany and Spain, where the difference in crop profitability can decrease about 20 %. Indeed, although wheat and rapeseed areas are similar in Germany (17 % and 6 % of arable land according to Eurostat and FAO) and France (16 % and 4 % respectively), the average price for wheat sold by farmers in Germany was EUR 180/tonne in 20/21 compared with EUR 164/tonne in France (farm gate as extracted from FADN). One possible explanation is the higher protein content of German wheat. In Spain, rapeseed accounts for 0.3 % of Spanish arable land. As dry conditions are not favourable to growing rapeseed, coupled support of EUR 101.00/ha for the production of rapeseed (and sunflower) has been set up in the CAP National Strategic Plan. On the other hand, in Hungary, growing rapeseed is particularly advantageous compared to wheat. But wheat and rapeseed account for 19 % and 6 % respectively of Hungarian arable land. Thus, these comparative data on crop gross margins are not really reflected in the distribution of arable land. It is therefore likely that other decision factors than gross margin are significant in the case of rapeseed (agronomic vulnerability in particular), as developed in SQ11.

The gross margin for wheat specialists has also been compared to the one for protein crop specialists. The composition of this category varies depending on the Member State studied (see Figure 42) and includes soya in some cases (mainly in Romania). Soya is also studied on its own in comparison to maize in Table 31 below.

Figure 42: Composition of the total UAA for the samples of protein crop specialists



Source: Agrosynergie based on FADN

The gross margin obtained from protein crops is significantly higher than for wheat in Romania (mainly led by soya) and in Spain (where alfalfa is a significant production) (see Table 30 above). On the other hand, protein crops have a low gross margin compared to wheat in Hungary and Poland (albeit with a high variability among producers in Poland). In Germany, France and Italy, crop gross margins are similar.

Whatever the case, protein crops account for 0.2 %, 0.8 %, 2 %, 1.3 % and 1.1 % respectively of Hungarian, Romanian, Spanish, French and German arable land. In the case of Spain, a significant share of protein crops is devoted to human consumption.

Finally, the crop gross margin for maize specialists has also been compared to the one of soya and sunflower specialists[163] in Table 31 **Table 31** below. In all Member States studied, the crop gross margin for maize specialists is significantly higher than for soya and sunflower specialists. Member States where soya and sunflower gross margins are the most favourable compared to maize are Hungary and Romania, where the differential is around 10–20 %.

Table 31: Crop gross margin for specialists in maize, soya and sunflower (EUR/ha) – 2017, 2018, 2019

Cell colour keys: Maximum ratio 1 Minimum ratio

Member State/ region	Maize		Soya		Ratio Gm Soya/ Maize	Sunflower		Ratio Gm Sunflower/Maize
	Gross margin	CV	Gross margin	CV		Gross margin	CV	
France	962	51 %	646	*62 %	0.67	487	*56 %	0.51
Hungary	647	39 %	597	*58 %	0.92	541	33 %	0.84
Italy	1 230	42 %	878	44 %	0.71	711	57 %	0.58
Romania	580	32 %	458	*38 %	0.79	488	47 %	0.84
Spain	1 056	43 %	405	*95 %	0.38	559	52 %	0.53

* When the specialist sample was not sufficient, we selected 100 farms where the studied crop type represents the highest share in their crop output
Source : Consortium based on FADN

2.6.4 Main findings

Economic impact on livestock producers: manufacturers would include alternatives in their concentrates only if their price is inferior or equal to the price of interest[164] of their feed composition. Thus, overall, the change in the price of manufactured feed will be marginal. The Prospective Aliment model, available only for France, makes it possible to assess the extent of feed cost changes: **shifts in raw materials between species can marginally change the cost of feed for an animal sector (+/- 1 %).** In the case of scenarios based on a higher use of forage, the price of concentrates for bovines may drop 5 % to 10 % when the commercial feed profile is adapted to a lower need in protein content and to the decrease in the volume of concentrates used (30 % in the beef cluster, 13 % for small ruminants, 1 % for dairy cattle). However, given the low share of manufactured feed in the total ration of ruminant subclusters, there is no significant change overall in total feed costs due to the various scenarios.

Indeed, **the various subclusters under study are more or less sensitive** even to a slight change in the price of manufactured feed. In the broiler poultry sector in particular, feed costs account for 76 % of total farm costs. Feed costs are also significant, but to a lower extent, in the sheep meat (51 %), pigmeat (49 %), organic laying hens (46 %) and non-conventional beef (40 %) sectors.

Finally, when the change in total commercial feed costs is applied to FADN data to simulate the change in income for the farmers, **the overall change in income obtained is low (+/-2 %). The pigmeat subcluster is generally disadvantaged** by the scenarios, in particular in the case of the introduction of the HiPro rapeseed meal (-1.15 %), **while income in the broiler subcluster would tend to increase** by 2 %. The systemic modelling of all the clusters at national level shows that **a lever can have winners and losers when one subcluster is able to pay more for one**

[163] Germany and Poland are excluded from the analysis because of insufficient sample sizes.
[164] Feed manufacturers incorporate the raw materials tested at the price needed to consume the volume (realistic volume over a 5-year horizon) of these materials proposed in the assumptions (the more you have, the cheaper they are). By definition, the price of interest obtained corresponds to an equivalence in terms of the total cost of the feed.

diversification lever than another, which is forced to fall back on more expensive raw materials. **In the case of ruminants**, where on-farm sourcing is significant, **the change in other production costs (storage, labour costs, etc.) may have a more significant impact on economic viability than the change in commercial feed costs**.

<u>Economic impact on feed manufacturers</u>: the effects stemming from several of the considered scenarios would probably adversely affect– albeit to a varying extent – the competitiveness and economic viability of EU feed manufacturers. This is particularly true for: a) the scenarios which are based on increased importance of forages as a protein source in the diets, since forages are agricultural products that can be included directly in the rations without industrial processing; and b) the scenarios where on-farm production, or supply of feed materials by operators other than EU feed manufacturers, could play a more or less important role. Generally speaking, **the effects of most of the considered scenarios are unlikely to be beneficial for the competitiveness and economic viability of EU feed manufacturers, even though the severity of the adverse effects might prove to be relatively limited**. One exception is the use of HiPro rapeseed meal, which tends to decrease manufacturers' costs.

As stated previously, to introduce alternative raw materials in the composition of manufactured feed, their interest price must match the market price. For peas, in the systemic scenario presented above, this corresponds to a 16 % drop in the current peas/wheat price ratio. It is more complicated to calculate such a differential for the co-products tested (French soya bean meal, HiPro rapeseed and sunflower meal), since the market price of oilseeds depends to a large extent on the price of oilseed oil, which in turn depends on the world market for other oils. The price ratio for high-protein rapeseed meal is estimated at 88 % compared to imported soya bean meal (73 % for standard rapeseed in the 2020/21 price context). High-protein sunflower meal valuation is 99 % of the price of imported soya beans, which corresponds to a premium of 29 % (EUR 88/tonne).

The diversification scenarios considered would not have any economic impact as such <u>on arable crop producers</u>. Indeed, they would not grow alternative crops in the event of negative economic impacts. The issue was thus to identify whether the reluctance to grow other crops for feed, as alternatives to wheat or to maize, could be explained by differentials in gross margins (calculated from FADN data as a rough proxy for profitability in the absence of data specific to single crops).

In some cases, gross margin differential can explain the stagnation of alternative crop areas: soya and sunflower compared to maize; rapeseed (in DE, ES) and protein crops other than alfalfa and soya (in HU, PL) compared to wheat; industrial crops in specific regions concerned (processed tomatoes in northern IT).

But, in most cases, gross margins of rapeseed and protein crop specialists are comparable to those of wheat specialists. Other drivers are thus likely to constrain the development of alternative crops, price and yield volatility, in particular as reported in SQ11.

2.7 SQ7: Which production systems and which feed sources have the highest potential for economically viable diversification strategies at EU level?

2.7.1 Comparing the impact of "replacement scenarios" on different production systems

This step consists in a critical review and comparative analysis of the results of quantitative models under SQ2 and SQ5 aimed at comparing the impacts of different replacement scenarios on different livestock production systems (i.e., livestock clusters or groups of clusters with similar enough characteristics and requirements in terms of feeding), and their potential for generalised application outside the specific context in which they were tested. This exercise defines the starting point for the assessment under SQ7, i.e., the **set of potential diversification strategies** (each identified by a replacement scenario) analysed under SQ2 and SQ5. The exercise has been carried out for each species of interest for the study. The output of step 1 is a synoptic matrix (Table 32) providing a complete overview of the results of the comparative analysis, in terms of:

- main strengths and expected positive impacts of each scenario;
- main weaknesses/limitations and expected negative impacts of each scenario;
- potential for application outside the operational context in which each scenario was tested.

The scenarios with limited/no weaknesses, minimised negative impacts and significant potential for application to other operational contexts (even with some limitations, in certain cases) are the candidates for the assessment at step 3 (see Section 2.7.3). At least one scenario for each subcluster has been selected.

The selected scenarios (see below) cover all the species and specialisations of interest; among the scenarios tested for the **non-conventional segmentation** of three species (dairy cattle, pigs, laying hens), none stood out in terms of limited/no weaknesses, minimised negative impacts and significant potential for application to other operational contexts: for each of these three sub-clusters, the scenario that presented the most limited drawbacks was selected. In any case, the definition of suggested diversification strategies under step 3 (see Section 2.7.3) for the concerned species/segmentations will have to consider also the results of the assessment under step 2 (Section 2.7.2), focused on the identification of economically viable strategies.

Table 32: Comparative analysis of the impacts of replacement scenarios on different production systems

Cell colour keys – potential for application to other operational contexts: ***high***/*significant*; uncertain; *limited*/***unfeasible*** Text in red = weaknesses

The replacement scenarios that are identified as candidates for the assessment at step 3 (limited/no weaknesses, minimised negative impacts and high/significant potential for application to other operational contexts) are ***highlighted in bold italics*** in the table

Species / clusters / sub-clusters* / *scenarios*	**Main strengths / expected positive impacts**	**Main weaknesses / expected negative impacts**	**Potential for application to other operational contexts**
Dairy cattle conv – *Increase roughage share and improve grassland quality* **SELECTED**	Significant decreases in the use of imported oilseed meals (soya bean meal and rapeseed meal in particular)	The switch from silage maize to meadows entails significant operational challenges, organisational adaptations, and some risks It also implies increased use of wheat (produced on the farm or purchased)	*Significant, even though the switch from silage maize to meadows would be challenging in some Member States*
Dairy cattle conv – *Increased production of French soya beans and protein crops + increased availability of HP+ sunflower meal* **SELECTED**	Modest decrease in the use of imported standard soya bean meal; more significant decrease in the use of non-GM soya bean meal	Limited potential for growing soya in several Member States, due to lack of varieties suited to potential production regions, and the need for irrigation.	*Significant, even though a significant expansion in the area under protein crops is deemed unfeasible in some Member States, unless strongly incentivised through the granting of coupled support*
Dairy cattle NC – *Forage improvement (energy)* **SELECTED**	Significant decrease in the use of concentrates and oilseed meals	Protein-rich forage crops like alfalfa and clover grass have lower yields than other forage crops (e.g., silage maize) à serious drawback where land availability is limited	In areas with significant summer rainfall (Northern and Central EU), harvesting and storage of protein-rich forage crops poses significant operational and organisational challenges
Dairy cattle NC – *Increased protein content in forage* **SELECTED**			
Beef conv – *Improved grass share and grass quality of the ration* **SELECTED**	Middle-range protein meslin[165] (10-15%) can replace part or all of maize silage, and reduce/eliminate soya bean meal use High-range protein meslin (15-20%) can eliminate soya bean meal and maize silage use Reduction in concentrate (nitrogen correctors) use *(which is however a weakness from the feed manufacturers' perspective)*	High volatility of meslin nutritional values Potentially negative effects on the duration of the fattening cycle of beef cattle	*Significant, but in some Member States (Belgium and The Netherlands, among those studied in the cluster) silage maize is preferable to meslin silage (forage area is a limiting factor in these Member States)*
Beef conv – *Increased availability of HP+ sunflower meal*	HP sunflower meal (40% crude protein content DM), can fully replace soya bean meal when combined with wheat and maize	HP and HP++ price levels that would make it possible their inclusion in the diet are much lower than recently observed ones.	Sunflower cannot be cultivated over the entire EU territory, and not even in some Member States of the cluster (Belgium, The Netherlands) other than France (where the scenario was tested)

165 mixture of cereal forage and legume forage.

	HP+ sunflower meal (48% crude protein content DM) can eliminate the use of soya bean meal	The cost of recovering hulls and the cost of the treatment to obtain a higher protein content are difficult to recover	
Beef NC – *Increased inclusion of dried alfalfa (non-dehydrated)* **SELECTED**	Allows a substantial decrease in soya bean meal use	Dried alfalfa price levels that would make its inclusion in the diet possible are much lower than recently observed ones in Italy and Spain (albeit the price gap may be lower in other Member States, e.g., in France)	*Irrigation is needed to cultivate alfalfa in Spain, the other Member State of the cluster à the related additional costs may favour the destination of (dried) alfalfa to more lucrative/attractive outlets (e.g., dehydration[166], export to non-EU premium markets) than beef cattle feeding* *In traditional alfalfa growing regions, climate change represents a major challenge*
Beef NC – *Improved protein content of meadows* **SELECTED**	Allows a substantial decrease, and even the elimination of soya bean meal use (in the case of meadows with medium to high crude protein content)	Unsuitable to fattening in intensive systems	Its implementation is deemed unfeasible in Member States (like Italy, where the scenario was tested) that rely heavily on the use of silage maize for fattening in intensive systems
Sheep meat conv – *Inclusion of dried alfalfa (non-dehydrated)* **SELECTED**	Allows a significant decrease in soya bean meal use, and in concentrate use in general	Domestic prices for (dried) alfalfa in Spain: are much higher than the levels that would make its inclusion in the diet possible, due to the influence of lucrative exports of dehydrated and dried alfalfa on premium non-EU markets. The price gap may be lower in other Member States (e.g., France)	*Irrigation is needed to cultivate alfalfa in some Member States (Spain and Greece in particular) à the related additional costs may favour the destination of dried alfalfa to more lucrative/attractive outlets (e.g., dehydration[167], export to non-EU premium markets) than sheep feeding in the EU* *In traditional alfalfa growing regions, climate change represents a major challenge*
Sheep meat conv – *Improved pastures* **SELECTED**	Reduction/elimination of soya bean meal in the diet for gestating and lactating ewes (early lactation); significant reduction of soya bean meal in the diet of lactating ewes (late lactation)	Protein input from grassland is already high in sheep feeding in certain Member States (France, among those studied) ☐ relatively limited room for further increase	*In the Mediterranean area, arid conditions in certain regions may significantly constrain the improvement of pastures*
Dairy goat conv - *Increased protein input through grass-based roughage* **SELECTED**	Reduction in concentrate use *(which is however a weakness from the feed manufacturers' perspective)*	Protein input from grassland is already high in dairy goat feeding in certain Member States (France, the Netherlands among those studied) ☐ relatively limited room for further increase Dairy goat diets already use relatively little soya bean meal; there would mostly be	*Some of the switches between meals and/or between cereals would be undesirable in certain Member States (e.g., less use of sunflower seed meal in Spain)*

[166] The importance of dehydrating plants as an outlet in both Italy and Spain, and the very high prices of dehydrated alfalfa on premium export markets, should be considered, including in terms of influence on farmgate prices for green and dried alfalfa. In these two Member States, arable crop farmers can opt for supplying green alfalfa to dehydrating plants (often through contractual arrangements) instead of selling dried alfalfa on the market, since the first option may entail better margins, cost savings and less operational challenges (alfalfa is harvested green, and dehydrating plants usually manage harvesting).
[167] See the previous footnote for an explanation of the influence that a sizable forage dehydration sector can have on the market for green and dried alfalfa.

		switches between meals (less sunflower seed meal, more soya bean and rapeseed meals) and cereals (less wheat, more maize)	
Dairy goat conv - *Increased availability of HP rape meal (45% vs 37% protein)*	Significant potential reduction in the use of imported raw materials for animal feed, such as soya cake and DDGS, but especially in other animal sectors.	Availability of protein-enriched seeds would be ensured only within 5/8years Would imply segregation costs for HP rapeseed meal, at least in the initial development phase (not after a complete switch to HP varieties) Dairy goat diets already use relatively little soya bean meal à relatively limited potential for substitution	Would provide an alternative protein source with no additional industrial costs Rapeseed is difficult to cultivate in the Mediterranean area There is an unfavourable attitude towards rapeseed use as feed in certain Member States (especially Spain) and by some large retail chains[168]
Pigmeat conv – *Insect meal*	Interesting potential for reduction in soya bean meal use, but only in the early stages of the rearing cycle (including piglet feeding)	Extremely low interest prices[169] vs. actual market prices Insect meals are not yet commercially available Insect meals currently have extremely high production costs Food security and traceability issues if the insects are fed with waste Insect feeding would use materials previously used for farmed animals, and thus would not help closing the protein gap	*Theoretically high (no specific geographical limitations), but clearly oriented towards other more profitable outlets (petfood, human food) that are essential to the business model*
Pigmeat conv – *Legume seeds* SELECTED	The "optimistic" scenario (processed legume seeds with higher energy values, higher limits for inclusion in the diet and higher prices to incentivise cultivation) makes it possible to reduce by almost 50% the use of soya bean meal	Still limited availability of legumes Current pea prices do not incentivise an expansion in cultivated areas Some legume species (especially lupines) are not competitive	*Significant with effective support to cultivation of legume seeds*
Pigmeat NC - *Enzymes*	Modest decrease in soya bean meal use (which was already low in Spain, where the scenario was tested)	Limited potential in terms of further improvement of already well-optimised diets Some enzymes are still very expensive	***Theoretically high (no specific limitations related to geography or specialisation in PDO/PGI production)***
Pigmeat NC – *Ideal protein*	Modest decrease in soya bean meal use (which was already low in Spain, in the	Limited potential in terms of further improvement of already well-optimised diets	*No specific geographical limitations, but may be difficult to apply in specific PDO and PGI*

[168] In the specific case of Spain, such attitude dates back to a serious food scare involving rapeseed oil that occurred in the country in 1981, which resulted in over 20,000 persons affected, of which approximately 300 died shortly after the onset of the disease, and a larger number developed chronic disease (see this 2002 article by Gelpí *et al*. for details: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1240833/pdf/ehp0110-000457.pdf). In the other cases, the unfavourable attitude has different reasons, but the high erucic acid content of traditional rapeseed varieties is among the main ones, in spite of the availability of rapeseed varieties with low erucic acid content.

[169] The interest price corresponds to the price at which the first tonne of the alternative feed tested is used by the manufacturer without changes in the cost of the manufactured feed. This implies that to be introduced in the composition of manufactured feed/of the ration, the market price must match the interest price.

	specific case of Iberian pigs for PDO ham production)	Some of the consulted stakeholders deem that amino acids are still very expensive; the EU is heavily dependent on non-EU suppliers for some amino acids	*productions, due to limitations in the use of certain feed materials*
Pigmeat NC – *Contractualization of legume crops* **SELECTED**	Increased use of legumes (especially peas) in the diets, in combination with increased use of sunflower seed meal, has significant potential for reduction in soya bean meal use	Contractualization alone cannot ensure sufficient economic incentives to a significant expansion of the area under legume crops for feed use and to the inclusion of legumes in diets	The cultivation of peas in areas with limited rainfall presents challenges May be difficult to apply in specific PDO and PGI productions, due to limitations in the use of certain legumes
Broiler conv – *Legume seeds* **SELECTED**	Allows a significant, albeit theoretical, decrease in soya bean meal use	Interest prices are much lower than actual ones Availability of legume seeds Limited competitiveness of legume crops vs. other crops as feed materials Some legume seeds contain anti-nutritional factors (ANF) that make them unsuitable for broiler feeding	Significant only if legume crops are more profitable than other crops in the Member States (support to cultivation is required) The development potential of the different types of protein crops varies greatly from one Member State to another. The pig sector could use protein crops more easily (i.e., could pay higher prices for them) than the poultry sector.
Broiler conv – *Industrial amino acids* **SELECTED**	Allows a significant decrease in soya bean meal use	The cost of some industrial amino acids is still very high; the EU is heavily dependent on non-EU suppliers for some amino acids	***No specific geographical limitations***
Broiler conv – *Use of HP rape meal* **SELECTED**	Significant potential reduction in the use of imported raw materials for animal feed, such as soya bean meal and DDGS	Availability of protein-enriched seeds would be ensured only within 5/8 years Would imply segregation costs for HP rapeseed meal, at least in the initial development phase (not after a complete switch to HP varieties)	Would provide an alternative protein source with no additional industrial costs Rapeseed is difficult to cultivate in the Mediterranean area There is an unfavourable attitude towards rapeseed use as feed in certain Member States (especially Spain) and by some large retail chains[170]
Laying hens NC - *Diversify local raw materials in the formula via mini-incorporation rate (shelled field beans, soymeal, sunflower meal)* **SELECTED**	Allows further improvement of an already very good mass autonomy	Low interest prices compared to actual prices Limited availability of legume seeds in specific Member States Additional costs for dehulling legume seeds	Some of the relevant crops (soya beans and sunflower seed in particular) cannot be cultivated over the entire EU territory, and not even in some Member States of the cluster (Denmark, Sweden) other than France (where the scenario was tested)
Laying hens NC – *Develop plant raw materials with a high rate of digestible methionine*	Allows a significant, albeit theoretical, decrease in soya bean meal use	Low interest prices compared to actual prices HiPro+ sunflower seed meal is not yet commercially available in the needed volumes	Sunflower cannot be cultivated over the entire EU territory, and not even in some Member States of the cluster (Denmark, Sweden) other than France (where the scenario was tested).

[170] See the explanation provided in a previous note concerning HP rape meal use in conventional goat farming.

		Insect meal is not authorised in organic laying hens farming Insect meal is too expensive as feed material, despite the fact that organic feed is theoretically more profitable than conventional feed	

* conv = conventional / NC = non-conventional

2.7.2 Identification of a selection of economically viable diversification strategies

Step 2 consists in a critical review and comparative analysis of the results of the assessment of the impacts of replacement scenarios on the economic viability of operators (arable crops producers; feed manufacturers; livestock producers) made under SQ6 (see Section 2.6). The exercise aims at identifying, for the different livestock production systems (livestock clusters or groups of clusters with similar enough characteristics and requirements in terms of feeding), a **selection of economically viable diversification strategies**, which constitutes the output of step 2.

The **criteria** applied for the selection are the following:

1. wherever any of these have been identified under SQ6, economically viable diversification strategies meeting the "**first best**" condition (i.e., decreasing production costs / no variation of production costs for all the affected categories of operators) must be preferred to diversification strategies only meeting the "**second best**" condition (i.e., increase in production costs limited enough to avoid negative margins for all the affected categories of operators);
2. diversification strategies resulting in negative margins for one or more of the affected categories of operators are excluded from the selection only in case the deterioration of economic viability is serious for at least one category; if the negative effects are relatively limited, and/or are counterbalanced by positive or at least neutral/unclear/undetermined effects for other affected categories, the strategy is not discarded.

The main implication of this approach is that to cover all the species of interest to the study with at least one "economically viable" – or more precisely, "not clearly unviable" – scenario, also several scenarios that deserved a "neutral/uncertain" judgment need to be included in the selection. Among those scenarios, the preferable candidates for inclusion are those that are not affected by significant limitations concerning their practical feasibility and/or how realistic the underlying assumptions are.

The exercise has been carried out for each species of interest for the study.

In the case of **feed manufacturers**, the assessment of the economic viability of replacement scenarios under SQ6 was mostly based on qualitative elements, mainly due to the lack of quantitative data on the extent of the costs and margins of these operators for the feed products of interest, which are considered confidential.

In the case of **arable crops producers**, the assessment of economic viability was based on FADN data, and was performed in terms of a comparative analysis of crop gross margins per hectare in a sample of farms specialised in the various arable crops used for feed, in the absence of better data.

The assessment of the economic viability of **livestock producers** was also based on FADN data, and was based on the impact of changes in diet cost on the farm net income (FNI) of specialist producers.

Due to the qualitative nature of part of the results of the assessment under SQ6, and to some limitations related to the available evidence, the comparative analysis of the economic viability of operators in each replacement scenario was carried out **qualitatively**, and is affected by a **degree of indeterminateness**, mostly deriving from limitations in the partial assessments under SQ6.

Table 33: Identification of a selection of economically viable diversification strategies

Cell colour keys - economic viability: ***clearly improved***/*basically unchanged* viability; undetermined/uncertain viability; ***seriously reduced***/*reduced* viability; not relevant/unfeasible assessment

Cell colour keys - overall judgment: ***clearly positive à meets the "first best" condition***; fairly positive à meets the "second best" condition; uncertain/neutral; fairly negative; ***clearly negative***

Species / clusters / sub-clusters* / *scenarios*	**Economic viability of:**			**Overall judgment on economic viability**
	Feed manufacturers	Arable crop farmers	Livestock producers**	
Dairy cattle conv - *Increase roughage share and improve grassland quality* **SELECTED**	Possible reduction in feed demand Probably cost-neutral	If grown on highly productive land instead of cereals, which is unlikely, arable crop producers' competitiveness could decrease. Needs more wheat area to compensate the decrease of maize silage in the ration (to cover energy needs)	Increased pasturing/hay harvesting may reduce diet costs, but also increase labour costs, or determine land use changes à opportunity costs of difficult quantification	No clear improvements in the economic viability of any of the affected categories of operators
Dairy cattle conv - *Increased production of French soya beans and protein crops + increased availability of HP+ sunflower meal* **SELECTED**	*Probably only modest improvements*	Soya beans are the most economically attractive alternative crop, albeit only rarely vs. maize, and are not an option in Northern EU Protein crops are economically attractive vs. wheat in fewer Member States		No clear improvements in the economic viability of feed manufacturers and arable crop farmers; no elements available for livestock producers
Dairy cattle NC – *Forage improvement (energy)*[171]	*Reduction in feed demand*		*Negligible reduction in FNI (-1.4%)*	No clear improvements in the economic viability of any of the affected categories of operators
Dairy cattle NC – *Increased protein content in forage* **SELECTED**	*Reduction in feed demand*		*Negligible increase in FNI (+1.6%)*	No clear improvements in the economic viability of any of the affected categories of operators
Beef conv - *Improved grass share and grass quality of the ration*	***Significant reduction in feed demand***	If grown on highly productive land instead of cereals, which is unlikely, arable crop producers' competitiveness could decrease.	***Significant increase in FNI (+16/17% with meslin crude protein content >15%)***	The positive effects for livestock producers are offset (albeit to an unquantifiable extent) by negative effects for feed manufacturers

[171] The difference between the two scenarios tested for non-conventional dairy cattle is the following: in the "forage improvement (energy)" scenario, it was assumed that improved forage management resulted in an improvement of forage nutritional quality, which was expressed in terms of increased energy value of the forage component of the diet; in the "increased protein content in forage" scenario, the effect of increased contribution of forages to meet the total protein needs was modelled by decreasing the protein requirements in the non-forage component of the diet (concentrates).

SELECTED				
Beef conv - *Increased availability of HP+ sunflower meal*	*No significant cost variations if low sunflower price is assumed*		*Negligible change in FNI, but only since a low sunflower price is assumed à probably unviable at current prices*	The absence of clear improvements for feed manufacturers and the probable unviability for livestock producers leads to a fairly negative overall judgment
Beef NC – *Increased inclusion of dried alfalfa (non-dehydrated)*	Potentially significant reduction in feed demand	No impact on arable crop farmers' viability	*Negligible change in FNI, but only since a low alfalfa price is assumed à probably unviable at current prices (albeit there may be differences across the EU)*	The absence of clear improvements for feed manufacturers and arable crop farmers, and the probable unviability for livestock producers (albeit there may be differences across the EU), lead to a fairly negative overall judgment
Beef NC – *Improved protein content of meadows*	Potentially significant reduction in feed demand; alternative diets may be unfeasible in some Member States		***Significant to substantial increases in FNI (+10.6/+24.7%)*** (but may be unfeasible in some Member States)	Probable unfeasibility in some Member States and potentially negative effects (albeit unquantifiable) for feed manufacturers do not allow for a positive overall judgment
Sheep meat conv – *Inclusion of dried alfalfa (non-dehydrated)* **SELECTED**	*Probably limited reduction in feed demand*	No impact on arable crop farmers' viability	*Moderate increase in FNI (+2.4/+2.7%)*	***Probably limited negative effects for feed manufacturers, combined with moderately positive improvements for livestock producers, lead to a clearly positive overall judgment***
Sheep meat conv – *Improved pastures*	*Probably limited reduction in feed demand*		No quantification of changes in FNI available, but improved pastures should reduce diet cost and lead to an increase in FNI, even though there may be opportunity costs of difficult quantification	No clear improvements in the economic viability of any of the affected categories of operators
Dairy goat conv - *Increased protein input through grass-based roughage*	Probably limited reduction in feed demand; feasibility in some Member States was questioned	If grown on highly productive land instead of cereals, which is unlikely, arable crop producers' competitiveness could decrease.	No quantification of changes in FNI available: may reduce diet costs, but also increase labour costs	No clear improvements in the economic viability of any of the affected categories of operators
Dairy goat conv - *Increased availability of HP rape meal (45% vs 37% protein)*	Interest for feed manufacturers but not particularly for this animal species (more for poultry)	Rapeseed is economically attractive in some Member States (mostly vs. wheat or other cereals, rarely vs. maize)		Insufficient elements to draw a conclusive overall judgment for this animal production

	Impacts would depend on the extent of direct supply to farmers (instead of inclusion in feed)			
Pigmeat conv – *Insect meal*	***At current insect meal prices, production costs and selling price of feed would be too high to be sustainable***		***Extremely substantial decreases in FNI (-31.4%/-85.6%)***	***Substantially negative effects for all the affected categories of operators lead to a clearly negative overall judgment***
Pigmeat conv – *Legume seeds* **<u>SELECTED</u>**	Potentially significant reduction in manufactured feed demand; farm-level implementation of the most optimistic hypothesis would face serious challenges	Protein crops are economically attractive vs. wheat in relatively few Member States	*Moderate increase in FNI (+6.4%) (but farm-level implementation of the most optimistic hypothesis would face serious challenges)*	The positive effects for livestock producers (albeit with operational challenges) are offset (albeit to an unquantifiable extent) by negative effects for feed manufacturers
Pigmeat NC - *Enzymes*	Uncertainty on actual enzyme price levels and EU vs. non-EU enzyme supply		*Negligible increase in FNI (+1.2/+1.9%) (uncertainty on actual enzyme price levels)*	No clear improvements in the economic viability of any of the affected categories of operators
Pigmeat NC – *Ideal protein*	*No significant cost variations*		*Moderate decrease in FNI (-2.5%); the scenario is unfeasible in organic farming with the current legislation (Regulation (EU) 2018/848)*	No clear improvements in the economic viability of any of the affected categories of operators; the scenario is unfeasible in organic farming with the current legislation (Regulation (EU) 2018/848), and would be unfeasible in PDO/PGI productions not allowing the use of synthetic amino acids
Pigmeat NC – *Contractualization of legume crops* **<u>SELECTED</u>**	Impacts on feed demand would largely depend on the extent to which legume crops (especially peas) included in the diets derive from on-farm production	Protein crops are economically attractive vs. wheat in relatively few Member States		In the case of prices below the shadow price, these legumes should be able to enter the diets
Broiler conv – *Legume seeds* **<u>SELECTED</u>**	Impacts on feed demand would largely depend on the extent to which peas and faba beans included in the diets derive from on-farm production	Protein crops are economically attractive vs. wheat in relatively few Member States	*Moderate increases in FNI (+2.6/+4.1%)*	Even with some uncertainties/limitations concerning feed manufacturers and arable crop producers, moderate improvements for livestock producers lead to a fairly positive overall judgment
Broiler conv – *Industrial amino acids* **<u>SELECTED</u>**	Increase in demand for amino acids, which may create tension on the European market and limit the economic interest		***Substantial increase in FNI (+26.5%) in case of minimum requirements for metabolizable energy and digestible amino acids*** *(however, meeting more demanding requirements may*	The remarkable variations in the effects on livestock producers according to variations in feeding requirements, do not allow for a clear judgment

			translate into substantial decreases in FNI, up to -46.3%). For example, intensive chicken production (fillets for export) requires soya.	
Broiler conv – *Use of HP rape meal* **SELECTED**	*Decrease in feed production costs*	Rapeseed is economically attractive in some Member States (mostly vs. wheat or other cereals, rarely vs. maize)	*Moderate increase in FNI (+2.1%)*	***The positive impacts on feed manufacturers, and moderate improvements for livestock producers, lead to a clearly positive overall judgment***
Laying hens NC - *Diversify local raw materials in the formula via mini-incorporation rate (shelled field beans, soymeal, sunflower meal)*	***Clear improvements*** *(if assumptions prove to be realistic)*	Soya beans are the most economically attractive alternative crop, albeit only rarely vs. maize, and are not an option in Northern EU Protein crops are economically attractive vs. wheat in fewer Member States		The uncertainties concerning the assumptions, and the lack of elements for livestock producers, do not allow to draw a conclusive overall judgment
Laying hens NC – *Develop plant raw materials with a high rate of digestible methionine (varietal selection)*	***Clear improvements*** *(if assumptions prove to be realistic)*			The uncertainties concerning the assumptions, and the lack of elements for livestock producers, do not allow to draw a conclusive overall judgment

* conv = conventional / NC = non-conventional
** FNI = farm net income

Table 33 provides a synoptic overview of the results of the exercise, identifying the economically viable diversification strategies that form part of the selection, synthetically outlining the grounds for their inclusion/exclusion, and formulating an overall judgment. The scenarios are indicated as selected on the following grounds.

Overall, just two replacement scenarios - inclusion of **dried alfalfa** in the diet of **conventional sheep** for meat production and use of **HP rape meal** for **conventional broiler production** - resulted to meet the "first best" condition, thus deserving a **clearly positive** overall judgment in terms of economic viability. Another scenario – inclusion of **legume seeds** in the diet of **conventional broilers** – resulted to meet the "second best" condition, thus deserving a **fairly positive** overall judgment. However, it is highly likely that the prices of legume seeds used in the model do not reflect market reality, and that market prices are actually higher, given that actual broiler diets do not include legume seeds.

The **mixed** (positive vs. negative) **impacts** assessed in **most scenarios**, together with some uncertainties on the direction/magnitude of certain impacts, and some doubts on the actual feasibility of specific scenarios and/or in how realistic the underlying assumptions were, resulted in a prevalence of **uncertain or neutral** overall judgments.

The prevalence of negative impacts in two scenarios for **beef** (increased availability of **HP+ sunflower meal** for **conventional** beef; increased inclusion of **dried alfalfa** in the diet of **non-conventional** beef, albeit in this case there may be significant differences across the EU[172]) resulted in a **fairly negative** judgment on their overall economic viability.

Finally, the substantially negative effects for all the affected categories of operators lead to a **clearly negative** overall judgment for the scenario based on the inclusion of **insect meal** in the diet of **conventional pigs**.

2.7.3 Definition of a selection of suggested diversification strategies

In this step, the results of the exercises carried out under step 1 (identification of replacement scenarios where negative impacts are minimised, and showing significant potential for generalised application – see Section 2.7.1) and 2 (economically viable diversification strategies – see Section 2.7.2) are critically reviewed to define a selection of "suggested diversification strategies", which constitutes the output of the step. This selection is defined for each species of interest for the study, and for the relevant livestock production systems (livestock clusters or groups of clusters with similar enough characteristics and requirements in terms of feeding).

The considerations made for each of the species of interest are reported in the following Sections. In certain cases, the combination in a "mixed strategy" of multiple levers assessed in the case studies seems advisable. For some of the segmentations, limitations in terms of potential for generalised application of a certain strategy make it advisable to suggest the adoption of geographically differentiated strategies (i.e., a specific lever/combination of levers may be advisable in a certain geographical area, whereas a different lever/combination of levers may be advisable in another area).

2.7.3.1 Ruminants

2.7.3.1.1 Bovines (dairy)

For the conventional segment, the assessments at steps 1 and 2 indicated that the two strategies considered, i.e., "increase roughage share and improve grassland quality"; "increased production of soya beans and protein crops + increased availability of HP+ sunflower meal":

- allow modest to significant decreases in the use of (imported/non-GM) soya bean meal and rapeseed meal;

[172] This diversification strategy was in fact tested in two Member States, i.e., Italy and Spain, where the presence of a sizable forage dehydration sector can have a significant influence on the market for green and dried alfalfa; the situation may be rather different in other Member States, e.g., in France.

- have as significant drawbacks some operational challenges and organisational adaptations related to the switch from silage maize to meadows in the first strategy, and more generally the fact that prospective expansion of cultivated areas under the concerned crops would be constrained by the limited availability of arable land in the EU;
- have a significant potential for application also in other operational contexts[173] than the one in which they were tested (i.e., France);
- would not result in significant deterioration of the economic viability of the concerned actors.

On the above grounds, both strategies are possibilities for conventional dairy farming.

As for the <u>non-conventional segment</u>, the assessments at steps 1 and 2 revealed mixed outcomes from the considered strategies, i.e., "*improved energy content in forage*" and "*increased protein content in forage*". More specifically, the strategies would allow a significant decrease in the use of concentrates and oilseed meals, but also present a significant drawback in areas with limited availability of arable land, due to the lower yields of protein-rich forage crops like alfalfa and clover grass compared to silage maize. In addition, harvesting and storage of protein-rich forage crops would pose significant operational and organisational challenges in areas with significant summer rainfall (Northern and Central EU), thus limiting the potential for an EU-wide application of these strategies. Last but not least, neither strategy would determine clear improvements in the economic viability of any of the affected categories of operators. If a strategy might be identified for the segment in any case, a slight preference would go to "*increased protein content in forage*", mainly due to the slight increase in farm net income that would result from its implementation in livestock farms.

2.7.3.1.2 Bovines (meat)

As far as the <u>conventional segment</u> is concerned, the assessments at steps 1 and 2 revealed that the strategy focusing on "*improved grass share and grass quality of the ration*" (thanks to the inclusion in the diets of meslin[174] with middle-to-high - 10/20% - crude protein content) has clear advantages over the other considered strategy, based on "*increased availability of HP+ sunflower meal*". Indeed, whereas both strategies would result in the reduction or complete elimination of soya bean meal use, the strategy based on HP+ sunflower meal:

- is based on assumptions on price levels that are much lower than recently observed ones;
- suffers from limitations in its potential for application to other operational contexts than the one in which it was tested (i.e., France), mainly due to the fact that sunflower cannot be cultivated over the entire EU territory.
- Furthermore, the assessment of the economic viability revealed that:
- the strategy focusing on "improved grass share and grass quality of the ration" would cause (unquantifiable) negative effects for feed manufacturers that would however be counterbalanced by a significant increase in farm net income for livestock producers (+16/17% with meslin with a crude protein content >15%);
- by contrast, the strategy based on "increased availability of HP+ sunflower meal" would determine no clear improvements in the economic viability of feed manufacturers, and probable unviability for livestock producers (due to the "optimistic" assumptions on sunflower price levels).

In the light of the considerations made above, the strategy based on ***improved grass share and grass quality of the ration*** emerged as the suggested one for conventional beef production, even though its applicability may be constrained in Member States (e.g., Belgium, the Netherlands, Italy) where silage maize is preferable to meslin silage.

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[173] The potential of these strategies was also assessed in Czechia and Poland.
[174] mixture of cereal forage and legume forage.

As for the **non-conventional segment**, the identification of the suggested strategy is based on the outcomes of the sole assessment at step 1, since the assessment of economic viability under step 2 did not reveal any clear advantages of a specific strategy: the only potentially positive effects in terms of economic viability were identified for the strategy based on "*improved protein content of meadows*", but they were limited to livestock producers, and the feasibility of the strategy in some Member States was seriously questioned, as explained below. The assessment at step 1 revealed that:

- The strategy based on "*increased inclusion of dried alfalfa in the diets*" would allow a substantial decrease in soya bean meal use, even though the dried alfalfa price levels that would make the inclusion possible are much lower than recently observed ones, at least in Italy and Spain, where the strategy was tested[175] (the situation may be different in other Member States, e.g., in France). In addition, the assessment did not identify any serious limitations to the application of the strategy to other operational contexts than the one in which it was tested (i.e., Italy).
- Even though the strategy based on "*improved protein content of meadows*" would result in a substantial decrease, and even in the elimination of soya bean meal use (in the case of meadows with medium to high crude protein content), its implementation was deemed unfeasible in Member States (like Italy) that rely heavily on the use of silage maize for beef cattle fattening in intensive systems.

On the above grounds, a **geographically diversified approach** seems advisable:

- the strategy based on "***improved protein content of meadows***" would be preferable in Central-Northern EU Member States, where meadows already have an important role in beef cattle farming;
- "***increased inclusion of dried alfalfa in the diets***" would be preferable in the Member States (like Italy and Spain) where alfalfa can be profitably cultivated, and/or where the switch from maize silage (which is currently prevailing) to meadows would present serious operational challenges.

2.7.3.1.3 Sheep (meat + milk)

The two strategies considered - "***inclusion of dried alfalfa in the diets***" and "***improved pastures***" - were both judged favourably in the assessment under step 1: they would both lead to a significant decrease in soya bean meal use, and the "improved pastures" strategy would even lead to elimination of soya bean meal in the diet for gestating and lactating ewes (early lactation). No serious drawbacks were identified for the two strategies, and the most significant limitations to their EU-wide application concern areas with an arid climate, where irrigation would be needed to cultivate alfalfa, and where the improvement of pastures may be challenging. The assessment under step 2 revealed that the strategy based on the "*inclusion of dried alfalfa in the diets*" would be slightly preferable from the viewpoint of economic viability, since probably limited negative effects for feed manufacturers would be combined with moderately positive improvements in terms of farm net income for livestock producers (by contrast, the other strategy would not lead to clear improvements in the economic viability of any of the affected categories of operators). On these grounds, **both strategies can be suggested**, with a slight preference for the one based on "*inclusion of dried alfalfa in the diets*".

[175] The importance of dehydrating plants as an outlet in both Italy and Spain, and the very high prices of dehydrated alfalfa on premium export markets, can have an influence on farmgate prices for green and dried alfalfa in these two Member States: arable crop farmers can opt for supplying green alfalfa to dehydrating plants (often through contractual arrangements) instead of selling dried alfalfa on the market, since the first option may entail better margins, cost savings and less operational challenges (alfalfa is harvested green, and dehydrating plants usually manage harvesting).

2.7.3.1.4 Goats (meat + milk)

The identification of the suggested strategy is based on the outcomes of the sole assessment at step 1, since the assessment of economic viability under step 2 did not reveal any clear advantages of a specific strategy. The assessment at step 1 revealed that the strategy based on "*increased protein input through grass-based roughage*" has some advantages over the strategy based on "*increased availability of HP*[176] *rape meal*". More specifically:

- The strategy based on "*increased protein input through grass-based roughage*" would lead to a drastic reduction in concentrate use (it should be noted that this would be a significant weakness from the feed manufacturers' perspective) without serious drawbacks; in terms of potential for an EU-wide application, the most significant limitation is related to the fact that some of the switches between meals and/or between cereals that are related to the implementation of the strategy would be undesirable in certain Member States (e.g., less use of sunflower seed in Spain).
- By contrast, even though the strategy based on *"increased availability of HP rape meal*" would result in a significant reduction in the use of such imported feed materials as soya bean meals and DDGS, it could have, according to some stakeholders interviewed for the study, a significant drawback in the additional costs for segregating HP meals, and is affected by limitations to potential EU-wide application: rapeseed is difficult to cultivate in the Mediterranean area, and there is an extremely unfavourable attitude towards the inclusion of rapeseed meal in the diets of farmed animals in certain Member States (especially Spain) and by some large retail chains[177].

Given the above elements, the suggested strategy for dairy goats is identified in "***increased protein input through grass-based roughage***".

2.7.3.2 Monogastrics

2.7.3.2.1 Pigs

In the **conventional segment**, the assessment at step 1 revealed a clear advantage of the strategy based on the "*inclusion of legume seeds in the diets*" over the strategy based on the "*inclusion of insect meal in the diets*". The strategy based on legume seeds would allow to achieve a more substantial reduction in the use of soya bean meal, is affected by less serious drawbacks than the one based on insect meal, and has significant potential for application also outside the operational context in which it was tested (i.e., Germany). Peas emerged as the most competitive legume seeds to include in the diets, whereas the competitiveness of other species (lupines in particular) was found to be extremely weak. The most significant limitations to the implementation of the strategy based on legume seeds would derive from still limited availability of legumes at EU level, and from the fact that current pea prices would not incentivise an expansion in cultivated areas. Even at an interest price[178] for feed manufacturers that is €40/t lower than the current price, there is little inclusion rate and therefore little decrease of soya bean meal. This strategy would only be possible through a sharp fall in its production price (which explains why there is little production today, as there are no outlets at current prices). The assessment under step 2 revealed a clear advantage

[176] 45% vs. 37% crude protein content.
[177] In the specific case of Spain, such attitude dates back to a serious food scare involving rapeseed oil that occurred in the country in 1981 (see Gelpí *et al*. for details: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1240833/pdf/ehp0110-000457.pdf). In the other cases, the unfavourable attitude has different reasons, but the high erucic acid content of traditional rapeseed varieties is among the main ones, in spite of the availability of rapeseed varieties with low erucic acid content.
[178] The interest price corresponds to the price at which the first tonne of the alternative feed tested is used by the manufacturer without changes in the cost of the manufactured feed. This implies that to be introduced in the composition of manufactured feed/of the ration, the market price must match the interest price.

of the strategy based on legume seeds also in terms of economic viability[179], since the other strategy was found to be currently unsustainable for both feed manufacturers and livestock producers, due to the still very high production cost of insect meal. In conclusion, the suggested strategy for conventional pigmeat production was identified in the "***inclusion of legume seeds in the diets***".

As for the **non-conventional segment**, the assessment at step 1 revealed that two of the three strategies considered, i.e., those based on the "*use of enzymes*" and on the "*application of the ideal protein concept*", would only allow a modest decrease in soya bean meal use (which was already low in Spain in the specific case of Iberian pigs for PDO ham production), and that their implementation might be constrained by the cost of enzymes and industrial amino acids, which is perceived to be high by some stakeholders Furthermore, the EU is heavily dependent on few non-EU suppliers for a number of industrial amino acids. It is hence essential to support the development of European amino acid production, to avoid moving from one dependency to another. The assessment under step 2 revealed no clear improvements in the economic viability of any of the affected categories of operators for both strategies. By contrast, the strategy based on "***contractualization of legume crops***" was found to have a significant potential for reduction in imported soya bean meal use (if combined with increased use of sunflower meal in the diets), and was hence identified as the suggested diversification strategy, although it is affected by some drawbacks and constraints:

- contractualization alone would not ensure sufficient economic incentives to a significant expansion of the area under legume crops for feed use and to the inclusion of legumes in diet;
- the cultivation of peas in areas with limited rainfall would present challenges;
- the strategy would be difficult to apply in specific PDO and PGI productions, due to limitations in the use of certain legumes in the diets established by the related product specifications.

2.7.3.2.2 Broilers

The three strategies assessed in step 1 - respectively based on the "***inclusion of legume seeds in the diets***", on the "***use of industrial amino acids***", and on the "***use of HP rape meal***" – were all found to allow a significant decrease in soya bean meal use, and to have significant or high potential for application also outside the operational contexts in which they were tested (i.e., Poland for the first two strategies, France for the third one). The most significant drawbacks of the strategies were identified in the following: i) some legume seeds contain anti-nutritional factors (ANF) that make them unsuitable for broiler feeding; ii) the EU is heavily dependent on non-EU suppliers for some amino acids; (iii) the limited interest for amino acids as alternative in intensive broiler production for low-cost catering; ; iv) as for HP rape meal, the main limitations are the same identified for its use in goat farming (Section 2.7.3.1.4). As for the assessment of economic viability under step 2:

- In the case of the strategy based on the "*inclusion of legume seeds in the diets*", even with some uncertainties/limitations concerning feed manufacturers and arable crop producers (in particular the need for support to ensure that market prices connect with the relatively low interest prices paid by feed manufacturers), the moderate improvements in farm net income that it would allow for livestock producers led to a fairly positive overall judgment.
- The strategy based on the "*use of industrial amino acids*" was found to have uncertain effects on feed manufacturers, and the effects on livestock producers in terms of variations in farm net income were found to vary substantially, including in their direction (increase/decrease), according to variations in feeding

[179] Even though the positive effects that would derive from the implementation of the strategy (albeit with some operational challenges) for livestock producers would be offset (albeit to an unquantifiable extent) by negative effects for feed manufacturers.

requirements: for these reasons, the judgment could not be fully positive according to the type of production required[180].

- The strategy based on the "*use of HP rape meal*" would allow a moderate improvement for livestock producers and positive effects on feed manufacturers, thus deserving a clearly positive overall judgment.

Given the above elements, **all the three strategies are suggested** for conventional broiler meat production, with a preference for the one based on the "*use of HP rape meal*", stemming from its better overall economic viability. They could also be applied in combination, or in the framework of a geographically diversified approach, according to the availability of legume seeds/HP rape meal at Member State level.

2.7.3.2.3 Organic laying hens

Two strategies were considered and tested in the organic segment:

1. Diversifying local raw materials (shelled field beans, soymeal, sunflower meal) in the formula via mini-incorporation rate, a mixed strategy that combines multiple levers, and that was tested in France
2. Developing plant raw materials with a high rate of digestible methionine through varietal selection.

In the assessment under step 1, the two strategies were found to have the potential to determine significantly positive effects in terms of improved protein autonomy; however, it also emerged that:

- Both strategies are affected by significant drawbacks: additional costs would have to be incurred for dehulling legume seeds; availability of legume seeds in still limited in certain Member States; HiPro+ sunflower seed meal is not yet commercially available in the needed volumes.
- The potential for EU-wide application is seriously constrained for both strategies by the fact that some of the relevant crops (soya beans and sunflower seed in particular) cannot be cultivated over the entire EU territory.

As for the assessment under step 2, some uncertainties concerning the underlying assumptions in both scenarios, and the lack of elements concerning the impacts on the economic viability of livestock producers, did not allow to draw a conclusive overall judgment.

Since the **mixed strategy** based on the "***diversification of local raw materials in the formula via mini-incorporation rate***" seems to present less serious drawbacks than the other one, it is proposed as suggested strategy, at least for the Member States where the cultivation of soya beans and sunflower seed is technically feasible and economically profitable. In the Member States that are not suited to soya bean and/or sunflower cultivation, other feed materials – e.g., peas, dehulled faba beans, rapeseed meal - may provide an alternative.

2.7.4 Main findings

Table 34 provides a synthetic "at-a-glance" overview of the suggested diversification strategies for the species of interest, highlighting their key strengths and a synthetic judgment on their overall potential (high/medium/low), based on the weight of the concerned species/segments in terms of livestock units and of reliance on imported feed materials.

[180] However, in the future, if the decarbonisation of agriculture tended to be remunerated (carbon credits), this lever could have an improved financial impact for the breeder (as well as for other players in the supply chain).

Table 34: Overview of the suggested diversification strategies for the species of interest

Species – segments*	Suggested diversification strategies		
	Synthetic description	Key strengths	Overall potential
Bovines (dairy) – conv	Increase in roughage share and improvement of grassland quality**	Modest to significant decreases in the use of (imported/non-GM) soya bean meal and rapeseed meal Significant potential for application to other operational contexts than the one in which they were tested (France) No significant deterioration of the economic viability of the concerned actors	**Medium** *(large in LU terms, but relatively less reliant on imported feed materials)*
	Increased production of soya beans and protein crops combined with increased availability of HP+ sunflower meal		
Bovines (dairy) – NC	Increased protein content in forage**	Slight increase in farm net income for livestock producers	**Low** *(medium in LU terms, relatively less reliant on imported feed materials)*
Bovines (meat) - conv	Improved grass share and grass quality of the ration**	Significant reduction or complete elimination of soya bean meal use	**Medium** *(large in LU terms, but relatively less reliant on imported feed materials)*
Bovines (meat) - NC	Geographically diversified approach: • improved protein content of meadows**: suggested for Central-Northern EU Member States; • increased inclusion of dried (non-dehydrated) alfalfa in the diets**: suggested for Member States where the switch from maize silage to meadows would present serious operational challenges.	Substantial decrease in/complete elimination of soya bean meal use	**Low** *(small in LU terms, and relatively less reliant on imported feed materials)*
Sheep	Inclusion of dried (non-dehydrated) alfalfa in the diets**	Significant decrease in soya bean meal use	**Low** *(medium in LU terms, but relatively less reliant on imported feed materials)*
	Improved pastures**	Significant decrease in soya bean meal use, and elimination of soya bean meal in the diet for gestating and lactating ewes (early lactation)	
Goats	Increased protein input through grass-based roughage**	Reduction in concentrate use	**Low** *(small in LU terms, and relatively less reliant on imported feed materials)*
Pigs - conv	Inclusion of legume seeds in the diets	Substantial theorical reduction in the use of soya bean meal Significant potential for application outside the operational context in which it was tested (Germany)	**High** *(large in LU terms, and heavily reliant on imported feed materials)*
Pigs - NC	Contractualization of legume crops	Significant theorical potential for reduction in soya bean meal use (if combined with increased use of sunflower meal in the diets)	**Low** *(medium in LU terms, but relatively less reliant on imported feed materials)*
Broilers - conv	Inclusion of legume seeds in the diets	Significant theorical decrease in soya bean meal use	**High**

		High potential for application outside the operational context in which they were tested (Poland)	*(medium in LU terms, but heavily reliant on imported feed materials)*
	Use of industrial amino acids	Significant decrease in soya bean meal use Significant potential for application outside the operational context in which they were tested (Poland)	
	Use of HP rape meal	Significant decrease in soya bean meal use Overall positive effects in terms of economic viability	
	The three strategies could also be applied in combination, or in the framework of a geographically diversified approach, according to the availability of legume seeds or HP rape meal		
Laying hens - NC	Diversification of local raw materials in the formula via mini-incorporation rate	Potential to cause significantly positive effects in terms of improved protein autonomy, at least for the Member States where the cultivation of soya beans and sunflower seed is technically feasible and economically profitable. *In the Member States that are not suited to soya bean and/or sunflower cultivation, other feed materials – e.g., peas, dehulled faba beans or rapeseed meal - may provide an alternative.*	**Low** *(small in LU terms, and relatively less reliant on imported feed materials)*

* conv = conventional segment; NC = non-conventional segment
** all the diversification strategies based on increased and improved protein content of the forage component promote a reduction of variable extent in concentrate use

2.8 SQ8: How are supply chains currently organised for both, feed and animal products, in view of their contractual arrangements as well as defined process and quality requirements? Which consequences would different replacement scenarios have on the organisation of supply chains, for both, feed and animal products?

2.8.1 Analysing the current organisation of the supply chains

The first step consists of an in-depth analysis of the key characteristics of the supply chains of interest, starting from the supply of ingredients used in feed/feeding rations, up to the animal products marketed (i.e., meat, dairy products, eggs). The internal organisation of supply chains, their functioning mechanisms and their relationships with other supply chains were mainly investigated qualitatively through desk research, interviews with experts and case studies.

2.8.1.1 Organisation of the feed supply chain

A key distinction must be made between the supply of manufactured feed and the supply of non-industrial feed. Moving from the upstream stages to the downstream stages, the **manufactured** (i.e., industrial) **feed supply chain** includes:

1. **Arable crop farmers and other primary producers** (mainly for feed materials of animal origin, e.g., fishermen).
2. **Processors of primary products**. Several feed materials (e.g., oilseed meals, bran, DDGS, sugar beet pulps, fish meal, etc.) are the products or co-products of the industrial processing of agricultural and other primary products. The main industrial sectors supplying feed materials include: cereal milling, oilseed crushing, starch and derivatives, distilleries, sugar beet processing, milk processing, slaughtering and meat processing, fish processing. For a number of these processed feed materials (oilseed meals in particular, since the EU imports substantial volumes of them) the concerned operators are in part located outside the EU.
3. **Feed manufacturers**. These operators source a wide range of feed materials and ingredients from primary producers and processors of primary products, and process them into manufactured feed.
4. **Animal farmers**. These operators are the final customers of the feed manufacturing sector.

Besides the core actors described above, the manufactured feed supply chains generally include other actors, usually providing services, i.e.: i) **market intermediaries** (agri-brokers, traders, etc.), which can promote and support the transactions between the other actors; ii) **providers of storage, handling and transportation services**, which allow the material flows along the chain to take place[181].

The overall structure of the **supply chains of non-industrial feed materials** is much simpler, and the chains are shorter, since those materials:

- are produced directly on the farm in agricultural holdings rearing livestock;
- are produced in other (nearby) farms, and purchased by agricultural holdings rearing livestock, sometimes with the support of market intermediaries.

The supply chains of feed materials in the **organic** and **PDO** sub-segments also tend to have a more local dimension, which derives from requirements concerning a minimum level of on-farm production of feed materials (organic sub-segment), or the sourcing of a minimum amount of feed materials from the geographical areas where live animals or raw milk are sourced (PDO sub-segment). More specifically, with regard to **organic**

[181] According to Areté (2017), intra-EU flows of cereals, oilseeds and protein crops, including for feed use, move by inland waterway (barges), rail, road or short-sea vessels, whereas oceangoing vessels carry the near-totality of EU imports of feed materials. Most of the core actors in the chain (categories at points 1-4 above) manage storage and handling facilities (of extremely variable capacity), which are also managed by specialised operators.

production, general nutrition requirements in Regulation (EU) 2018/848 establish that "feed for livestock shall be obtained primarily from the agricultural holding where the animals are kept or shall be obtained from organic or in-conversion production units belonging to other holdings in the same region". The share of feed that must come from on-farm production varies among species: 60% for ruminants (to rise to 70% from 1 January 2024); 30% for pigs and poultry. In the case of **PDO products of animal origin**, article 1 of Regulation (EU) No 664/2014 establishes as a general rule that "for the purposes of Article 5 of Regulation (EU) No 1151/2012, feed shall be sourced entirely from within the defined geographical area" (which is the one from which live animals can be sourced, or from which raw milk can be produced). However, it also establishes that "insofar as sourcing entirely from within the defined geographical area is not technically practicable, feed sourced from outside that area can be added, provided that the product quality or characteristic essentially due to the geographical environment are not affected. Feed sourced from outside the defined geographical area shall in no case exceed 50 % of dry matter on annual basis". The share of specific feed materials that must come from the defined geographical area is defined in the product specifications, and varies remarkably among individual PDO products. Differently from organic and PDO production, the supply chains of feed materials intended for **non-GM** and/or **PGI** productions may concern wider geographical areas, since requirements concerning the origin of feed materials may be looser, or outright absent.

Whereas the overall structure of the supply chains in the clusters/sub-clusters of interest to the study generally mimics the general model outlined above, there are **more important differences among clusters/sub-clusters** in terms of:

- **organisation** of the chain (markets, vertical coordination/integration, etc.);
- **functioning mechanisms**, such as contractual arrangements, process/quality requirements, standards, etc.;
- **linkages with other supply chains** within the EU and/or outside the EU.

The study team could collect rather scarce evidence on the contractual arrangements between feed manufacturers and their suppliers of raw materials- i.e., individual arable crop farmers and their organisations, industrial processors (oilseed crushers, distillers, starch producers, beet sugar producers, etc.) and traders (for imported feed materials) - mainly because these arrangements are confidential: the detailed conditions of these arrangements are generally not available to third parties. Elements emerged from interviews and case studies refer to very specific concrete cases: this does not allow for their generalisation at national and EU level[182]. Nevertheless, those elements suggest that:

- Pricing mechanisms are the core element, especially where domestic price dynamics are influenced by global ones (this is the case for the three major oilseeds, soya in particular): in this case, pricing mechanisms tend to be adjusted more frequently, and may combine a fixed component with a variable one, which may be linked to futures markets (where these exist and are liquid enough). Linkages of pricing mechanisms with futures markets also allow the application of hedging techniques by the operators that have the necessary expertise.
- Requirements concerning product features and quality parameters (e.g., crude protein content) that determine the suitability and the economic value of agricultural products for use as ingredients in manufactured feed are also important.

Based on the study team's expertise, pre-harvest supply contracts between arable crop farmers and/or their cooperatives/associations, and feed manufacturers are relatively common for cereals. Pricing formulas for feed grains may be linked to futures markets, where EU ones exist and are liquid enough (for instance, Euronext is liquid enough for

[182] Some consulted experts deem that in Germany around 80% of the supply of agricultural raw materials for feed use is covered by contractual arrangements between individual farmers or their organisations, and feed manufacturers. The duration of these arrangements generally ranges from six months to one year, but some arrangements cover two years.

wheat and rapeseed, but not for maize). There are no reference futures markets in the EU for soya beans or protein crops: referring to the futures market of [Chicago Board of Trade (CBOT)]() in the USA entails management of exchange rate risk and of other risks. Milling co-products and other cereal products are currently priced at a premium to wheat (in connection with the futures markets). The lack of reference futures markets in the EU for soya beans and protein crops, and the limited liquidity of the markets for protein crops (mainly due to the limited underlying supply base, which is also concentrated in relatively few areas) may act as limiting factors for the development of the related supply chains, to the extent that they impede the development of more advanced contractual arrangements, and of risk management approaches that can effectively address price volatility and variability in yields (the latter is particularly significant for protein crops).

The prices of the main oilseed meals, fodder cereals, and other imported raw materials for feed manufacturing change on a daily, or even intra-daily basis. Based on the study team's expertise, the prices of individual shipments are established by the sellers (EU-based importers) and relayed to EU-based feed manufacturers or livestock farmers' organisations by brokers (intermediaries who never hold the goods but facilitate market transparency). The reference prices change daily, or even intra-daily, according to the dynamics of the futures markets, of exchange rates and of other benchmarks (e.g., the soya bean premium in Brazil).

Feed manufacturers must ensure constant raw material supply to their plants: based on the study team's expertise, they tend to buy limited volumes on the spot market (first quoted expiry), except for restocking. Feed manufacturers tend to position themselves, according to their market analysis, on medium and long-term contracts, where they can arbitrate on futures markets. Livestock farmers can also use futures markets to hedge their price risks (usually via "options", which are cheaper and simpler to master than a futures contract), but they rarely rely on long-term contracts. Raw materials like sugar beet pulp and dehydrated alfalfa are often purchased for the next 12 months, i.e., until the production of the next campaign starts to be marketed.

Advanced supply arrangements do not seem to be common for the less used protein sources (such as legume crops), but there are exceptions to that[183].

Organisational arrangements concerning the supply of feed materials within vertically integrated systems, including cooperative ones, seem to be more common in the poultry sector, for both broiler and egg production, and can also be found in the pig sector.

A noteworthy example of integrated approach to supply chain development is represented by the "Protein Partnerships" promoted by *Donau Soja*[184], a multi-stakeholder, non-profit organisation with a special focus on sustainable European non-GM soya production (Box 28).

Box 28: Donau Soja's protein partnership programme[185]

Launched in 2019, the programme is aimed at promoting the development of the upstream stages of the sustainable soya supply chain, i.e., cultivation and primary collection. The programme was developed to respond to the EU retail sector's demand for animal products obtained through sustainable rearing techniques, with special emphasis on the use of sustainably produced, non-GM soya from Europe; it is supported by a number of leading EU retail chains. The programme aims to increase the volume of non-GM sustainable soya produced for the most part in European

[183] Workshop discussions for the case study on non-conventional pigs in Italy highlighted an advanced initiative within an integrated cooperative system to promote the cultivation of legume crops for feed use by member farmers, for processing in a feed mill owned by the cooperative. Most of those member farmers are located in the southern plains of Lombardy region, an area that supplies feed materials to leading Italian GI production systems, including those of *Grana Padano* PDO cheese, and *Prosciutto di Parma* and *Prosciutto di San Daniele* PDO hams.

[184] https://www.donausoja.org/

[185] https://www.donausoja.org/agriculture/protein-partnership/ and https://www.donausoja.org/wp-content/uploads/2022/10/Protein_Partnership_Brochure_2022-1.pdf

countries outside the EU (Serbia, Croatia, Bosnia and Herzegovina, Moldova and Ukraine) through a combination of:

- knowledge transfer and farmer trainings on sustainable agricultural production approaches and techniques;
- support to quality management and standard implementation: Donau Soja covers the costs incurred by farmers and agricultural collectors to obtain the Donau Soja/Europe Soya certification, including those for the related analytical tests;
- activities for value chain building and market development, in the form of platforms aimed at improving market access for farmers.

Soya beans produced through the programme are certified non-GM, zero deforestation and land use change. The volume of soya beans produced in the framework of Donau Soja's protein partnerships has risen from 93.000 tonnes in 2020 to 500.000 tonnes in 2022.

Source: Consortium

Production standards and the related specifications often include requirements that have a direct or indirect influence on the organisation of the supply of feed materials and on the related arrangements.

Non-GM products of animal origin are covered by specific production standards in a number of Member States, including Austria, Czechia, France, Germany, Hungary, Italy, Poland, Slovenia. These standards are established through voluntary agreements among business operators[186] in the framework of national legislation on non-GM labelling (Box 29), and have evident implications on the supply of raw materials to feed manufacturers.

Box 29: Non-GM standards covering products of animal origin

The Association of Food without Genetic Engineering (*Verband Lebensmittel ohne Gentechnik - VLOG*) is a noteworthy example of voluntary standard governing non-GMO production in Germany. VLOG member businesses include farmers, processors, wholesalers and retailers, food and feed producers, trading companies, laboratories and certification bodies, as well as business associations. VLOG assigns the *VLOG geprüft* quality certification for animal feed. In principle, any feed manufacturer can market its products with the *VLOG geprüft* seal, provided that it meets the requirements of the VLOG standard (or any other standard recognised as equivalent by VLOG), and concludes a license agreement. To be eligible for the *VLOG geprüft* certification, feed manufacturers must credibly demonstrate that their products do not have to be labelled as "genetically modified" according to regulations (EC) No. 1829/2003 or No. 1830/2003. This requirement has straightforward implications for the supply of feed materials to manufacturers, since the GM free requirement clearly applies to those materials. Other noteworthy exemples of voluntary standards covering non-GMO feed production include: *Donau Soja* non-GM standards; *ARGE Gentechnik-frei* (Platform for GMO-free Food Production) standards in Austria; the non-GMO feed standard developed in Slovenia by *IKC Inštitut za kontrolo in certifikacijo UM*.

Source: Consortium

Nutrition-related requirements set out by processors and/or retail chains in their supply arrangements may have a more or less important influence on the organisation and functioning of the supply chains of manufactured feed intended for non-GM and organic animal farming: generally speaking, the stricter the requirements in terms of

[186] https://www.enga.org/non-gmo-production-in-europe

allowed feed materials[187], minimum/maximum inclusion rates of specific feed materials in the diets/formulas of manufactured feed, and quality parameters of feed materials, the more important the influence. Nutrition-related requirements set out by EU organic legislation are a key element determining the organisation and functioning of the supply chains of manufactured feed intended for organic animal farming. Finally, nutrition-related requirements in the relevant EU quality scheme legislation and in the specifications set out for individual PDO (especially) and PGI products have an extremely important influence on the organisation and functioning of the supply chains of manufactured feed used in these specific sub-segments.

Nutrition-related requirements applying in the non-conventional animal farming sub-segments (non-GM, organic, PDO/PGI) may shape and/or limit more or less substantially the **linkages with the supply chains of specific feed materials located in non-EU countries**, insofar a more or less sizable portion of the supply of these feed materials (e.g., GM soya bean products) does not comply with these requirements.

The main specificities in the organisation of the feed supply chains at cluster/sub-cluster level, as emerged from desk research, interviews and case studies, are reported in Table 35.

Table 35: Organisation of the feed supply chain: cluster/sub-cluster-specific aspects

Clusters / sub-clusters covered by the case studies*	Functioning mechanisms *(contractual arrangements, process/quality requirements, standards, etc.)*	Linkages with other supply chains *(within the EU / outside the EU)*
Pigmeat conv	In integrated systems, the entities coordinating the supply chain (processors, in most cases) are sometimes also involved in feed production and supply to pig farmers	Similar to other granivores (mainly poultry) with diets that are significantly based on oilseed products for which the EU is not self-sufficient, pig farming may have more or less tight linkages with the related supply chains in non-EU countries, also considering the specific nutrition-related requirements applying
Pigmeat NC	Out of 176 product specifications for **PDO/PGI** processed pigmeat analysed in Slow Food (2021), only two[188] (1.1% of total) included an explicit prohibition to use GM components in the diets of pigs for the entire length of the rearing cycle. This means that the inclusion of GM components (mostly derived from soya beans and maize) in the diet is implicitly allowed for the overwhelming majority of pigs reared for producing PDO/PGI processed pigmeat products across the EU. The product specifications of the two leading Italian PDO hams (*Prosciutto di Parma* and *Prosciutto di San Daniele*) include nutrition requirements in the form of a positive list of allowed feed materials, which specifies the maximum inclusion rates in the diet. The inclusion of a specific feed material (acorns) in the diets characterises two out of three product categories of Spanish *Iberico* PDO hams. Examples of successful initiatives aimed at promoting an expansion in the domestic supply of legume crops for feed use through contractualisation are rare in Italy, and basically absent in Spain.	
Dairy cattle conv	*No specificities of relevance for the assessment to highlight in the functioning mechanisms in place*	*No specificities of relevance for the assessment to highlight in existing linkages*
Dairy cattle NC	For the **organic** sub-segment, EU legislation establishes that GM and synthetic amino acids are banned, that feed must be 100% organic, and that at least 60% of raw feed materials must be sourced locally (on-farm or within the	*No specificities of relevance for the assessment to*

[187] Some of the consulted stakeholders reported about nutrition-related requirements that referred to extensive negative lists of prohibited feed materials.
[188] Jambon du Kintoa and Jambon de Bigorre (French PDO hams).

	region). Dairy cattle shall also have permanent access to pasture whenever conditions allow it. In Germany there are some examples of voluntary milk quality schemes aimed at extracting value from specific feeding requirements (e.g., pasture-based and/or non-GM dairy farming, use of local/regional feed materials only, etc.).	*highlight in the existing linkages*
Broiler conv	In integrated systems, the entities coordinating the supply chain (processors, in most cases) are often also involved in feed production and supply to poultry farmers, but there are exceptions (e.g., in Poland, where the leading processors are not involved in feed supply)	Similar to other granivores (mainly pigs) with diets that are significantly based on oilseed products for which the EU is not self-sufficient, poultry farming may have more or less tight linkages with the related supply chains in non-EU countries, also considering the specific nutrition-related requirements applying In the specific case of *laying hens*, this also applies for DDGS
Laying hens NC	There is only one **PGI** egg product in the EU: PGI *Oeuf de Loué* in France. According to the specifications, hens must be fed with at least 65% of regional cereals (INAO, 2006). As for the **organic** sub-segment, EU legislation establishes that GM and synthetic amino acids are banned, that feed must be 100% organic (derogations 95% possible young poultry), and that at least 30% of raw feed materials must be sourced locally (on-farm or within the region). In the French organic egg farming segment there are particular contracts between poultry farmers and feed manufacturers, called "3-0" contracts. The feed manufacturer sets the prices of pullets and of feed, and collects the eggs.	
Beef conv	*No specificities of relevance to the assessment to highlight in the functioning mechanisms in place*	*No specificities of relevance to the assessment to highlight in the existing linkages*
Beef NC	For the **organic** sub-segment, EU legislation establishes that at least 60 % of the dry matter in daily rations shall consist of roughage, fresh or dried fodder, or silage. This poses a limitation in the inclusion of manufactured concentrate feed in the diet. Product specifications for two leading Italian PGI fresh beef products (*Vitellone Bianco dell'Appennino Centrale* and *Vitelloni Piemontesi della coscia*) include restrictions to the use of specific feed materials, or indicate the specific feed materials that can be included in manufactured feed.	*No specificities of relevance to the assessment to highlight in the existing linkages*
Dairy goat conv	The level of horizontal and vertical integration/coordination along the chain appears to be limited	*No specificities of relevance to the assessment to highlight in the existing linkages*
Sheep meat conv	The level of horizontal and vertical integration/coordination along the chain appears to be limited	*No specificities of relevance to the assessment to highlight in the existing linkages*

Source: Consortium

* *conv = conventional / NC = non-conventional*

2.8.1.2 Organisation of the supply chains for animal products

Moving from the upstream stages to the downstream stages, the chains include (with some cluster/sub-cluster and/or country-specific peculiarities) the following typologies of core actors:

1. **Animal farmers**, which supply live animals, raw milk and eggs to operators in the downstream stages.
2. **Processors/packers**. Live animals are purchased by slaughterhouses/cutting plants; from there, they can undergo further processing into a wide range of more or less elaborated meat products. Raw milk is collected by the dairy sector for processing into a wide range of products and ingredients, from drinking milk to cheeses, from whey to caseins. Fresh eggs can be sorted and packed by specialised operators, or processed into a range of egg ingredients/products.
3. **Wholesalers**, which can act as intermediaries between processors/packers and retailers.
4. **Retailers**. The animal products of interest are sold to final consumers via different typologies of retail outlets.

The supply chains for animal products also include actors providing services, mainly **intermediaries** other than wholesalers (e.g., independent sales agents) and **providers of (cold) storage, handling and transportation services**.

The supply chains of **non-GM animal products** often have as "driving actor(s)" (including combinations of these three main typologies): i) a retail chain that has developed its own non-GM product line; ii) a processor that has opted for the same strategy; iii) a group of agricultural producers and/or processors that share a common vision and approach to product differentiation focusing on the non-GM segment. Some of the non-GM chains tend to have a local dimension, whereas other chains may involve multiple Member States and even non-EU countries. The overall structure and the "driving actors" of the supply chains of **organic animal products** are in many respects similar to those of the non-GM sub-segment.

Broadly speaking, the supply chains of **PGI animal products** tend to concern wider geographical areas (which may include also non-EU countries) and a higher number of animal farmers than those of **PDO animal products**, where the sourcing of live animals or raw milk can take place only within a more or less limited geographical area of the concerned Member State, which is precisely defined by the relative product specifications.

The most noteworthy differences among clusters/sub-clusters can be observed in terms of **organisation and functioning** of the chains (markets, vertical coordination/integration, etc.).

As for **functioning mechanisms**, generally speaking the requirements set out by retail chains in their supply arrangements emerged as a key element in the organisation and functioning of non-GM and organic supply chains for meat, dairy products and eggs. SQ 1 (Section 2.1) revealed that these requirements are often shaped by the perceptions that retailers have about consumption trends, consumer preferences and public opinion, and by the retailers' strategic priorities. These requirements may also be linked to such themes as health and nutrition, animal welfare, environment conservation and climate change. Generally speaking, interviews and case studies revealed that the requirements set out by retail chains in their arrangements with suppliers of animal products may impact the feeding strategies both directly and indirectly:

- Retailers may include in their supply specifications requirements explicitly concerning animal feeding, in the form of positive or negative lists of allowed/not allowed feed materials, of exclusive use of non-GM and/or deforestation free feed materials[189], etc. (direct impact).

- Retailers may establish requirements concerning the organoleptic features and/or specific quality parameters of the products that imply the use of specific feeding practices/feed materials, and/or that rule out the use of other ones (indirect impact)[190].

The organisation and functioning of the supply chains for PDO/PGI meat products are shaped and regulated by the relevant EU legislation and by the specifications set out for individual products. Besides the explicit nutrition requirements included in the product specifications for PDO products of animal origin, which were discussed in the previous section, PGI product specifications, even in the absence of explicit nutrition requirements, may include requirements concerning the organoleptic features and/or specific quality parameters of the products that can only be met through the use of certain feeding practices/feed materials, and/or that make the use of other practices/materials impossible[191].

The main specificities in the organisation of the supply chains for animal products at cluster/sub-cluster level, as emerged from desk research, interviews and case studies, are reported in Table 36.

Table 36: Organisation of the supply chains for animal products: cluster/sub-cluster-specific aspects (* *conv = conventional / NC = non-conventional*)

Clusters / sub-clusters covered by the case studies*	Organisation *(markets, vertical coordination/integration, etc.)*
Pigmeat conv	The bulk of EU pigmeat production is obtained either in fully integrated systems (control by a single entity over pig farming, slaughtering and sometimes also further processing into consumer products), or in systems that are coordinated by processors. The control of processors over the supply chain derives from a relatively high techno-economic concentration in the processing stage: in 2021, 30 companies slaughtering more than 1.5 million heads each accounted for over 56% of the total number of pigs slaughtered in the EU-27 (IFIP, 2022).
Pigmeat NC	Forms of horizontal (consortia of producers) and vertical integration/coordination in the farming and processing stages are rather common in the supply chains of many PDO/PGI pigmeat products. These include a number of fully integrated systems (some of them are agribusiness cooperatives) where the leading operator controls all/most of the stages of the production process, from the breeding of piglets to the marketing of the final products. Outside the vertically integrated systems, contractual arrangements for the supply of pigs for slaughter between individual pig farmers (or their organisations, including cooperatives) and processors seem to prevail over purchases of live animals on the spot market, also considering that pigs for PDO production must meet more or less extensive requirements, including in terms of nutrition.
Dairy cattle conv	In the EU dairy sector, cooperatives have an important market share, owing partly to the perishable nature of the product, which entails high transaction costs in trading, and also to the instability of markets. In 2015, about 64 % of all European cow's milk deliveries

[189] The 2020 edition of IDH European Soy Monitor reports information on some noteworthy initiatives for sustainable soya sourcing that are promoted or supported by EU retailers. The *Retail Soy Group (RSG)* was founded in 2013 by seven leading European retailers; it now counts 13 member companies. The *Danish Alliance for Responsible Soy* was founded in 2019: its membership includes some of the country's largest retailers (COOP, Salling Group, Dagrofa, REMA 1000, Lidl, Aldi). In Germany, the initiative *Forum Nachhaltigere Eiweissfuttermittel* (Forum on More Sustainable Protein Feeds), coordinated by the Federal Office for Agriculture and Food (BLE), aims to reach 100% certified soya bean use in animal feed. The forum members, which include a number of retailers, have issued individual statements with different levels of soya-related commitments. The *Swedish Soy Dialogue* was launched in 2014: it is a multi-industry network (also backed by the retailing sector) that aims at ensuring that all the soya that reaches Swedish consumers through its members' supply chains is responsibly produced by 2025.

[190] In the framework of this study, it was not possible to identify concrete examples of similar requirements actually promoted by EU retailers.

[191] In the framework of this study, it was not possible to identify concrete examples of such requirements in existing PGI product specifications.

Dairy cattle NC	were handled by cooperatives. Dairy cooperatives are a specific form of producer organisation (PO) often engaging in processing activities (Augère-Granier, 2018).
Broilers conv	The bulk of EU broiler meat production is obtained either in fully integrated systems (control by a single entity over poultry farming, slaughtering and sometimes also further processing into consumer products), or in systems that are coordinated by processors. In the EU there are large transnational companies operating upstream and downstream of the poultry farming level (managing hatcheries, feed mills, slaughterhouses, and processing facilities). They can negotiate contracts directly with individual farmers or with their organisations.
Laying hens NC	The bulk of the EU production of packed eggs and egg products is obtained either in fully integrated systems (control by a single entity over hen farming, fresh egg collection and selection, packing and – where relevant – processing), or in systems that are coordinated by packers/processors. In the EU there are large transnational companies operating upstream and downstream of the hen farming level (managing feed mills as well as packing and processing facilities).
Beef conv **Beef NC**	Beef and veal production in the EU is closely interlinked to the dairy one: since a substantial share of dairy cows are slaughtered to produce meat and two thirds of the EU cow herd is of the dairy type, changes in the herd structure have an impact on beef supply. There are ten recognised interbranch organisations (IBOs) in the mainland EU beef and veal sector: five in France, two in Spain, and one each in Belgium, Greece and the Netherlands[192].
Dairy goat conv	There are significant differences in the organisation of the goat milk supply chain across EU MS. The most advanced forms of organisation, based on the cooperative model, are found in France and Spain.
Sheep meat conv	There is scarce information about the EU sheep products' supply chain structure. Generally speaking, sheep meat production in the EU presents a lack of structured supply chain organisational patterns.

Source: Consortium

2.8.2 Assessing the consequences of replacement scenarios on the organisation of the supply chains

This step involves the actual assessment of the different impacts related to one or more replacement scenarios on the organisation of each supply chain of interest. The main impacts are analysed separately for the feed supply chains (i.e., up to marketing of manufactured feed) and the animal products supply chains (i.e., up to marketing of meat, dairy products, eggs). To the extent possible, elements concerning public perception or social impacts are also taken into account, where relevant. The replacement scenarios considered in the assessment are those that have emerged as the desirable ones from an economic viability/competitiveness standpoint (see the replies to SQ6 – Section 2.6 - and SQ7 – Section 2.7). Additional elements for the assessment are drawn from the modelling exercise, in particular to draw some conclusions on changes (e.g., in input or output volumes, or in the economic viability of operators) that may, or may not, lead to changes in the organisation of the supply chains of interest (e.g., with regard to contractual arrangements, reorientation of material flows, etc.). However, the bulk of the elements for the assessment comes from desk research and from interviews with sectoral experts and stakeholders, who were asked to identify (and, possibly, to define quali-quantitatively) the key changes in terms of supply chain organisation that would derive from the relevant replacement scenarios.

2.8.2.1 Consequences on the organisation of the feed supply chain

The most significant implications of the suggested strategies on the **linkages with other supply chains** (within the EU and/or outside the EU) that emerged from the assessment are the following:

- All the suggested strategies that allow significant to substantial **reductions in the use of soya bean products** (meal in particular) clearly imply **less strong**

192 DG Agriculture and Rural Development – List of recognised IBOs: https://agriculture.ec.europa.eu/document/download/d7fd1da9-6f78-4dea-8813-b25baefc6963_en?filename=recognised-ibos_en.pdf

linkages with the supply chains of these products in third countries, due to reduction of imported volumes.
- In the specific case of **conventional broiler meat**, the suggested strategy based on the use of industrial amino acids would imply – in the absence of an expansion in the EU production capacity – even **stronger linkages with the suppliers of industrial amino acids in China, South Korea and the United States**.

Besides the ones highlighted above, the **significant organisational implications** of the suggested scenarios that emerged from the assessment are rather few, and concern the **"soft" elements of supply chain organisation** (such as internal organisation/operational procedures of operators, vertical coordination/integration, contractual arrangements, process/quality requirements, standards, etc.). In this regard, it should be considered that the surveyed feed manufacturers attach rather limited importance to contractualization of the supply of agricultural raw materials as a driver for increasing the use of EU-grown raw materials, especially if compared to such drivers as the price of raw materials, or the granting of subsidies to compensate for competition from imported raw materials (see SQ3, Section 2.3). Only the scenarios characterised by significant organisational implications are considered in Table 37.

Table 37: Consequences on the organisation of the feed supply chain by replacement scenario

Sub-clusters* - *scenario*	**Organisation** *(internal organisation/operational procedures, vertical coordination/integration, etc.)*	**Functioning mechanisms** *(contractual arrangements, process/quality requirements, standards, etc.)*[193]
Pigmeat conv – *Legume seeds*	Due to the small quantities of legume seeds often involved, collectors may be unwilling to make the silos designed for larger quantities available. The small quantities of legume seeds that are grown are hence primarily fed on farms or sold to nearby farms that use them as feed. On-farm feeding of legume seeds or trading between neighbouring farms requires livestock farms to have a mixing facility An additional step in the process, toasting of legume seeds, is needed to address the issue of anti-nutritional factors	Contractual arrangements between arable crop farmers and/or their organisations, and feed manufacturers would be needed to incentivise an expansion in the cultivation of legume seeds for feed use. Due to the importance of ensuring attractive enough prices to farmers that are also economically sustainable for feed manufacturers, price-setting mechanisms should be the key element of the arrangements. Additional incentives, in the form of coupled subsidies to farmers, will probably be needed to promote expansion on a large scale.
Dairy cattle conv - *Increase roughage share and improve grassland quality*	The switch from silage maize to meadows entails significant operational challenges and organisational adaptations, mostly related to: • harvesting: concentrated in a relatively short period for silage maize, spread over a much longer period for meadows;	An organisational solution that could contribute to a wider uptake of the strategy is promoting exchanges between arable crop farmers and livestock farmers. The development of online exchange platforms allowing rapid and reliable contracting between the parties, also ensuring a minimum of guarantees, seems to be an organisational approach worth considering.

[193] For all the sub-clusters, and in particular for the ones where no specific organisational implications of the analysed scenarios emerged from the assessment, it is worth noticing that, based on the findings of DG AGRI's pilot project "*Establishing an operational programme: structuring the agri-food sectors to safeguard the handing-on of family farms and the sustainability of local agriculture*", the extension of Operational Programmes to the concerned sectors pursuant to Regulation (EU) 2021/2115 could contribute to the implementation of the suggested feed diversification strategies.

	• post-harvest handling: field drying implies additional operational challenges; • storage: silage maize is much easier to store, and ensures availability of more palatable fodder in winter months.	
Dairy cattle conv - *Increased production of soya beans and protein crops + increased availability of HP+ sunflower meal*		Contractual arrangements between arable crop farmers and/or their organisations, and feed manufacturers, in combination with financial support from subsidies, would be needed to incentivise an expansion in protein crop cultivation
Broiler conv – *Legume seeds*	The use of faba beans can require an additional operation, i.e., dehulling	Contractual arrangements between arable crop farmers and/or their organisations, and feed manufacturers, in combination with financial support from subsidies, would be needed to incentivise an expansion in the cultivation of legume seeds for feed use
Beef conv - *Improved grass share and grass quality of the ration*	In intensive fattening systems that rely heavily on silage maize, substantial adaptations would be needed to implement the strategy, mostly concerning: • harvesting: concentrated in a relatively short period for silage maize, spread over a much longer period for meadows; • storage: silage maize can easily be stored, differently from fresh grass; • feeding: silage maize is more suited to the "unifeed" technique, which is widespread in intensive fattening systems	*No specific organisational implications emerged from the assessment; potential contribution of Operational Programmes to the implementation of the suggested feed diversification strategies*
Beef NC – *Increased inclusion of dried alfalfa*	Increased inclusion of dried alfalfa in the diets entails significant operational challenges and organisational adaptations in intensive fattening systems that rely heavily on silage maize, mostly related to: • harvesting: concentrated in a relatively short period for silage maize, organised around multiple (3-5) mowing windows for alfalfa; • post-harvest handling: field drying implies additional operational challenges; • storage: silage maize is much easier to store, and ensures availability of more palatable fodder in winter months.	*No specific organisational implications emerged from the assessment; potential contribution of Operational Programmes to the implementation of the suggested feed diversification strategies*
Sheep meat conv – *Inclusion of dried alfalfa*	In the arid regions of the Mediterranean area, the cultivation of alfalfa requires irrigation, which implies significant operational and organisational challenges	*No specific organisational implications emerged from the assessment; potential contribution of Operational Programmes to the implementation of*

		the suggested feed diversification strategies
Dairy goat conv - *Increased protein input through grass-based roughage*		*No specific organisational implications emerged from the assessment; potential contribution of Operational Programmes to the implementation of the suggested feed diversification strategies*

* conv = conventional / NC = non-conventional

Source: Consortium

2.8.2.2 Consequences on the organisation of the supply chains for animal products

Very few elements emerged with regard to possible organisational implications of the strategies suggested under SQ7 for the supply chains of animal products (i.e., the downstream stages up to retailing and final consumption). In most cases, the assessment revealed no concrete effects related to the theoretically relevant implications.

The only significant concrete effects were found to be related to **changes in the quality parameters/organoleptic features of animal products** that can require adaptations in the **organisation of the retailing stage** - with particular regard to **marketing practices** - for **animal products <u>intended for final consumption</u>**, in particular **meat** and **eggs**. In the case of **non-conventional beef** production, several consulted stakeholders underlined that increasing the content of dried alfalfa in the diet would determine changes in the organoleptic quality of meat (darker colour, yellowish fat) that are not in line with the currently prevailing consumer tastes. For that reason, the consulted stakeholders deemed that innovative marketing strategies and communication efforts would probably be needed to successfully market beef meat with such organoleptic features. By contrast, in the case of **sheep meat**, the consulted stakeholders generally deemed that the suggested strategies - both focused on the forage component of the diet – would lead to an improvement of the quality of sheep meat, which implies that no adaptation of marketing practices would be needed. The assessment did not reveal any significant effects of the suggested feeding strategies on the quality of pigmeat, broiler meat and eggs.

As for possible adaptations in the **organisation of the processing stage** for **animal products <u>used as ingredients</u>**, in particular **raw milk** and **eggs**, the assessment did not reveal any significant concrete effects stemming from the suggested/considered feeding strategies for: i) raw milk from conventional and non-conventional dairy farming, and from dairy goat farming; ii) eggs used as ingredient.

2.8.2.3 Consequences on public perception and social impacts

The only significant implications on such aspects as **public perception and social impacts** were highlighted with regard to **feeding strategies including insect meals and/or protein sources of animal origin**. Several consulted stakeholders observed that the **attitude of consumers** of animal products towards these protein sources used as feed is generally **unfavourable**, with the partial exception of insect meals fed to poultry, since insects are rather widely perceived as being part of the "natural" diet of poultry. That said, it should be underlined that no feeding strategies based on the inclusion of insect meals or animal proteins were selected as suggested ones in SQ7, so this specific issue was not explored further in the assessment.

2.8.3 Main findings

2.8.3.1 Feed supply chain

The study team could collect rather scarce evidence on the **contractual arrangements between feed manufacturers and their suppliers of raw materials**[194], mainly because these arrangements are confidential. Nevertheless, the available elements suggest that:

- **Pricing mechanisms are the core element**, especially where domestic price dynamics are influenced by global ones (this is the case for the three major oilseeds, soya in particular): in this case, pricing mechanisms tend to be adjusted more frequently, and may combine a fixed component with a variable one, which may be linked to futures markets (where these exist and are liquid enough)[195].
- **Requirements concerning product features and quality parameters** (e.g., crude protein content) that determine the suitability and the economic value of agricultural products for use as ingredients in manufactured feed are **also important**.

The influence of **nutrition-related requirements** set out by processors and/or retail chains in their supply arrangements on the **organisation and functioning of the supply chains** of manufactured feed intended for non-GM and organic animal farming depends on the **strictness of the requirements**: generally speaking, the stricter the requirements in terms of allowed feed materials[196], minimum/maximum inclusion rates of specific feed materials in the diets/formulas of manufactured feed, and quality parameters of feed materials, the more important the influence. Nutrition-related requirements set out by EU organic legislation are a key element determining the organisation and functioning of the supply chains of manufactured feed intended for organic animal farming. Finally, nutrition-related requirements in the relevant EU quality schemes legislation and in the specifications set out for individual PDO (especially) and PGI products have an extremely important influence on the organisation and functioning of the supply chains of manufactured feed used in these specific sub-segments.

The **significant organisational implications of the suggested scenarios** that emerged from the assessment are **rather few**[197], and concern the **"soft" elements of supply chain organisation**, such as internal organisation/operational procedures of operators, vertical coordination/integration, contractual arrangements, process/quality requirements, standards, etc.

2.8.3.2 Supply chains for animal products

With regard to **functioning mechanisms**, generally speaking the requirements set out by retail chains in their supply arrangements emerged as a key element in the organisation and functioning of non-GM and organic supply chains for meat, dairy products and eggs. The requirements set out by retailers may impact the feeding strategies both directly and indirectly:

Retailers may include in their supply specifications requirements explicitly concerning animal feeding, in the form of positive or negative lists of allowed/not allowed feed materials, of exclusive use of non-GM and/or deforestation free feed materials, etc. (direct impact).

- Retailers may establish requirements concerning the organoleptic features and/or specific quality parameters of the products that imply the use of specific

[194] i.e., individual arable crop farmers and their organisations, industrial processors (oilseed crushers, distillers, starch producers, beet sugar producers, etc.) and traders (for imported feed materials).

[195] Linkages of pricing formulas with futures markets also allow the application of hedging techniques by the operators that have the necessary expertise.

[196] Some of the consulted stakeholders reported about nutrition-related requirements that referred to extensive negative lists of prohibited feed materials.

[197] In this regard, it should be considered that the surveyed feed manufacturers attach rather limited importance to contractualization of the supply of agricultural raw materials as a driver for increasing the use of EU-grown raw materials (see SQ3, Section 2.3).

feeding practices/feed materials, and/or that rule out the use of other ones (indirect impact).

- The organisation and functioning of the **supply chains for PDO/PGI meat products** are shaped and regulated by the relevant EU quality scheme legislation and by the specifications set out for individual products. Besides the explicit nutrition requirements included in the product specifications for PDO products of animal origin, PGI product specifications - even in the absence of explicit nutrition requirements - may include requirements concerning the organoleptic features and/or specific quality parameters of the products that can only be met through the use of certain feeding practices/feed materials, and/or that make the use of other practices/materials impossible.

The potentially significant **organisational implications of the suggested scenarios** identified under SQ7 (Section 2.7) are related to **changes in the quality parameters/organoleptic features of animal products** that can require:

1. Adaptations in the **organisation of the processing stage** for **animal products used as ingredients**, in particular **raw milk** and **eggs**. However, no significant practical effects in this regard emerged from the assessment: this suggests that these organisational implications are probably limited or negligible.

2. Adaptations in the **organisation of the retailing stage** - with particular regard to **marketing practices** - for **animal products intended for final consumption**, **meat**[198] in particular. By contrast, the assessment did not reveal any significant effects of the suggested feeding strategies on the quality of pigmeat, broiler meat and eggs, which suggests that the concerned organisational implications are likely to be limited or negligible.

[198] In the case of non-conventional beef production, several consulted stakeholders underlined that increasing the content of dried alfalfa in the diet would determine changes in the organoleptic quality of meat (darker colour, yellowish fat) that are not in line with the currently prevailing consumer tastes. For that reason, the consulted stakeholders deemed that innovative marketing strategies and communication efforts would probably be needed to successfully market beef meat with such organoleptic features.

2.9 SQ9: How could supply chains for both, feed types and the animal product(s), be improved to facilitate diversification of feed sources?

2.9.1 Approach to the assessment and main limitations

The approach to the assessment was based on two analytical steps:

1. the identification of the main potential areas for improvement of supply chains to facilitate the diversification of feed sources;
2. The collection of ideas for improvement through the consultation of stakeholders and independent experts.

The main potential areas for the improvement were defined:

- with regard to the supply chains considered in SQ8 (see Section 2.8), i.e., the feed supply chain and the supply chains for animal products;
- with regard to the following key aspects:
  - supply chain structure (number and size of operators, geographical distribution, etc.);
  - supply chain organisation (markets, vertical coordination/integration, etc.);
  - supply chain functioning mechanisms (contractual arrangements, process/quality requirements, standards, etc.);
  - linkages with other supply chains (within the EU / outside the EU);
  - use of CAP measures, focusing on the ones that are relevant for improving the organisation of supply chains (policy instruments that can facilitate feed diversification are analysed under SQ10 in Section 2.10).

The main potential areas for improvement were identified based on the findings of SQ8 and of inputs from stakeholder consultation through surveys, interviews (at EU and case study level) and workshops held for case studies. The consultation was targeted at: i) supply chain stakeholders; ii) non-business stakeholders (EU institutions and national/regional competent authorities; consumer associations) and independent experts (consultants and academics).

The **collection of ideas for improvement** was also made through the consultation of the stakeholders and independent experts indicated above. Few among the consulted stakeholders did put forward detailed operational suggestions on how to improve the supply chains (of feed and of animal products) to facilitate diversification of feed sources; most of the consulted stakeholders only put forward general suggestions, without any reference to concrete cases of successful application of the same. This can also be related to rather widespread scepticism – which emerged especially among the consulted business stakeholders – about the relevance and effectiveness of organisational solutions to address such issues as poor/unknown nutritional performance and/or lack of economic competitiveness of alternative feed materials vis-à-vis traditional ones. In any case, the **scarcity of detailed and concrete suggestions for improvement** from the consulted stakeholders and experts constitutes a **significant limitation** in terms of depth of the assessment under SQ9.

2.9.2 Areas for improvement and ideas for improvement

Generally speaking, the consulted stakeholders identified the **main potential areas for improvement** with regard to the **"soft" elements of the supply chains**, i.e. (in decreasing order of preference), their organisation, the use of CAP measures to improve such organisation, and, especially among business stakeholders, their linkages with other supply chains. This can be related to the fact that these "soft" elements are easier to modify/implement through the coordinated action of the concerned actors. By contrast, the consulted stakeholders identified more limited room for improvement with regard to the structure of the supply chains (number of actors, geographical distribution), which is a "hard" element that usually evolves under the influence of many external factors, in the context of processes that need time to take place. The clusters centred on pigmeat, poultry meat and eggs were most frequently linked with a high or medium potential for supply chain improvement to facilitate diversification of feed sources by the surveyed stakeholders (NCAs and business operators in the downstream stages of supply chains). By contrast, these stakeholders saw low potential for supply chain improvement in the clusters centred on dairy goats, sheep meat and ewe's milk. However, a significant minority position also emerged, where some stakeholders considered that the organisation of the pigmeat, poultry meat and egg supply chains, which is generally characterised by high levels of integration/coordination, is already very advanced, and there is hence limited room for its further improvement to facilitate diversification of feed sources. Finally, some of the consulted stakeholders deemed that the organisation of the dairy goats, sheep meat and ewe's milk supply chains, which is currently characterised by a limited presence of horizontal and vertical coordination forms, presents significant potential for improvement from an organisational standpoint.

The following synoptic tables present the main potential areas for improvement, and the related ideas for improvement, in the organisation of the feed supply chain (Table 38) and of the supply chains for animal products (Table 39). Some noteworthy concrete examples of improvement are presented in dedicated boxes. It is important to underline that CAP measures providing a direct support to the production of alternative and innovative feed materials are discussed in SQ10 (Section 2.10).

Box 30 provides a focus on the ideas for improvement put forward by the consulted non-business stakeholders: EU institutions and national/regional competent authorities; consumer associations; consultants and academics.

Table 38: Areas for improvement and ideas for improvement in the organisation of the feed supply chain

Areas for improvement	Ideas for improvement
Organisational solutions aimed at promoting **increased supply of alternative**[199] **feed materials** and/or **commercial production of innovative feed materials**.	**Stronger coordination along the chain** is seen by a number of stakeholders as a solution that can improve the overall efficiency of the supply chains of alternative feed materials, reducing transaction costs and ultimately incentivising additional operators to start their production. *Donau Soja*'s protein partnership programme, together with the multi-stakeholder initiatives for the development of sustainable soya supply chains[200] that were presented under SQ8 (Section 2.8.1.1), represent successful examples of approaches aimed at strengthening the coordination along the chain, starting from suppliers of feed materials up to retail distribution of animal products. Among the few consulted stakeholders that elaborated further on this concept, a preference emerged for strengthening the organisation through collective processes involving all the relevant stakeholders. Besides the initiatives mentioned above, this kind of collective processes typically take place within the consortia for PDO and PGI animal products, with the involvement of other actors, in particular researchers and competent authorities. However, several stakeholders observed that when the performance of alternative feed materials is clearly inferior - nutrition-wise - when compared to established feed materials that the EU needs to import (typically, soya bean products), and/or when their cost is much higher than the cost of established feed materials, organisational solutions like stronger supply chain coordination cannot do much to close the gap[201].
	The **setting up of contractual arrangements** was also indicated as a solution showing some potential in terms of: i) promoting increased production of alternative feed materials; ii) establishing a techno-economic framework for developing commercial production of innovative feed materials. Contractualization of legume crops was explicitly proposed as an alternative scenario in a number of case studies, and its impacts were modelled and discussed in some of them. Business stakeholders showed mixed interest for the solution, partly because the nutrition performance of legume crops as alternatives to soya bean products is often unsatisfactory, partly because of economic considerations (the inclusion of various typologies of legumes in the diet could only be made at prices that would not provide a sufficient incentive for their large-scale cultivation). Some stakeholders observed that contractual arrangements alone are not enough to overcome issues deriving from poor performance and/or lack of economic sustainability in the use of legume crops as feed materials. Based on the study team's expertise, the granting of **subsidies for transportation and/or storage** of these raw materials might - in theory - help the development of their domestic supply through contractualization. However, most of the consulted business stakeholders did not mention any need for this kind of subsidies, and some of them were rather sceptical about their actual effectiveness. As for concrete examples of grain transportation subsidies, the Russian Federation has been applying them extensively[202], mainly in the form of refunds to railway companies transporting grain at subsidised rates between specific origins and destinations. These subsidies raised questions within the WTO, with several members raising concerns about their export-oriented nature. Canada[203] also has a long history of subsidised grain transportation schemes, which over time have included different forms of direct and indirect delivery mechanisms (e.g., government-controlled rail freight rates for grains, subsidies to railway companies to keep in operation loss-making rural branch lines that were of critical importance to grain shippers, etc.). Generally speaking, subsidised grain transportation schemes are

[199] By "alternative feed materials" we refer here to feed materials that are less used than mainstream ones (e.g., the three main oilseed products, or cereals such as maize), and whose production in the EU is still limited.

[200] E.g., the *Retail Soy Group (RSG)*, the *Danish Alliance for Responsible Soy*, the German initiative *Forum Nachhaltigere Eiweissfuttermittel* (Forum on More Sustainable Protein Feeds), coordinated by the Federal Office for Agriculture and Food (BLE), and the *Swedish Soy Dialogue*.

[201] It is also worth highlighting that the surveyed feed manufacturers attach rather limited importance to contractualization of the supply of agricultural raw materials as a driver for increasing the use of EU-grown raw materials (see SQ3, Section 2.3).

[202] See on the topic: Global Trade Alert – *Russian Federation: Transportation Subsidy to Grain Producers – 2019*.

[203] See on the topic: Earl, P.D, Prentice, B.E. (2016), *Western Grain Exceptionalism: transportation policy change since 1968*, Canadian Transportation Research Forum; PricewaterhouseCoopers Consulting (Australia) Pty Limited (2017), *Technology and Supply Chains for Critical Industries - Agriculture sector* (Working paper 2 of 3) - *Appendix B: Western Canadian Grain Export Supply Chain*.

Areas for improvement	Ideas for improvement
	characterised by remarkable complexity in terms of both design and management, and have traditionally raised questions concerning their distortive effects on competition.
	The **elaboration of process/product specifications** was seen by some stakeholders as a way to help the development of commercial production of innovative feed materials, and/or of alternative feed materials that currently see limited production and use. The underlying reasoning is that specifications provide certainty and clarity to both suppliers and customers with regard to the production process and the properties of the products. Also in this case, some stakeholders observed that the main issues with innovative feed materials derive from their poor (or unknown) performance in terms of nutrition, and/or from their still non-competitive cost: these problems cannot clearly be overcome through the sole elaboration of process/product specifications. An interesting concrete example of revised product specifications that should promote increased feed diversification[204] emerged from the case study on non-conventional pigmeat production: it concerns one of the leading PDO hams in Italy, *Prosciutto di Parma*[205], and is presented in more detail in Box 30.
Organisational solutions aimed at promoting **increased use of alternative feed materials** and/or at **allowing the use of innovative feed materials**[206]	The most interesting idea put forward by the consulted stakeholders focused on the **revision of nutrition-related requirements in existing product/process specifications and quality standards concerning the final products**, to allow for increased use of alternative feed materials and/or for the use of innovative feed materials. This idea concerns the downstream stages of the chain (where most of the process/product specifications and quality standards are devised), and is hence discussed in Table 39.
Promoting research and development of innovative feed materials, and/or research aimed at improving the capacity of farmed animals to exploit alternative/innovative feed materials.	Several of the consulted stakeholders attached great importance to **research and development (R&D)** as an essential preliminary step in the scaling-up of production and use of alternative/innovative feed materials. Besides R&D focusing on the development of genetically improved arable crops for feed use (such as high-protein rapeseed), also R&D aimed at improving the capacity of farmed animals to exploit alternative/innovative feed materials was deemed of paramount importance. Most of the consulted stakeholders generically mentioned the need for "public support" to R&D activities, but a few referred to specific instruments available in the CAP (in particular the ***European Innovation Partnership for agricultural productivity and sustainability*** at Article 127 of Regulation (EU) 2021/2115), and/or to other EU policy instruments promoting R&D (in particular the new EU research programme ***Horizon Europe***[207]).
CAP measures aimed at **strengthening the**	Some of the consulted stakeholders also mentioned the need for "public support" to:

[204] It is important to consider that nutrition requirements in quality schemes may also discourage the use of alternative protein sources. For instance, according to the study team's experience, the obligation established by the French *Label Rouge* scheme to incorporate in the diets a minimum rate of cereals and protein crops promotes the use of soymeal, rather than of alternative protein sources.

[205] Adjustments of this kind are easier to introduce in the product specifications of high-value-added animal products, where possible increases in feed cost due to revised requirements can better be absorbed thanks to higher retail prices.

[206] The focus is especially on the revision of existing product/process specifications and quality standards, with special regard to those concerning the final products, in particular as far as the requirements for animal nutrition that they establish are concerned. PDO product specifications, which often have rather restrictive nutrition requirements (aimed at preserving product quality and typicity), were identified by the consulted stakeholders as the main candidates for such a revision, also because the definition of product specifications is the result of a collective process that involves business operators, researchers and competent authorities. Voluntary quality standards (like, e.g., the set of standards for beef and eggs within the *Sistema di Qualità Nazionale zootecnia* in Italy), which are defined through collective processes that are similar to those for PDO/PGI products, including in terms of involved actors, were also identified by some stakeholders as interesting candidates for a revision. By contrast, specifications and standards imposed by retailers or processors on their suppliers were not seen as promising candidates for a revision, even less so under the influence of external entities/factors. In any case, these specifications and standards concern the downstream parts of the chain, and are hence treated in Table 2.

[207] https://ec.europa.eu/info/research-and-innovation/funding/funding-opportunities/funding-programmes-and-open-calls/horizon-europe_en

Areas for improvement	Ideas for improvement
organisation of feed supply chains and/or at **promoting cooperation and coordination** within those chains, such as those included in the CAP 2023/27 (Regulation (EU) 2021/2115).	i) strengthen the organisation of the supply chains of alternative/innovative feed materials, with particular regard to legumes for feed use, and to feed materials currently not covered by the CAP (e.g., algae); ii) promote the development of cooperation and coordination forms in those supply chains. Whereas most of the consulted stakeholders only made generic statements in that regard, a few referred to specific CAP measures established by Regulation (EU) 2021/2115, and in particular to: i) the possible extension of financial support to recognised Producer Organisations (POs) through the tool of **Operational Programmes** (Ops) to "**other sectors**"[208], including the protein crops sector (Articles 42, 46, 47, 66, 67, 68); ii) **support to cooperation** in the framework of interventions for **Rural Development** (Article 77).
Organisational solutions to improve the **links between the feed supply chain and other supply chains** (also outside the EU), with a view to **promoting increased availability**: 1. of feed materials meeting **special requirements** and/or destined to specific **non-conventional segments** (e.g., non-GM); 2. of innovative feed materials deriving from **non-agricultural supply chains**.	Some of the consulted stakeholders deemed that the following organisational solutions have some potential for improving the linkages of the feed supply chain with other supply chains, both within and outside the EU: • the development of **coordination forms**, in particular between EU feed manufacturers and EU and non-EU suppliers of non-agricultural feed materials (e.g., those deriving from biobased processes, or former food products (FFPs); • the setting up of **contractual arrangements** between EU feed manufacturers and: i) non-EU suppliers of feed materials; ii) EU and non-EU suppliers of non-agricultural feed materials; • the development and fine-tuning of **process/product specifications**. In particular, the linkages with the following supply chains were mentioned: • the non-EU part of the supply chains of feed materials intended for specific non-conventional segments (non-GM, organic) and/or meeting specific requirements ("sustainable/responsible" feed materials in particular); • the supply chains of innovative non-agricultural feed materials (e.g., those deriving from biobased processes, or former food products (FFPs)). The underlying rationale is based on the improvement of the overall efficiency of the interlinked supply chains, in the reduction of transaction costs, and in ensuring certainty and clarity on the production processes and the properties of products to both suppliers and customers: the combination of these elements would contribute to incentivise additional operators to participate in the interlinked chains, both in the EU and in third countries.

Source: Consortium

Table 39: Areas for improvement and ideas for improvement in the organisation of the supply chains for animal products

Areas for improvement	Ideas for improvement
Development of organisational solutions aimed at **improving the competitiveness** of the supply chains for animal products, with a view to ensuring the **economic conditions that would allow (increased) use of costlier alternative/innovative feed materials**. This includes support to	The reasoning developed by some of the consulted stakeholders is that organisational solutions aimed at improving the competitiveness of the supply chains for animal products (e.g., through strengthened coordination/vertical integration along the chain, contractual arrangements to reduce transaction costs, setting up of quality schemes to extract a price premium, etc.) would contribute to ensuring **economic conditions that would allow (increased) use of costlier alternative/innovative feed materials**, thanks to the reduction of other cost components and/or to more remunerative prices for the final products. However, other stakeholders questioned the feasibility of this approach wherever the cost disadvantage of alternative/innovative feed materials is substantial, and also in market conditions similar to the current

[208] i.e., sectors other than fresh and processed fruit and vegetables, wine, apiculture, hops and olive oil and table olives.

Areas for improvement	**Ideas for improvement**
livestock farmers for implementing and managing changes in production practices.	ones, characterised by reduced purchasing power of consumers, with adverse impacts on the marketing of "premium" animal products (including those in the organic and non-GM segments).
Revision of nutrition-related requirements in existing product/process specifications and quality standards concerning the final products, to allow for increased use of alternative feed materials and/or for the use of innovative feed materials.	Several supply chain stakeholders deemed that a revision of nutrition-related requirements in product/process specifications and quality standards for animal products could have a significant potential in terms of promoting increased use of alternative feed materials and/or the use of innovative feed materials. This would be especially true wherever nutrition-related requirements: i) restrict significantly the range of feed materials allowed in the diets, by allowing a relatively limited selection of "established/traditional" feed materials, and/or by explicitly prohibiting a more or less extensive selection of alternative/innovative feed materials; ii) limit significantly the quantity of alternative/innovative feed materials that can be included in the daily rations. The situations outlined above can often be found: i) in **PDO product specifications**[209] (much less so in PGI product specifications, which tend to have looser nutrition-related requirements, or no nutrition-related requirements at all); ii) in the specifications of **non-GM and "sustainability-oriented" products**; iii) in **private quality standards imposed by retail chains and processors** (which often have extensive "black lists" of prohibited feed materials, which can include even pretty "mainstream" feedstuffs, such as rapeseed meal). In the case of the **organic segment**, restrictive nutrition-related requirements directly derive from the EU legislation in force[210], and might discourage the substitution of imported soya bean organic expellers with alternative, domestically produced organic protein sources, mainly because the cultivation of organic soya beans, legumes for feed use and oilseeds in the EU is still limited, and is not evenly distributed across the EU territory. In the views of the supportive stakeholders, the rationale for the revision should clearly be towards less restrictive nutrition-related requirements, thus allowing the inclusion of a wider range of alternative/innovative feed materials in the diets. However, the above reasoning is challenged by several stakeholders, mainly due to the potentially adverse implications for the quality/typicity of the final products, which could not be acceptable for the prevailing consumer tastes.

Source: Consortium

[209] For instance, product specifications for Italian PDO cheese *Parmigiano Reggiano* do not allow the inclusion in the diets of – among others – rapeseed products, sunflower seed products with a crude protein content lower than 30%, lupins, and silage maize. It is worth noticing that these restrictions have implications also outside the *Parmigiano Reggiano* supply chain: from the case study on non-conventional beef, it emerged that several Italian feed manufacturers that supply feed for dairy cows and for beef cattle in Northern Italy often do not include rapeseed products in the formulas of feed intended for beef because they fear contamination of production lines destined to produce feed for dairy cows.

[210] In particular, livestock farms that operate in organic production need to source 30% of their feed locally, pursuant to Regulation (EU) 2018/848.

Box 30: Revision of the list of feed materials allowed for *Prosciutto di Parma* PDO ham (Italy)

The recent revision of the product specifications for this leading Italian PDO ham included a **revised list of feed materials allowed in the diet**, which included some feed materials that were previously not allowed, and where the maximum inclusion rates of several main feed materials were significantly or substantially increased (see Table 40). According to the consulted stakeholders, the revised product specifications should offer a much wider room for manoeuvre to both feed manufacturers and livestock farmers to make adjustments in the formulas of industrial feed and in the composition of the diet. Among the allowed protein sources, the substantially increased inclusion rate for peas stands out, together with a significantly increased inclusion rate for other legume seeds.

Source: Consortium

Table 40: Changes in the nutritional requirements of pigs* destined to Parma ham PDO production

Main feed materials	Product specifications in force	Revised product specifications**	Difference
Grain maize	55%	65%	+10
Maize cob mix	55%	55%	-
Sorghum	40%	55%	+15
Barley	40%	55%	+15
Soft wheat	25%	55%	+30
Triticale	25%	55%	+30
Oats	25%	25%	-
Bran and other by-products of wheat milling	20%	20%	-
Whey	Up to 15 litres/head/day	Up to 15 litres/head/day	-
Dehydrated alfalfa meal	2%	4%	+2
Molasses	5%	5%	-
Soya bean meal	15%	20%	+5
Whole toasted soya beans / soya bean expeller	-	10%	+10
Sunflower seed meal	8%	10%	+2
Peas	5%	25%	+20
Other legume seeds	5%	10%	+5

* Maximum inclusion rates (as % of dry matter in the ration, except where otherwise indicated) of selected main feed materials in the diet – fattening stage (beyond 80 kilos, live weight)

** Request for approval 2022/C 429/08, published on the Official Journal of the European Union on November 11, 2022. The revised version of the product specifications has not entered into force yet, since the related control plans still have to be defined.

Box 31: Ideas for improvement put forward by the consulted non-business stakeholders*

In general, all the ideas for improvement put forward by supply chain stakeholders were also supported by at least some of the consulted NCA representatives and/or by some independent experts, albeit not necessarily with a similar strength. The **consulted NCAs** tended to put more emphasis and to elaborate more than business stakeholders on the solutions based on the use of CAP measures, also highlighting the importance of CAP National Strategic Plans in their implementation at Member State level.

Academics and consultants tended to elaborate especially on the techno-economic drivers that can facilitate the diversification of feed sources (these were discussed under SQ3, Section 2.3), and provided much less inputs on the organisational drivers. Nevertheless, as already observed in the reply to SQ8, some of these independent experts also highlighted the organisational implications of the implementation of specific alternative feeding strategies (in particular those for ruminants which are based on increased importance of the forage component of the diet vis-à-vis concentrates and/or silage crops), which may put in question their actual feasibility and sustainability for operators. In doing so, those experts indirectly indicated the organisational constraints to the implementation of those alternative feeding strategies as a noteworthy area for improvement.

Finally, the **consulted consumer association** felt that it lacked the specific expertise to put forward ideas for improving the organisational aspects of the supply chains, but confirmed the importance of those aspects (and of process/product specifications and quality standards in particular) in the marketing of animal products, especially in the organic, non-GM and "sustainability-oriented" segments.

Source: Consortium

* *EU institutions and national/regional competent authorities; consumer associations; consultants and academics*

2.9.3 Main findings

The consulted stakeholders identified the **main potential areas for improvement** with regard to the "soft" elements of the supply chains, i.e. (in decreasing order of preference), their organisation, the use of CAP measures to improve such organisation, and - especially among business stakeholders - also their linkages with other supply chains.

With regard to the **organisation of the feed supply chain**, including the related **functioning mechanisms**, two main areas for potential improvement were identified by the consulted stakeholders:

1. Organisational solutions aimed at promoting **increased supply of alternative feed materials and/or commercial production of innovative feed materials**. The related ideas for improvement focused in particular on improved coordination along the chain[211], the setting up of contractual arrangements[212], and the elaboration of process/product specifications[213].
2. Organisational solutions aimed at **promoting increased use of alternative feed materials** and/or at **allowing the use of innovative feed materials**. In this case, ideas for improvement were especially focused on the revision of existing product/process specifications and quality standards, with special regard to those concerning the final products, in particular as far as the requirements for animal nutrition that they establish are concerned; since their focus was on the downstream stages of the chains, they are discussed below.

As for the use of **CAP measures**, leaving aside the ones providing a direct support to the production of alternative and innovative feed materials (which are discussed in SQ10), the attention of the consulted stakeholders focused on:

1. Measures aimed at promoting **research and development** of innovative feed materials, and/or research aimed at improving the capacity of farmed animals to exploit alternative/innovative feed materials. A few consulted stakeholders indicated specific instruments available in the CAP, in particular the ***European Innovation Partnership for agricultural productivity and sustainability*** at Article 127 of Regulation (EU) 2021/2115, and/or other EU policy instruments promoting R&D, in particular the new EU research programme ***Horizon Europe***[214].
2. Measures aimed at **strengthening the organisation** of feed supply chains and/or at **promoting cooperation and coordination** within those chains, such as those

[211] *Donau Soja*'s protein partnership programme, together with the multi-stakeholder initiatives for the development of sustainable soya supply chains that were presented under SQ8 (Section 2.8.1.1), represent successful examples of approaches aimed at strengthening the coordination along the chain, starting from suppliers of feed materials up to retail distribution of animal products.

[212] Contractualization of legume crops was explicitly proposed as an alternative scenario in a number of case studies, and its impacts were modelled and discussed in some of them. Business stakeholders showed mixed interest for the solution; some stakeholders observed that contractual arrangements alone are not enough to overcome issues deriving from poor performance and/or lack of economic sustainability in the use of legume crops as feed materials.

[213] An interesting concrete example of revised product specifications that should promote increased feed diversification concerns one of the leading PDO hams in Italy, *Prosciutto di Parma*. The recent revision of its product specifications included a revised list of feed materials allowed in the diet, which included some feed materials that were previously not allowed, and where the maximum inclusion rates of several main feed materials (peas and other legume seeds in particular) were significantly or substantially increased.

[214] https://ec.europa.eu/info/research-and-innovation/funding/funding-opportunities/funding-programmes-and-open-calls/horizon-europe_en

included in the CAP 2023/27 (Regulation (EU) 2021/2115). A few consulted stakeholders indicated specific CAP measures established by Regulation (EU) 2021/2115, and in particular:

a. the possible extension of financial support to recognised Producer Organisations (POs) through the tool of **Operational Programmes** (OPs) to "**other sectors**"[215], including the protein crops sector (Articles 42, 46, 47, 66, 67, 68);
b. **support to cooperation** in the framework of interventions for **Rural Development** (Article 77).

The main area for potential improvement of the **links between the feed supply chain and other supply chains** (also outside the EU) was identified in the development or enhancement of organisational solutions and functioning mechanisms (contractual arrangements, process/product specifications, etc.) that can promote an increased availability:

1. of feed materials meeting special requirements and/or intended for specific non-conventional segments (e.g., non-GM, deforestation-free, etc.);
2. of innovative feed materials deriving from non-agricultural supply chains.

With regard to the **organisation of the supply chains for animal products**, two main areas for improvement were identified by the consulted stakeholders:

1. Development of **organisational solutions** (such as strengthened coordination/vertical integration along the chain, contractual arrangements to reduce transaction costs, setting up of quality schemes to extract a price premium) **aimed at improving the competitiveness** of the supply chains for animal products, with a view to ensuring the economic conditions that would allow (increased) use of costlier alternative/innovative feed materials.
2. **Revision of nutrition-related requirements** in existing product/process specifications and quality standards concerning the final products, to allow for increased use of alternative feed materials and/or for the use of innovative feed materials. **PDO product specifications**, which often have rather restrictive nutrition requirements (aimed at preserving product quality and typicity), were identified by the consulted stakeholders as the main candidates for such a revision, also because the definition of product specifications is the result of a collective process that involves business operators, researchers and competent authorities. **Voluntary quality standards**[216], which are defined through collective processes that are similar to those for PDO/PGI products - including in terms of involved actors - were also identified by some stakeholders as interesting candidates for a revision. By contrast, specifications and standards imposed by retailers or processors on their suppliers were not seen as promising candidates for a revision, even less so under the influence of external entities/factors.

[215] I.e., sectors other than fresh and processed fruit and vegetables, wine, apiculture, hops and olive oil and table olives.
[216] For instance, the set of standards for beef and eggs that have been established within the *Sistema di Qualità Nazionale zootecnia* in Italy.

2.10 SQ10: Which actions / policy instruments / sector strategies are most promising to facilitate feed diversification?

2.10.1 Key conditions

There is no single key condition for diversification of feed in the EU. Only a combination of different conditions, depending on the context and agricultural regions, will enable the EU to reduce its dependency on imports of plant proteins. The main key conditions apply at several levels:

- Global scale: extra-EU trade agreements, consistency of regulations within and outside the EU.
- European scale: policies implemented, regulations, access to markets, outlets, availability of raw materials, supply of raw materials.
- National and territorial scale: objectives of national regulations/plans, and means implemented by Member States, agronomic and climatic conditions, organisation of the sectors, consumer demand.

There are technical solutions to limit EU dependence on imported soya (see SQ2 Section 2.2 and SQ5 Section 2.5), and most of them have long been known but have never really taken off in the EU. **Unsurprisingly, the answers to previous study questions underline the fact that, in most cases, economic interest takes precedence in decisions to implement these levers in animal feed.**

The main reason (but not the only one) remains the lack of competitiveness to produce and consume them. Several conditions underlie the competitiveness of alternative feed and are detailed below. In addition, market and consumer demand, social acceptability, and the resulting regulations also encourage, to a certain extent, diversification of livestock feeds. However, according to several stakeholders, these conditions are not sufficient for large-scale diversification.

2.10.1.1 Competitiveness of raw materials and diversification of livestock feeds

The EU market is an open one, subject to international competition. The use of a raw material in animal feed depends on its implementation cost, which is itself made up of the production cost of the commodity, logistical costs (storage, transport), and any processing costs (crushing for seeds, dehulling or treatments to make the product more digestible, etc.). The market price reflects both the availability and the nutritional qualities of the raw material. But the economic interest of a product can only be considered in comparison with another and for a specific livestock system (animal species, age, etc.). This is why, rather than the intrinsic price, which is subject to fluctuations on the world market, **it is the price ratio between a raw material and its benchmark (imported soya bean meal in terms of protein) that matters.**

2.10.1.1.1 Competitiveness factors for arable crops

From a technical point of view, **crop yields and their stability** are essential aspects for their competitiveness (increased crop gross margin) and to influence farmers' decision.

The yield depends on several factors: the pedoclimatic context of the areas, as well as the choice of species and varieties, the technical solutions proposed to control pests and diseases, access to irrigation, and even the knowledge and expertise necessary to implement competitive production methods (see SQ3 Section 2.3). But it also mainly depends on the research that is dedicated to the crop. As protein crops have over time been reduced in the land use of arable farms, the research dedicated to them decreased accordingly and for some of them was completely stopped and the term 'orphan crops' applied.

The table below give examples of the trend in yields of some of the main studied crops of this study over time. It clearly shows why protein crops are less and less competitive.

Table 41: Trends in the EU 27 Member States in the yields over time of some studied crops.

Yield (T/ha)	Average 1971-1973	Average 2015-2017
Maize	3.8	7.2
Wheat	2.9	5.6
Peas	1.4	2.6
Rapeseed	1.9	3.2
Sunflower	1.3	2.1
Soya bean	1.4	2.8

Source: FAOSTAT, 2023

This data clearly shows that the two main cereals in the EU (maize and wheat) are major crops and have benefited from significant genetic improvement, availability of plant protection products, as well as intensification, which is reflected in their yield trends over time (which is not the case for protein crops or is so to a significantly lesser extent). This also shows that the competitiveness of these protein crops slightly decreased over time and that now it is very difficult for them to compete with the two major cereals that benefit from significant private investments in genetics and plant protection products.

Land availability is also a factor in competitiveness. Available arable land is limited and the growth of alternative crops would impact existing crop patterns: it could improve crop rotation, currently mainly relying on cereals. In addition, oilseeds and protein crops that could diversify imported proteins suffer from competition with cereals, which are currently the main profitable crops for broad markets in the EU[217] (European Commission, 2018). According to the stakeholders interviewed in the study and the modelling results, the vast majority of farmers are not encouraged enough, under the current conditions, to reduce their area devoted to cereals and maize and to significantly develop protein crops, oilseeds or grasslands.

In addition to its competitive price, soya bean meal has a high protein content, good palatability and advantageous amino acid contents. The price/amino acid profile ratio of soya beans makes it a very difficult raw material to avoid in the current feeding strategies of many production systems. To increase the attractiveness of alternative raw materials, one of **the key conditions is improving their nutritional quality in their amino acid profile and ANF content** (as detailed in SQ2 and SQ5). The same applies to the other alternatives studied: synthetic amino acids or insect meals can only be included in rations if they have **a competitive entry price in comparison to the relevance of the nutritional value** they bring to the ration (SQ5).

Furthermore, in the animal feed supply chain, **the optimisation of existing tools** (crushing plants, food processing industries, storage centres, etc.) must be fully integrated into the diversification approach to improve the competitiveness of the feed (SQ9). Any change in these chains has then to be programmed, and this implies that all levels of the supply chain agree on the changes and benefit from them.

[217] Providing high yields for medium/small farms.

Box 32: Support to farmers to develop the use of soya beans processed at farm level.

The Horizon 2020 project OK-Net Eco-Feed identifies options at farm level to produce on-farm protein feed for organic poultry and pigs. One of the levers tested in the project is to implement **soya bean toasters on farms**. For instance, a family farm in Linz, Austria, adopted a soya bean toasting facility for pig fattening. On-farm produced soya press cake represents 15 % of the ration. This implementation enabled reduction of around 20 % of the amount of feed required, while maintaining consistent yields. This experiment reports better digestibility for pigs and an excellent pigmeat quality.

The implementation at farm level of soya bean toasters reduces dependence on feed imports and gives farmers more control over their feed. The project also identifies different facilities that could be implemented at farm level, such as extrusion technologies using a combination of pressure and friction or oil presses.

Source: Ok-Net Eco-Feed

Box 33: Example to develop the relationship between arable crop and livestock producers in Germany

Leguminosenmarkt.de is a subproject of the nationwide 'pea/bean demonstration network' and emerged from the commodity exchange for domestic protein feed of the State project 'Protein feed from Lower Saxony -EFN'. The offer from organic farming is imported from the organic goods exchange.

On the one hand, this virtual marketplace is intended to help farmers network with each other. Through direct transactions between farmers, the 'defence prices' of the agricultural trade and compound feed mills that have emerged in recent years can be avoided, and an average price can be found between these (too low) revenue sources and the pure feed values. On the other hand, targeted purchasing of local protein feed components should also be made possible, especially for rural retailers.

Furthermore, this website is also intended to serve as a platform for finding marketing communities in order to be able to offer the trading companies a larger quantity of protein fruits in a bundle. This requires cooperation between growers to create private collective storage of the harvest on a farm until the goods can be marketed at a reasonable price. The project also wants to support this effort.

Source: Hintergrund -Leguminosen Market

Box 34: levers to improve the competitiveness of rapeseed, sunflower and protein crops

Sunflower and rapeseed meals have lower protein content than soya. Their price, based on protein content, is not competitive with soya. However, there are varietal and technical solutions that would make it possible to increase the protein content of these meals:

- Protein-enriched rapeseed is an ongoing varietal innovation which will enable a high-protein rapeseed meal on a commercial scale to be on the market within 5 years and could be deployed across the EU over the next 10 years. This solution will be available at no additional cost compared with standard rapeseed and requires no adaptation of crushing equipment. It will be versatile enough to compete with soya bean meal while still saving money.
- The sunflower meal most in demand is shelled sunflower meal, which has a protein and fibre content more likely to compete with soya meal. To increase its competitive potential, the idea is to lower the product's fibre content, which also increases its protein content, making it more digestible. The industrial process (sifting) is available, but while it increases the selling price of oil meal, it also makes it necessary to add value to the fibre fraction.

Protein crop production is struggling to take off despite successive protein plans and their technical potential to diversify feed. These products have an intermediate nutritional composition (SQ2). They therefore lack production stability, an essential quality for manufacturers that do not have unlimited storage capacity.

Source: Consortium

2.10.1.1.2 Developing grassland systems in the EU

For ruminants, increasing the proportion of grass, fodder and legumes coming from grassland in the ration; optimising its management; and improving its quality appear to be among the most relevant and realistic levers (SQ2). Rations based on maize silage need to be supplemented with soya. The most promising lever is to reduce the proportion of maize in the ration and replace it by increasing the proportion of grass or by better grass management to increase the proportion of protein, in particular through mixtures between grasses and fodder legumes. SQ2 details the technical levers available to increase the protein content of forages.

In theory, all European herbivore farms could do without soya meal, without significantly affecting milk and meat production (IDELE, 2022), if they had optimised, targeted and specialised grassland management. These comments were also made during a workshop on fattening young beef cattle[218]. This could have a significant impact on imports, as the bovine sector (milk + meat) is the biggest consumer of soya protein in the EU.[219]

According to IDELE (IDELE, 2022), many references have confirmed the productivity of grasslands rich in legumes and have specified the management method. According to them, simple associations or complex mixtures of grasses and legumes are traditional practices that are increasingly updated and could develop very rapidly in the EU. Indeed, these mixed legume pastures are eligible for CAP support. At EU level, grasslands and meadows are supported by the conditionality of the first pillar of the CAP, by EAFRD aid and by AECM (see descriptive part). Most of this support consists of at least maintaining – and at best increasing – grassland areas. **According to IDELE, 4 million hectares of leguminous grassland are needed to achieve a strategy of self-sufficiency for European ruminants in relation to imported soya beans.** Nevertheless, the availability of land for grassland requires a reallocation of crops, with a reduction in maize silage in favour of grassland.

2.10.1.2 The trade and regulatory context

At the end of the Second World War, the agreements between Europe and the USA resulted in a share of the production, with Europe supporting cereal production at the expense of oilseed, produced mainly in America. As a result, and even 70 years later, soya beans imported from the United States are still exempt from duties. Beyond any policy instrument, **global trade agreements therefore explain part of the EU's dependency on soya bean imports.** The 1960 agreements abolished duties on soya meal, as well as on oilseeds and oilseed meals from the United States, but also from any origin and led to a substantial increase in imports. In the end, it is Brazil and, to a lesser extent, Argentina that have become the most competitive exporters, thanks to this off duty mechanism and the implementation of a policy of strong incentives for soya bean cultivation. These latter include a large amount of land made available[220], a very favourable climate, GMO crops that allow better yields and low production costs by using herbicide resistant varieties, all combined with national export incentive policies.

These countries (USA, Brazil, Argentina) have technical and commercial competitive advantages for producing and exporting plant proteins, in particular soya. For European stakeholders, the use of imports appears to be preferable to local supply, and this opinion

[218] By video conference on 5 April 2023.
[219] See Nature 2020 study https://doi.org/10.1038/s43016-020-00203-7
[220] The acreage of arable land in Brazil rose from 24 M ha in the 1960s to 53 M ha in the 1980s and then stabilised (source FAO 2023).

continues to be reflected in the recent negotiations on free trade agreements (Canada and Mercosur) and in the various interviews conducted as part of this study.

Box 35: Contradictions in GMOs regulations[221]

GMO seed crops have been prohibited in the EU since 2008 (only one crop – maize – is authorised in the EU and is mainly grown in Spain). On the other hand, **about 100 GMO crops and their derived products are authorised for import and use in animal nutrition**. These include in particular soya beans and derived products such as soya bean oil and meals. (INSEE, 2022)

GMO cultivation began in the mid-1990s and has grown continuously since then, recently approaching 190 million hectares, i.e. more than 10 % of the world's arable land, concentrated in three countries: the United States, Brazil and Argentina. They mainly consist of soya beans, maize, cotton and rapeseed**. As a result, almost 80 % of the world's soya is GM, making it increasingly difficult to supply certified non-GM soya in the EU** (INSEE, 2022).

Source: Consortium

2.10.1.3 European and national policies

Since the 1960 agreements, European policy has aimed to balance the consequences of trade agreements with supporting the competitiveness of EU-produced oilseeds. The CAP introduced several support instruments for the sector (see descriptive part and following paragraph). Several Member States also recently implemented national protein plans (see descriptive part). In addition to the effects of European and national policies specifically dedicated to protein production, other policies may have indirect effects, encouraging or limiting the diversification of plant protein sources for animal feed. In particular, European environmental policies (see question 12) and the various agricultural regulations (limiting nitrogen inputs, authorising the use of some pesticides, etc.) may have a strong influence on farmers' crop rotation choices.

Policy coherence between the different scales is nevertheless needed (see SQ12). On the other hand, territories that favour specific AECMs make it possible, for example, to maintain grassland or even to diversify crop rotations with legumes and protein crops.

Many interviewees mentioned that the policy strategy must be more coherent and comprehensive, but it must also be stable in the long term. Stability is as essential for the agricultural sector, research (work on the improvement of crops and breeds) and development as for the implementation of structural change along the value chain.

Box 36: Improving the environmental performance of the livestock sector while reducing feed demand? The role of livestock control policy in the Netherlands.

With 3.4 livestock units per hectare (EUROSTAT, 2023), the Netherlands has the highest livestock density in the EU, with a significant impact on environmental pollution from excess animal manure. But it is a model that is no longer sustainable: emissions of phosphates and nitrogen from densely packed herds mean the country exceeds the limits allowed by the EU's Habitats Directive.

Following a Court ruling in 2019, the Dutch Government has allocated EUR 24.3 billion for a transition fund for the sector to improve the environmental performance of farms, with a focus on ammonia emissions but also on other environmental issues. The plan for this fund includes a reduction in the number of livestock in the country as well as the closure of some farms, based on voluntary and compulsory buyouts or investments in

[221] New Genomic Technics (NGTs) materials are GMOs subject to the rules of the EU GMO legislation.

innovation or relocation of livestock farmers for a limited group of 'peak loaders' with high emissions in sensitive areas (OECD, 2023)[222].

The new policy aims to reduce nitrogen emissions by 50 % by 2030, which implies a 30% reduction in livestock as well as a proportional cut in feed demand. The Dutch Government has started to collect data on the impact of the new livestock policy. However, it is still too early to draw any firm conclusions from this data; the Dutch Government is expected to publish a report on the impact of the policies in 2025.

Source: Consortium

2.10.1.4 Consumer demand and public opinion

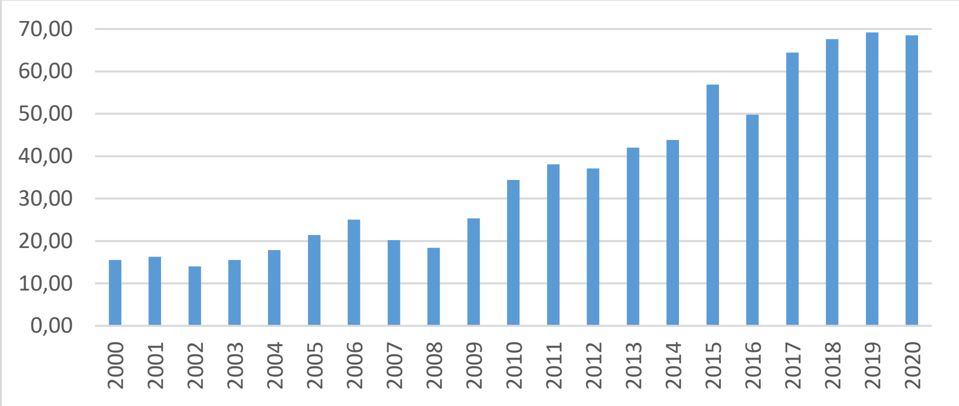
The FAO estimates that 420 million hectares of forest were converted to agricultural use between 1990 and 2020. EU consumption is responsible for around 10 % of global deforestation, with palm oil and soya accounting for more than two thirds of this deforestation. (FAO, 2020)[223] Awareness of the environmental impact of our imports is growing in European societies, although it varies from region to region. In 2021, the EU adopted a new regulation to prevent deforestation and forest degradation caused by the import of products into the EU, covering a list of products including soya (see SQ12). The regulation requires companies to check and publish a 'due diligence' statement that their goods sold in the EU have not contributed to deforestation or forest degradation anywhere in the world after 31 December 2020.

Besides its impact on deforestation, the importation of agricultural products, mainly GMOs, is increasingly criticised by European consumers. In the various interviews conducted with stakeholders, two aspects emerged in particular:

- Operators highlight a lack of coherence in public policies: if GMOs are banned in the EU, why is it possible to import them? Or, conversely, why is it forbidden to produce what can be imported? Under these conditions, European soya is less competitive.
- Many consumers and much public opinion in some Member States reject GMO products. This movement is still negligible in some parts of the EU but is growing in some Member States such as Germany[224] and Austria. Austria has seen its non-GMO products grow very rapidly in recent years. It is also interesting to note that this demand has been accompanied by a significant increase in soya bean area in Austria over the last 10 years (see figure below). In France, several studies show a potential demand from French consumers for GMO-free foods and, more generally, for locally produced foods (FranceAgriMer, 2018). Faced with this potential demand, stakeholders are gradually positioning themselves to respond to it, as detailed in the Estates General on Food (Terres Univia, 2017).

[222] OECD (2023), Policies for the Future of Farming and Food in the Netherlands, OECD Agriculture and Food Policy Reviews, OECD Publishing, Paris, https://doi.org/10.1787/bb16dea4-en.
[223] https://www.fao.org/3/ca9825en/ca9825en.pdf
[224] The case study in the dairy cow sector in Germany showed that conventional production does not exist anymore, as more than 80 % of production is GM free now in this Member State. It is becoming the same in the eastern part of France.

Figure 43: Soya production in Austria (thousand hectares)



Source: Eurostat

2.10.2 Effects of existing policies

2.10.2.1 CAP instruments since 1960

The descriptive part gives details on the currently existing European support schemes to produce plant proteins in the EU. These schemes are the result of several decades of implementation of different instruments to support the production of plant proteins in the EU. Each of these instruments was introduced in part to offset the effects of trade agreements or fluctuations in the world market leading to an excessive loss of competitiveness of oilseeds and protein crops produced in the EU. Most instruments have been implemented within the framework of the CAP, although there are major differences with the support measures for cereals.

The first regulatory instrument was introduced after 1960, following the abolition of duties on imported soya beans. It applied to animal feed producers, to encourage them to continue using Community produced soya. For each tonne of Community seed purchased, direct aid was paid to producers to compensate for the additional costs.

In the 1970s, following the embargo on soya bean exports from the United States, the EU increased intervention prices for proteins through the instruments of the CAP in order to secure production in the EU. However, these mechanisms were abolished following the Blair House Agreements of 1992, which committed the EU to the area payment system and abolished the support guaranteed to farmers, which was considered to be a disguised form of aid. Soya beans imported from the United States remained duty-free, and the abolition of these mechanisms had the effect of aligning the price of EU-produced seed with the price of imported seed, slightly offset by direct aid to production. In addition, the agreements limited specific European support for oilseeds (soya, rapeseed, sunflower) to a maximum area determined by the Member State. In addition, coupled aid to producers was reduced. [Evaluation of the Community Oilseeds Policy, 2001, EC].

In 2003, following a major reform of the CAP, direct aid to farmers was decoupled from production. However, the implementation of Article 68 of Council Regulation (EC) 73/2009 allowed Member States to maintain coupled aid for specific objectives[225], which some Member States used to maintain aid for the production of protein crops (Agrosynergie,

[225] (a)(i) for specific types of farming important for the protection or enhancement of the environment; (a)(ii) for improving the quality of agricultural products; (a)(iii) for improving the marketing of agricultural products; (a)(iv) for practising enhanced animal welfare standards; for specific agricultural activities entailing additional agri-environment benefits; (b) to address specific disadvantages affecting farmers in the dairy, beef and veal, sheep meat and goat meat and rice sectors in economically vulnerable or environmentally sensitive areas, or, in the same sectors, for economically vulnerable types of farming; (c) in areas subject to restructuring and/or development programmes in order to ensure against land being abandoned and/or to address specific disadvantages for farmers in those areas; (d) in the form of contributions to crop, animal and plant insurance premiums; (e) by way of mutual funds for animal and plant diseases and environmental incidents.

2015). The budget for Specific Support was (among others) limited to 10 % of national ceilings for direct payments.

2.10.2.2 The recent CAP

The main support measures which existed at EU level were part of the post-2013 CAP, with coupled support still linked to legume areas, including forage. These voluntary measures were taken by some Members States, the amounts varying between less than EUR 100/ha up to more than 200 EUR/ha. These crops were nevertheless supported indirectly through the eligibility criteria for direct payments under the first pillar of the CAP, which accounted for most of the budgetary support for agriculture. Under greening scheme, there was an obligation set ecological focus area (minimum area for environmental and biodiversity) which allowed inclusion of leguminous but without pesticide from 2017. The AECM of the second pillar of the CAP constituted another public instrument favouring protein crops (INSEE, 2022). However, the implementation of AECMs favourable to oilseeds and protein crops depends on the will of Member States and regions to propose them, and of farmers to apply them.

Most of the policies implemented by the EU would require cooperation between Member States in order to succeed. The descriptive part highlights the heterogeneity of national plan policies on feed diversification between Member States. If it is the intention of the Member State, 8 % of the total budget +2 % for proteins could be allocated to fragile products (see descriptive part). But, without this intention, Member States were not obliged to produce results in terms of diversification of plant protein sources.

Only a few Member States[226] have implemented a national protein plan, with very uneven means and objectives (see descriptive part).

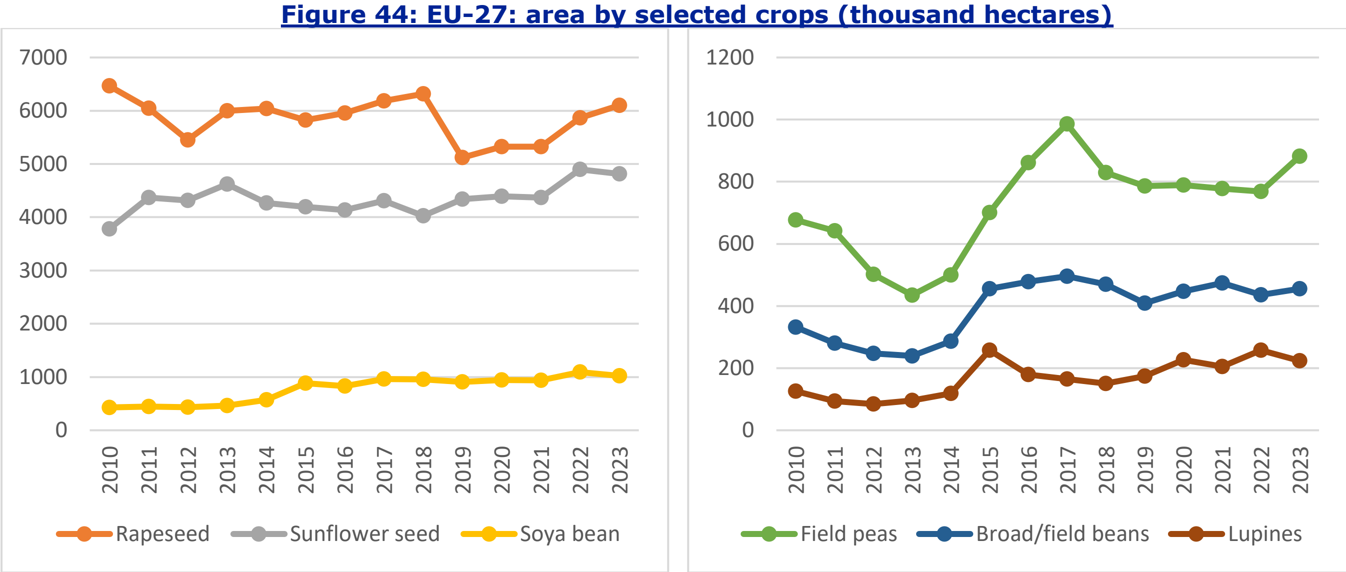
An IDELE study (IDELE, 2022) showed that the development of proteins and oilseeds in the EU was penalised by a lack of attractiveness which is not compensated by support policies considered as too weak and in the long term unpredictable. Under certain conditions, the instruments were sometimes inadequate, and economic realities generally prevailed in the technical choices of farmers. For example, stakeholders in Italy remember that, in 2022, with high market prices, farmers may have decided to forego CAP payments (whose value has declined over time anyway) and produced exclusively maize for the market, as it was more profitable.

The impacts of the policies are mitigated according to numerous stakeholders, and the measures taken are insufficient in relation to the needs:

- The area for protein crop and oilseed production in the EU is still low (see figure below), and according to stakeholders' opinions, the results achieved in recent years in several Member States may be explained more by the development of the biofuels sector than by agricultural support measures.
- **Support for grassland is necessary and has to be sufficient to compensate for the competitiveness of alternative cereal crops**, for example through high yields, high selling price, expertise in cultivation practices for farmers, etc. Grassland is more unstable, with less control over the level of protein obtained, several mowing operations per year, vulnerability to drought and climatic conditions, complex management, etc. In addition, although it is difficult to estimate the indirect costs of increasing grassland, all stakeholders agree on the increase in working time and the financial loss, vs the sale of more profitable crops.

[226] Belgium-Wallonia, Belgium-Flanders, Denmark, Finland, France, Germany, Netherlands.

Figure 44: EU-27: area by selected crops (thousand hectares)



Source: European Commission, 2023[227]

2.10.2.3 The new CAP

The descriptive part gives the detail of the main instruments that were introduced by the new CAP in addition to those already existing. In relation to oil seeds, protein plants and grassland, they mainly concern:

- The conditionality linked to direct payments, which requires the farmer receiving direct payment to comply with a number of rules related to farm management and agricultural practices[228]. Conditionality rules relevant for the purposes of this study include GAEC 1 (Maintenance of permanent grassland) and GAEC 7 (Crop rotation in arable land).
- The eco-schemes that are completely new and that can provide – if activated through national CAP strategic plans – incentives for farmers to adopt a wide range of practices that can help in reducing the EU's protein dependency, such as the inclusion of leguminous crops in rotation, transition to low-intensity grass-based livestock systems, establishment and maintenance of permanent grassland, etc. (European Commission, 2021b). The financing of eco-schemes is devoted 25 % of the allocations each Member State has for income support[229].
- Coupled income support, which also existed in several previous CAP reforms, and which has a ceiling of 13 % of the budget for income support. This ceiling can be increased by a maximum of two percentage points, provided that the amount corresponding to the percentage exceeding the 13 % is allocated to the support for protein crops. A number of crops also used in livestock feed are theoretically eligible for coupled income support under the new CAP. Among these are cereals, oilseeds, protein crops (including legumes and mixtures of legumes and grasses) and dried fodder. Animal products under the scope of this study eligible for coupled income support are milk and dairy products, sheep meat and goat meat, and beef and veal.
- Operational programmes (OPs) of producers' organisations, which are now open to the protein crop sector (among 'other sectors'[230]). Operational programmes presented by recognised producers' organisations (and/or associations of

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[227] https://agriculture.ec.europa.eu/data-and-analysis/markets/overviews/market-observatories/crops/oilseeds-and-protein-crops_fr. From 2021, figures are estimates.
[228] Conditionality rules are classed as statutory management requirements (SMR) and standards for good agricultural and environmental condition of land (GAEC). They are listed in Annex III to Regulation (EU) 2021/2115.
[229] Art. 97 of Reg. (EU) 2021/2115.
[230] i.e. sectors other than fresh and processed fruit and vegetables, wine, apiculture, hops and olive oil and table olives.

producers' organisations) may allow such groupings of operators to fund specific activities and support their medium- to long-term planning, thus boosting a structured development of the sector[231].

- Rural development measures that existed long ago and that can be used, for example, to finance the investments in value chains; the AECM related to crop rotation/diversification and also grasslands; as well as training sessions, advice at farm level, EIP-Agri innovation operation groups, etc.

2.10.2.4 Substantial but insufficient R&D support

In addition to policies, research and development efforts are being made at European level, but also at national and territorial level (see introductory chapter). The means allocated to research projects on the development of protein autonomy reflect the desire to remove the technical constraints to the implementation of these levers. Protein crops are subject to particular attention in the context of European research programmes, which were considerably strengthened for the 2014–2020 period. For example, under the 7th Framework Programme, we can mention the 'Legume Future[232]' and the Eurolegumes[233] projects and even the project on insects as a new source of protein. The European Partnership for Research and Innovation set up a specific focus group on protein, which published its report in 2014, concluding that significant increases in yields are within reach.

For oilseeds (especially rapeseed), which have not benefited from the same history of selection as cereals (see the 'Competitiveness factors for arable crops' chapter above), there is considerable potential for further progress in yields, provided that these crops continue to benefit from significant public or private research investment. However, according to a key stakeholder in genetic research in the EU, European varietal research suffers from a major disadvantage: the main global funding and research findings in the world relate to GMO varieties. Hence, the financial needs of the EU to finance its own varietal research, without having to benefit from the results of outside research, are therefore very substantial. In addition, references to organic production are even less developed. Case studies have shown, particularly for monogastrics, that it is difficult for farmers to obtain EU supplies and that the levers are more limited (SQ2).

2.10.3 Collecting ideas for prospective actions

A combination of levers is needed to diversify plant protein sources on EU farms, with flexibility to allow agricultural regions to find the right balance according to their situation, context and objectives. The policy levers are many and detailed in this part. This question does not cover policies to strengthen the organisation and coordination of the supply chain, which is covered in SQ9.

2.10.3.1 Ensuring coherence between intra- and extra-EU policies

EU vegetable protein production suffers from a lack of competitiveness. The elimination of tariffs on soya beans imported from the USA, Brazil and Argentina strengthens an already very competitive product. Moreover, the Blair House Agreements limit the areas of the three main oilseeds (soya, rapeseed, and sunflower) that can benefit from financial support in the EU, even if at this stage the EU is far from reaching the ceiling of 7.8 million ha included in the agreement[234].

In addition, several stakeholders mentioned the inconsistency of environmental regulations within and outside the EU, particularly with regard to the regulation of GMO products (see 1.3.1.3). The authorisation to import GMO products, despite their prohibition in the EU, is a very strong competitive advantage for non-EU countries. Similarly, products imported

[231] EU financial assistance is limited to 50 % of the actual expenditure incurred for the activities included in the OP and up to 6 % of the value of marketed production of the producer's organisation (or association of producers' organisations). The actual uptake of this tool is linked to its inclusion in the National Strategic Plans of EU Member States.

[232] https://www.legumehub.eu/legume-futures/

[233] https://cordis.europa.eu/project/id/613781

[234] Presently the supported protein crops cultivated in the EU concern around 1.1 M ha.

into the EU are not subject to the same environmental regulations (e.g. marketing authorisation for some pesticides, regulation of doses, authorised varieties, etc.).

2.10.3.2 Supporting the competitiveness of EU plant protein production

The technical levers for diversifying plant protein sources are known, and some have already been implemented. The challenge for the EU is to encourage increased adoption so that imports can be reduced accordingly. As described throughout the report, this deployment is largely (but not exclusively) limited by the lack of competitiveness of EU production.

The main financial support for protein crops and oilseeds production is 'Coupled Income Support' and is therefore subject to the will of the Member States to implement it. In addition, almost all stakeholders consider that the support granted is not sufficient to compensate for the lack of competitiveness in two ways:

- Imported soya and proteins remain more competitive than those produced in the EU.
- It is still more advantageous to produce maize and cereals than oilseeds and protein-rich plants, even with financial incentives.

Only substantial support will make it possible to compensate for the EU's cereal-based tradition. According to several studies carried out in France, the soya/maize price ratio that makes soya production attractive in France is between 2.5 and 3. However, SQ6 shows big differences between Member States. Several policy levers could thus be considered to support this competitiveness:

- **A significant increase in incentives for the production of protein and oilseed crops, (even including grassland richer in legumes),** through existing instruments (CIS, AECM, etc.), provided that this support does not exceed the EU's international commitments.
- **Through support to operational programmes of producers' organisations, incentivisation in the value chains of a system of contractualisation to guarantee the long-term availability of products and the price paid to producers.** This would link the selling price of the concerned crops to the crop in competition (e.g. soya beans vs **maize**), with ratios adapted to the Member States' conditions. The same instrument could be used **to better organise the sector(s) and the whole supply chain at EU level.**

Investing massively in varietal research is also crucial in order to develop varieties adapted to climate change and, earlier, to conquer new territories (see SQ9 for R&D on the feed manufacturers' share).

The sunflower meal most in demand is shelled sunflower meal, which has a protein and fibre content more likely to compete with soya meal. To increase its competitive potential, the idea would be to lower the product's fibre content, which also increases its protein content, making it more digestible. The industrial process (sifting) is available, but this increases the selling price of oil meal, while at the same time making it necessary to add value to the fibre fraction. **The objective of the policy could be to reduce these additional industrial costs (through investment support from RDR** (Rural Development Regulation) **or others), while ensuring a level of crop production that will better amortise the fixed cost of the value chains while reducing the needs for imports.**

2.10.3.3 Derisking the production of proteins crops

The risks mentioned in the previous questions highlight the fact that it is more and more difficult for farmers to decide on cultivating protein crops, even with the agronomical need of rotation, as they are less profitable than their cereal competitors and riskier (e.g. stagnation over time and annual volatility of yields). Hence, it would be helpful to develop an insurance to reduce financial risk for farmers, among the set of tools included in the EU strategy for developing protein crops.

Box 37: The insurance instrument of the CAP to limit the risk of protein crop cultivation.

Leveraging the CAP 2023–2027 agricultural insurance scheme offers an opportunity to create a tool tailored to the unique traits of these crops. This could assist farmers in effectively managing the financial risks associated with the cultivation of some protein crops (e.g. pulses), ultimately encouraging increased production.

The new CAP strategic plan for the 2023–2027 period provides for an increase in the subsidy rate for agricultural insurance to 70 % (compared with a subsidy rate of between 45 and 65 % depending on the level of cover taken out for the period before 2023) and a lowering of the threshold for triggering the subsidisable excess to 20 % (compared with 25–30 % before 2023). However, there is room for adjustment in these rates, especially for specific crops. This would allow for a higher proportion of the payment to be covered, making it more accessible for farmers to invest in insurance products that offer enhanced risk coverage, even if they are pricier, such as parcel insurance for damaged capital.

A review of the Olympic average as a criterion for insuring against climatic accidents could also be considered to encourage the adoption of agricultural insurance mechanisms[235].

It is important to emphasise that qualified technical expertise is indispensable for the effective operation of the proposed systems.

Source: Consortium

2.10.3.4 Paying for the positive environmental impacts of diversification crops

Grassland and protein leguminous crops have a positive environmental impact (Q12). Developing these levers would, in addition to reducing dependence on imports of plant proteins, contribute to several environmental objectives of the strategies implemented by the EU. According to SQ12, protein crops (depending on how they are managed) can provide various positive environmental services: providing carbon sequestration under certain conditions; increasing the flow of nitrogen and carbon into the soil; and improving water retention capacity, biodiversity, soil quality, etc. In addition, lower fertiliser requirements for leguminous crops are rarely taken into account when calculating protein crop and subsequent crop margins, thereby leading to underestimation of their economic advantage in addition to their environmental benefits.

The ‘additionality’ of funding would be essential to integrate virtuous crops into rotations. To enhance the value of farmers’ activities, they would need to be better remunerated if they provide additional services benefiting society as a whole. These instruments do not exist yet in the CAP, but eco-schemes and AECMs can offer clear opportunities in that regard. **The EU would need to move away from simply supporting agriculture and consider farmers as entrepreneurs who can provide increased environmental services (e.g. water, carbon sequestration, biodiversity, agriculture, etc.).**

Several countries (EU and non-EU) have established a payment for environmental services (PES) system. These schemes vary from one country to another. In the CAP 2023, PES schemes have been discussed, and several studies have been carried out to evaluate these schemes in recent years.

The implementation of a such PES system at EU level, adapted to the specificities of territories, would make it possible to recognise (through remuneration) the

[235] The amount of capital insured is currently calculated based on average historical yields over the previous five years; against a backdrop of increasingly frequent climatic hazards adversely affecting yields, this measure ultimately results in a reduction in the calculation of the level of capital insured and thus limits farmers’ incentives to take out insurance. Among the solutions proposed, extending the reference period to 10 years, for example, could help to eliminate this bias. Changing the reference for calculating the amount of capital insured, such as considering the yield of the best year over a given period or quantifying the impact of climatic hazards upstream based on technical expertise, as is currently done in Spain, could also be options to consider.

environmental services provided by leguminous crops and by grassland, and to thus increase their attractiveness.

2.10.3.5 Ensuring equal access to diversification for all EU agricultural regions

Import dependency varies greatly from one Member State to another. There are many reasons for this, but this finding nevertheless underlines the need to propose European policies that facilitate equal access for all Member States to EU protein crop production. For pedoclimatic reasons, not all Member States are able to competitively produce all the crops needed. For example, some Member States are more adapted to rapeseed, others to sunflower, while some have the capacity to produce soya beans, peas, fava beans, dried alfalfa, etc., and others do not. Similarly, the introduction of new solutions and innovations, such as protein-enriched rapeseed and HiPro sunflower across the EU requires the establishment of suitable crushing facilities close to the production areas. Public support should encourage the setting up of processing plants in all the places where the development of protein crops is possible, at a sufficient scale to allow the investment. Local value chains can be competitive to provide feed to local livestock producers, with limited carbon footprint, local employment, and possible development of short-circuit markets.

In addition, most of monogastric and dairy cow basins of production are based close to large ports (e.g. Rotterdam, Hamburg, Barcelona, etc.). This is directly linked to the EU dependency on imports. Reversing this situation and allowing the development of a more equitable distribution of the production centres could also be a policy orientation consistent with environmental challenges related to high livestock densities in those regions. Hence, **infrastructure development to support intra-European flows is an avenue worth investigating.**

According to the INRAE researchers interviewed in France, grassland systems are now very well-known and studied. However, implementation, exploitation in the agricultural environment and adoption by farmers are still very weak. **All support provided must thus be accompanied by training plans and training programmes to ensure that the whole profession, in all Member States, improves its knowledge and management of grasslands, including which species to use according to areas and production objectives, mowing times, conservation methods, and knowledge of the protein content of the grass.**

This is also true for livestock producers with regard to feed nutritional value, animal needs, and breed choice, etc., who require more technical advice in order to improve their competitiveness and also reduce their use of imported material. Hence, **improving training and continuous advice to farmers should also be a goal of the strategy to develop EU production and limit importation**.

2.10.4 Main findings

Diversification alternatives exist and are well known. Although there are still some technical obstacles to be solved (stabilisation of protein crop yields, increase of protein content of rapeseed and sunflower meal, selection of soya bean varieties adapted to the pedoclimatic conditions in the EU, production of amino acids on a larger scale, etc.), it is interesting to note that all these alternatives are already being implemented on EU farms. Reducing imports of soya protein therefore requires an organised and balanced implementation of these practices throughout the EU.

The key condition for this implementation is the competitiveness of alternatives at all levels of the supply chain. Alternative crops and strategies must be competitive enough to produce yields for cereal farmers, competitive enough to be incorporated into feed formulations for feed manufacturers, and competitive enough to guarantee a good price/nutritional value ratio for breeders. To be competitive, they must at least be available in sufficient volume and stably over time, meet the nutritional needs of animals and be reasonably priced. But they must also be known and handled by all the actors in the sector so that they can be used correctly and wisely.

Only public policies can currently support such implementation at EU level, through investment of substantial resources; otherwise, maize will always be more advantageous to produce in most of the EU than soya. This also applies to maize silage vs grassland and wheat vs rapeseed, and imported soya beans will always remain the most economically and nutritionally interesting meal for breeders.

Policy instruments are available through the CAP instruments. It is clear that they have not been sufficient to reduce imports. Stakeholders interviewed during the study argue **for a substantial increase in existing aid,** which would provide a real incentive for operators[236].

At the supply chain level, the existing systems would be complemented by the introduction and widespread use of a contracting system guaranteeing a price for soya based on that for maize.

Research and innovation are key sectors not only for overcoming the last technical barriers, but also for providing innovations to make alternatives more competitive. Many projects are already supported and funded, but **efforts need to be intensified, particularly in the area of varietal and breed selection,** in comparison to investments in the main EU cereals and also to where the EU is disadvantaged in terms of varietal research and GMOs worldwide.

Production chains (storage, processing, transport) have to face additional costs to integrate new processes into existing production chains (e.g. shelled beans, HiPro sunflower, amino acids production). The level of production in the EU needs to be increased thanks to **targeted public policy support for producers and processors**.

Harvest insurance is also a tool from the CAP that could be tailored specifically to limit the risk taken by farmers when producing certain protein crops.

In addition to what the CAP and Member States do and could do through crop rotation support with GAEC/ES/AECM, **PES is a payment system that could definitely be applied to the development of meadows, grasslands, legume fodder crops and, under certain conditions, protein crops.** Taking into account the positive environmental impact of some alternative practices, a specific and ambitious payment scheme for environmental services would increase their attractiveness and competitiveness.

Finally, the use of the alternatives studied cannot be achieved without improving the skills of all actors, from producers to distributors, in the management of all these techniques. **Training, support and advice on a large scale are necessary to achieve a level of competence** that enables the cultivation and production of competitive alternatives.

[236] It has been shown in the only evaluation made on the AECM (Oréade-Brèche 2005) that payment of the income losses and uncured costs was not sufficient for the farmer to decide on its uptake. An incentive aspect is still necessary. This is also true for coupled payments that have to compensate a bit more than the loss of margin between the two crops in competition.

2.11 SQ11: What are the main drivers for changing land use to increase the availability of the EU feed supply?

2.11.1 Drivers of land use change at farm level

2.11.1.1 Drivers for arable crop producers

According to the interviews and case studies, **land use is determined foremost by economic factors**, even if rotation does play a role in farmers' decisions. Indeed, farmers' planting decisions are mostly based on the expected crop margin. Farmers choose to produce a certain crop only if the economic return expected is sufficient and if the risk is not too high. If the crop fails, the farmer could generate a negative margin for a given parcel/crop and consequently lose some of their annual revenue. The expected crop margin is the difference between sales and costs of inputs, multiplied by a risk factor. Therefore, the development of a crop that could be used for feed depends mainly on these various factors.

In addition, farmers take into account synergies between crops by thinking at the scale of the farm as a whole. They also consider policies and regulations as well as the degree of organisation of the sector when choosing their cropping patterns. Each of these drivers has been identified and discussed during case-study interviews and is analysed below.

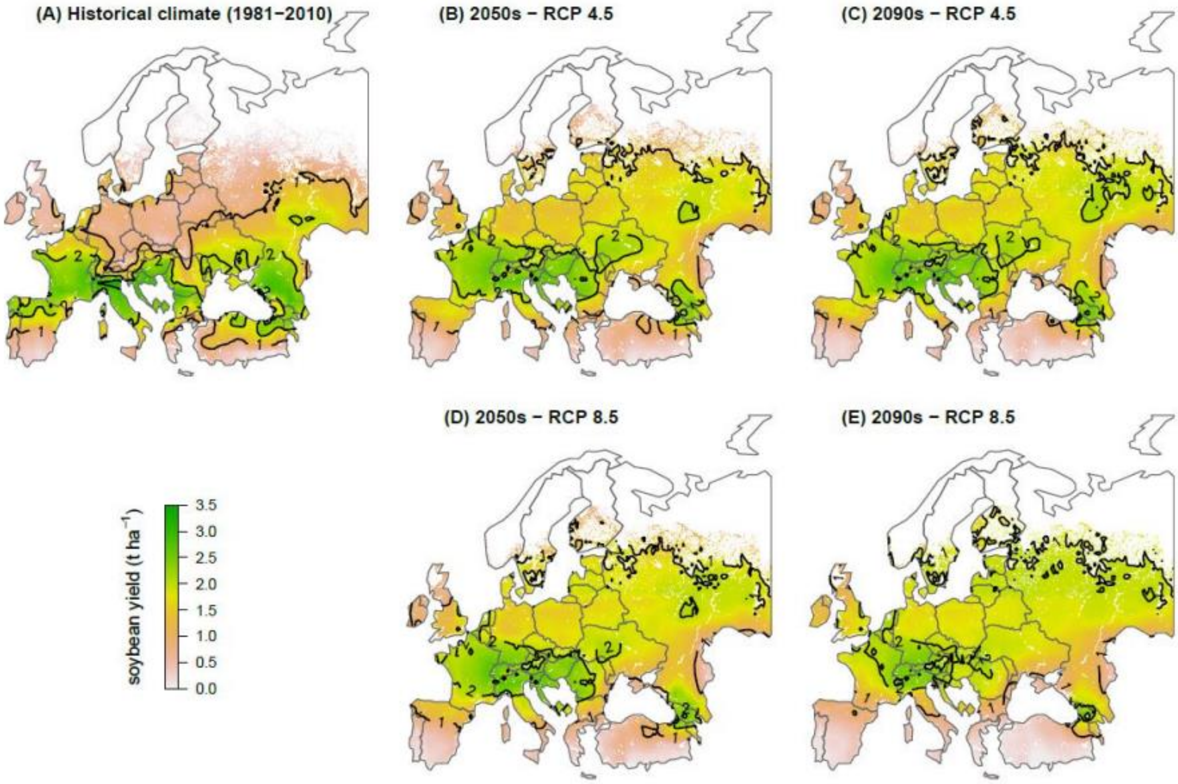
<u>Prices and market trends</u> are considered as a constraint for developing areas of alternative crops for feed. In particular, in regions specialised in the production of highly profitable arable crops (such as processed tomatoes and sugar beets in Italian regions where most Italian non-GM beef farms are concentrated), it is extremely difficult to plant alternative crops at the expense of industrial crops. This is also true for maize areas. Furthermore, farmers are responsive to price **variations**. Indeed, sunflower saw a sharp increase in surfaces in 2022 due to the high prices that followed the beginning of the war in Ukraine. However, as oilseed yields are more variable from one year to another, market prices can be highly volatile[237], and this **price volatility** may be a constraint for further development of oilseed areas. The profitability of protein crops is also generally lower than the profitability of cereals, but only soya bean is subject to market volatility, other protein crops being not much subject to export[238]. In conclusion, oilseeds and protein crops are difficult to develop as alternatives for feed because of prices that are either too low or too volatile compared to cereals.

<u>Yields:</u> oilseeds and legumes are more subject to **agronomic and soil-climate constraints** than cereals, and this leads to **volatility in yields**. This is a vicious circle: crops that are too uncertain are therefore **reserved for the poorest land**, which in turn keeps yields down. Due to its good productivity, maize tends to be preferred to sunflower or soya bean, its competitors in rotation. In the case of legumes, as the varietal panel is limited, they are sensitive to soil-borne diseases and other pests. In the organic sector, as reported in France, the yield risk can be overcome by sowing a mix of crops (e.g. wheat associated with peas) so that the yield of wheat can compensate in the event of low pea yield. But this requires specific machines to sort the different grains after harvest, which are not widespread in farms.

[237] In addition, crop market prices are sometimes related to other international trends, such as variations on the oil market for rapeseed for instance.

[238] One exception was mentioned during the organic laying hens case study: dehulled fava bean exported from France to Norway for fish feed.

Figure 45: Projected soya bean yields in Europe under historical and future climate



Source: (Guilpart, Iizumi and Makowski, 2022)

Consequently, the perspective of climate change and the **recurrence of extreme drought events may limit the development of alfalfa, rapeseed and soya bean**, as mentioned in the Spanish, French and Italian case studies. In 2022, a study on EU soya bean self-sufficiency was conducted. The authors traced a map of the potential yields in the EU, under various climates, as seen in the maps above. The optimal growing zones for soya bean are expected to shift northwards due to future warmer climates. It is also notable that even though the overall favourable culture zone will expand, the yields will be lower. The modelling does not exist for all protein crops, but it is highly probable that they will follow the same trend.

Hence, yields of oilseeds and protein crops are likely to continue to be highly variable, which is not an incentive for farmers to grow them.

Mechanisation and labour costs: interviews revealed that the need for changing equipment or work organisation is not a constraint for changing their cropping pattern. Machines needed for cereals and legume seeds are roughly equivalent. A smoother organisation of work along the year could even be a driver, although not significant, as mentioned during the German case studies.

Agrochemical costs: in the process of deciding cropping patterns, and particularly the development of alternative crops for feed, the needs of the various crops are taken into account, as are input price fluctuations. Nitrogen fertilisers are particularly expensive and volatile, as shown on the graph below[239].

Figure 46: Price of 33 % ammo-nitrates in France, from May 2020 to May 2023, in EUR/tonne

Source: https://www.web-agri.fr/marches-agricoles/engrais

Thus, when pedoclimatic conditions are favourable, the development of sunflower is favoured due to its hardy nature and its low **need for plant protection products**. In addition, **when nitrogen fertiliser prices increase, farmers may be more likely to favour the use of N-fixation by protein plants** instead of application of synthetic fertiliser. Indeed, when **rotational benefits** are monetised, as shown in a comparison of gross margins for main crops in the Champagne area in France (CDER, 2018), the profitability of pea and alfalfa can be comparable to that of rapeseed and wheat. Furthermore, the non-conventional beef and conventional dairy cattle case studies insisted on the fact that the environmental and agronomic criteria were becoming more and more important in crop choice, although relatively recently. The increasing economic and environmental costs of using fertilisers could thus be a driver for developing oilseeds and proteins crops. On the other hand, as regards rapeseed, the need for high levels of agrochemicals can be a limit to its development.

Thinking at the scale of the whole farm: as stated above, farmers are beginning to take into account the benefits of legumes in crop rotation. However, the decision to include a new crop in their rotation is not an easy one for farmers who are used to simplifying their cropping patterns over the years. Once a rotation is established, it has implications for farm management, and it influences the farmer's **long-term programming**. For instance, the **multi-year cropping cycle of alfalfa** reduces the possibility for farmers to quickly adapt to changing market conditions, compared to yearly crops. Furthermore, **as legumes are sensitive to soil-borne diseases**, their occurrence in rotation and cropping patterns **cannot be easily increased**. Finally, Polish stakeholders explained that dissemination and educational activities would need to be carried out on a large scale and would have to clearly indicate the benefits of including local protein crops. Providing this advice is also one of the ways to develop oilseeds and proteins crops.

Regulations and policy support: as developed in the second part of the question, CAP coupled supports also plays a role in cropping pattern choices, as they increase the concerned crop margin. According to case studies and interviews at EU level, such incentive can certainly be a lever for farmers to produce certain crops. However, it may not be sufficient to guarantee that the supply chain will be sustainable in the long term, especially if the support is not extended beyond a CAP programming period. **Continuity and complementarity in the policies are a factor of confidence for farmers and value**

[239] The prices are to be considered keeping in mind that wheat fertilisation requirements can go as high as 100 kg N/ha. Arvalis (2023) *Dose d'azote sur blé dur: comment assurer taux de protéines et rendement élevés ?* Available at: https://www.arvalis.fr/infos-techniques/assurer-un-rendement-et-un-taux-de-proteines-eleves 2023). Similarly, rapeseed can also require more than 100 kg N/ha. Bretagne, C. d. A. d. (2022) *Colza: fertilisation azotée*. Available at: https://www.bretagne.synagri.com/ca1/PJ.nsf/TECHPJPARCLEF/35488/$File/FICHE%20COLZA%20FERTILISATION%202021%2002%2002.pdf?OpenElement 2023).

chains. In that sense, the current context, in which CAP coupled support to protein crops is complementary to national plans, is perceived as favourable to their development. Another example mentioned in Germany and France is the development of rapeseed, which has benefited from successive **biofuel support plans**. On the other hand, some interviewees in Germany and France argued that rapeseed development at the EU scale is somewhat limited by the regulation on non-productive features (**GAEC 8)** and by the restrictions on plant protection products. Hence, complementarity between policies is also needed.

Structuring of the sector: generally, crop production is sold based on campaign contracts between farmers and collectors on the one hand, and collectors and buyers on the other (generally agri-food industries, but also feed manufacturers in some cases). In such integrated supply chains, there may be no or a low demand for alternative crops. The **lack of structured logistical networks (collection, sorting and storage)** was identified as a major constraint for the development of protein crops ((CERESCO, 2021) and confirmed during several case studies). Similar constraints were identified at EU level, namely (i) **lack of varieties** because fewer breeding programmes were launched than for cereals, (ii) subsidies for nitrogen fertilisers and irrigation networks that allow highly profitable crops to be grown, (iii) lack of investments in logistical and processing networks by the food industry, and (iv) lack of interest from consumers and farmers. (Ferreira, Pinto and Vasconcelos, 2021). Absence of a structured outlet for their products dissuades farmers from increasing their protein crop area. Indeed, case studies highlighted the success of rapeseed development in Germany and also France, where strong actors were able to invest in the structuring of biofuel logistical networks.

In these conditions, one other lever to develop forage protein crops, identified in all French case studies, is the development of **contractualisation** between farmers and livestock producers, in particular between organic farms. The goal is to set up a legal framework for forage and manure or slurry exchanges. On the one hand, it secures an outlet for the crop producers, who are often reluctant to grow forages because of the scarce outlets, and on the other it allows breeders to source their forages at a local level in the event that the UAA on their farm is not sufficient to grow it directly.

Research: another possible lever is **agronomic research** to enable the creation of new varieties and overcome the challenges identified above:

- Varieties that are better **adapted to warmer and drier conditions**, more productive and more resistant to diseases, in order to decrease farmers' risk and further reduce use of pesticides. In particular, great hope is put on the prospect of adapted varieties of soya beans (for conventional broilers in Poland and organic laying hens in France).
- In addition, new varieties can also be **better suited to animals' nutritional needs** by lowering their ANF content. Zero-tannin lupine and low-vicine-convicine Fava bean varieties already exist, but they are not always used by arable crop farmers because their yields are generally lower than the yields of usual varieties of fava bean (ITAB, 2014). Research can help create more low-ANF varieties to allow farmers all over the EU to grow them and facilitate their inclusion in feed formulations. Some research on processing is also needed to increase the digestibility of raw materials and enable broader use and thus more potential outlets for these crops.

2.11.1.2 Drivers for livestock producers

The same types of drivers can be identified for livestock producers.

Prices and market trends: as stated in SQ1, the **price ratio between cereals, feed and milk or meat** can provide an incentive to livestock producers. If the price of cereals is very high, livestock farmers will usually prefer growing cereals to selling them and buying the feed. On the contrary, if the price of protein feed is high and the price of cereals low, farmers will tend to grow their own protein crops to use them as feed. This has been highlighted in many clusters (conventional and non-conventional beef, conventional and non-conventional dairy cattle, conventional broilers) with an even higher intensity in regions benefiting from highly profitable crops (high-quality maize silage in the Netherlands, industrial crops in Northern Italy).

Yields: furthermore, as **grass production is much more variable than maize silage**, both in total dry matter and nutrient contents per hectare, maize silage can be seen by farmers as an insurance policy, and they may wish to keep it in their ration. Therefore, the impact of climate change was mentioned repeatedly in terms of **increasing risks of productivity loss of grasslands** due to droughts (for the non-conventional beef subcluster in Spain, the dairy cattle subcluster in France and even for conventional pigmeat in Germany). Hence, the yield risk in the production of grass is a limiting factor in its development.

Production costs: as for crop producers, the **cost of agrochemicals** can be a driver. Humphreys et al. have identified a tipping point in the ratio of fertiliser nitrogen price and the farm-gate price of milk in Ireland (Humphreys, Mihailescu and Casey, 2018). When the ratio of the cost of 1 kg of nitrogen to the price of 1 kg of milk exceeds about 3, grass-white-clover-based production (mixed pastures) tends to be no longer economically disadvantaged. Nonetheless, this is only valid in areas with low livestock density; otherwise, nitrogen sourcing is not an issue given the excessive organic nitrogen load to be dealt with.

Workload was cited as a constraint for increasing protein self-sufficiency in the French dairy goats and dairy cattle subclusters. Indeed, growing alfalfa instead of maize silage or temporary grassland has been shown to be more costly in terms of the labour required: 11 to 15 hours are needed to manage a hectare of alfalfa, compared to 8 to 10 hours for maize silage or 6 to 8 hours for Italian ryegrass (see table below). The **higher costs for alfalfa** can be explained by the fact that maize is harvested in a single time and that Italian ryegrass is cut twice a year, compared to 4 to 5 times for alfalfa[240].

Table 42 : Comparison of labour time and cost to manage alfalfa vs maize silage and temporary grassland in the French context in 2016.

	Alfalfa	Maize silage	Italian ryegrass
Labour/ha (h/ha)	11–15 hours	8–10 hours	6–8 hours
Labour cost (EUR/ha)	EUR 290/ha	EUR 220/ha	EUR 200/ha
Average yield (tonnes of DM/ha)	10	10.8	10

Source: (Bossis et al., 2016)

Equipment costs: in the French cattle and dairy goat subclusters, the need for support to invest in specific equipment (e.g. for grass harvest, feeding in green fodder, fences, etc.) was mentioned as a constraint to developing grass feeding. Indeed, the **equipment required for green forage feeding** is very expensive and rarely available second hand.

Thinking at farm scale: in several case studies (conventional and non-conventional beef subclusters in France, Italy and the Netherlands, French dairy goat and dairy cattle subclusters), the **availability of UAA** is mentioned as a major constraint to increase grazing. Depending on contexts, this was attributed in particular to urbanisation or

[240] On the other hand, the higher number of cuts in the case of alfalfa enables it to be less vulnerable to climatic hazards.

photovoltaic installations. In addition, if the **UAA is scattered**, it is difficult to set grazing areas on the plots of land. As mentioned in the conventional goat case study, grouping the plots and promoting better adequation between herd and UAA at farm and territory level would favour grasslands and feed crops.

Research and training needs: in the Belgian dairy cattle subcluster, **knowledge of grass species** is considered still insufficiently widespread in the sector, and the Belgian stakeholders note a need for research and development by research centres. Similarly, some stakeholders in the French dairy goat subcluster mentioned the need to overcome the **apprehension of farmers** to switch to systems less known and often considered as riskier and more difficult to manage. Indeed, dairy goat farmers are sometimes reluctant to develop grazing because goats are very sensitive to parasitism, which can be a major issue if the density of goats per hectare is high.

Regulations and policy support: German interviewees underlined that GAEC 1, which prevents farmers from ploughing grasslands after five years, acts as a deterrent to convert arable land to grasslands because land would lose value. This was not mentioned in other Member States, where the decline in permanent grassland areas is calculated at a higher scale (region or Member States rather than farm scale).

2.11.2 Drivers of land-use change at policy level

The CAP can have direct effects on farmers' decisions. The list of the main measures that can affect decisions on cropping patterns is presented below. In addition, other regulations can potentially affect farmers' decisions. In particular, the EU regulatory framework related to climate and environmental protection has been changing fast since the publication of the European Green Deal[241] in 2019 and impacts on agricultural production factors. The main regulations that could theoretically drive or constrain farmers' choices are briefly recalled and highlighted if they were mentioned during the case studies. In addition, national and regional policies can also have an influence on farmers' decisions.

2.11.2.1 Regulations directly related to agriculture

Measures and instruments of the CAP (Regulation (EU) 2021/2115[242]) provide a regulatory framework and incentives to farmers on the use of their land.

First, Good Agricultural and Environmental Conditions (GAECs) consists of standards that all EU farmers must respect. Established at European level, these standards are further refined at Member State level to take into account the specific characteristics of areas concerned. Some of them may have an influence on the development of areas dedicated to feed production:

- GAECs 1, 2 and 9 are dedicated to maintaining the area of permanent grassland and to protect grasslands that have specific environmental benefits. However, in Germany, GAEC 1 has been reported as having a counterproductive effect: conversion of arable land into grassland is limited by the fact that after five years grassland may no longer be converted back into arable land and thus, the land may lose considerable value.
- GAECs 7 and 8 may support a minimal development of protein crops.

[241] Communication from the Commission to the European Parliament, the European Council, the Council, the European Economic and Social Committee and the Committee of the Regions – The European Green Deal (COM(2019) 640 final, 11.12.2019).
[242] Regulation (EU) 2021/2115 of the European Parliament and of the Council of 2 December 2021 establishing rules on support for strategic plans to be drawn up by Member States under the common agricultural policy (CAP Strategic Plans) and financed by the European Agricultural Guarantee Fund (EAGF) and by the European Agricultural Fund for Rural Development (EAFRD) and repealing Regulations (EU) No 1305/2013 and (EU) No 1307/2013.

In addition, financial instruments provide incentives to farmers or cover part of their costs. Depending on their specific needs, Member States determine measures in their CAP Strategic Plan instruments that can influence farmers' choices on land use and cropping patterns and can help increasing the availability of the EU feed supply. These include the following:

- Coupled income support for protein crops
- Voluntary schemes for the climate, environment and animal welfare ('eco-schemes')
- Environmental, climate-related and other management commitments such as measures supporting rotation and maintenance of mountain pastures, etc.

All these measures and instruments, their implementation in the various clusters under study, and the way they effectively influence farmers' decisions are described in the descriptive chapter and SQ10.

2.11.2.2 The EU Environmental regulatory framework and the Green Deal

The Water Framework Directive (WFD, Regulation (EU) 2000/60) and the Nitrates Directive (Regulation (EU) 91/676): the WFD provides a European regulatory framework for national water policies, with the aim of preventing deterioration in the status of water and to achieve 'good status' for environmental objectives for all surface and groundwater bodies. Depending on how it is implemented in Member States, it can constrain the quantitative use of water (for instance with water pricing policies) and thus provide more or less incentive to grow irrigated crops. Furthermore, regarding pollution pressures, application of fertilisers and manure can be limited, in particular in 'Nitrate Vulnerable Zones', as provided for by the Nitrates Directive, one instrument of the WFD. These provisions can also influence decisions regarding cropping patterns.

The Fertilisers Regulation (Regulation EU 2019/1009) lays down common rules on safety, quality and labelling requirements for fertilising products. Among other things, it determines thresholds for contaminants presence in fertilising products, notably cadmium, to minimise soil pollution. Depending on local conditions and soil fertility, it can theoretically influence farmers' choices on their cropping pattern. However, this was not mentioned during the case studies. On the other hand, the legislation on Plant Protection Products (Regulation EU 1107/2009), which ensures that industry demonstrates that substances or products produced or placed on the market do not have any harmful effect on human or animal health or any unacceptable effects on the environment, was mentioned as a constraint for developing rapeseed, for which authorised products have been recently reduced.

The complementarity between oilseed used for producing biofuel and the production of oilseed meals for feed, as a by-product, was mentioned in the French and German subclusters. But the production of oilseeds for biofuel may be limited by the renewable energy framework and indirect land use change. Indeed, biofuel production may lead to the extension of agricultural land into non-crop land, possibly including areas with high carbon stock. This process is known as indirect land use change (ILUC). To address this issue, the revised Renewable Energy Directive (EU) 2018/2001 (RED II) sets limits on high ILUC-risk biofuels[243]. Food-crop-based biofuels should not displace the existing use of crops for food and feed but should be produced from a new feedstock base which is additional to current production levels.

[243] Provisions determining high ILUC-risk feedstock and criteria to certify low ILUC-risk biofuels are thus set in the Delegated Regulation on indirect land-use change ((EU) 2019/807), the ILUC Directive.

In November 2022, as part of the LULUCF Regulation[244], the European Commission prepared a proposal for a certification framework for carbon removals[245]. At Member State level, rules and/or incentives are being developed and can potentially drive farmers' decisions regarding land use in the near future. This concerns the use of catch crops in particular and the development of permanent grassland.

Expected impact of the Carbon Border Adjustment Mechanism on imported fertiliser price: the EU's Carbon Border Adjustment Mechanism (CBAM), established by Regulation (EU) 2023/956, is aimed at putting a fair price on the carbon emitted during the production of carbon-intensive goods that are entering the EU, and to encourage cleaner industrial production in non-EU countries. The CBAM will ensure the carbon price of imports is equivalent to the carbon price of domestic production. **As of 1 October 2023, it will apply to a selection of imports** whose production is carbon intensive and at most significant risk of carbon leakage, including **fertilisers**. Its scope will be progressively expanded. In addition, in return for the CBAM, EU industries will gradually cease receiving ETS allowances.

This initiative might thus increase costs of N-fertilisers, due to the set-up of procedures to demonstrate the carbon efficiency of imported products, or it might limit the entry of imported fertilisers in the EU (SWD (2021)643 final). As seen above, farmers may then be more likely to favour the use of N-fixation by protein plants or to increase their use of pastures if the farm context allows it.

Expected impact of the regulation on deforestation-free products on imported feed costs: Regulation (EU) 2023/1115 implemented as of July 2023 is aimed at addressing deforestation caused by agricultural expansion outside the EU, by putting in place a regulatory framework that covers seven commodities (beef, palm oil, soya, wood, cocoa, rubber and coffee). While incentivising the sustainability transition in all producing countries, it will create a level playing field for companies operating in the EU market.

As developed in the impact assessment of the regulation (SWD (2021)326 final[246]), the main side effect should be to favour soya imports from the USA (rather than Latin America), the largest global producer and already a major supplier to the EU. To a lesser degree, it may incentivise an increase in domestic production (of soya or other protein sources). Indeed, domestic EU production is already increasing, among other reasons due to growing demand and higher prices for GM-free soya.

This new regulation might also affect livestock producers by increasing feed prices, in particular in Member States with large livestock populations and exports[247]. However, they may benefit from the absence of competition from products from supply chains associated with deforestation. Thus, the cost incurred by the EU operators could be absorbed by a reduced profit for operators along the value chain and/or eventually passed through to the final consumer. In addition, the increase in feed cost could also encourage livestock producers to develop alternative feeding strategies.

[244] Regulation (EU)2018/841 on the inclusion of greenhouse gas emissions and removals from land use, land use change and forestry in the 2030 climate and energy framework, and amending Regulation (EU) 525/2013 and Decision 529/2013/EU.

[245] Proposal for 'establishing a Union certification framework for carbon removals', COM(2022) 672 final.

[246] European Commission (2012) Commission Staff Working Paper. Impact assessment: minimising the risk of deforestation and forest degradation associated with products placed on the EU market. (SWD(2021)326 final). 17.11.2021, Brussels.

[247] Op. cit.

2.11.2.3 National and regional policies

National and regional policies were described in detail during the case studies. The main elements that come out of these descriptions are reported below.

Implementation of the EU regulatory framework at Member State level: Member States have some margin of manoeuvre on specific provisions related to the directives and regulations mentioned above. In particular:

- For the CAP, the choice of eco-schemes, coupled payments and environmental and climate-related and other management commitments may favour (or not) the development of grasslands or of protein crops.
- For the WFD, the Programmes of Measures of River Basin Management Plans may provide financial incentives to change cropping patterns to improve water status.
- Member States decide on areas concerned by the Nitrate Vulnerable Zone classification.

In addition, case studies revealed that Member States might also take initiatives that have an influence on the development of alternative sources of protein for feed. While it is not possible to detail all of them, the following points can be highlighted:

- Several Member States have set up plans aimed at developing plant protein production.
- Member States have also proposed plans on carbon farming.
- Other initiatives such as, in Greece, Law 4351/2015 on Pasture lands, with a view to the registration, protection and proper management of pastures.

In any case, generic drivers identified in the present SQ may not apply evenly to any specific region or territory. Coherent strategies need to be developed that take into account local specificities in terms of pedoclimatic conditions, natural resources quality/availability, farming systems, existing supply chains, and local policies, etc.

2.11.3 Main findings

At farm level, stakeholders interviewed during the case studies mentioned, as a major driver for the development of alternative protein sources for feed, **expected crop margin and its components** (price trend and volatility, yield and risk (especially with regard to changing climate conditions), production costs such as agrochemicals, mechanisation and labour costs). In particular, the increasing economic and environmental costs of fertilisers can be a driver for developing oilseeds and protein crops, while the need for high levels of agrochemicals can limit the development of rapeseed. In the case of livestock producers, equipment costs can sometime constrain the development of grassland (for green fodder feeding).

The **impact on the organisation of the whole farm** is also taken into account to decide on the development of alternative protein sources for feed (benefits and disadvantages of alternative crops in rotation for arable crop producers and workload for livestock producers). For livestock producers in regions with a high density of animals per hectare, the availability and scattering of land is often a major constraint to the development of pastures. Training on the best use of grass was also mentioned repeatedly.

Next, as developed in previous questions, **existing outlets and the organisation of the supply chain** can be a significant constraint to introducing alternative crops for feed, in particular the existence of structured logistical networks (collection, sorting and storage). Finally, there are high expectations for research for developing new oilseed and protein crop varieties that would be more competitive, more adapted to climate change, and that would provide more regular yields.

At policy level, policies on agriculture, the foremost one being the CAP, provide various regulatory and financial incentives for changing land use and cropping patterns in favour of higher production of protein sources for feed. This is the case of the **GAECs**: GAECs 1, 2 and 9 for maintaining and protecting permanent grasslands, and GAECs 7 and 8 for supporting a minimal development of protein crops. **Additional financial instruments** can be chosen by Member States: coupled income support for protein crops; eco-schemes; and environmental, climate-related and other management commitments. Finally, a new certification framework for carbon removal may favour the use of catch crops and the development of permanent grassland.

Furthermore, the EU regulatory framework sets **provisions that can constrain the use of production factors**, such as water or fertilisers, and thus guide choices on cropping patterns. In that respect, the regulation related to the protection of climate and environment is changing fast since the Green Deal publication and recent regulations might further change the context of European production and in particular the cost of fertiliser and soy imports.

Finally, **Member States and regions may also provide incentives for the development of protein sources** for feed, either when implementing and adapting the provisions of EU regulations to their local context, or by designing their own national initiatives (for protein plant production or carbon farming for instance). In any case, the drivers of land use change identified for diversifying protein sources may not apply evenly to any specific region or territory. **Coherent strategies need to be developed that take into account local specificities.**

2.12 SQ12: How would the defined scenarios for diversification provoke/require land use changes and/or adjustments in livestock production systems at aggregated EU level? What environmental impacts associated with this change could be expected?

Livestock farming has two main types of negative impacts on the environment and climate:

- Direct impact due to the emissions from enteric fermentation, manure management and excretion of feed nutrients (pollution of soil and water with nitrate and phosphorus, ammonia emissions, GHG emissions)
- Indirect impact from feed production (conversion of forests and grasslands into arable land, synthetic fertilisers production and application, etc.)

Such impacts can be significantly mitigated or amplified depending on local agroecological conditions and on the farming practices implemented. In particular, the **valorisation of grasslands for feeding has multiple environmental and climate benefits** (increased carbon sinks, preserved biodiversity, reduced nitrate leaching, reduced ammonia emissions, and reduced phosphorus runoff). In contrast, **a higher density of animals intensifies the negative externalities of livestock farming (through manure concentration) at farm and/or region scale**. Roughly, the negative environmental and climate impacts are higher in the case of ruminants, but these also have the highest potential to alleviate impacts through grazing. In particular, grassland-based ruminants can be efficient protein producers, i.e. they produce more protein in milk and meat than they consume (as human) edible protein sources (European Commission 2020. Peyraud J.-L., MacLeod M.).

Least-cost optimisation models, used by feed manufacturers to determine the content of their feed products, are available only at the scale of one cluster (FeedMod model) or, at best, of one Member State (Prospective Aliment for France). Given the impossibility of displaying such results in an aggregated GIS analysis, specific analyses are first provided to provide information on the potential development of soya bean area at EU level, on potential adjustments of the livestock production systems needed and on the additional grassland area needed.

Potential environmental impacts are derived from the diversification scenarios modelled and from literature in the bibliography:

- All scenarios modelled provided quantitative results on land used, GES emitted and energy needed to produce manufactured feed (see Section 2.12.1).
- Only the Prospective Aliment model made in possible to obtain quantitative information on land area needed for forage supply in the case of ruminant sectors (in the case of conventional dairy cow and dairy goat clusters) (see Section 2.12.21.3.3),
- The impacts not available from the models and on other environmental indicators (biodiversity, water quality, etc.) were estimated qualitatively from an extensive literature review (see Section 2.12.3).

2.12.1 Changes needed at aggregated EU level

2.12.1.1 Soya bean expansion and land use change in the EU and abroad

Imports of oilseed equivalents (soya bean, rapeseed and sunflower) reached 49.5 Mt in 2021/2022, representing 18 million ha, taking into account the average yield for each crop. This 'offshore' surface represents 13 % of the 135 million ha devoted to crops potentially consumable by animals[248] in the EU. At the same time, the EU exports 61 % (2.2 Mt) of the dehydrated alfalfa produced in the EU, as well as 13 % (0.5 Mt) of its protein crops, while 0.8 Mt of the same protein crops are also imported in the EU.

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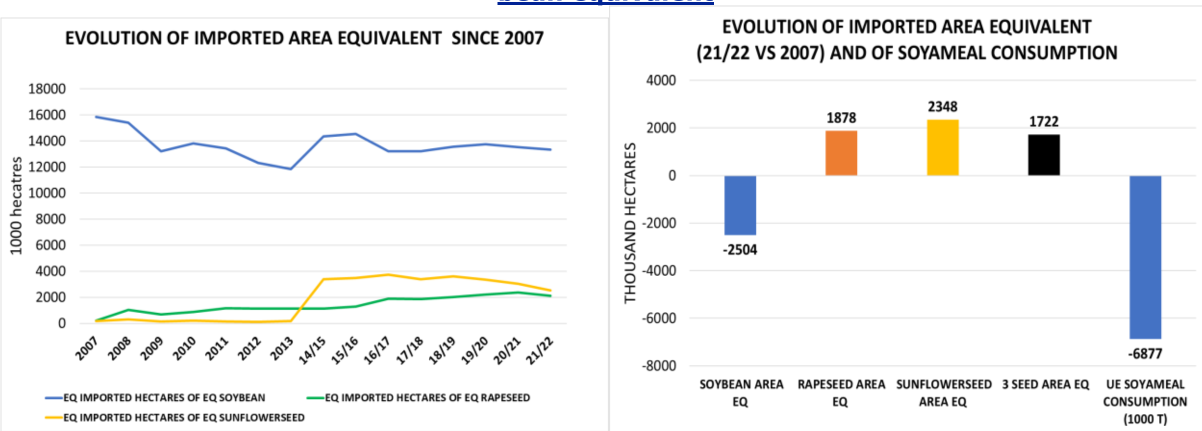
[248] Roughly: arable land plus permanent grassland, excluding crops intended exclusively for human consumption (root crops, fibre crops, fresh vegetables, permanent crops and others).

Imports of soya beans, expressed in hectare equivalent, fell by 2.5 million ha between 2007 and the 2021/22 season, a drop of 16 %. At the same time, imports of rape (mainly seeds) and sunflower (mainly oilmeals) rose sharply (+4.2 million hectares). All in all, the net balance was +1.7 million ha. This has enabled consumption of soya bean meal in the EU to fall by almost 7 Mt over the last 15 years, stabilising at around 30 Mt. Nevertheless, soya-bean-equivalent imports[249] still represented 13.3 million ha in 2021/22, around 8 % of the EU 27's UAA, while EU soya bean production represents less than 1 million ha in 2021/22, or 0.6 % of the EU's UAA.

Figures 47 and 48: Change in imported area equivalent and comparison with soya bean equivalent



Source: consortium from Eurostat et Oil world

Replacing 100 % of soya-bean-equivalent imports (38 Mt in 2021/22) would therefore mean swapping 13.3 million ha of other crops. Leaving forage crops (excluding silage maize) and vegetable crops untouched, **almost 19 % of the remaining EU agricultural area (71.4 million ha) would have to be converted**. Similarly, a 50 % import reduction target (i.e. 6.65 million ha/19 Mt) would mean converting 9.5 % of the EU area. With the 0.9 million ha of soya beans already in place in 2020, oilseeds would represent 4.6 % of the EU 27's UAA, i.e. thirteen times more than in 2020. But, according to (Guilpart, Iizumi and Makowski, 2022), **only three Member States have a high yield potential for this crop: France, Italy and Croatia** (see Figure 45 in §2.11.1.1)**.** And it would be inconceivable to concentrate soy production on these countries, since soya is rarely competitive with maize (as shown in Section 1.1.3) and requires sufficient water availability for irrigation in regions where it is most appropriate to grow it.

Four main crops currently occupy the areas most suitable for soya bean production (yield >2 t/ha) to achieve 100 % soya bean self-sufficiency: wheat is the main crop with 36 % of the area, followed by maize (14 %), barley (10 %), and sunflower (7 %). If we consider only these four crops[250], this means that **the EU would 'lose' 3.6 million ha of wheat, 1.4 million ha of maize, 1 million ha of barley and 0.7 million ha of sunflower**. Figure 3 summarises the impact on acreage, tonnage and potential exports of the four targeted crops.

This raises the question of our export positioning for these four crops, as for two of them (maize and sunflower seeds) the EU is already a net importer, and the question of which countries would be most affected (France exports 36 % of European wheat). Furthermore,

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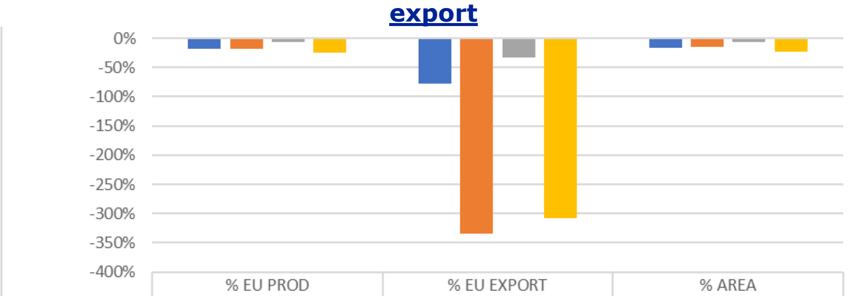
[249] Soya-bean-equivalent imports are calculated as imports of soya beans added to soya meals, dividing the latter by 80 % (meal yield) to obtain tonnages of beans, which are then converted into hectares (using average European yields).

[250] Using the weighted average yield of these crops in the three countries likely to grow soya beans with sufficiently competitive yields, i.e. France, Italy and Croatia, as done in Guilpart, N., Iizumi, T. and Makowski, D. (2022) 'Data-driven projections suggest large opportunities to improve Europe's soybean self-sufficiency under climate change', *Nature Food,* 3(4), pp. 255-265.

the increase of forage in ruminant rations calls for more wheat to partially compensate for maize silage (energy contribution).

Figure 49: Impact of 100 % soya self-sufficiency in EU grains area, production and export



	% EU PROD	% EU EXPORT	% AREA
BLE	-18%	-78%	-16%
MAIS	-18%	-334%	-15%
ORGE	-7%	-34%	-6%
TOURNESOL	-24%	-308%	-23%

Source: consortium from Eurostat et Oil World

With regard to the impact on international soya bean trade, and taking the average breakdown of our suppliers in soya bean equivalent over the 2020/2021 season, the 19 Mt drop in soya-bean-equivalent imports would correspond to a loss of outlets of 9 Mt, 4 Mt and 3 Mt of soya bean equivalent respectively for Brazil, Argentina and the USA; i.e. 9 %, 11 % and 4 % of their soya-bean-equivalent exports over 20/21. It should be remembered that world soya bean trade (in eq seeds) rose by 78 % between 2008 and 2020, i.e. 108 Mt, and that world trade projections remain on an upward trend. **It is likely that the decline in trade with the EU will be more than offset in the coming years by other outlets** (Africa, South-East Asia and the Middle East).

<u>In terms of economic effects</u>, several studies underline the technical feasibility of growing soya beans well beyond their current perimeter under current and future climatic conditions (in particular (Guilpart, Iizumi and Makowski, 2022)). However, average yields (estimated at 2.8 t/ha in 2020 by the OECD) remain lower than those obtained in the Americas[251], and this lack of profitability is the main reason for its lack of development, while at the same time wheat yields are high in the EU (5.5 t/ha) compared to other producers[252]. Average maize yield (other spring crops) is 7.2 t/ha in the EU but is well positioned in France (8 t/ha) and Italy (11.2 t/ha) compared to foreign competitors[253]. It should be noted that the increase in soya bean production will have to be accompanied by the construction of crushing plants, which, located close to production zones, raises the question of transport to consumption zones, if cultivation remains localised in high-potential areas (three Member States).

<u>In terms of environmental impacts</u>, **the impact of the European soya import decrease on global deforestation would be limited**. Indeed, according to Trase, the hectares potentially exposed to deforestation corresponding to imports from the EU reached 29 000 ha in 2020, or 7 % of the Brazilian total area at risk of deforestation, but this figure will decrease to 0 % by 2025, when the recent European regulations will be applied. By contrast, in Brazil, deforestation is essentially driven by Chinese (57 %) and Brazilian (23 %) demand[254].

[251] https://ag.purdue.edu/commercialag/home/wp-content/uploads/2021/06/202107_Langemeier_InternationalBenchmarksforSoybeanProduction.pdf, Purdue University, 2021.
[252] https://ag.purdue.edu/commercialag/home/wp-content/uploads/2019/05/2019_05_LangemeierPurdy_International_Benchmarks_for_Wheat_Production.pdf, 2019.
[253] https://ag.purdue.edu/commercialag/home/wp-content/uploads/2021/06/202106_Langemeier_InternationalBenchmarksforCornProduction.pdf, 2021.
[254] https://www.trase.earth/2020

An expansion of the soya bean area also questions agricultural water management, soya being particularly water-hungry and a candidate for water stress. Indeed, an increase in soya bean acreage will have an impact on water demand, and this impact can be negative or positive depending on which crop is replaced by soya bean. On the other hand, **N-fertiliser savings may result in the EU from the replacement of fertilised crops (e.g. wheat) by unfertilised soya bean**, both directly and indirectly (additional N-fertiliser savings could be expected from reducing N-fertiliser rates applied to non-legume crops following soya bean in the crop sequence).

2.12.1.2 Adjustments in livestock production systems

As concluded from other SQs, the most promising alternative EU raw materials intended for livestock feeding are already produced and used in most Member States. In addition, other possible strategies to diversify feed composition or at least reduce the need for protein-rich crops have already been implemented by players in some sectors and some Member States. Interviews reveal that there is not one unique solution consisting in setting up a single lever that would be applicable to all production systems, all livestock and all regions of all Member States. The diversification of protein sources will require the implementation of different combinations of levers, depending on the specific needs and conditions of the agricultural sectors and need to be adapted to the various EU regions and to the various types of farms (e.g. intensive vs extensive).

As a result, although some alternatives identified may have more potential for replication across the EU, interviews concluded that **the objective of diversifying protein sources for feed, as well as reducing soya bean imports, will not result in any rapid and significant changes in livestock production systems at EU level**. As seen above in the simulation for soya bean development, such rapid changes are made very unlikely given the significant economic impacts they would bring: the land use change needed to produce alternative protein sources would be at the expense of wheat and maize in particular, with significant impacts for EU external trade and for exporting Member States. In addition, the present context and other strategic objectives, such as the decarbonation of agriculture, might have additional or even opposite effects regarding the change in livestock production systems[255].

Quantitative impacts of the share of concentrates in feed modelled per studied sub-cluster

The models available make it possible to estimate the potential effects of the introduction of an alternative protein source on the composition of manufactured feed and the related impacts on land used, GES emitted and energy needed to produce it. However, in the case of ruminant clusters, they do not directly make it possible to estimate similar impacts regarding the development of pastures.

Two commonly used databases describing Life Cycle Analysis (LCA) for feed ingredients[256] provided the data needed to quantitatively estimate the impacts of the change in the type and quantity of manufactured feed.

[255] For instance, an intensification of milk production to improve methane emission efficiency would mean increasing the maize share in the ration and decreasing grazing.

[256] See diagrams for system perimeters in:

- For ECOALIM: Wilfart A, Espagnol S, Dauguet S, Tailleur A, Gac A, et al. (2016) "ECOALIM: A Dataset of Environmental Impacts of Feed Ingredients Used in French Animal Production".
- For GFLI: GFLI (2020). GFLI Guidance document, "How to read and use the database".

There is not always correspondence between the raw materials to be compared (in particular the choice of crop itinerary used in the LCA, or the origins of imported raw materials, etc.). In particular, the European GFLI database has GHG emission values for imported soya bean meal that are much higher than those of EcoAlim. However, beyond the difference in absolute values in the two databases, the ratios between raw materials are quite similar. For the French clusters, using the French EcoAlim database was more relevant, whereas the GFLI database was used for other clusters.

How these three indicators studied are defined and computed is detailed in the box below.

Box 38: Definition of environmental indicators estimated by the models

The environmental impact of the diets is expressed using three parameters described in the GFLI (Global Feed LCA Institute) 2.0 database (and the ECOALIM V7 in some cases), using economic allocation.

Land use: this indicator accounts for the loss of habitat available for living species, caused by land use by human activities (agriculture, forestry and deforestation, transport networks, urbanisation, etc.). The indicator is expressed in area-time, m² used for a year to produce one tonne of product (m²y crop eq / tonne product).

Energy (abiotic resources): this flow indicator expresses the quantity of non-renewable energy used for the provision, transport, use or end of life of tonne of feed produced, in the feed life cycle. It is expressed in equivalent of crude oil per tonne of feed product (kg oil eq /t/d, 1 tonne of crude oil = 41.868 gigajoules).

Global warming: in the ECOALIM and GFLI databases, the carbon footprint is expressed in kg carbon dioxide equivalent (kg CO_2 eq.) emitted to produce one tonne of feed product, including the production of energy, machines, chemical inputs and seeds. The method allocates a characterisation factor to each substance contributing to climate change, including land use change and destruction of peatlands, making it possible to calculate its contribution to climate change over a generally accepted period of 100 years, in kg CO_2 equivalent.

Source: consortium

The results of each scenario modelled on environmental impacts of the share of the concentrate of the feed are presented in Table 42. Results with less than +/-5 % variation should be considered insignificant. Between +/- 5 and 10 %, they should be considered part of a trend. Results must exceed +/-10 % to be considered as significant.

Regarding monogastric animals, **the scenarios modelled are generally beneficial for environmental indicators but rarely significantly**. The main noticeable effects concern:

- Introducing legume seeds (tested for the conventional pigmeat and broiler clusters) makes it possible to decrease the contribution of concentrate production to climate change and to a lesser extent to land use.
- The same is true for introducing synthetic amino acids to optimise the diet (for the broiler cluster), but a high level of energy is needed for the production process.
- As for synthetic amino acids, producing insect meals requires high energy use (conventional pigmeat).

Table 43: Quantitative environmental and climate impacts of the scenarios modelled for the of the concentrate part of the feed

Sub-cluster* *- scenario*	Sub-scenarios	**Land use**		**Energy demand**		**Global warming**		
		m2a eq /t/d	*%*	*kg oil eq /t/d*	*%*	*kg eq CO_2 /t/d*	*%*	*Comment*
****Pigmeat conv** – DE *Legume seeds*	All legumes, no caps	29.735	6 %	1.091	-4 %	12.617	-5 %	The positive effect on environmental impact of the diet is mostly felt when inclusion rates are raised, with a reduction of 11–14 % of GHG emissions. The effects are less noticeable on land use and energy demand. The latter actually slightly increases in the 'optimistic' scenario due to a higher level of processing.
	All legumes, with caps	28.114	0 %	1.140	0 %	13.344	0 %	
	All legumes, Weber rates	27.705	-1 %	1.104	-3 %	11.931	-11 %	
	Optimistic	27.420	-2 %	1.150	1 %	11.511	-14 %	
***Pigmeat conv** – DE *Insect meal*	BSF 4 % fat, 200€/t	27.916	-1 %	1.649	45 %	14.258	7 %	Energy demand and global warming increase when insect meal is introduced significantly, and they are more or less neutral on land use. This is due to the high Global Warming value attributed to black soldier fly (BSF) meal BSF in Smetana et al. (2019). The BSF needs a warm environment to be developed and its production requires a high quantity of energy.
	BSF 11 % fat, 200€/t	27.819	-1 %	1.719	51 %	14.310	7 %	
	BSF 32 % fat, 200€/t	27.536	-2 %	1.995	75 %	14.732	10 %	
***Pigmeat NC** – **ES** *Enzyme NE-80*	Growing 20-60 kg	17.807	-11 %	886	-6 %	8.124	-9 %	NE-80 provides better environmental results than N-50. When comparing with the baseline, the effect of using enzymes tends to be positive on the global warming and energy indicators and negative on land use, except in the case of piglets, though these effects remain limited.
	Fattening 60-100 kg	19.486	4 %	889	1 %	8.579	-3 %	
	Finishing > 100 kg	16.448	3 %	782	-5 %	5.829	-3 %	
	Lactating sows	21.296	3 %	903	1 %	8.810	-7 %	
Pigmeat NC – **ES** *Ideal protein*	Growing 20-60 kg	32.210	62 %	1.193	27 %	10.682	20 %	The Iberico pig already has an optimised diet. It was possible to calculate a diet with a lower protein content with a larger use of industrial amino acids but, it resulted in a significatively larger environmental impact, in particular regarding land use, due to the increase in the share of cereals in the ration.
	Fattening 60-100 kg	26.606	42 %	1.038	18 %	9.494	8 %	
	Finishing > 100 kg	24.665	54 %	1.030	25 %	6.776	12 %	
	Lactating sows	23.837	16 %	981	10 %	10.163	7 %	
****Broiler conv** – PL *Legume seeds*	Legumes	16.916	-1 %	676	0 %	9.066	-7 %	Legume seed use has a positive effect on the global warming impacts of the concentrate (around a 10 % decrease in GHG emissions) and to a lesser extent on land use. In any case, the extent of the changes is limited compared to some other clusters.
	Legumes, RSM, DDGS	15.921	-6 %	712	5 %	8.569	-13 %	
Broiler conv – PL *Industrial amino acids*	Low requirements	14.710	-14 %	751	11 %	7.756	-21 %	Optimising amino acid requirements also has a positive effect on global warming, a lower positive effect on land use, and a negative effect on energy demand, partly due to the production process of amino acids. Environmental benefits are slightly lower when adjusted requirements are complemented with legumes and rapeseed meal.
	Ross + legumes + RSM	15.842	-7 %	760	12 %	8.590	-12 %	
****Beef conv** *– FR Improved*	Meslins 5-10 % CP - 2.5 kg	4,329	6 %	359	2 %	2,414	2 %	HiPro meslins (15-20 % CP) are the most effective to reduce soya bean meal and maize silage, and it is theoretically possible to provide diets

Sub-cluster* *- scenario*	Sub-scenarios	**Land use**		**Energy demand**		**Global warming**		
		m2a eq /t/d	*%*	*kg oil eq /t/d*	*%*	*kg eq CO_2 /t/d*	*%*	*Comment*
grass share and grass quality of the ration	Meslins 15-20 % CP -2,5 kg	3.030	-26 %	137	-61 %	941	-60 %	containing only this meslin and a cereal (plus minerals and vitamins). This would result in a significant decrease in all the environmental impacts of the non-forage share of the diet (decrease of more than 25 % in land use and more than 50 % in energy demand and global warming effect).
	Meslins 5-10 % CP - 5 kg	5.334	-19 %	375	-14 %	2.534	-14 %	
	Meslins 10-15 % CP -5 kg	6.592	0 %	323	-26 %	2.215	-25 %	
	Meslins 15-20 % CP -5 kg	4.725	-28 %	207	-53 %	1.426	-52 %	
***Beef conv** – FR *Increased availability of HiPro sunflower meal*	SFM HP40 % CP - 2.5 kg	7.329	80 %	90	-17 %	1.900	-20 %	The scenarios with HiPro sunflower seed meals lead to positive impacts as regards the energy demand (-15 %/-25 %) and global warming impacts (-17 %/-32 %) of the ration (forage not being taken into account). However, both scenarios lead to a significant increase in land use (between +30 % and +80 %) to grow wheat and sunflower.
	SFM HP48 % CP - 2.5 kg	6.643	63 %	254	-28 %	1.606	-32 %	
	SFM HP40 % CP - 5 kg	9.972	51 %	369	-15 %	2.451	-17 %	
	SFM HP48 % CP - 5 kg	8.736	33 %	351	-20 %	2.290	-23 %	
***Beef NC** – IT *Increased inclusion of dried alfalfa*	High	23.169	-18 %	788	-21 %	5.715	-22 %	The introduction of alfalfa in the diet makes it possible to halve soya bean meal inclusion, but it sharply increases grain maize to compensate for the lower energy provided by alfalfa. All scenarios have positive results in environmental impact of non-pasture feed components, with a decrease of around 20 % for each indicator.
	Middle	23.217	-18 %	791	-20 %	5.798	-21 %	
	Low	22.332	-21 %	772	-22 %	5.675	-23 %	
****Beef NC** – IT *Improved protein content of meadows (legumes)*	High	4.461	-84 %	181	-82 %	1,054	-86 %	The medium and high-quality pastures allow for complete elimination of soya bean meal and grain maize from the diets, whereas the low-quality pasture only reduces soya bean meal from the diet and needs more grain maize. All sub-scenarios have very positive environmental impacts, especially the middle protein content one, which is fully self-sufficient.
	Middle	0	- 100 %	0-	- 100 %	1,054	- 100 %	
	Low	5,811	-80 %	277	-72 %	2,382	-68 %	
****Dairy cattle conv** – FR - *Increase roughage share and quality*	Mixed scenario (roughage quantity and protein content)		-18 %		2 %		3 %	In the tested scenarios, results for climate change and energy indicators are not significant. Results are significant for the decrease in land use: this is due to the hypothesis of a reduction of 30 to 50 % in the share of maize silage in the ration. **However, the impact of the increase in grass areas is not provided by the model**.

Sub-cluster* *- scenario*	Sub-scenarios	**Land use**		**Energy demand**		**Global warming**		
		m2a eq /t/d	*%*	*kg oil eq /t/d*	*%*	*kg eq CO_2 /t/d*	*%*	*Comment*
Dairy cattle conv – FR *Increased local protein crops + HiPro sunflower*	Average mandatory scenarios		10 %		-5 %		-6 %	In mandatory consumption scenarios for dairy cattle, climate change and energy consumption show a downwards trend without becoming significant. Concerning land use, the indicator shows an upwards trend and is significant in some sub-scenarios, due to the increased area needed for growing protein crops and sunflower.
Dairy cattle NC – DE - *Forage improvement*	*+Forage CP +5 % energy (mixed scenarios)*	12.135	-16 %	489	-22 %	5.106	-13 %	The effect of increased protein content in forage is rather negative for global warming and land use, as the model reaches its solution ('economically optimal') by using more palm oil (which may or may not be realistic), but this negative effect is mitigated by the improvement of the energy content, due to the general decrease in feed consumption. All in all, each environmental indicator is improved by the mixed scenario.
****Dairy goat conv** -FR – *grass roughage*	Mixed scenario (higher roughage share and protein content)		-7 %		-5 %		-3 %	The change in the environmental impact of manufactured feed is never significative (i.e.>10 %) but shows a decreasing trend regarding the three indicators. These results do not take into account the effect of increased pasture areas.
***Dairy goat conv** --FR – *HP rapemeal*	Average 5 sub-scenarios		2 %		-7 %		-4 %	The environmental impact is not significative, except regarding energy consumption in some specific sub-scenarios.
****Sheep meat conv** – ES *dried alfalfa*	Alfalfa 15 % CP	2.263	-1 %	88	-1 %	621	-4 %	The effect of the inclusion of alfalfa in the ration on the three indicators remains relatively limited, except for global warming (decrease of GHG emissions by 4-6 %).
	Alfalfa 17.5 % CP	2.207	-3 %	88	-1 %	610	-6 %	
***Sheep meat conv –** ES *Improved pastures*	High		-86 %		-97 %		-88 %	The use of pasture with a higher protein and energy content has a direct positive effect on the reduction of the need for protein supplements. The concentrate proportion of the diet goes down, leading to a decrease in the environmental effect of the non-pasture part of the diet.
	Middle		-63 %		-97 %		-85 %	

* Scenario developed in SQ2 or SQ5, * Scenario mentioned in SQ2 or SQ5; the other scenarios were not developed in the main report. NB: For organic laying hens, the model could not simulate the environmental impacts of those scenarios because of a lack of references in the organic sector.

Source: Case study models

Regarding ruminants, the **modelled scenarios generally have higher positive environmental impacts** compared to the baseline diets than monogastric scenarios. The main highlights are the following:

The improved share and protein content of meadows and pastures has significant positive impacts on all three indicators, except in the case of conventional dairy cattle and goats, given that they only concern the production of manufactured feed. However, the decrease in the land needed to grow crops for producing concentrate feed is more than offset when taking into account the increase in pasture area (see 2.12.2 below).

Scenarios increasing the use of dried alfalfa also help decrease the impact of concentrate production on the three indicators – significantly for non-conventional beef and to a lesser extent for conventional sheep meat.

Scenarios introducing high protein seed meals (sunflower or rapeseed) are rather beneficial in terms of energy demand and global warming but tend to increase the area of land needed to grow the oilseeds as well as wheat to replace maize. However, these effects are mainly significant for conventional beef, whereas they are not significant for conventional dairy cattle and goats.

2.12.2 Estimation of the impact on land used for forage supply

However, for ruminants, **the environmental impact of increases in forages and pastures are not taken into account by the models**, due to the absence of relevant data in GFLI and ECOALIM databases. For the same reason, methane emissions could not be incorporated into the models. It was therefore only possible to estimate the total land area needed, including for forages, for conventional dairy cattle and goats in France, with the use of the French modelling tool Prospective Aliment. The land use change estimated below includes the result for the corresponding change in concentrate content presented above.

2.12.2.1 Land use change in the French conventional dairy cow sub-cluster

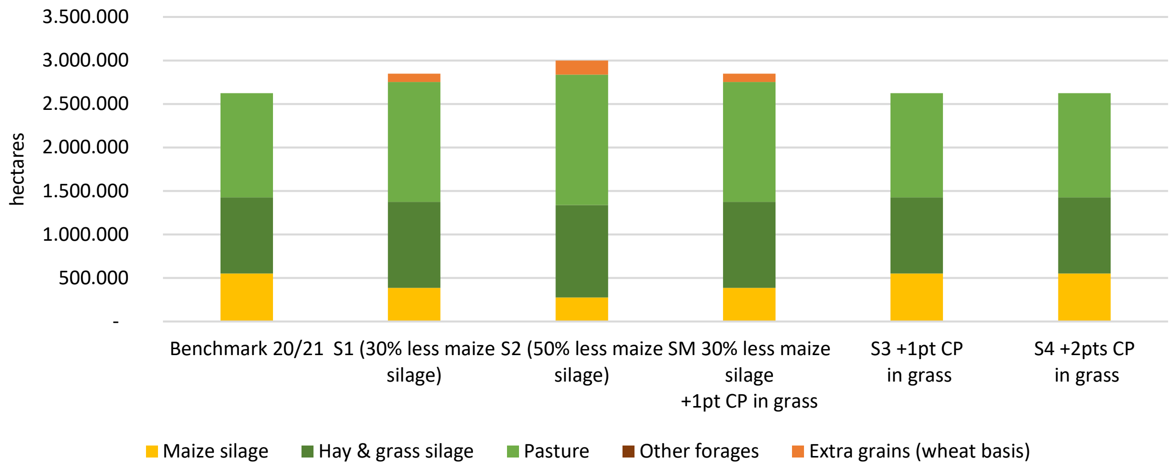
Among the five tested scenarios, two introduced a reduction in the maize silage part of the dairy cow diet (S1: -30 %, S2: -2 %). High-yield crops such as maize need to be replaced by other forages such as hay and pasture. The remaining two scenarios improved protein content in the existing grass provided to the cows, without impacting the rest of the diet (in particular, the maize silage share remains at the same level) (S3: +1 point of protein content in grass, S4: +2 points). Maize silage replacement in diets also requires an extra source of starch to fuel rumen activity. It has been approached by an extra supply of cereals (considered as wheat, but it could be triticale/barley), in order to supply nutritional needs of dairy cows (energy, protein, fibres, dry matter, etc.). The overall intake is very stable from one scenario to another, with grass replacing maize silage through increased pasture and hay/silage use. Other forages (beet pulp, sorghum forage, etc.) have been considered stable. One last scenario mixing the two types of hypotheses has also been tested, SM: -30 % of maize silage in the ration and +1 point of protein content in grass).

Maize silage decrease in areas is offset by a greater need of area to produce grass in all forms (pasture/hay). S1 and SM save 165 000 ha in maize silage, but need 110 000 ha more for hay, 180 000 ha more for pasture, and almost 100 000 ha for grains (see Figure 50). Overall, the extra surface needed is 225 000 ha, representing 9 % of total area for dairy cows. Results are even more significant regarding S2 (decreasing maize silage intake by 50 % and replacing it by grass). **This switch in diets represents a net increase of 375 000 ha, i.e. around 14 % in the total area mobilised to feed dairy**

cows. This result largely offsets the decrease in land needed for producing the concentrate share of the feed[257].

On the other hand, **S3 and S4 (respectively modelling the increase of 1 and 2 points of protein content in grass) would enable a relatively stable total land use for forage supply**. However, such scenarios suppose that farmers can afford to increase their pasture areas without interfering with their practices (e.g. milking, transportation, extra work, etc.). Furthermore, potential variations in yields are also a key factor in farmer choices, which usually favour maize, as discussed in SQ11.

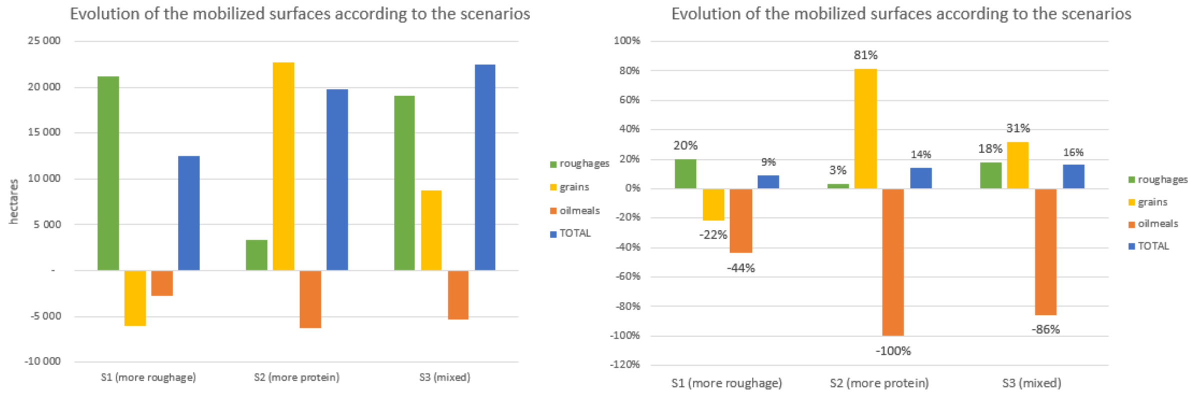
Figure 50: Required area for forage supply (hectares/y) in the French conventional dairy sector



Source: own results from the modelling

2.12.2.2 Land use change in the French conventional dairy goat sub-cluster

Figure 51: Impact of the sub-scenarios' rations on surface



Source: own results from the modelling

Scenario S3, mixing a higher quantity <u>and</u> quality of roughage, leads to an 18 % increase in forage areas (19 000 ha) and a 31 % increase in cereal areas (8 700 ha). At the same time, oilseed areas decrease by 86 % (5 400 ha). Overall, this leads to an increase of 16 % (22 300 ha) in land area needed for the mixed scenario.

[257] Indeed, the -18 % calculated in Section 2.12.1 concerns only the area needed to grow the cereal share of the concentrate. In contrast, the +14 % in land area needed for forage supply concerns the total UAA needed for feeding the whole French cattle herd (concentrate + on-farm forage and pastures).

2.12.3 Qualitative assessment of other environmental and climate impacts

The modelling tools available could not provide quantitative results concerning all types of environmental impacts. The quantitative assessment is therefore complemented by a qualitative assessment of the following, derived from the literature review and feedback from case studies at the level of the whole clusters:

- The environmental impacts of increases in pastures in the case of ruminant clusters, in addition to the impact of feed manufacturing
- The environmental impacts on other environmental indicators (water quality, biodiversity and soil quality, efficient use of resources, climate change adaptation).

A matrix tabulation is used to display (1) quantitative results from the modelling, (2) qualitative results from literature review and (3) a synthesis of all environmental impacts and their possible extrapolation at cluster and EU level.

Environmental impacts have to be assessed compared to an initial situation that differs depending on the context in terms of natural resources quality/availability, weather conditions as well as common agricultural practices. In Table 44 the intensity of the effects is quoted depending on how it was reported in the literature review, as well as on the size of the cluster in terms of livestock units. As previously stated, the context has also been taken into account, for instance concerning the development of grazing depending on the Member States composing the cluster. Regarding the effect of tropical deforestation on biodiversity, the extent of the decrease in the need for imported soya bean, deriving from the scenarios modelled, has been taken into account. Finally, the need for water to grow the crops has also been quoted depending on the local context in terms of water scarcity.

Overall, all the scenarios have rather positive impacts on the various types of environmental and climate pressures, except in a few cases detailed below. **The main potential negative impact concerns the need for water resources, in the event that some of the scenarios would be extended to the whole cluster**. Indeed, it was often stated during interviews that the development of alfalfa or rapeseed would be limited by water availability in Italy, Spain and southern France. This was also a concern regarding the development of pastures, in the event of drought years. On the other hand, the potential decrease in maize area has also been taken into account (with a positive effect) in some scenarios.

Scenarios involving the development of grassland grazing have very positive effects on climate change (thanks to their capacity to sequester carbon under certain conditions), water quality (by reducing the risks for nitrate leaching, ammonia emissions and phosphorus runoff) and biodiversity and soil quality (grasslands being a good habitat for many species) (EC, 2020. Peyraud J. -L., MacLeod M.).

Depending on how they are managed (in particular regarding the use of pesticides and fertilisers), development of legumes can offer benefits. For example, they can provide carbon sequestration benefits because they increase the fixation of nitrogen and carbon into the soil, thereby benefiting its carbon stocks, improving water retention capacity and reducing the need for additional fertiliser inputs. Depending on management practices, they may reduce nitrogen leaching in watercourses. They can also have benefits for biodiversity and soil quality.

Table 44: Qualitative assessment of other environmental and climate impacts of the scenarios in the clusters studied

	GHG emissions			Water quality				Air quality	Biodiversity and soil quality				Efficient use of resources	
Scenario	Direct emissions from enteric fermentation	Grassland grazing	Introduction of legumes in the cropping pattern	Excretion of feed nutrients by animals	High share of pastures	Phytosanitary treatments	Introduction of legumes in the cropping pattern	Ammonia emissions due to feed nutrients excretion	Tropical deforestation	Maintenance of permanent grasslands	Pesticides used on crops	Introduction of legumes in the cropping pattern	Need of water for growing	Nitrogen inputs decreased by the introduction
Pigmeat conv – *Legume seeds*	+		+				+		+			+		+
Pigmeat conv – *Insect meal*									+					
Pigmeat NC - *Enzyme NE-80*	+			+				+						
Pigmeat NC - *Ideal protein*	+			+				+						
Broiler conv – *Legume seeds*	+		+				+		+			+		+ +
Broiler conv – *Industrial amino acids*	+			+				+	+					
Laying hens NC – Diversify local Raw Materials (shelled field beans, soymeal, sunflower meal)			+				+		+			+	+/-	+ +
Laying hens NC – Mixed scenarios around methionine: insect and de-hulled sunflower meal				+				+					+	
Beef conv – *Improved grass share and grass quality of the ration*	-	+	+		+ +	+	+		+ +	+ +	+	+	+/-	+
Beef conv – *Increased availability of HP+ sunflower meal*						+					+		+	
Beef NC – *Increased inclusion of dried alfalfa*			+				+		+ +			+	-	+
Beef NC – *Improved protein content of meadows (legumes)*	-		+				+		+ +	+ +		+	-	+
Dairy cattle conv – *Increase roughage share and quality (alfalfa and other legumes)*	+	+	+		+ +		+		+ +	+ +		+	+/-	+
Dairy cattle conv – *Increased local protein crops + HiPro sunflower*			+				+					+	+	+
Dairy cattle NC – *Forage improvement*	+		+				+		+/-	+ +		+		+
Dairy goat conv – *grass roughage (alfalfa)*	+	+	+		+		+		+	+		+	-	+
Dairy goat conv – *HP rape meal*						-					-		+/-	

	GHG emissions			Water quality				Air quality	Biodiversity and soil quality				Efficient use of resources	
Scenario	Direct emissions from enteric fermentation	Grassland grazing	Introduction of legumes in the cropping pattern	Excretion of feed nutrients by animals	High share of pastures	Phytosanitary treatments	Introduction of legumes in the cropping pattern	Ammonia emissions due to feed nutrients excretion	Tropical deforestation	Maintenance of permanent grasslands	Pesticides used on crops	Introduction of legumes in the cropping pattern	Need of water for growing	Nitrogen inputs decreased by the introduction
Sheep meat conv – *dried alfalfa*	+		+				+		+		-	+	-	+
Sheep meat conv – *Improved pastures*	+	+ +	+		+ +		+		+	+ +		+		+

Source: Literature review and case studies

Scenarios involving feed additives and precision feeding (optimisation of amino acids, ideal protein, enzymes) allow for better absorption of protein content and thus a higher feed efficiency. This has positive effects on water and air quality by lowering excretions of nutrients by animals. They also have a direct effect on lower enteric methane emissions that is generally estimated to be low to medium, but they can achieve substantial indirect effects on emission intensity by improving feed efficiency and animal productivity (taken into account in the quantified impact of change in manufactured feed) (FAO, 2013. Gerber, P.J. et al.).

The inclusion of sunflower in the ration generally has positive environmental effects: it does not need many treatments, fertilisation, nor water. This is the reverse for rapeseed, although its environmental impact is much improved when grown during the winter (thanks to soil coverage and its capacity to make use of soil nutriments and water), compared to spring.

Beside the needs for water, negative reactions were also reported in the case of beef clusters. Indeed, interviews highlighted that a longer fattening period could lead to higher total emissions from enteric fermentation. In the case of non-conventional dairy cattle, some palm oil has been introduced in the ration which can contribute to tropical deforestation; however, this is a hypothesis of the modelling tool that may not be realistic.

2.12.4 Main findings

At EU aggregated level, the least-cost optimisation models available do not make it possible to present a single set of results for all clusters and all Member States. However, a macroscopic simulation of the impact on land use shows that **targeting 100 % replacement of imported soya beans by EU-grown soya beans would have significant economic impacts.** Indeed, compensating 100 % of soya bean imports by local soya bean production would mean replacing 3.6 million ha of wheat, 1.4 million ha of maize, 1 million ha of barley and 0.7 million ha of sunflower, a significant share of which is exported. **This is all the more unlikely given that the effect would be concentrated on a few Member States** and that, in parallel, the forage increase in ruminant rations calls for additional wheat to compensate for corn silage. **Furthermore, the impact of such a replacement target on global deforestation would be rather limited**, given that the latter is increasingly driven by demand from emerging countries.

Such significant economic impacts make it **very unlikely that significant changes occur in livestock production systems at EU level in the short term.** The diversification of protein sources will instead require the implementation of different combinations of levers, depending on the specific context. The land use and environmental impacts of protein source diversification will thus depend on such combinations of levers. The main effects to be expected, deriving from the cluster scenarios, are the following.

Regarding land use, the change related to scenarios was generally not significant in the case of monogastrics. In the case ruminants, it was not always possible to obtain quantitative figures that take into account the change in forage and pasture areas. However, the available results indicate the following:

- **Scenarios based on increased availability of local oilseeds require a greater land area than the baseline situation** (HiPro rapeseed meal for dairy cattle, HiPro sunflower meal for conventional beef and dairy cattle).
- This is **also the case for scenarios based on a higher share of roughage in the ration** (about a 15 % increase in land area for French conventional dairy cattle and goats), although less land is needed to produce manufactured feed.
- In the specific case of French conventional dairy cattle, an improved protein content of grass requires a land area comparable to the baseline.

Regarding environmental impacts, most scenarios allow for the introduction of virtuous practices and decrease pressures on the environment compared to the baseline situation:

- **Overall positive effects on biodiversity and soil and water quality**, mainly due to the introduction of legumes in the cropping pattern in most scenarios, which may reduce the need for fertilisers. Scenarios based on pastures also have positive effects, whereas scenarios based on rapeseed development could increase negative pressures depending on the local context in terms of the usual cropping pattern and of the season when rapeseed is grown.
- **Some positive effects on air quality** for scenarios with enzymes or optimisation of amino acids, which tend to increase the ratio between protein retention and intake, thus enabling a reduction of nutrient excretion and related ammonia release. Other scenarios do not have significant impacts on air quality.
- **An overall decrease in GHG emissions for most scenarios**, even if beef scenarios based on grass have mixed effects, since the lengthening of the fattening period might lead to higher methane emissions.
- **Regarding the efficient use of natural resources, effects are overall positive or mixed.** Indeed, most scenarios benefit from a lower need in nitrogen inputs, due to the introduction of legumes. Regarding monogastrics, several scenarios are based on energy-intensive industrial processes. For ruminants, in contrast, several alternatives proposed appear not to be adapted to some local contexts in terms of water availability, especially in the current context of climate change. This is, for example the case for alfalfa and rapeseed in southern Member States.

Table 45: Qualitative assessment of other environmental and climate impacts of the scenarios in the clusters

Scenario	**Land use**	**GHG emissions**	**Water quality**	**Air quality**	**Biodiversity and soil**	**Efficient use of resources**	**Replicability**
Pigmeat conv – *Legume seeds*		+	+		+	+	Limited
Pigmeat conv – *Insect meal*		-			+	-	Limited
Pigmeat NC - *Enzyme NE-80*		+	+	+			Relevant
Pigmeat NC - *Ideal protein*			+	+		-	Relevant
Broiler conv – *Legume seeds*		+	+		+	+	Relevant
Broiler conv – *Industrial amino acids*		+	+	+	+	-	Relevant
Laying hens NC – *Diversify local raw materials*		+	+		+	+	n/a
Laying hens NC – *Mixed scenarios for methionine*			+	+			n/a
Beef conv – *Improved grass share and grass quality of the ration*	**n/a**	**+/-**	+		+	**+/-**	Relevant
Beef conv – *Increased availability of HiPro sunflower or rapeseed meal*	-	+	+		-	+	Relevant (but rather rapeseed in NL, BE)
Beef NC – *Increased inclusion of dried alfalfa*	**n/a**	+	+		+	**+/-**	Limited in ES
Beef NC – *Improved protein content of meadows (legumes)*	**n/a**	**+/-**	+		+	**+/-**	Limited in IT
Dairy cattle conv – *Increased roughage share and quality (alfalfa, other legumes)*	**+/-**	+	+		+	**+/-**	Relevant in FR only

Scenario	Land use	GHG emissions	Water quality	Air quality	Biodiversity and soil	Efficient use of resources	Replicability
Dairy cattle conv – *Increased local protein crops + HiPro sunflower*	-	+	+		+	+	Relevant
Dairy cattle NC – *Forage improvement*	n/a	+	+		+	+	Limited
Dairy goat conv – *grass roughage (alfalfa)*	-	+	+		+	+/-	Relevant
Dairy goat conv – *HP rape meal*	-		-		-	-	Relevant but limited in ES
Sheep meat conv – *dried alfalfa*	n/a	+	+		+/-	+/-	Relevant
Sheep meat conv – *Improved pastures*	n/a	+	+		+	+	Relevant

Source: Literature review and case studies

3 CLOSING CHAPTER

3.1 MAIN CONCLUSIONS OF THE STUDY

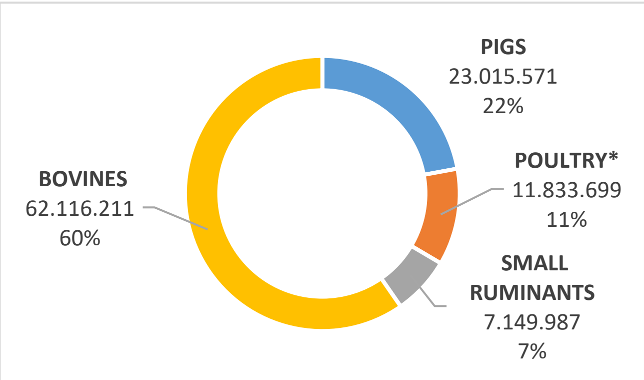
3.1.1 Demand and supply for plant proteins dedicated to livestock sector in the EU

The volume of the EU crude protein demand for feed in the 2021/2022 campaign was 72 million tonnes. 55 million tonnes of crude proteins came from the EU, **representing around 77% of protein autonomy**. **The EU feed market is self-sufficient in roughage. In addition, 90 % of cereals feed is produced in the EU. Nevertheless, only 37% of co-products (e.g. protein meals) are produced in the EU. The self-sufficiency ratio for oilseed meals is 23% and 3% for soya bean meals.** Soya bean meal is mainly imported from the Americas for the conventional sector, and from Africa or Asia for the organic sector. Imports of soya beans, rapeseeds and sunflower seeds and their meals reached 14.46 million tonnes of crude proteins (49.5 million tonnes of raw product) in 2021/2022, requiring roughly 18 million hectares of land, taking into account the average yield for each crop. This 'offshore' surface represents approximately 13% of the 135 million hectares devoted in the EU to crops potentially consumable by animals[258].

The EU Member States represent a complex mosaic in terms of soil, climate, resources and geographical location (e.g. seafront or landlocked). The type of livestock raised in each Member State reflects these various specificities as well as historical habits and economic opportunities and constraints. For example, Belgium, the Netherlands, and Spain produce far more animals than their 'intrinsic' resources allow, thanks to imports of oilseeds and/or oil meals, as well as cereals.

In 2021, total EU livestock amounted to more than 104 million livestock units (LU[259]). Bovine animals are the most numerous, as they represent more than half of the total herd, with more than 62 million LU. Pigs come second with 23 million LU, representing 22%. Laying hens and broilers are less numerous, and the small ruminants (sheep and goats) are the least numerous, representing 7% of total livestock in LU.

Figure 52: Breakdown of LU in the EU (2021=104 115 468)



Source: CEREOPA, based on available data (Eurostat, FEFAC)
*hens 2021 and broilers 2016

The nutritional requirements of ruminant and monogastric animals are very different. Ruminants rely mostly on forages, while monogastrics rely mostly on concentrates (e.g. cereals, oil meals, etc.). Due to the differences in composition of these diets and to the level of availability of feed components, **monogastric farming (for conventional and non-conventional systems) tends to be more dependent on imports than is ruminant farming**, even though the dairy cow sector is the second-biggest user of soya meals.

Throughout the EU, feeding strategies are mainly driven by **economic reasons and more precisely by price ratios**: price ratio of the on-farm produced crops vs purchased feed

[258] Roughly: arable land plus permanent grassland, excluding crops intended exclusively for human consumption (root crops, fibre crop, fresh vegetables, permanent crops, and others), according to CEREOPA data.
[259] Livestock units are used here, as it is difficult to compare animals with very different sizes (e.g. cow vs chicken), and in addition the cycles of the species over the year are very different (e.g. poultry produce several generations a year). Hence, to make comparisons in feed consumption, it was preferrable to work in LU.

for livestock farmers; of EU produced crops vs imported soya bean for suppliers, including arable crop producers; and nutritional quality/price for farmers and feed manufacturers. **Farmers** are also influenced by **contractual arrangements**, **legislative requirements**[260] and **traditional practices**[261]. The behaviour of **raw material suppliers** is also economically driven but is dependent on **regulatory requirements** and **other markets**, since there is competition with other sectors for some raw materials (e.g. pet food, human consumption, industrial use, bioenergy, etc.). **Feed manufacturers** then have to strike the right balance between **nutritional quality, availability,** and **prices**.

Finally, it is all about the **needs of each type of animal** (species, age, certification, etc.). Among the three main components of feed, all proteins are not equal (particularly in terms of amino acid profile, energy supply is just as essential, and fibre is more or less necessary[262]). In addition, the protein ingestion capacity of animals, particularly ruminants, can also be a limiting factor. **The range of solutions can therefore be different for each category of operators and even for each livestock production context (e.g. cluster), which means that there are multiple solutions.**

Nevertheless, and even though this study is based on in-depth analysis of 10 different clusters in 13 Members States, most of the analysis and recommendations apply to all the studied clusters, with the following caveats:

- There are, of course, differences between monogastrics and ruminants: the feed of the latter relies mostly on grass/forage/roughage grown in the EU and most of the time at farm level.
- There are slight differences between conventional and non-conventional (organic, non-GM and PDO/PGI) clusters, apart from some restrictions due to regulation and standards (see below).

Hence, in the following executive summary, we treat mainly ruminants and monogastrics, rarely mentioning a given cluster, as explanations could quickly become highly confusing. For example, the systemic modelling of all the clusters at national level shows that **a lever can have winners and losers when one cluster is able to pay more for one diversification lever than another**[263]. These differences are presented in detail in the full study report.

3.1.2 The diversification levers are known

3.1.2.1 Crops already grown in the EU

Most of the identified alternative raw materials intended for livestock feed are already produced in the EU and used in most Member States. Among the most important levers that were analysed in this study, the most relevant are the following:

- Increase in **the quality and/or the share of proteins in the forage/roughage ration of ruminants** through several possible strategies: integration of fodder

[260] E.g. in organic farming the minimum percentage of feed coming from the farm.
[261] Practices usually carried out on the farm or in the region in the long term, implying a fear of change.
[262] Ruminants need more fibres than monogastric species.
[263] In the modelling work, we have tried to identify which species would benefit from the introduction of a new solution in a global system where species/formulas are in competition to capture the cheapest, most suitable raw materials to fill their needs. Our systemic approach depicts the existing fact that when several formulas are in competition for the same (and limited) resource, formulas with the highest constraints will often come first and use it as much as they can. More versatile formulas, which can put several types of raw materials to good use and can easily switch from one to another, are more likely to use the remaining raw materials. In cases where we introduced a new raw material with high protein density, good amino acid composition and digestibility, and high energy level, the formulas that would benefit the most from it are calculated through its shadow price (which is, for each formula, the highest possible price of this raw material to enter this formula, entirely based on its nutritional composition). For protein and amino acid, species that require the densest raw materials are chickens and turkeys (due to their fast-paced growth, with high energy and amino acid requirements). That often makes them the first to capture new raw materials such as the ones we tested. At the other end of species' competition, more versatile species are able to put most of the raw materials to good use, and with limited nutrient requirements: e.g. ruminants, swine, and gestating sows. These formulas are less likely to access new raw materials if volumes are limited, as the first tonnage will be dedicated to the most competitive formulas (broilers especially).

legumes (dried alfalfa), improved pastures and grassland management (balanced grass and legumes mixtures), or meslins (i.e. mixture of cereals and grain legumes).
- Increase in the production of **soya bean, sunflower, rapeseed and of pulses** in the EU.
- **Replacement of soya meals by the development of improved meals** from sunflower or rapeseed (high protein (HiPro) sunflower[264] or rapeseed[265] meals) or from legume crops (e.g. shelled beans) cultivated in the EU.

But, of course, increasing the production of these crops/grasslands implies reducing others and particularly cereals, which can have an incidence on the EU market and also on exports of these products (see Section **Erreur ! Source du renvoi introuvable.**).

3.1.2.2 Various complementary strategies for diversification

The livestock sectors are not equivalent in terms of import needs. It is clearly the conventional pig and poultry meat sectors that are the most dependent on soya meals imports. Ruminants rely more on fodder even if some concentrates are supplied. All non-conventional livestock sectors (i.e. non-GM, organic and PD/PGI) are usually less dependent on imports.

Apart from diversifying diets with EU-grown raw materials, there are many other strategies to diversify feed composition or at least reduce the need for protein-rich materials (imported or not). Some strategies have already been implemented by operators in some sectors and some Member States:

- **Better characterisation of livestock needs (at least by age) to avoid an excessive supply of certain nutrients** while guaranteeing a good yield.
- Better characterisation of the nutritional values (e.g. amino acid profile, content in starch, fibre, etc.) **of the raw materials** used in the ration and in particular of forages.
- **Selection of new crop varieties less rich in anti-nutritional factors (ANF), or richer in specific amino acids** (e.g. fava beans).
- Selection of **crops providing stable and higher yields** (e.g. HiPro rapeseed), better adapted to various pedoclimatic regions of the EU (e.g. soya beans varieties[266]).
- **Selection of more robust animal species (especially monogastric species), less sensitive to ANF and more adapted to diversified diets.**

Some others are more in the experimental phase and cannot be developed without changes in the regulatory framework such as:

- The introduction of **insects that is relevant in terms of nutritional values** and complementary to raw materials grown in the EU[267].
- A **circular economy approach** that could help keep nutrients in the feed system, for example by recovering Processed Animal Proteins **(PAPs)** and **former foodstuffs[268]**.
- Contributions of **amino acids[269] or enzymes in rations** in order to optimise the use of nutrients from raw materials or to reduce the need for some raw materials

[264] HiPro sunflower meal is produced into factories which concentrate their protein content.
[265] HiPro meal is produced from a variety of rapeseed having a higher protein content.
[266] Able to grow in Northern areas than presently.
[267] This lever must nevertheless be nuanced: the study revealed widespread skepticism about the potential of insect meal for animal feed in the supply chains of interest, due to a number of technical and economic limitations, as well as low perceived acceptance by end consumers and retailers.
[268] For these sources, however, the animal feed sector suffers from competition from other outlets (e.g. pet food, biogas production) and some regulatory and technical barriers still need to be overcome. For PAPs, consumer acceptance is still low; however, other actors in the supply chain are more open to their use than in the past (e.g. retailers), especially for monogastric species.
[269] Amino acids are widely seen as a solution to include in the diets of EU-produced raw materials, which have a sub-optimal amino acid profile compared to soya products.

such as soya bean meal. However, the heavy dependence of the EU livestock sector on imports of amino acids, particularly from China, remains of concern.

3.1.2.3 Constraints and advantages of 'non-conventional' markets

The levers identified for organic farming, Protected Designation of Origin (PDO) Protected Geographical Indication (PGI) and non-Genetically Modified (GM free) sectors are globally similar to the levers of the conventional segments, with a few exceptions:

- Non-conventional sectors are governed by regulations and specifications (organic, PDO/PGI standards, non-GM regulations). Therefore, not all of the alternatives mentioned can be used in all sectors if they do not meet the requirements of these regulations and specifications. For example, **synthetic amino acids are prohibited by organic regulations.**
- The outlets of co/byproducts can be a limiting factor. For example, HiPro[270] sunflower meals and shelled beans are processes that increase the protein content of these raw materials. **But the market for co/byproducts** (e.g. oil for human consumption), **must also exist at the same time and also be profitable** for the sector to develop, which is not always the case[271].

3.1.2.4 Several combinations of levers: the only diversification solution

The advantages and technical obstacles of these alternatives are known and documented in the various literature dealing with the subject. The stakeholders interviewed during the study are also informed of all the advantages and limitations. In the opinion of the operators and experts met during the study, there is not one single solution that would be applicable to all production systems, all livestock, and all regions of all Member States. **The challenge of diversification is to implement different combinations of levers adapted to the needs and conditions of the agricultural sectors and adapted to the various EU regions and to the various types of farms** (e.g. intensive vs extensive, small vs large, growing ruminants or monogastrics, etc.)**.**

Results of the scenarios modelled demonstrated the relevance of some levers compared to others. It is obvious that the major lever for **diversifying the diet of ruminants consists in increasing the share of proteins ingested via an increase of grass or roughage/forage in the ration and by integration of fodder legumes** (e.g. dried alfalfa), **as well as improved pasture and grassland management**. This can nevertheless be limited for some sectors where production is very intensive (e.g. conventional milking cows) or in systems lacking available land (e.g. small farms).

Increasing the production of protein crops[272] and oilseeds, as well as developing varieties and processes to improve their nutritional profile and limit their yields variation, is systematically emerging as another relevant lever. Presently, one of the major constraints to their use is their low overall availability due to variable yields, low profitability for some of them[273] and lower competitiveness in terms of nutritive profile compared to imported soya bean/soya meal[274]. They also sometimes have fluctuating nutritional values, requiring a regular adaptation of feed mix to variable raw materials. All these barriers are avenues for research programmes.

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[270] High protein (content).
[271] For organic sunflower HiPro for example, meals must be produced at a competitive price, but the oil produced in the process also has to find a market in the organic sector (in quantity and quality), which is not always possible.
[272] In the context of this study, **protein crops** correspond to legumes (including mixtures of legumes and grasses), and soya bean.
[273] Particularly compared to main crops in rotation, such as wheat and maize.
[274] They also have an energy and protein content not sufficiently concentrated compared to their competitors, which makes them less versatile in their uses.

3.1.3 Competitiveness (and complexity) are the core challenges

The first main reason why these alternatives have not yet been sufficiently deployed is the **competitiveness of the related crops compared to imported soya bean, as well as vs cereal crops in competition in crop rotation. But this is not the only reason**, and the issues are too complex to be reduced to a single consideration of relative competitiveness.

The advantages and technical obstacles of the alternatives depend on many factors: the pedoclimatic situation of the regions, the production systems and the various associated regulations, the production capacities, the staff implications, etc. **This study was able to identify a number of significant drivers that influence stakeholders' decisions to use more EU-produced feed sources**. They are of various categories in economic, technical, organisation and political.

Economic factors are the most important determinant in the choice of raw materials for arable crop farmers and feed manufacturers. The two key factors are: the **relative price/yield and availability** (i.e. satisfactory availability of protein sources produced in the EU – in terms of quantity and quality in terms of nutritional composition and amino acid profile). For both key factors, **volatility and risk** are also significant drivers/constraints, in particular for arable crop producers.

The grass lever for animal breeders is slightly different from the other diversification levers from an economic point of view, as there are many other specific indirect costs influencing livestock farming. Hence, the economic factors (price and availability) can be less central for some of them. **Land availability, working time, agronomic expertise, zootechnical knowledge and yield variability are also crucial factors besides economy that induce livestock breeders to increase the proportion of grass in the ration or not** (due to a lack of available land, for example)**.**

3.1.3.1 Feed price: top priority of the operators concerned

The diversification crop (whether rapeseed, sunflower, soya bean or other protein crop) must first be economically attractive[275] to produce for **arable crop farmers.** The study compared the average gross margins of crops for farms specialising in crops that could be alternatives either to wheat or maize.

Some examples of these comparisons are given below.

- **Rapeseed is generally competitive compared to wheat** in most Member States[276].
- **For protein crops[277] and sunflower, it is hard to compete with maize[278] across the whole EU:** in all Member States surveyed, the gross margin of maize crop is significantly higher than those of soya bean and sunflower.
- It is **more difficult to draw conclusions for the protein crops traditionally produced in the EU[279]**, as they depend on the protein crop species and on the region considered[280].

The manufacturer includes an alternative raw material in its formulation only when it is available on a long run, in sufficient volume, with a required quality and at an attractive price. If this is not the case, the manufacturer should be able to increase its selling price, but this is often not possible due to competition from other manufacturers that use cheaper raw materials. **Incorporation can be forced** (e.g. if

[275] Some farmers or advisers also work on rotation margin, which is generally more favourable to protein crops.
[276] Except most of the Mediterranean zone.
[277] soya, peas, beans, faba bean, etc.
[278] Both for grain and silage purposes.
[279] I.e. all protein crops (peas, beans, faba beans, etc), except soya.
[280] For example, in Romania, the gross margin of farmers cultivating soya bean is significantly higher than that of wheat.

requested by standards) **or incentivised through regulation, contractualisation initiatives[281] or consumer demand for a niche product, etc.**

Pricing mechanisms are central to the contractual arrangements between feed manufacturers and their raw material suppliers, in particular when the dynamics of EU prices are influenced by world prices, which is the case for the three main oilseeds, in particular soya bean. For these crops, the pricing mechanisms tend to be adjusted more frequently. The price could be determined by a fixed component and a variable component, which may be linked to the futures markets (when they exist and are sufficiently liquid)[282], which will limit the volatility of prices. But these mechanisms are less developed in the EU than in the US.

Animal breeders face other challenges. The ambition to increase feed autonomy may lead them to develop production of protein crops for self-consumption[283]. The notion of competitiveness of the produced crop could be combined with other issues at stake (as there is not systematically the objective of selling the products on the market); however, when there is a limited availability of or access to land[284], the production of alternative crops also competes with more profitable cereal crops. The farmer's choice is then whether the self-sufficiency provided by the crop compensates for the loss guaranteed by a saleable crop (e.g. maize or wheat), which depends on a comparison of their related opportunity costs. Furthermore, as grass production is much more variable than silage maize, silage maize can be seen by farmers as an insurance against risk, and they may wish to keep it in their ration.

Nevertheless, although core issues, the competitiveness of each raw material and its relative prices are not the only decision-making factor, as explained below.

3.1.3.2 Increasing the availability of proteins from EU-grown raw materials: a question of relative competitiveness, but not just that…

In addition to the purely financial aspects, the choice of the crop for the raw material producer **also depends on other aspects** such as availability of land, crop adaptation to local pedoclimatic conditions, crop management, crop protection (including availability of phytosanitary products for this crop), production costs, knowledge of the crop, equipment needed, etc. Profitability remains central to develop protein production in the EU.

Nevertheless, increase in diversification of production in the EU (grass, pasture, oilseeds, protein crops) requires, at EU level, available agricultural land suitable for the crops of interest. At farm level, the study shows that farmers are not equal in terms of land availability (particularly for small intensive farms) and that in most cases land availability in the EU is limited.

Indeed, an increase of the availability of protein from raw materials grown in the EU, would be done at the expense of crops already in rotation. Rapeseed and some protein crops will compete mainly with wheat and soya, and sunflower mainly with maize. As described earlier, **maize has higher gross margins overall**. For wheat, the situation is more mixed, and other drivers are likely to hinder the development of alternative crops.

At the EU aggregated level, the target of 50% replacement of imported soya bean by local protein-rich plants would have significant economic impacts**. Replacing 50 % of soya bean-equivalent imports** (19 in 21/22) would mean swapping 6.6 million ha of other crops, i.e. around 4% of the EU 27's UAA. Leaving forage crops (excluding silage maize) and vegetable crops untouched, this would mean converting almost 9.5% of the remaining area, i.e. roughly 3.6 million hectares of wheat, 1.4 million hectares of maize,

[281] Thanks, for example, to the use of operational programmes for producers' organisations of the new CAP.
[282] The linking of pricing formulas with the futures markets also allows for the application of hedging techniques by operators with the necessary expertise, which mainly concerns big players.
[283] The stakeholders interviewed during the study relativise this fact, as feed self-sufficiency would not be the priority for most animal breeders.
[284] For dairy cows, access to grassland is less easy when the there is a pre-set milking facility, which represents the majority of cases.

1 million ha of barley and 0.7 million ha of sunflowers. The land-use change needed at the expense of cereals **would thus have significant impacts on EU external trade and on exporting Member States**. Such significant economic impacts make it **very unlikely that significant changes occur in livestock production systems at EU level in the short term.** The diversification of protein sources will instead require the implementation of different combinations of levers, depending on the specific contexts, and pathways for change for the medium/long term.

In terms of EU land use, the change related to scenarios was generally not significant for monogastrics. In the case of ruminants, it was not possible to obtain quantitative figures for all clusters. But available results suggest that **scenarios based on increased availability of local oilseeds require greater land area in the EU than the baseline situation** (HiPro rapeseed meal for dairy cattle, HiPro sunflower meal for conventional beef and dairy cattle). This is **also the case for scenarios based on a higher share of roughage in the ration** (e.g. about a 15 % increase in land area for French conventional dairy cattle and goats), although less land is needed in the EU to produce manufactured feed.

The impact on the organisation of farm activities as a whole also has to be taken into account. For example, the indirect agronomic impacts after the introduction of a new crop in rotation, in terms of working time generated, transport time between potentially scattered plots, available plots and size, or even the tools and equipment needed, are examples of factors that each farmer will integrate in his/her reasoning before deciding to include a new crop in his/her rotation or to expand some of them (e.g. pasture). The lack of experience and knowledge regarding a new production also influences the farmer's choice.

Finally, the existing outlets and the organisation of the sector constitute a major constraint to the introduction of alternative crops, in particular the existence of outlets for co/byproducts and structured logistics networks, tools, machinery, and equipment (e.g. collection, sorting, and storage capacity).

Farmers are also aware of the **regulatory requirements on crop production**. Regulations on irrigation, fertilisers and available pesticides for a given crop, or private standards, etc., influence the choice of crop production/rotation. In this respect, the regulations on climate and environmental protection are changing rapidly since the publication of the Green Deal, and recent regulations could still change the context of European production (concerning imports of fertilisers and soya beans in particular).

3.1.3.3 Quality and nutritional requirements throughout the chain

Technically, for both animal breeders and feed manufacturers, product characteristics and quality parameters (e.g. crude protein content, organic, non-GM, etc.) are major factors to consider. Above all, the feed must be nutritionally adapted to the needs of the animals at a given age and in a given sector or cluster (e.g. private standards). **The nutritional requirements set by processors and/or distribution chains in their supply methods can have a greater or lesser influence on feeding strategies.** In general, the more stringent the requirements are in terms of (i) permitted raw materials, (ii) minimum/maximum inclusion rates of specific raw materials in the manufactured feed diets/formulae and (iii) raw material quality parameters, the greater the influence. The use of synthetic amino acids enables a ration to be better balanced from a nutritional point of view. This lever, already well established in some livestock sectors (mostly monogastric) and some Member States, has been recently applied to ruminants, but up to now, to a still limited extent in almost all Member States.

Nutritional requirements (mostly sourcing of the raw material and method of production) set by EU legislation[285] are also a key element that determine the choice of manufactured feed for organic farming, non-GM production and in the

[285] https://agriculture.ec.europa.eu/farming/organic-farming/legislation_en

specifications set for PDO and PGI products (especially for PDO). Sectors that have chosen to develop in such specific segments have thus facilitated the development of alternative crops in their territories. For example, Austria has significantly increased its soya bean production since the introduction of incentives (by public authorities) to produce animal products without GMO feed. Germany has developed soya bean production to meet the needs of the non-GMO poultry and milk sectors.

3.1.3.4 Impacts on the organisation of the supply chain

The scenarios on supply chains identified only a few impacts[286] concerning the **'soft' elements of the organisation of the supply chain,** such as the internal organisation / the operational procedures of the operators, the vertical coordination/integration, contractual arrangements, process/quality, and requirements, standards, etc.

With regard to the **organisation of the feed supply chain**, including the **associated regulatory mechanisms**, two main areas for potential improvement were identified by the stakeholders consulted:

1. Organisational solutions[287] to promote **an increased supply of alternative raw materials and/or the commercial production of innovative raw materials**. Ideas for improvement included increasing coordination along the chain (e.g. deciding investment in partnership, establishing contractual arrangements in the medium term, and developing process/product specifications, setting up private standards, etc.).
2. Organisational solutions aimed at **promoting increased use of alternative raw materials** and/or enabling the use of **innovative raw materials**.

As for the **organisation of the animal product sectors**, two main areas for improvement were identified by the stakeholders consulted:

1. Development of **solutions to improve the competitiveness** of animal product supply chains, with a view of ensuring the economic conditions that would allow the (increased) use of more expensive alternative/innovative, such as, EU-grown raw materials (e.g. establish private standards and communicate on the EU origin of the feed through outreach campaigns for these products, etc.).
2. **Revision of nutrition-related requirements** in product/process specifications and existing quality standards for end products (e.g. PDO/PGI), to allow for increased use of alternative raw materials and/or for the use of 'innovative' raw materials (e.g. PAPs).

3.1.4 The impact of alternatives studied on the environment

Overall, the literature shows a global positive effect for the environment of grassland and protein crops. However, **these impacts cannot be made widespread because they are highly dependent on the cropping methods used by farmers and even on the crop itself**[288]. In addition, environmental impacts will depend on the area and the geographical context concerned by changes in land use. Given the diversity of possible levers, context, and management strategies, it was possible to quantify only some of the environmental impacts of the alternative strategies. Additional literature review made it possible to add some additional points. It is with these limits in mind that the following chapter must be read.

[286] In this respect, it should be considered that the feed manufacturers interviewed attach rather limited importance to the contractualisation of the supply of agricultural raw materials as a driver for the increased use of raw materials grown in the EU (see SQ3).

[287] The possibility in the new CAP to use operational programmes of producers' organisations, which applies to all sectors, should be explored by the different value chains aiming at developing this type of diversification.

[288] Rapeseed, for example, requires more treatments than soya or sunflower.

A majority of scenarios reduce the pressure on the environment compared to the reference situation and show the following:

- **An overall positive impact on biodiversity, soil, and water quality,** mainly due to the introduction of legumes into the cropping system in most scenarios, which can reduce the need for nitrogen fertilisers. Pasture-based scenarios also have positive environmental impacts. In contrast, scenarios based on rapeseed development could increase negative pressures on the environment[289].
- **Some positive air quality effects can be expected** for scenarios with enzymes or amino acid optimisation, which tend to increase the ratio of protein retention to intake, thus allowing for reduced nutrient excretion and the associated ammonia release.
- **An overall decrease in GHG emissions for a majority of scenarios.** However, in the beef scenarios, the proportion of grass in the ration should be increased due to the extension of the fattening period, which could lead to increased enteric methane emissions.
- **With regard to the efficient use of natural resources, the effects are generally positive, depending on the growing methods [290].** Indeed, most of the scenarios benefit from a lower nitrogen supply requirement, due to the introduction of legumes. However, as regards monogastrics, several scenarios are based on energy-intensive industrial processes leading to increased GHG emissions. In addition, several alternatives proposed for ruminants appear unsuited to certain local contexts in terms of water availability, particularly in the current context of climate change. This is for example the case for alfalfa and rapeseed in the EU southern Member States.

Apart from a number of issues to be considered, and provided that growing methods do not result in increased use of PPPs or N losses into the environment, or loss on biodiversity in agricultural land, the **diversification of protein sources should, with variations in function of the crop and growing methods, have a positive impact on the environment.**

Moreover, as explained above, the strategies will not rely on a single solution, but on several combinations of levers adapted to the local context. The considerations on the combination of levers (to be carried out by territory according to specific situations) will therefore have to take into account environmental issues to propose a mix of solutions that is as positive as possible for the environment. This means, for example, avoiding solutions based on the use of monocultures (such as soya or rapeseed) and **favouring levers based on grasses, protein crops and fodder legumes.**

The impact on global deforestation by replacing imported soya with EU-grown proteins would be rather limited: deforestation is increasingly driven by demand from other countries, and the potential deforested area corresponding to EU imports is estimated at 7 % of the Brazilian total area at risk of deforestation and should decrease to 0 % by 2025 due to the EU ban.

3.1.5 Policy instruments for diversification

Enhancing domestic protein crops to reduce import dependency requires an organised and balanced implementation of all the alternatives described in this study. This can be done at different levels, from the EU to Member States and regions, and even sectors or clusters within these sectors.

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[289] Rapeseed is more dependent on pesticides, especially insecticides. But this highly depends on the local context in terms of usual cropping patterns and the rapeseed growing season, since the environmental impact of oilseed rape is improved when grown during winter, thanks to the ground cover and its ability to make the best use of soil nutrients and water.

[290] It can be mentioned that, in general, animals can be efficient protein producers, i.e. producing more protein in milk and meat than the protein they consume edible protein sources. This is particularly true for grassland-based ruminants (European Commission 2020. Peyraud J.-L., MacLeod M.). Furthermore, grasslands are central in the EU climate strategy and the implementation of the LULUCF Regulation.

One of the most essential conditions for this development is the competitiveness of each envisaged alternative. But it is not the only one: the alternatives must also be available over a longer period of time (as they almost always imply significant investments along the whole value chain), meet the nutritional needs of animals (meaning with performance able to compete with the imported products), and be reasonably priced. They must also be known and handled by all the operators in the cluster, so that they can be developed in partnership and used appropriately. Public policies can indeed support such a development at EU level through the design of the CAP instruments, public research programmes, etc., but further partnership with the private sector is also required in developing for example new varieties or breeds, treatment products more adapted to proteins crops, etc. because substantial resources[291] and commitment will be needed to succeed[292].

To improve competitiveness, research and innovation are also key sectors that could overcome many obstacles and bring innovations that make alternatives more competitive. Many projects are already supported and funded, but efforts need to be intensified.

At farm level, the study has shown that crop diversification rules in **the past regulatory framework – particularly the conditionality or greening measures for direct support – and the financial support currently available under the CAP (e.g. coupled payments) have not significantly modified the situation prevailing for decades**. Hence, to significantly change this situation, this study argues **for a substantial increase in the existing coupled income support for the crops/productions concerned**[293] (provided that this is not in breach of any international agreement), to provide a real incentive for farmers.

The **EU coupled income support to oilseeds (soya, rapeseed, and sunflower) could theoretically be extended in the EU up to 7.8 million ha**, i.e. the maximum limit under the Blair House Agreement, compared to only 1 million ha presently supported. In this way, the EU could provide support to an area equivalent to roughly[294] half of the present importations, which would be already very significant. Furthermore, some of these crops could also grow in the most suitable regions, without any support from the CAP, meaning that this ceiling has little chance to be reached[295]. Given that these crops are grown intensively, it would be important to remain vigilant that growth does not result in increased use of PPPs or N losses to the environment, or on loss of biodiversity in agriculture land.

Such coupled support could be rounded out by **better-tailored harvest insurance**, focusing on protein crops, to reduce the risk for farmers cultivating these plants. This tool is too little used in the EU.

The **lack of investment to support diversification** is true for all the operators of the value chains (e.g. farmers, collectors, processors, etc.), as the investments made in the EU to support diversification (e.g. storage facilities[296], processing machinery, etc.) are still lacking in some regions/value chains to help provide local solutions and develop protein

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[291] Additional to public ones.
[292] Such programmes mixing public and private initiatives have already been implemented in different countries (e.g. grass development in New Zealand, canola development in Canada, etc.) to reach common strategic goals.
[293] Article 33 of the new CAP regulation includes, in the list of products/sectors eligible for coupled income support, oilseeds (excluding confectionary sunflower seeds) and protein crops, including legumes and mixtures of legumes and grasses, provided that legumes remain predominant in the mixture.
[294] And depending on the crops concerned.
[295] Beyond the use of coupled support, it could be conceivable - from a pure theoretical point of view - to raise the import tariff for a good such as soya bean under the procedure of GATT Art. XXVIII, but this option would probably be extremely costly politically. Actually, such a decision would also require granting adequate compensations for exporters, generally in the form of a tariff rate quota equivalent to the level of EU imports before the increase of the tariff. Hence, there is little chance for that to happen.
[296] Adding a new crop in the region where it is not produced requires investment at least in additional storage capacity.

crops or improved fodders[297]. Significant room for manoeuvre exists here to support the equipping of the concerned value chains.

The new CAP **Strategic Plan Regulation** (SPR) in CAP 2023/27 (Regulation (EU) 2021/2115)[298] has extended the support of operational programmes of producers' organisations beyond the historical 'fruit and vegetable' sector. This means that arable crop producers and livestock producers organisations can now apply for this instrument that can finance both material (e.g. equipment) and immaterial expenses (e.g. studies, advice, etc.). These new possibilities have then to be explored.

National policies can also have a great influence on the protein crop sector. This is for example the case in the Netherlands, on the limitation of their herd, but also in the Members States which developed 'proteins plans' such as Belgium, Denmark, Finland, France, Germany, and the Netherlands. These policies could also favour a priority access to irrigation water for these crops in the event of competition with maize, for example.

Public policies should also promote training, support and advice on a large scale to ensure the upgrading of the skills of most of the operators in these sectors, including on sustainability[299]. Traditions are deeply rooted in the choice of production methods and feed strategies. Resources must therefore be ambitious and accessible to all because **the increase in skills must be rapid and global.** The **technical gap between research and training should also be supported to bring concrete solutions** to farmers, but also the other operators of the chains. Technical institutes have a great role to play in this regard.

On a wider scope, in terms of EU policy, as suggested in the **Parliament protein strategy**[300] adopted this autumn, some improvements could be done in some regulations such as: '*a feed additive regulation that enables stability and innovations in feed additives[301]; a novel food legislation that simplifies and speeds up authorisation processes; a directive on waste that enlarges the types of **biodegradable waste to be considered as feed[302]**; a renewable energy directive that allows for **long-term stable regulation for biofuel production[303]**; a **regulation on new genomic techniques**; a combination of CAP rules that provide incentives for production of protein-rich crops, grassland and legumes*'.

Examples from abroad are also interesting to observe. **The social food security** which is part of the US farm bill would also be interesting to study, if the support to families could be directed to animal products grown with feed produced in the EU.

Finally, it would be necessary to **keep looking for the differences in regulation between production in the EU and imported production**. Some current examples are the import of GMO products, (whose cultivation is not allowed in the EU), and the differences in environmental standards between countries. These examples show that

[297] Most of the big factories to treat (e.g. to crush) protein crop seeds are located in port cities, but it could be useful to have some in EU production basins to support some local value chains.

[298] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A02021R2115-20220422

[299] This is possible through the CAP, with notably the operational groups in EIP-AGRI and other Farm Advisory Service (FAS) related funding.

[300] European protein strategy, European Parliament resolution of 19 October 2023 (2023/2015(INI)) - P9_TA(2023)0375.

[301] In terms of amino acids, EU industry is in a poor position due to Chinese competition. There could be a 'sovereignty exemption' on the energy prices of this type of company if the EU wants to keep this type of industry. Regarding additives, it could be emphasised that their authorisation in organic feed could resolve certain obstacles (notably deficiencies which impact animal welfare and performance) and would limit the use of imported soya.

[302] Here it is mainly about supplying insects with material other than bran and spent grain previously allocated to livestock. This would undoubtedly be a way to reduce costs (but apparently not well suited to the very precise nutrition of insects, with too much variability in raw materials such as fruit and vegetable waste). In addition the present factories in operation, are not on this model, which would change part of their carbon footprint as they are mostly presently adjacent to starch factories (meaning with no transport costs).

[303] This is particularly true for rapeseed value, whose meals come from oil plants. Reducing the consumption of biofuel would indubitably reduce the production of these meals and hence the EU production.

attention should be paid to all these differences that can favour imported products to the detriment of EU ones.

3.2 RECOMMENDATIONS

The present dependence of the EU on significant imports of protein-rich products is partly linked to historical reasons (post-Second World War agreements and the WTO agreements of the 1990s) but also to pedoclimatic and structural reasons (e.g. average size of holdings, available land on the continent, cost of production, etc.) that make the EU less competitive in producing these crops than other parts of the world. At the same time, the choice to develop cereals within the EU has led to significant research efforts on them and has resulted in a gradual increase in their yields and consequently improved their competitiveness compared with rich protein plants (e.g. sunflower, peas, beans and to a lesser extent rapeseed).

Nevertheless, even with strong political will, the shift (if even possible) from the present situation to 'zero importation of protein-rich products' would necessarily take decades. Hence, our first recommendation is to start a process of reducing imports, even significantly, and then to adopt new measures once the first import reductions are in place.

Another complementary strategy would be to diversify and secure protein sources with close partners (e.g. Ukraine[304]) for protein crops, soya beans and HP sunflower meals, which would be favoured and protected[305]. This would not reduce the EU dependency in imported plant proteins (except if Ukraine enters the EU) but would limit the risk of a too limited number of suppliers and disruption of international transport.

Among the following recommendations, some are relatively simple to put in place and could be implemented quickly. At the opposite some would require a long-term perspective. They are presented by category, from those applying to all sectors to those that are more specific.

3.2.1 Generic recommendations

Some recommendations apply to almost all sectors. These are presented below.

Improve the competitiveness of proteins sources within the EU by:

- **Developing a significant research plan associating public and private research** to, among other objectives, **increase protein crops yields and protein content, limit their variability, and reduce limiting factors** (e.g. antinutritional contents), **develop innovative raw materials,** etc. Over the past decades, protein crops and oil seeds have not benefited from the same level of research as their cereal competitors (mainly wheat and maize). Consequently, their competitiveness has progressively decreased, making it difficult now to reverse the situation. The only solution is thus to start a long-term approach to make all these crops, which were historically cultivated in the EU, competitive again compared with cereals. Research plan should additionally cover the production and the use of innovative raw materials. The main fields in which to intensify research could be:
  - variety selection to improve yield, yield regularity and protein content, as protein/leguminous crops and grassland have suffered from a lack of research in comparison to dominant crops such as cereals;
  - development of innovative raw materials (e.g. algae)
  - improvement of the ability of livestock to valorise less rich plant proteins as well as innovative raw materials/feed through genetic improvement of livestock;
  - selection of protein crops that have a lower antinutritional factor content and that are more disease-resistant;
  - life cycle analysis of these crops[306]; and
  - products to protect the concerned crops[307].

[304] Which is a candidate to join the EU.
[305] To take the case of HiPro sunflower meal, global export supplies are presently all being taken by Russia.
[306] There is a clear lack of references for tomorrow's formulation of local eco-environmental foods.
[307] The lack of research concerning these plants compared to cereals has also concerned treatment products, and now very few products are available for their cultivation.

- **Temporarily (and in compliance with WTO rules), increase[308] support to plant protein cultivation in the EU** to enable an increase in production and a shift (which will take time) of value chains to more EU-grown plant proteins. There are many examples of supported crops in the EU in the past, and they have proved to be effective when sufficiently supported[309]. Even if some unsuccessful examples led to overproduction, we are far from this risk for these crops. Hence, the **coupled income support of the CAP** could be used to cover the gap identified in this study between the relative main price of interest[310] of feed manufacturers for a given production and livestock cluster, and the relative price allowing farmers to obtain a sufficient margin[311] compared to other crops in competition.
- **Support the value chains and farmers for the necessary investments linked to the development of all the alternatives**. The investments supported by the second pillar[312] offer possibilities that could be explored along those lines, as do other structural funds for the industry. Many investments could then support the development of the alternatives studied. This could cover the following levels:
  - The farm or local cooperative/producer organisation level, in which simple equipment could support farm self-sufficiency, e.g. by financing toasters to enable farmers to use soya or fava seeds directly on-farm, or solar driers for fodder, etc.
  - The collector level, in which sorting and storage facilities, for example, could help develop the variety of the collected products.
  - The processor and feed manufacturer level, by supporting new processes to be developed, such as the equipment needed for HiPro sunflower meal, or by developing new plants in areas far from the big crushing factories often located in maritime harbours.
  - The whole value chain, by incentivising a long-term biofuel supply, to enable the related production of oilseed meal.
- **Increase support through the harvest insurance included in the CAP.** One of the limiting factors behind the development of protein crops is the farmer's fear of risk. Setting up specific rules for this instrument, dedicated to protein crops (e.g. increase of the ceiling of support[313], reduction of the 'excess' [314] part, cancelation of historical reference for yields, etc.). Developing this possibility would certainly incentivise farmers to come back to these crops, with which almost all of them are familiar.

Through support to operational programmes of producers organisations[315], incentivise, in the value chains, a system of negotiation to guarantee the long-term availability of products and the price paid to producers, by linking the selling price of the concerned crops to the crop it is in competition with (e.g. soya beans vs maize), with ratios adapted to the Member States' conditions. With the same instrument, **an**

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[308] From 7 to 10 years to secure private investments.

[309] In the only evaluation made on the agri-environment and climate measures (Oréade-Brèche 2005), it was shown that the payment of the income foregone and uncured costs were not sufficient for the farmer to decide its uptake. An incentive part is still necessary. This is also true for coupled income support that has to compensate sufficiently the loss of margin between the crops in competition in order to make the production of the targeted crops worthwhile for the farmers.

[310] i.e. the price at which the first tonne of an alternative feed material is used by a manufacturer without changes in the cost of the final product. This means that, to be introduced in the composition of manufactured feed, the market price of the alternative feed material must match the price of interest.

[311] Some examples of capture of the margin by the downstream sector have existed with such support, but mechanisms could be tested to avoid these practices and make the increase of margin available for the farmer.

[312] By Rural Development Programmes or by Sectoral Interventions of operational programmes of producer's organisations in the 'other' sectors.

[313] There are two CAP schemes available for harvest insurance for arable crops: RD (Art 76 SP Regulation) and a sectoral operation programme for other sectors (Article 68(1) SPR). Presently, a maximum 50 % of the expense is covered by the EU.

[314] An 'excess' is the first amount payable by the person insured in the event of a loss and is the uninsured proportion of the loss.

[315] Including the RD support for the setting-up of PGs, and POs (Art. 77(8)(b) SPR). This may lead to a better concentration of supply, a benefit for farmers from operational programmes' implementations, and a higher value of marketed production which triggers higher revenues for farmers members of a PG/PO.

attempt should be made to better organise the sector(s) and the supply chains at EU level (e.g. support the development of platforms for connecting fodder producers (alfalfa) and breeders and/or breeders with too much fodder with other breeders (anti-waste), or the development of regional allotment centres[316]).

This would strengthen the concerned value chains and make the production of protein crops for diversification less risky all along the value chain. Hence, integrated sectoral strategies that combine the different/complementary CAP intervention systems above and beyond these operational programmes of producer organisations and that include the environmental tools related to crop rotation could now be developed. Extension of such support to interbranch organisations would also help to develop bigger and more integrated initiatives to reduce the EU protein dependency[317].

As proposed by the EU Parliament, **improve and simplify some EU regulations** on feed additives, food legislation, wastes and biofuels, for a broader support to the production of protein-rich crops, grassland and legumes.

Mitigate the situation by which currently – and for decades – most monogastrics and dairy cows have been mostly produced in proximity to large harbours, thereby giving a competitive advantage to imported protein sources compared to inland EU production that must be shipped to these zones. To this effect, develop intra-EU infrastructure (e.g. trains, canals and river equipment) to reduce transport costs in the long term and bring the protein sources from the production zones to the consumption zones.

Ensure the long term development of the whole profession in the field of protein feeds and alternative techniques, by providing the following:

- Funding for training and support plans dedicated to the whole profession, and without delay to all those who work in technical advice and monitoring of farming practices with farmers.
- Financial support to farmers who wish to benefit from support and technical advice and monitoring.

Encourage Member States to set up national policies in line with the objectives of an EU protein policy, and that support a transition to sustainable food systems, for example, by:

- Include measures in their CAP SP to ensure that the expansion of certain protein crops does not result in adverse environmental effects (increased use of PPPs, increased losses of N to the environment, loss of biodiversity in agricultural land), and support sustainable growth of these crops.
- Setting up a system of payment for environmental services, in complement to eco-schemes and agri-environment and climate measures, to take into account the numerous environmental services provided by some plant proteins and grasslands when grown sustainably.
- Defining ceilings of animals by available land (e.g. like in the Netherlands) which will de facto reduce the import of protein crops from outside the EU and at the same time reduce the environmental issues related to high density of animals in a given place.
- Implementing the standards of good agricultural and environmental conditions of land (GAEC) with the view of further promoting the development of protein crops and grassland[318].

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[316] As is done in the USA.

[317] Support to the industry is not the goal of the CAP, but they can be covered by other EU instruments such as the European Regional Development Fund (ERDF).

[318] When implementing GAECs, Member States should keep in mind that the development of protein crops and grassland is important and that the GAECs can be a mean to develop them.

- Developing rules that favour the concerned crops compared with the cereals in competition (e.g. preference for irrigation water for these crops in the case of competition mainly with maize).

Retailers and consumers can also play a significant role in reaching the objectives of an EU protein policy. Hence, outreach campaigns incentivising consumers to buy animal products fed with EU-produced feed that is free of deforestation[319], non-GM[320], organic, etc., could also help in developing EU production of protein crops and grass.

Would the EU protein plan be a success, **some international agreements could limit its full deployment**. This is particularly the case for the **Blair House Agreement limiting support to oilseed in the EU at 7.8 million ha**. However, while presently about 1 million ha of oilseed are supported, to replace the imported grains, around 13 million ha would be necessary for production if the EU goal is to cover 100 % of the present importations. Even if this is unlikely to happen, it should be taken into account in the political agenda.

It is also necessary to continue identifying the **differences in regulation between EU production and imported production**. Some examples are the import of GMO products, whose cultivation is not allowed in the EU[321], or the differences in environmental standards between countries. These examples show that deep attention should be paid to all these differences that can favour imported products at the expense of the EU ones.

Finally, at EU level, it would also significantly help if **price observatories of these crops** could exist at all levels (between farms, collectors and processors), to monitor the exchanges properly in each value chain and to consequently adapt the support to these crops.

Above all, long-term commitments are crucial in the agricultural sector. Hence, policies must remain in place for a long time[322], avoiding the too frequent changes to which all sectors often have difficulty adapting.

3.2.2 Sectoral recommendations

3.2.2.1 Ruminants and forages

Work on forages concerns almost exclusively ruminants, but these represent two thirds of the livestock units to be fed in the EU. It is definitely recommended, where possible and relevant, to increase the proportion of forages in the rations of cattle and small ruminants, and to increase the protein content of the forages[323] (via varietal selection, drying and storage). It should be noted that, for cattle, this should reduce the use of maize silage but be accompanied by greater use of wheat. It also would enable the rest of the ration to be deconcentrated and should encourage the use of so-called secondary cakes (rapeseed and sunflower).

Dried alfalfa is a good candidate to support diversifying strategies. Produced on the farm, it represents an advantageous source of ration diversification, as well as possibilities for rotation. But production zones are not always the same as consumption zones. A great deal of work is needed to organise flows and match supply and demand. This solution is the quickest to implement, but only concerns ruminants.

[319] From 2025 all soya marketed in the EU, be it produced domestically or imported, should be deforestation-free.
[320] The example of German mass distribution, in which all poultry is now non-GM, shows that shifts are possible if all the operators of a chain work together.
[321] It could also be possible to open an EU-wide debate on the appropriateness of maintaining domestic bans on cultivation of GM soya and/or reaping the opportunities of a possible future authorisation of New Genomic Techniques (NGTs).
[322] Even if some instruments can be temporary, such as coupled income support.
[323] In this case some equipment to easily measure the nutritional value of forages would be necessary.

Hence, the recommendations for these animals are:

- Significantly but temporarily[324] increasing production aid to make temporary grassland and mixtures of legumes and grasses more competitive than more profitable crops (like, maize and wheat). Coupled income support of the CAP could be used for this purpose [325].
- Support farmers in producing high-protein grass by increasing support for local R&D projects on grassland management, species to sow, mowing periods, drying and conservation methods.
- Support farmers in accessing equipment to better appraise the nutritive value of their forages and, as mentioned above, to directly process on-farm production (see the example of toasters and driers above).
- Supporting grassland management aiming at grazing by multiple livestock species.

3.2.2.2 Amino acids

The EU is extremely dependent on synthetic amino acids in animal feed. However, with some of the solutions proposed (in particular the use of protein crops), animals will need increased use of amino acid supplements in order to reduce soya in their diet; otherwise, the zootechnical performance of the animals and/or their well-being will decline[326]. This industrial sector needs to be strengthened within the European Union, especially as we have the necessary resources for lysine fermentation (beet) to improve the environmental balance of this product compared to its Chinese competitor. The future of this solution will depend on the willingness of institutions to support this industrial sector. It would help avoid falling from one dependency to another and would enable the use more EU-grown material.

3.2.2.3 Soya bean development

Soya bean production in the EU is limited by less favourable soil and climate conditions than in South and North America, and by an uncompetitive effect of scale (plot size). Importations represent the equivalent of 14 million hectares, and in 2020 the EU produced 2.6 million tonnes from 1 million hectares. Doubling the surface area would already be a good objective and would reduce soya bean meal imports by 2.2 million tonnes (less than 9% of the current consumption of 30 million tonnes).

The main obstacles remain genetic and economic. For the genetic issue, it would be necessary to invest massively in varietal research (orphan crops), in order to develop varieties adapted to climate change[327] and, earlier, to conquer new territories. For the

[324] From 7 to 10 years to secure private investments.

[325] For now, only mixtures between legumes and grasses are eligible, with the predominant criteria on legumes, which are not easy to define/control over time.

[326] Animal nutrition aims at reducing protein wastes for economic, environmental and animal health purposes. Instead of considering protein as a need for animals, feed formulation has identified the right amount of amino acids (components of the protein) and switched from a global protein need to amino acids requirements in feed composition. It started with lysin and methionine requirements, and today formulas can calculate up to nine amino acids required for broiler formulas. For a given growth/production performance level, it thus has been possible to significantly decrease protein amounts in animal feed. This drop in protein content has been coupled with the use of synthetic amino acids (lysine, methionine, threonine, tryptophan and others), and made it possible to better exploit alternative oilseed meals in several species. The most significant gap that has been bridged with this approach is the possible substitution of soya bean meal with sunflower and rapeseed meals, combined with synthetic lysin use for swine and layer nutrition. Substitution in animal nutrition is a matter of economic competitiveness, but also linked with animal requirements, which narrows raw material mix solutions to obtain the targeted feed composition. Soybean meal is very competitive for protein content (one of the highest for plant-based feed), and particularly rich in lysin. However, with synthetic lysin available on the market, competitiveness is mostly a matter of price ratios. Moreover, soybean meal is methionine deficient, which can be a disadvantage for some species, especially laying hens, with low protein needs (around 16 % of the feed) but with high methionine requirements. At a time of protein content reduction (for economic savings, but also to reduce nitrogen excretion, resulting in animal health and environmental performances enhancement), that makes it more likely to substitute soybean meal with sunflower or/and rapeseed meals, combined with synthetic lysin.

[327] Besides adaptation to drought, the selection of varieties with better resistance to pests is becoming an urgent need. For example, in Southwest France, in the Sojadoc value chain, the cycles of the soya bean borer (Etiella zinckenella) have shifted from one cycle a year some years ago to up to three cycles in recent years, seriously threatening production.

economic issue, one of the solutions to develop the crop would be in the value chain, by indexing its price to that of maize[328] in the contracts.

3.2.2.4 Protein-enriched rapeseed

Protein-enriched rapeseed is an ongoing varietal innovation[329] which would enable sales of a high-protein rapeseed meal on a commercial scale within five to seven years. This solution is all the more promising because it will be available at no additional cost compared to standard rapeseed and will be versatile enough to compete with soya bean meal. It requires no adaptation of crushing equipment. However, transformation plants are not necessarily located close to production areas. Infrastructure development to support intra-European flows is an avenue worth investigating for this particular case.

This solution could be deployed in the EU over the next 10 years. The versatility of the proposed meal means it can meet the needs of all species.

3.2.2.5 Sunflower

The EU imports the equivalent of 5 to 7 million tonnes of sunflower seeds annually, which corresponds to around 2.5 to 3.5 million hectares. The sunflower meal most in demand is shelled sunflower meal, which has a protein and fibre content more likely to compete with soya bean meal. To increase its competitive potential, the idea is to lower the product's fibre content, which also increases its protein content and makes it more digestible. The industrial process (sifting) is available but increases the selling price of oil meal, while at the same time making it necessary to add value to the fibre fraction.

The aim here would be to reduce or cover these additional industrial costs and to ensure a level of crop production that will reduce the need for imports. In the case of oilseeds, the difficulty arises from the importance of the oil market in crushers' margins. The price of oilcake is often an adjustment variable.

3.2.2.6 Peas, field beans, lupins

The production of peas, field beans, lupins (around 3.5 million tonnes) is struggling to take off despite successive protein plans. These products have an intermediate nutritional composition in terms of energy compared with cereals and of protein compared with oilcakes. They therefore lack versatility, an essential quality for manufacturers that do not have unlimited storage capacity. Although very interesting from an environmental point of view, they struggle to find their place in crop rotations, especially since their yields are highly volatile.

It is therefore necessary to take action at many levels in the supply chain to develop these crops. For example, storage and transport costs are higher for 'small atomised sectors' than for cereals[330]. In addition, lower fertiliser requirements for the following crop are rarely taken into account when calculating the legumes' margin, leading to underestimation of their economic interest and environmental benefits. This calls for a change in accounting rules.

Producing peas, field beans, lupins for animal feed requires good yields and prices. Numerous forms of support need to be developed at every level in the supply chain[331].[332]

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[328] In Western France, for example, a soya bean/maize ratio of 2.5 would be necessary to offer farmers a remunerative and attractive price and to protect the value chains of an abandonment of soya bean cultivation.
[329] See the 'Decoproze' project, winner of the France 2030 award (https://www.gouvernement.fr/sites/default/files/contenu/piece-jointe/2023/03/20230306_-_dp_115_laureats_agriculture_alimentation_de_france2030.pdf).
[330] Ceresco - Rapport final étude freins et leviers logistiques légumineuses- Nov. 2021.
[331] According to the director of the agricultural group IN VIVO (T. Blandinières. June 2021, OPINION seminar), the risk associated with the transition (integration of legumes into rotations in particular) is estimated at EUR 150/200/ha in France. 1/3 could be remunerated via agricultural added value, 1/3 via the carbon market and 1/3 via public policies.
[332] The setting up of a pea futures market could also be interesting. The main problem to start it would be the liquidity, as the available quantities are insufficient. But if the protein policy leads to an increase in quantity, this interesting tool would help in securing volumes.

3.2.2.7 Renumerating positive externalities of protein crops and grassland

The 'additionality' of funding is essential to integrate virtuous crops into rotations. Farmers need to be better remunerated in order to enhance the value of their profession. It would be then necessary to move away from simply supporting agriculture (through coupled income support, eco-scheme measures or, agri-environment and climate measures for example[333]) and consider farmers as entrepreneurs who also produce environmental services (e.g. food, water, carbon, biodiversity, etc.). Protein crops (depending on the cropping system and even the crop) and grassland have numerous additional benefits than simple production of raw material, and these benefits are not currently remunerated by the market. Hence, one of the conditions to increase their share in EU production – and to thereby reduce imports of meals in particular – is to set up such additional funding systems (e.g. **payment for environmental services[334]**) and among them consider favouring the crops concerned by this study, i.e. protein-rich crops (at least, soya, sunflower and pulses) and all forms of grassland.

[333] CAP instruments that have been developed by some Member States (e.g. on crop rotation/diversification including legumes as well as on grassland/grazing).

[334] At the present price, carbon credits seem not remunerative enough for farmers in the face of expensive audit costs, which could explain the very slow development.

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