EU CAP Network Focus Group

'Production of protein crops under climate change'

Mini Paper 1

Exchange and creation of knowledge for protein crops sustainability under climate change challenge

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June 2025

Funded by the European Union

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Introduction

The current document explores the critical role of knowledge exchange and skill development in advancing protein crop production within the European Union. As climate change increasingly impacts agricultural systems, the need for innovative, sustainable, and economically viable solutions becomes paramount. This paper emphasizes the importance of creating a systematic framework for knowledge sharing, fostering collaboration among stakeholders, and addressing challenges in protein crop production.

The content delves into various aspects of knowledge creation and transfer, including best practices, communication strategies, and industrial research and development. It highlights the necessity of integrating scientific research, farmer experiences, and industry insights to develop effective approaches for cultivating protein crops. Furthermore, it underscores the significance of transnational cooperation in adapting to climate change by leveraging expertise from regions with established practices.

The suggestions at the end of this document are based on the best practice case studies presented in the document. This document aims to provide actionable recommendations for farmers, researchers and industry players. It outlines strategies for improving knowledge dissemination, supporting innovative farming practices, and fostering a resilient agricultural sector capable of addressing the demands of a changing climate.

The purpose of knowledge and skills creation and sharing development

To prepare for protein crop production under climate change in the EU, it is essential to systematically create and transfer new knowledge and skills. This requires a common framework for development activities, guided by clear strategic goals—such as targeting capability of protein extraction from crop rather than just growing crops suited to the climate.

Breeding should focus on crops that allow efficient, resource-saving protein separation (e.g., varieties suitable for dry rather than wet extraction), and processing technologies must also be developed accordingly. Collaboration between research institutions and entrepreneurs is key, ensuring practical testing and ongoing knowledge transfer, while keeping long-term, broad objectives in mind rather than only solving immediate, narrow problems.

Economic feasibility is crucial: farmers need evidence of market demand and trends before adopting new crops. Recommendations should include market overviews to encourage an uptake.

A regional system for sharing and storing development results—including failed experiments—would benefit all stakeholders. International knowledge transfer is also important, especially learning from regions with established protein crop cultivation. Long-term programs are preferable to short-term projects, as plant breeding and knowledge transfer require sustained effort and broader stakeholder involvement for greater socio-economic impact.

In summary, farmers should have access to comprehensive information on protein crops, including:

- Suitable crops and varieties
- Growing methods and conditions
- Soil suitability
- Analytical techniques
- Risks (weather, pests)
- End uses and by-products
- Economic profitability and market trends

This would support informed investment decisions and improve access to financing.

Best practices and case studies

1. Communication and awareness-raising

Tangible benefits of protein crops have to be known, communicated and disseminated among the whole vegetal proteins value chain stakeholders, including consumers. A comprehensive approach of communication and awareness-raising measures is required to ensure that each stakeholder is informed and motivated to become an ambassador of the protein crops benefits. Scientific results regarding the value of protein crops in terms of yield, soil health, biodiversity, consumers health and crops economic profitability can be exchanged through the quadruple helix approach, involving academia, farmers, industry, consumers and government. Special emphasis should be placed on knowledge that comes from exchange between researchers, farmers and industry.

Communication and awareness actions can be based on outcomes from:

- Research results transfer workshops, on-farm demonstrations or field trials and farmer-to-farmer exchanges, under success stories format.
- Results of collaborative applied research, partnerships between academia, industry and farmers through innovation pilot, demonstrative and scale up projects related to vegetal protein process improvement or novel plant-based food development, for instance.

Although those initiatives could be tailored to the specificity of the region based on local growing conditions and crop varieties, they could integrate transnational dimension too: as there is a crop shift from south to north because of climate change, scientific and technical knowledge must shift from south to north too thanks to communication actions.

Educational and information campaigns to increase consumers' knowledge of protein crops and their environmental and nutritional benefits, and protein-based products branding and marketing strategies deployed by industries to promote local production, must be supported by scientific results and evidence.

All these communication and awareness actions that aimed at different links of the agrifood value chain of vegetable proteins, have to be coordinated over time and stakeholders. For example, in Spain, if the demand for human consumption lentils were to increase massively as a result of a successful advertising campaign, national farmers would not be able to respond to this demand immediately, they would require time for the adoption of new crop management technology and, in the short term would force market to resort to imports, producing the opposite effect than the expected one for the national lentil supply chain.

As an example of a knowledge exchange initiative, the Spanish National Research Council (CSIC) promoted in 2023 the creation of the Spanish Legume Network (RELEG) that aims at providing knowledge based technical solutions to contribute to the legumes crops production expansion in Spain. The network is composed by researchers from 15 different Spanish research groups and representatives of professional agricultural organizations. Activities are based on 4 working groups regarding:

- Germplasm characterization and genetic improvement.
- Omics technologies for conservation and improvement programs.
- Legumes in crop system: agronomy, symbiose and environmental benefits.
- Legumes quality: nutrition and health benefits.

RELEG organizes webinars with academia, companies and farmers to communicate applied research results of working groups, produce dissemination videos for farmers and promote participation to national and international technical and scientific events related to legume crops.

2. Practical measures

Discussion groups are an effective way to share best practices also concerning protein crops. Discussion groups process is a very popular way to develop farming processes for example in Ireland (Teagasc), UK (local based groups), Norway (NLR advisory), Iceland (RML advisory) and Finland (ProAgria advisory, Atria meat house).

At ProAgria Finland there has been active grassland and legumes discussion groups since 2004. The groups are divided to two main styles: educational discussion groups and best practices discussion groups. There is also a mixed group, which is between these two.

Of those, the best practices group has been most effective ones, because there the farmers actually open up themselves, share their best and worst mode of operation, let the group also know their results during the process and give the group an opportunity to find new ways to do the process or realize together, that this is the best practice at the moment and more farmers should try it on their farms. The best practice groups mainly meet on farms, to be able to really observe the process in practice. The role of the facilitator of the group is essential. The facilitator has to be able to encourage the farmers to share their habits and ideas and avoid lecturing him/herself. The facilitator is also an organisator, who keeps the group connected and makes sure, that the practices shared are proper information, not some kind of beliefs.

In cold climate like Finland, Norway or Iceland, it has also been recognized, that interactive group methods are needed especially on winter time, when there are limited possibilities to really observe protein crop production and instead the groups usually meet inside for several months. Also during the times when there is no possibilities to observe the fields, the groups have good meetings to analyse the last growing season, to plan the next, to calculate results and to compare different possibilities. Also learning new skills in theory in smaller sessions is winter time´s possibility. In for example Ireland it´s been easier to meet all year around at the farms and base the group system to actually observing in practice. If possible, it is recommended to mainly meet on farms and focus on a delimited theme each time the group meets, to be able to discuss it deeply enough. Comparison data is also essential part of the process.

Compared to the best practice groups, there are also very good educational discussion groups, which also means meeting with a small group, but typically the group is mainly learning about something, that they have not at all or limited knowledge and experiences. You can´t compare best practices if you don´t have them yet. This group type is typical and recommended for example if the group is learning about a new crop together. The group facilitator must be in this case a good expert of the new subject or a good facilitator, who can invite speakers to the group to improve everyones knowledge. In Finland there have been successful educational groups for example in the subject oilseeds.

An example of a protein crop discussion group 2 year process in a best practices group: Example subject producing protein to the forage by using legumes

- Meeting 1: Targets and learning to know each other. Mapping and delimiting the theme of the group.
- Meeting 2-9 (at one of the farms in the group): Theme 1: observing, sharing results, conclusions and lessons learnt. Each day has a subject, which helps the groups farms to develop their skills in legume production.
- For example subjects of each day:
    - Clovers, alfalfa, nitrogen fixation process, soil structure for legumes, nutrient balance for legumes, establishment styles with legumes, feeding quality of silage in legume based mixtures, preservation quality of legume based silage, grazing with legumes, annual legumes etc.
- Meeting 10: Summary of the group, lessons learnt, summary of results, setting new targets

During the group process the participants have learnt plenty of new practises from each other and from the facilitators. They have actually learnt about the possible results of these practices and they are capable of making better decisions on their own farms.

As a practical example:

Typical lessons learnt in discussion groups concerning protein crops for forage in Scandinavian countries:

- The growing rhythm of alfalfa compared to the cut strategy of silage is often challenging. In nordic countries it´s a problem to make the third cut in mid September
- Trampling will destroy the alfalfa fields easily especially if you drive with any machinery during the spring or later than 5 days after the silage cut
- Late varieties survive better during the changeable spring season

- In colder climate situations, the root nodules start to fix nitrogen in mid May-Late May. The pre-plant value is important in organic production. Fertilization with N is needed during the Spring in multiple grass mixtures, because of the cold soil for N fixation.
- Root rot is one of the main reasons to destroy red clover based leys
- Controlled traffic system, 2-3 year rotation and multiple clover types helps with the root rot. You can´t trust the clover after the 3rd yield year

Farm level trials with different practices are an important part of the farmers' discussion group processes. Sharing best protein crop practices in discussion groups is not only discussing them, but actually observing and comparing the results together. (Copyright: Anu Ellä)

Examples of discussion group meetings in Finland. Also outside the growing season it´s important to keep it practical. (Copyright: Anu Ellä)

3. Best practice sharing

Climate change poses completely new challenges for farmers. Crops that have so far been traditional for specific regions are becoming increasingly unreliable, as in many cases they cannot cope with increasingly frequent weather anomalies such as extreme heat or periodic droughts.

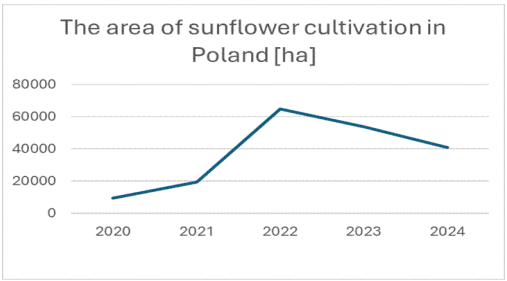
Therefore, farmers see the need to change current technologies and production directions. This is evidenced by the growing interest in simplified soil cultivation or regenerative agriculture aimed at reducing water losses from the soil during cultivation and improving soil health to increase the resistance of farms to weather anomalies.

The search for new production directions is aimed both at replacing the previously traditional but unreliable crops with those better adapted to the changing climate, and at enriching the crop rotation with plants that are valuable for soil health. This is clearly visible in the example of the growing popularity of growing plants typical of southern Europe such as soybeans or sunflowers in latitudes where their cultivation was previously risky or even impossible. These trends are an opportunity for protein plants, which in most cases meet the above requirements. Increasing the share of protein crops in crop rotations can improve the economic situation of farms by diversifying sources of income and increasing resistance to climate change.

On the other hand, many farmers have justified concerns about taking up new directions of production. Lack of experience and know-how is associated with the risk of successful cultivation and obtaining yields that provide a return on investment. Knowledge exchange and creation is therefore a very important element of methodical and complementary multidirectional activities in order to achieve the effect of a stable and changing economic situation-resistant increase in interest in the production of high-protein crops.

How the lack of appropriate knowledge affects farmers' decisions is demonstrated by experiences with sunflower cultivation in Poland. According to data from the Agency for Restructuring and Modernization of Agriculture, the area of cultivation of this plant, after rapid increases in 2021 and 2022, in the following two years fell by almost 17% and 24% year-on-year, respectively. This was partly influenced by fluctuations in the economy related to the war in Ukraine, but to a large extent this situation was caused by a number of problems resulting from the lack of knowledge and experience of growers, which resulted in low profitability of cultivation, and in many cases, none at all.

Initially, farmers saw opportunities associated with introducing sunflowers into crop rotation. These included relatively low soil and water requirements, relatively low cultivation costs combined with a positive effect on the physical properties and structure of the soil. However, agronomy proved problematic. The advisors in this area were mainly breeders and companies distributing seeds and pesticides, but their



recommendations were often contradictory. The state advisory services employ only 1-2 advisers on sunflower cultivation in each of the 16 provinces, which is insufficient.

The area of sunflower cultivation in Poland (Copyright: Andrzej Słomczewski)

As a result, the best source of knowledge for farmers growing sunflowers for the first time was often the experience of their peers, but they are still building their know-how. The correct selection of varieties proved problematic, many varieties turned out to be too late for the local climate, as a result of which the harvest was very difficult, time-consuming and expensive. Therefore, many farmers decided to conduct their own field experiments to assess the suitability of varieties for their farm conditions.

The farm's own varietal experiments - Strzelewo, Poland September 26, 2023 (Copyright: Andrzej Słomczewski)

There were contradictory recommendations regarding seed stocking and inter-row spacing, and a lack of practical knowledge on the use of pesticides, both in the sunflower itself and to control sunflower self-seeding in subsequent crops, e.g. no herbicide has a note on the label about combating sunflower self-seeding. Many herbicides registered for example in maize, often grown the year after sunflower, did not cope with this problem sufficiently. Ultimately, on many plantations, rapidly growing self-seeding sunflowers dominated maize and caused a significant decrease in yield.

A positive aspect is the support of Associations and Chambers of Agriculture, which is mainly limited to lobbying aimed at promoting and supporting sunflower cultivation, e.g. by entering it on the list of the Oil Plant Promotion Fund. One of the successes is also the development of a methodology and the inclusion of sunflowers on the list of

species that can be covered by the "integrated production certificate", which allows farmers to apply for additional subsidies.

The main institution in Poland responsible for conducting variety experiments is the Research Centre for Cultivar Testing. In the case of sunflower, as of 13.01.2025, only the "Preliminary yield results in reconnaissance experiments" are available, including the yield level and the length of the growing season. The experiments have been conducted since 2022 and initially covered only 3 locations, in 2023 5 locations, in 2024 5 locations, of which 1 was excluded. In subsequent years, experiments were conducted on 19 (2022), 27 (2023) and 18 (2024) varieties, of which only 3 varieties were tested for 3 years. This is definitely too few to make an informed choice of a variety adapted to the specifics of the region and farm based on the published data.

Over the last 2 years, there have been only a few field meetings and webinars devoted to sunflower cultivation, which were organized mainly by seed distributors in cooperation with breeders. Stationary events took place in the southern regions of the country, although the popularity of this crop was also growing in the rest of the country. The situation in this respect could be improved by intensifying the activities undertaken by the Regional Agricultural Advisory Centres, whose current activities in this field are carried out on an insufficient scale due to limited resources.

Knowledge transfer from abroad is small and mainly comes down to inviting foreign speakers to the above-mentioned events. There is a lack of transfer that would help solve current problems and threats emerging at the farm level. In recent years, an increase in knowledge transfer across borders has been observed thanks to the involvement of national partners in international projects, e.g. under Horizon 2020 or Horizon Europe. Supporting the networking of partners involved in national and international projects, e.g. through National CAP Networks, is an opportunity to improve the exchange of knowledge.

All this meant that despite the many advantages of sunflower cultivation, many growers became discouraged and gave up on the production of this plant. The above example shows how many risks result from a lack of knowledge or its insufficient availability, which may be the reason why farmers do not undertake or are quickly discouraged from planting new crops. In order not to repeat these mistakes in the case of protein crops, appropriate actions should be introduced in the field of exchange and creation of knowledge and sharing of best practices.

Below are the areas that require special attention:

- Strengthening the role of independent, objective and generally accessible public advice,
- Supporting cooperation and exchange of knowledge between farms on new crops,
- Sharing best practices on new crops in the farmers, researchers and advisors discussion group, as well as in international groups,
- Creating lists of varieties recommended for cultivation in the regions,
- Creating agronomic recommendations adapted to the specifics of the regions,
- Transferring knowledge from research and educating farmers,
- Identification of existing and continuous monitoring of changes in farmers' needs,
- Support for field trials (increasing farms' confidence in investing in protein crops).

Farmers who want to start the production of protein crops should seek knowledge from the following sources:

- Commercial advisory companies,
- State advisory services,
- EIP-AGRI Operational Groups conducting projects related to the cultivation of protein crops,
- Materials provided by Living Labs and Lighthouses,
- Materials from research projects of the Horizon programmes (e.g. EU-FarmBook)

4. Industrial R&D

A good example of industrial R&D in Estonia is the innovation cluster programme. In the area of plant protein development, the INNOVATION CLUSTER FOR PLANT PROTEINS brought together farmers, food industries and research and development institutions. The aim of one of the cluster projects was to identify which protein crops could be grown to produce novel end products for human consumption. One milk substitute and one meat substitute were in focus.

Four stages of development followed.

- Based on previous studies, varieties suitable for cultivation in Estonia were pre-selected, and field trials with cannabis, oat, fava bean, and green pea were carried out in cooperation with the Estonian University of Life Sciences, Estonian Crop Research Institute, and agricultural producers over three years to determine the effects of variety, growth year, and growing technology on yield. The suitability of less cultivated but protein-rich crops (millet and lentil) as sources of plant protein was also evaluated. The yield of crude protein per

hectare, the amino acid composition of the protein, and the content of inhibitors that inhibited protein uptake were determined.

- The aim was to provide an overview of the possibilities for isolating, purifying, and concentrating the researched plant proteins. It sought to map the possibilities for degrading the inhibitors and assessing the suitability of proteins for processing. Information was obtained on the effects of separation on protein structure as well as peptide and amino acid content.
- The goal was to develop technologies for valorizing domestic legumes and cereals through extrusion. New and innovative products based on consumer preferences were developed. For this purpose, experiments with single protein sources and mixtures of protein sources were conducted, along with experiments on the effects of pre-fermentation on texture, taste, and aroma. The final and semi-finished products underwent sensory analysis, texture profile analysis, and microscopic examination. Extrusion was used as a method because it increased the digestibility of plant proteins and starches and proved to be a flexible technology suitable for preparing various products.
- The aim was also to develop technologies for fermenting Estonian legumes and cereals to create plant-based milk and meat alternatives. New and innovative products based on consumer preferences were developed. Fermentation with lactic acid bacteria helped increase digestibility and nutritional value while improving flavor and aroma profiles. As a result of the research, technology was developed for producing fermented legume- and cereal-based meat- and dairy-like products.

Today, the developed products are on the market and further development of the products is underway.

Here are two examples: vegetable protein cutlet and vegetable protein dessert, milk substitute.

Vegetable protein cutlet from THORMY (L) and vegetable protein dessert, milk substitute, from TERE (R) (Sources: https://thormi.ee/tooted/taimevalgu-pihv-200g/ - https://www.tere.eu/tooted/taimsed-tooted/)

An important aspect of this example is the fact that all parties were involved in the development: farmers, processors and scientists/experts. In other words, based on this example, we can understand how important it is for farmers to understand what the final product of their crop production is. This also gives them the courage to start growing new/different crops. It also gives the farmer the opportunity to immediately enter the supply chain with their product.

Practical suggestions for action

Farmers starting the production of new crops for their farm need reliable and comprehensive support, including not only theoretical training or training on demonstration plantations. Before they gain the appropriate practical experience, which they can share with other farmers in their region, support for them should consider the specificity of the farm, or even the specific field. Therefore, it should primarily include field visits and on-site advice at every stage of production from planning to harvesting and storing agricultural products. In the case of feed raw materials, also preservation and development of feed rations.

For knowledge to be effectively developed and transferred to an increasing number of farms, it would be good practice to first provide support to farmers willing to take on the role of pioneers in their region. This will enable direct involvement of limited resources of scientists and advisors, and will also facilitate the transfer of knowledge between national borders. Pioneer farms could also become testing grounds, training centers for a larger group of advisors (state advisory services) and a source of new knowledge for scientists, farmers and other stakeholders.

Recommendations regarding communication and awareness-raising actions for knowledge on new, existing and forgotten protein crop cultivation in Europe

To get successful knowledge sharing dynamics between academia and farmers, it's relevant to reach farmers through an organization/entity they are part of, and they trust: cooperatives, trials network etc. Knowledge sharing can be based on practical dynamics, best practices exchange and discussions. Awareness activities must be based on endorsed knowledge, and target stakeholders of the whole chain. Awareness and communication actions must be deployed along the whole chain, connecting all its stakeholders, tailored to the specificity of the region, enriched by international exchanges, coordinated overtime and stakeholders.

Recommendations regarding the need for knowledge on new, existing and forgotten protein crop cultivation in Europe.

The broad expansion of protein crops should be preceded by the acquisition and systematization of basic knowledge, which determines the success of cultivation and is adapted to the conditions of modern agriculture. These activities should include:

- Creating a list of species and varieties recommended for cultivation in each region
- Developing agronomic recommendations for the recommended species adapted to the specificity of the region, including:
  - General information about the plant and the benefits of cultivation (e.g. nitrogen fixation, value as a feed or its component),
  - Recommended place in the crop rotation and its benefits (e.g. use of nutrients from deeper soil layers, phytosanitary role, improvement of soil structure),
  - Recommendations regarding the location (soil type, preferred pH, phytotoxicity of pesticides used in previous cultivation),
  - Nutritional requirements,
  - Sowing dates, possibility of cultivation in a mixture, soil preparation for sowing, sowing technique, plant density, possibility of using simplified tillage and direct sowing,
  - Recommendations regarding plant protection (weed control, diseases, pests),
  - Dates and identification of the harvest phase, harvest technique and storage technology,
  - Possible risks arising from weather and pests, practical tips on possible mistakes, FAQ.
  - Techniques and methodologies for performing the necessary analyses
  - Explanation of what the end products that can be made from this crop can be (including usage of by-products)
  - Potential economic profitability
  - Market trends of this crop

Recommendations for the exchange of knowledge on new, existing and forgotten protein crop cultivation in Europe

Supporting cooperation and exchange of knowledge between farms in the field of new crops by creating a network of cooperating demonstration farms, pioneers in the regions. On the basis of pioneer farms, discussion groups of farmers, scientists and advisors can be created, also international ones, as a place for sharing best practices in the field of new crops and mutual advice.

The network of demonstration (demonstration/research) farms would also be a place for transferring knowledge from research and education of an increasingly wide group of farmers. It would also allow for the identification of existing and constantly monitoring changing needs of farmers, and thus directing activities to the real needs of the interested parties themselves. Field experiments would also be carried out in the network in order to continuously expand knowledge on protein crops, on the basis of which clear information reports would be prepared as a compendium of knowledge for growers. It would also be a place for organizing workshops and field training.

An example of a network of farms that could be used for the activities described above is the National Network of Demonstration Farms operating in Poland, coordinated by the Agricultural Advisory Center in Brwinów. It includes over 200 farms, both private and institutional. This network cooperates with over 300 District Agricultural Advisory Teams employing over 1,500 Field Advisors, who could increase their knowledge and improve their skills in the field of protein crops thanks to this cooperation.

Since information consumption habits vary, it is important to use different methods for distributing information. Both traditional and modern methods must be used:

- Information days/trainings/field days
- Articles in sectoral publications
- Educational videos
- Podcasts
- Professional online chat rooms
- Sharing information through targeted channels (agricultural representative organizations, cooperatives, etc.)

In recent years, for example, in Estonia, interactive information distribution methods such as podcasts, specialized online chat rooms, online educational videos, etc. have become very popular among farmers.

Recommendations for the research and development on new, existing and forgotten protein crop cultivation in Europe

If we want to be competitive with other global regions, we need to significantly increase investment in research and development in Europe. It is particularly important to increase the share of applied research and industrial scaling in research.

When breeding a crop, we must not limit ourselves to yield indicators alone, but also identify the end products that can be made from this crop and the technologies for their

production. This is why it is important that different parts of the value chain are involved in development projects: scientists, farmers, processors and retailers.

The innovation cluster program is a good example in this regard.

Conclusion

The current document highlights the critical importance of knowledge exchange, skill development, and collaboration among stakeholders to advance protein crop production in the European Union under the challenges posed by climate change. It emphasizes the need for systematic frameworks to create and share knowledge, integrate scientific research with practical farming experiences, and foster transnational cooperation for sustainable agricultural practices.

- **Knowledge Creation and Transfer:** Effective protein crop production requires targeted breeding strategies, resource-efficient processing methods, and economic feasibility considerations. Collaboration between research institutions and entrepreneurs can ensure continuity in knowledge creation while addressing long-term goals.
- **Best Practices and Case Studies:** Sharing success stories, organizing farmer-to-farmer exchanges, and leveraging international expertise are vital for promoting protein crops. Initiatives like discussion groups and demonstration farms have proven effective in empowering farmers with practical insights.
- **Industrial Research and Development:** Involving farmers, processors, and researchers in innovation clusters can lead to the development of novel plant-based products, fostering competitiveness in global markets. Applied research must focus on end-product usability and efficient processing technologies.
- **Practical Recommendations:** Farmers need reliable support tailored to their specific needs, including comprehensive agronomic recommendations, market trends analysis, and field-level advice. Pioneer farms can serve as hubs for knowledge dissemination and training.
- **Communication and Awareness:** Coordinated efforts across the value chain are essential to raise awareness about the benefits of protein crops. Educational campaigns targeting farmers, industry players, and consumers can drive adoption while ensuring market readiness.
- In conclusion, addressing climate change challenges while expanding protein crop production requires a multidimensional approach involving strategic planning, stakeholder collaboration, knowledge sharing mechanisms, and robust policy support. By implementing these recommendations, the EU can build a resilient agricultural sector capable of meeting future demands sustainably.

Funded by the European Union