DIVINFOOD

Co-constructing interactive short and mid-tier food chains to value agrobiodiversity in healthy plant-based food

Deliverable D3.1

Repertoire of local farms and farming systems using NUCs in agroecology

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Executive summary

Objectives

Deliverable 3.1 "*Repertoire of local farms and farming systems using NUCs in agroecology*" aims to collect experiences and data on farms growing neglected and underutilised crops (NUCs) and using agroecological practices in 7 European countries, including the 9 Living Lab regions of the DIVINFOOD project. It highlights NUCs agronomic performances addressed with farmers and experts. The considered NUCs are minor cereals and legumes (see Table 1).

This document is based on farm and expert interviews conducted in all Living Labs (LLs) regions of the DIVINFOOD project using the same methodology, literature review, national and European level statistical data and secondary data from previous research projects. The report also includes information from grey literature, extension material, and ongoing projects. This information was firstly summarised at LL region level and secondly used to draw up a comprehensive repertoire of NUC farms across Europe, highlighting the diversity of farm types, with a particular focus on the regions where the 9 DIVINFOOD LLs are located.

The results and conclusions are addressed to the DIVINFOOD consortium and to all value chain actors, including not only farmers, but also processors, policy makers, researchers, consumers and all promoters of "more agrobiodiversity in use in farming systems".

Teams involved

The core text was made by the Hungarian Research Institute of Organic Agriculture (OMKI) based on the individual input from each LL and from members of the DIVINFOOD project with the main contribution from Laurane Desoutter (LL Bean-Lyon and LL Bean-Cast), Axel Wurtz (LL Bean-Cast and LL Cer-Occ), Luca Colombo and Mariateresa Lazarro (LL Leg-ItSwitz), Carlotta Vaz Patto (LL GPea-Port), Dylan Wallman and Inger Bertelsen (LL Faba-Nord, LL Leg-Nord), Zsofia Veér and Attila Králl (LL Leg-Hung), Fruzsina Szira and Judit Fehér (LL Cer-Hung).

The deliverable has been reviewed by Luca Colombo (FIRAB), Yuna Chiffoleau (INRAE), Laurane Desoutter (INRAE) and Cassandra Togna (IT).

Table 1. *List of NUCs and production systems considered in the DIVINFOOD project*

List of NUCs	Taxonomy	Production systems considered	Potential regions of applicability of the data	Name of the DIVINFOOD Living Lab concerned
Grain legumes	Order: Fabales Family: Fabacea			
'**Bean of Bresse**' or 'Meat bean' heirloom bean cultivars (*Phaseolus vulgaris)*	Genus: Phaseolus	• organic • conventional	Region Auvergne Rhône-Alpes (France)	LL Bean-Lyon
'**Lingot bean'** - heirloom bean cultivars (*Phaseolus vulgaris)*	Genus: Phaseolus	• organic • conventional	Lauragais - Region Occitanie (France)	LL Bean-Cast
White lupin (*Lupinus albus*)	Genus: Lupinus	• organic • integrated management system	Italy, Switzerland	LL Leg-ItSwitz
Grass pea *(Lathyrus sativus)*	Genus: Lathyrus	• conventional • organic • integrated protection system	Portugal	LL GPea-Port
Faba bean (*Vicia faba*)	Genus: Vicia	• organic • conventional	Denmark, Sweden, Hungary	LL Faba-Nord LL Leg-Hung
Narrow-leaved lupin	Genus: Lupinus	• organic	Denmark, Sweden	LL Leg-Nord

(Lupinus angustifolius)				
Lentil (*Lens culinaris*)	Genus: Lens	• organic • conventional	Denmark, Sweden, Hungary	LL Leg-Nord LL Leg-Hung
Grey pea (*Pisum sativum)* ssp. *arvense)*	Genus: Pisum	• organic	Denmark, Sweden	LL Leg-Nord
Common bean (*Phaseolus vulgaris*)	Genus: Phaseolus	• organic • conventional	Denmark, Sweden, Hungary, France	LL Leg-Hung LL Leg-Nord
Chickpea *(Cicer arietinum)*	Genus: Cicer	• organic • conventional	Hungary, Denmark, Sweden,	LL Leg-Hung
Dry pea or yellow pea (*Pisum sativum* ssp. *sativum*)	Genus: Pisum	• organic • conventional	Hungary	LL Leg-Hung
Cowpea *(Vigna unguiculata*)	Genus: Vigna	• organic	Hungary	LL Leg-Hung
Wheat species	Order: Poales Family: Poaceae			
Einkorn *(Triticum monococcum)*	Genus: Triticum	• organic	Region Occitanie (France), Hungary	LL Cer-Occ LL Cer-Hung

Emmer (*Triticum dicoccum)*	Genus: Triticum	• conventional conversion to organic • organic	Hungary	LL Cer-Hung
Rivet wheat *(Triticum turgidum)*	Genus: Triticum	• organic	Region Occitanie (France)	LL Cer-Occ

List of abbreviations

NUC: Neglected and Underutilized Crop

LL: Living Lab

PDO: Products with a protected designation of origin

AE: Agroecology

Introduction

The overall objective of the DIVINFOOD project is to facilitate the use and increase the value of NUCs in food chains to foster healthier diets and more sustainable food systems. The starting point is that both healthier diets and resilient food systems are based on diversified and local agricultural production where diversity is mainly ensured at the level of crops and raw materials, and not through processing.

While a wide variety of crops are grown and harvested around the world, just four individual crops account for half of global production: sugar cane, maize, wheat and rice (FAO, 2023). However, agricultural systems dominated by just a few species or varieties are highly vulnerable, have a negative impact on agrobiodiversity and can put food supply chains at risk. In contrast to dominant or major crops, NUCs are characterised by their limited geographical distribution or use and lack of wider adoption or support by technology providers, breeders, extension services or policy makers (Farooq et al., 2023). However, these species are important to diversified and traditional local farming systems, as they can contribute to increasing use of agrobiodiversity in value chains and thus to global food security. In addition, NUCs often have remarkable tolerance to growing under marginal or low-input conditions and may have special characteristics at the point of production or consumption.

In 2020, almost three fifths (58.2%) of EU farms were classified as specialised crop farms and this particular activity accounted for at least two thirds of their production. The most common types were: general field cropping (18.5% of all farms), specialised cereals, oilseeds and protein crops (15.9%) and specialised olive growing (8.9%). Just over a fifth (21.7%) of the farms in the EU were specialised livestock farms. Mixed farms, which included farms with crops and livestock or different types of crops including NUCs or different types of livestock, accounted for just under a fifth (19.3%) of all farms in the EU (see Figure 1) (Eurostat, 2023).

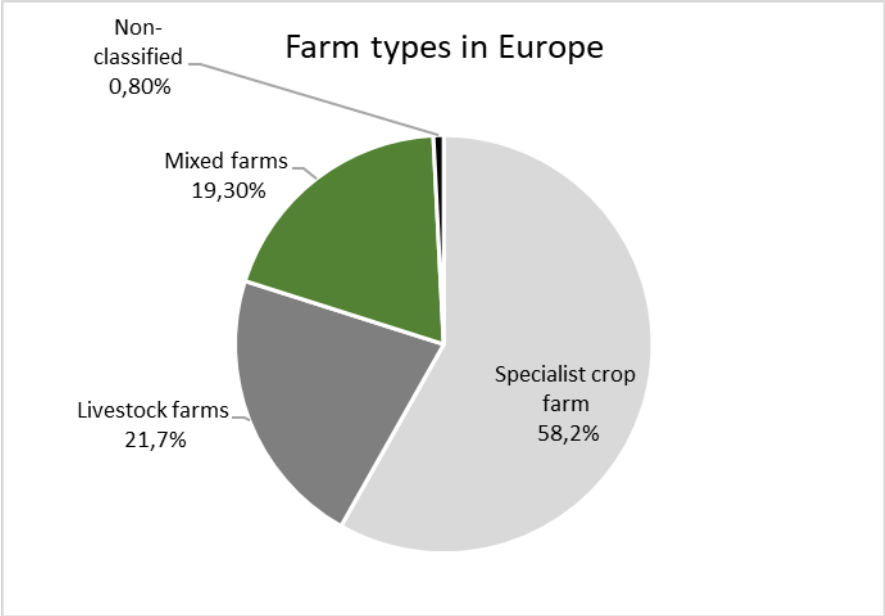

Figure 1. Farm types in Europe (Eurostat, 2023)

Unfortunately, the main characteristics of farms using NUCs cannot be described from the available statistics or literature data. In this report we present a repertoire of farms using NUCs in the DIVINFOOD LL regions, with a special focus on agroecological practices and agronomic performances. This repertoire encompasses the diversity of farm types using NUCs in the LL regions, identified on the basis of various criteria, including NUCs agronomic performances. At this stage, NUCs are not limited to the species considered in the project (**see Table 1**), but include any minor cereal or grain legume for human consumption that can be considered as NUCs in a broad sense, depending on the cultivation practices of the specific LL region. This approach ensures that the farms growing legume and cereal NUCs involved in DIVINFOOD on-farm studies and trials can be extended to cover and include the widest possible range of farm types existing in the LLs.

On the other hand, the DIVINFOOD project considers biodiversity in action throughout Genotype-Environment interactions (GxE) where the Environment is no longer limited to the Biophysical environment (Be) (soil, climate), but enlarged or extended to agricultural Management practices (M), processing/cooking technologies (T), marketing Channels (Ch), Social organisations (S) and regulations (R). NUCs performances, made from a G, have thus to be related to the E in which the G is cultivated.

The NUCs farm repertoire is based on farm and expert interviews conducted in all Living Labs (LLs) of the DIVINFOOD project using the same methodology, literature review, national and European level statistical data and secondary data from previous research projects. The report also includes data from grey literature, extension material, and ongoing projects. This information was firstly summarised at LL level and secondly used to draw comprehensive pictures of NUCs and NUC farms across Europe, including a farm typology, with a special focus on the regions where the 9 DIVINFOOD LLs are located.

1. Methodology

The report aims to provide a comprehensive understanding of farms and farming systems using NUCs, with a focus on legumes and minor cereals within the targeted regions/countries, agroecological conditions and agronomic performances. The scope of NUCs here extends beyond the specific species outlined in the DIVINFOOD project ('LL specific NUCs') to include any minor cereal or grain legume for human consumption ('broad sense NUCs'), depending on the cultivation practices of the LL region. In other words, LLs working on grain legumes collected information on any type of minor grain legume in their LL region/country, while LLs working on minor cereals collected information on any type of minor cereal (true cereals as well as alternative cereals such as millet or buckwheat).

The repertoire of farms using NUCs was not intended to be a catalogue of farms, as this would make it impossible to understand the diversity of situations in which NUCs are used. We proposed to build a repertoire encompassing the different types of farms using NUCs in the LLs regions. These types are constructed on the basis of several criteria presented below: practices applied to NUCs in 4 domains (production, processing, marketing, organisation) and motivations for growing NUCs. Information is also provided on the agronomic performance of NUCs in the different farm types.

To construct the farm repertoire, two main methods were used in each LL: i) expert interviews and literature review; ii) individual NUC farm interviews.

Expert interviews and literature review

In order to get a good overview of what are the main practices of farms producing NUCs, task members and LL coordinators mapped the diversity of NUC farms based on 4 sets of criteria, referring to 4 domains of practices: agricultural, (pre)processing, marketing, and organizational—with 2-3 main types of practices to be identified within each domain.

Domains of practices:

- **Agricultural Practices:** This domain relates to how farms cultivate NUCs, distinguishing between advanced/basic agroecological or conventional practices.
- **(Pre)processing Practices:** It refers to how farms pre-process and/or process NUCs, categorizing them based on whether they apply pre-processing, storage, the extent of processing (mild or industrial), and the transformation level.
- **Marketing Practices:** This domain considers how farms market NUCs and/or NUC-based products, distinguishing between short, mid-tier, and long-value chains.
- **Organizational Practices:** It questions whether farms collaborate with others, particularly in pre-processing, and considers organisational solutions.

Form of data collection:

- **Interviews:** Key informant interviews with technical experts, advisors, researchers, and farmers' representatives knowledgeable about farms using NUCs in the four domains of practices.

- **Other Sources:** Secondary sources such as previous projects, reports, statistical databases, and literature to complement information obtained from key informants.

Individual NUC farm interviews

Task members and LL coordinators also conducted interviews with farms growing the specific NUCs identified in the project proposal. These interviews aimed to gather detailed information on agro-ecological practices, pre-processing techniques, innovative practices, and agronomic performances. Indeed, it was decided to combine the 2 surveys planned in DIVINFOOD tasks 3.1 (NUCs performance) and 3.4 (pre-processing techniques) to avoid taking up too much of the experts' and growers' time. The number of farms interviewed was not fixed, as the primary objective was to cover the diversity of farms and practices existing in each LL region.

The data collected will not only feed into this report, but will also provide useful data and indicators for the GxE database being developed as part of the DIVINFOOD project (WP5).

For the list of key informants involved see **Annex 1** and for the questionnaire and reporting template see **Annex 2.**

2. The nine Living Labs in DIVINFOOD

Living Labs (LLs) have been widely used in different contexts since the 1990s, when the EU began to fund a number of large-scale Living Lab projects. As defined by the European Network of Living Labs (ENoLL), LLs are "user-centred, open innovation ecosystems based on a systematic user co-creation approach, integrating research and innovation processes in real communities and settings". The design of the DIVINFOOD project includes different types of activities to be carried out by each LL. LLs will promote co-construction with farmers, small processors, food SMEs, breeders, consumers and other stakeholders in the regional context and some tasks will be more specific to certain LLs according to local conditions and opportunities.

In the context of agroecological farming systems covering the main activity of DIVINFOOD WP3, LLs are territorial production systems incorporated into short and mid-tier value chains. DIVINFOOD Living Labs aim to perform multi-actor experiments in different geographical contexts and in a limited time. The size, number of members, farms involved, spatial distribution and other features of the DIVINFOOD LLs are influenced by a number of external factors (like institutional background of the LL Coordinator, regional rules, economic situation of the country where LL is located, etc.) and other characteristics (like social background and maturity of the LL) that make each LL in DIVINFOOD unique. What LLs in DIVINFOOD have in common is that each of them investigates and analyses the cultivation potential of at least one legume or cereal NUC under real operational and economic conditions and with close collaboration of different stakeholders. Main characteristics of LLs including farms and NUC crops are summarized in **Table 2** and **Figure 2** but are presented in detail in the following subsections.

Table 2: *The nine LLs in DIVINFOOD*

Name of the LL	NUCs considered	Broad sense NUC	Specific challenges	Size of the LL (km²)	Main crop at LL level	Size and location of the LL	Climatic zone
LL1 Bean-Lyon	Bean of Bresse 'Meat bean', *(Phaseolus vulgaris)*	chickpea, lentils, beans, soybean for human consumption	Rehabilitation of local and traditional but forgotten bean cultivars	69,700 km²	Wheat	**Lyon** and its nearby departments including Ain, Rhone and Isère (Region Auvergne-Rhône-Alpes, Eastern France)	Continental
LL2 Bean-Cast	Lingot bean (*Phaseolus vulgaris)*	chickpea, lentils, beans, soybean for human consumption	Cultivars adapted to organic conditions	2,400 km²	Wheat	**Lauragais-Castelnaudary** in region Occitanie, Southern France	Mediterranean
LL3 Cer-Occ	Einkorn *(Triticum monococcum)* Rivet wheat *(Triticum turgidum)*	Rye, oat and triticale for human consumption and emmer	Cultivars better adapted to drought	72,700 km²	Wheat	Region **Occitanie**, Southern France	Mediterranean
LL4 Leg-ItSwitz	White lupin (*Lupinus albus*)	All grain legumes except soybean in organic (Switzerland)	New varieties adapted to intercropping Stress tolerant and alkaloid-free varieties	191,300 km²	Winter wheat	Central and Northern Italy and Switzerland	Humid Continental - Mediterranean

LL5 GPea-Port	Grass pea *(Lathyrus sativus)*	common bean, chickpea	New varieties and intercropping	160 km^2	Olive	Region **Alvaiareze**, Central-Northern Portugal	Mediterranean
LL6 Faba-Nord	Faba bean (*Vicia faba*)	All legumes for human consumption except yellow dry pea and frozen green pea	Adapted varieties	292,900 km	Spring barley and winter wheat	Denmark, Sweden	Oceanic, humid continental
LL7 Leg-Nord	Narrowleaved Lupin (*Lupinus angustifolius*), Grey pea (*Pisum Sativum subsp. Arvense*), Lentils (*Lens culinaris*)	All legumes for human consumption except yellow dry pea and frozen green pea	Adapted varieties	292,900 km^2	Spring barley and winter wheat	Denmark, Sweden	Oceanic, Humid continental
LL8 Leg-Hung	Lentil (*Lens culinaris*) Dry pea or yellow pea (*Pisum sativum ssp. sativum convar. sativum*) Cowpea *(Vigna unguiculata*)	All grain legumes for human consumption	Adapted and drought tolerant cultivars	93,000 km^2	Winter wheat	Hungary	Dry Continental-Mediterranean

	Chickpea *(Cicer arietinum)*						
LL9 Cer-Hung	Emmer (*Triticum dicoccum)* Einkorn *(Triticum monococcum)*	Spelt (*Triticum spelta*)	Adapted cultivars selected from landraces	93,000 km^2	Winter wheat	Hungary	Dry Continental-Mediterranean

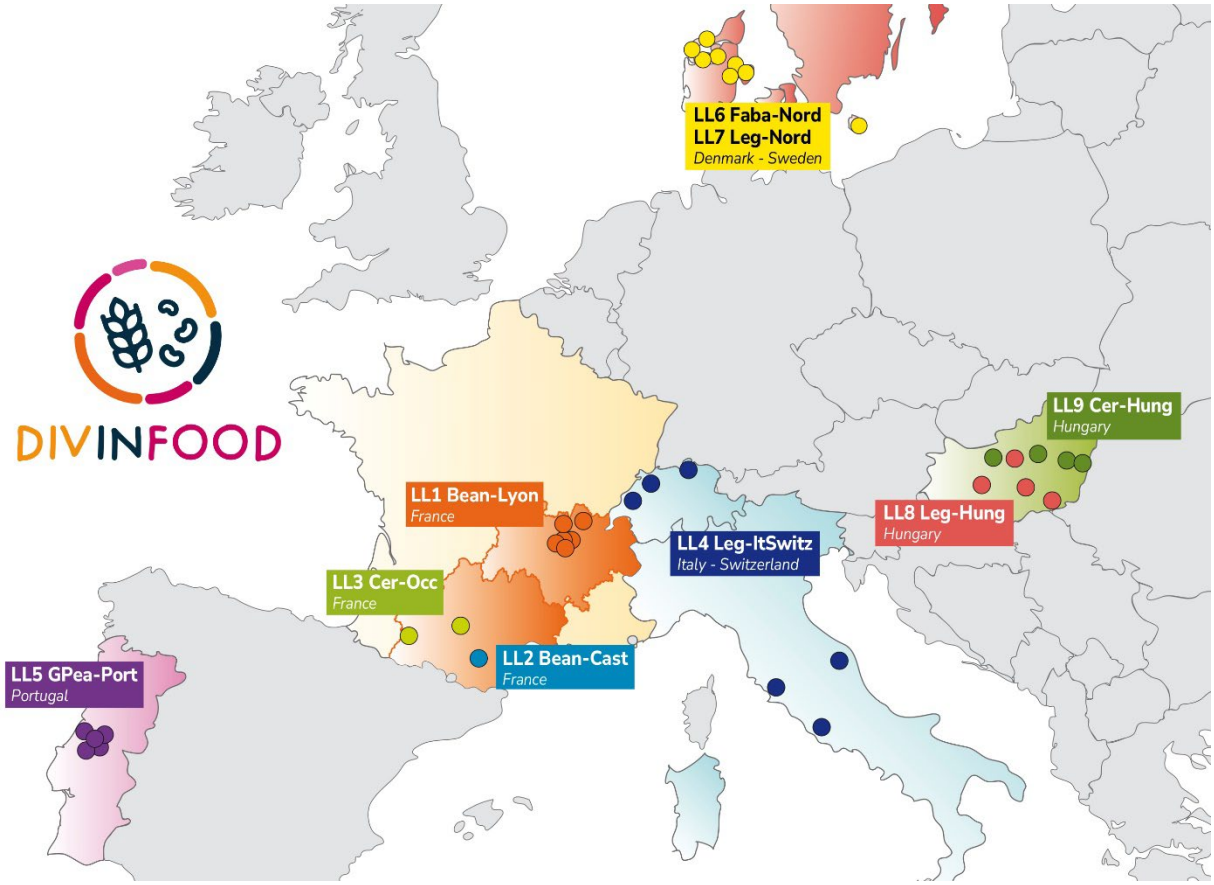

Figure 2. The nine LLs in DIVINFOOD. Points represent the location of the individual farms interviewed.

2.1 LL Bean-Lyon – Bean of Bresse (or 'meat bean')

LL Bean-Lyon is based in Lyon and its periurban area in Rhône department, which is located in the Auvergne-Rhône-Alpes (AuRA) region in south-east central France. This LL also includes Ain, and Isère departments, which are nearby Lyon, a mainly rural region.

In general, the AuRA region is a livestock farming region and has a wide variety of soil and climate characteristics that determine the characteristics of agricultural production. In the plains and valleys of the Loire and Rhône, cereals and legumes are the main crops and crop rotations vary according to access to irrigation and altitude. In the south-east, in Isère and Drôme, climate is warmer and crops are more varied, with orchards, vineyards and market gardening in addition to cereals and legumes.

The main crops in AuRA are soft wheat and corn, which account for 61% of the agricultural area, but soybeans are also grown on the irrigated plains (DRAAF AuRA, 2016). The production of legumes in AuRA region is quite heterogeneous but three main production area can be distinguished (Terres Univia, 2020; Agreste, 2021; Lesne-Seften et al., 2022). There is a chickpea production area (1) in the south of the region, Ardèche Drôme; a soybean production area (2) in the east (Rhône Valley, Savoie), and a lentil production area (3) in the south-west. The lentil production area is notably marked by the historical presence of 'The green lentil of le Puy', the

first PDO legume in France that is produced in 3,000 ha (corresponds over 70% of the lentil surface area in AuRA) and the PGI lentil 'The blonde lentil from Saint-Flour' produced on 130 ha, on average. Lentils are the most important legume in the region produced on 4,235 ha (among which 859 ha in organic agriculture) while bean production is quite marginal and produced on only 130 ha (2020) (Lesne-Seften, 2022). In general, the AuRa region represents 0.8% of the total legumes area and 4% of the organic legumes area in France (Agreste, 2021).

LL Bean-Lyon considers lentils, chickpeas, edible soya and beans to be NUCs in the broad sense and the Bresse bean to be a NUC in the narrow or LL-specific sense.

2.2 LL Bean-Cast – Lingot bean around Castelnaudary

The region under study is "Lauragais", whose "capital" is Castelnaudary and which is part of the Occitanie region. Occitanie is the leading producer of chickpea in France and one of the major production region for lentil and soybean. The '*Lauragais*', a rural area, is an historical and cultural region in the south-western part of France and associated with the wealth of its agricultural production. It covers both sides of the Canal du Midi, between Toulouse in the north-west and Carcassonne in the south-east and between Castres in the north-east and Pamiers in the south-west. This region is also called '*Pays de Cocagne*' or '*Granary of the Languedoc*' because this area had traditionally supplied grain not only to France but also to its neighbours due to the Canal du Midi. It is also famous for its dried or lingot beans, the '*lingots de Lauragais*', which are used to make the traditional dish of the area, the cassoulet (Office de Tourisme de Castelnaudary, 2024). In 2024, the area goes to 4 administrative departments and covers '*Le sillo Lauragais*', a sedimentary basin, and the surrounding hills.

Main crops in the *Lauragais* are hard wheat, soft wheat, and sunflower. Legumes for food are included in crop rotations, but unlike legumes for feed, it is improbable that they will be considered as a main crop in the future. Faba bean is the third most produced legume in France and in 2017, 14% of the faba bean was grown in Occitanie (Simmen et al., 2019).

LL Bean-Cast considers chickpeas, lentils, beans and soybean for food to be NUCs in the broad sense, and the Lingot bean, a special white bean used to make cassoulet, to be a NUC in the narrow or LL-specific sense.

2.3 LL Cer-Occ – Minor cereals in Occitanie

The state of Agriculture in Occitanie report confirms the region as France's second most important agricultural region (DRAAF Occitanie, 2020). With 64,200 farms providing employment to 194,000 full time or seasonal workers, it represents 7.4% of the working population of the region. Organic agriculture has tripled in the last 10 years rising from 5% to 17% of farms. Nearly one in five farmers is now organic in Occitanie. The three pillars of the Occitan agriculture are cereals (16%), wine (16%), and cows for meat (8%) (DRAAF Occitanie, 2020). Occitanie is the first French region for wine-growing, sheep production and for organic farming and second for fruit production and Occitanie possesses over one fourth of France's organic farmland. To confirm its commitment in favour of the organic sector, the Region adopted the "Plan Bi'O 2018-2020," in order to assist farmers and organic-food producers and to help the sector become more

structured (Taste France for Business, 2024). Occitanie is the fourth region in Europe by surface with 507,000 hectares certified organic or in conversion by late 2018. Occitanie has many different pedo-climatic contexts. The Occitanie/ Pyrénées-Méditerranée region boasts a rich variety of landscapes and microclimates, including two mountain ranges and 220km of Mediterranean coastline. This is one of the reasons why agricultural production is so diverse.

The main cereal production is in the west part of the region, up to the Pyreneans. The main food crops in Occitanie are soft wheat (274,000 ha) and sunflower (176,000 ha, includes sunflower for biofuel production).

LL Cer-Occ considers rye, oats, triticale (except for animal feed and only for human consumption) and emmer to be NUCs in the broad sense, and einkorn and rivet wheat to be NUCs in the narrow or LL-specific sense.

2.4 LL Leg-ItSwitz – White lupin for dairy-like food in Italy and Switzerland

Legumes in Italy

Italy is one of the biggest producer of legumes in Europe due to its highest production of soybeans with a production over 1 million tons. Beside soybeans, fresh beans, faba beans and fresh peas are the main grain legumes produced in Italy. While the market of soybeans is better known and more developed, those for the other legumes remain less known. In Italy, the main production (96 %) of soya is concentrated in the North and soybeans are principally used for biofuel (~78 % of the oil production). 20 % of the soya production ends up in the compound feed industry and only 2 % of the production are collected by the food industry, mainly for the production of soya milk (Mergenthaler et al., 2019). Fresh beans are the second most produced grain legume in Italy. They are grown for the human consumption and the conservation by canned is the principal used method to ensure the long life of fresh beans in Italy. Fresh peas are the third most produced grain legume for human consumption in Italy, but other dry grain legumes, like chickpeas and lentils also present a continuous increase in production from 2010 to 2018. Differently the production of dry beans remains almost constant (2010: 13,000 t, 2018: 12,000 t) and Piemonte with 31% of the total production is the main region where dry beans are grown in Italy.

However, the scale of lupin cultivation in Italy remains uncertain. According to official statistical data 695 hectares were cultivated in Italy in 2023 (2022: 710 ha, 2021: 648 ha) for a total production of 11,569 tons (9,400 t and 7,974 t in 2022 and 2021, respectively), with virtually no cultivation in Northern Italy, with the exception of Lombardy for 36 ha, and greatest cultivation in Southern and Insular regions (ISTAT, 2023). These statistics are considered unreliable by key informants who believe them underestimated as the scale of cultivation is deemed in a few thousand hectares. Anyhow, whether cultivations aim at grain for food, feed or green manure cannot be easily assessed and the scale of production for food uses remains hardly predictable.

Legumes in Switzerland

Switzerland has a total land area of 41,285 km^2 of which 9.9% is arable land. The total agricultural area diminishes steadily due to the spread of settlements (lowlands) and the range of forests (mountain areas).

All grain legumes except soybean in organic can be considered underutilised in Switzerland. Due to a considerable difference between quality demands and producer price, organic soybeans value chains for human nutrition and soybeans for feed are distinguished. The list of grain legumes for human consumption in Switzerland includes soybean, that is basically non-existing in conventional and the best established value chain in organic. This was boosted by the tofu production for one of the major Swiss retailers, Coop. About 2,000 hectares of soy were planted in 2020 and this resulted in a yield of 3,882 tons of soybeans (Soy Network Switzerland, 2023). In 2022, 2,895 ha soybean (both for food and feed) were cultivated in Switzerland, of which 1,259 ha in organic production. There are many soybean varieties available, including some developed by Agroscope (National Agricultural Research Institute for Switzerland) for Swiss growing conditions and organic soybean cultivation experiences an upscale at the moment in Switzerland (Klaiss et al., 2020).

Lupins (including white and blue lupins) were cultivated in Switzerland on an area of 347 ha in 2022 (SwissGranum, 2024) of which 131ha were organically farmed and mainly produced for animal feed. The blue lupin surface is higher compared to white lupin, with a total area of 247 ha in 2022, 304 ha in 2021 and 210 ha in 2020. In general, there are very few lupin growers in Switzerland, especially if considering white lupin cultivation for human consumption only. There are very new attempts to build local value chains for food products (e.g. coffee from blue lupin and yogurt from white lupin) and only few varieties are available, but resistance to anthracnose is needed and not present in most registered varieties.

In terms of major crops, given the grain price and import tariffs on wheat, this crop is less risky and well paid for the farmers. Looking at grain legumes only, the best developed value chain is for soybean (both feed and food). Farmers have less production risks and better prices (especially in the case of food value chain) for soybeans compared to lupins.

Other grain legumes like lentils (196 ha in 2020 with the focus on intercropping), chickpea or beans are cultivated in extremely small areas. In the case of beans, the cultivation is dominated by the promotion of landraces and the protein pea is mostly produced for feed but very recently attempts of production for human consumption have started.

In LL Leg-ItSwitz, all grain legumes, with the exception of organic soya (in Switzerland) and beans (in Italy), can be considered as NUCs in the broad sense and white lupin as NUCs in the narrow sense or specific to LL.

2.5 LL GPea-Port – Innovative grass pea food product in Portugal

Portuguese agriculture is highly varied, with significant diversity in climate, topography and soil conditions. The sectors with the largest production are wine, cereals, fruits and vegetables, olive oil, pigmeat and poultry. Improved marketing practices since the 1990s increased the demand for fresh horticultural and fruit products of Portuguese origin in both the domestic and export markets.

In Portugal, agricultural area covers about 4 million ha, which representing 43% of the country's total area (2019). The area sown with cereals has been in steady decline in the last decades falling from 878,969 ha (1986) to around 200,000 ha and Portugal's cereals production only meets

around 20% of consumption. Until the early 1990s, dried pulses were grown on an area of over 60,000 ha, which reached its minimum in 2014 on 40,040 ha as a result of an intensive decline. Since then, it has grown weakly and in 2022 dry pulses were again grown on an area of over 10,000 ha.

In 2022, the most important crops in Portugal the olive groves (379,565 ha) and grain cereals (196,993 ha), both with most of the production localized in the Alentejo region, followed by the vineyards (175,791 ha) with the main production localized in Trás-os-Montes region in the north of Portugal. The main legume crops in Portugal are common bean and chickpea, representing a cultivated area of 10,887 ha spread mainly in Beira Interior and Alentejo regions (PortData, 2022).

The legumes surface's (including dry pulses) depicts an increase of 94% since 2013 and is a result of a greening component of the European subsidies. Despite the rising grain legume production, the consumption trend of common bean remained the same at 3.1 kg/year/person from 2014-2015 until the present, while chickpea showed a slight increase from 0.9 kg/year/person (2014-2015) to 1.5 kg/year/person (2021-2022) (Instituto Nacional de Estatistica, 2022). For minor grain legumes, such as grass pea, no published data could be found; however, there has been a rising interest in its production, especially in the Alvaiázere region.

Although the main NUC legume in GPea-Port LL is grass pea, there are other grain legumes, such as common bean and chickpea, which farmers still produce and can be identified as broad sense NUC while grass pea as narrow sense or LL specific NUC.

2.6 LL Faba-Nord and LL Leg-Nord – Adapted varieties for minimal processed plant-based food

Sweden

Although Sweden is one of the largest countries in Europe in terms of area, the cultivated area is only some 2,7 million ha - about 6,5% of Sweden's total land area. The country's climate is diverse, therefore agriculture faces very different conditions between the north and the south.

Swedish crop production is dominated by cereals, mostly barley, oats and wheat, as well as by grassland. About 40 % of arable land is sown with cereals and Sweden belongs to the leading oats producing countries. NUC species of LL Leg-Nord namely grey peas, lentils and narrow-leaved lupins for human consumption are niche crops that only occupy some hundreds of ha in Sweden. Common beans occupy slightly larger areas, around 500 to 800 ha (varying between years), and mainly on the islands Öland and Gotland. Faba beans and yellow peas are grown on larger areas, around 20,000 ha each, but most of these crops are used for animal feed (especially for faba beans). Interesting data on legumes is the total production of faba bean that was 78,600 t in 2022 (Official statistics of Sweden, 2022). The Swedish LL-member Nordisk Råvara is the main company for organic legume NUCs in Sweden: for instance, the annual area of the Rättvik pea, Gotland lentil, Stäme grey pea and lupins is under 150 ha.

Denmark

Danish agriculture is a large net exporter of agricultural products and the contribution of agriculture plays an important role in the country's economy. Total cultivated area is 2,619,000 ha (61% of Denmark's area), of which 1,363,000 ha is used for cereals. Winter wheat, spring barley, grass and forages cover about half million hectares each, while pulses are cultivated on 34,000 ha (2021) (Danish Agriculture & Food Council, 2023). Barley is used for malt, while wheat and rye are used for flour.

Denmark has a temperate climate with average annual rainfall of 782 mm (2011 – 2020) most in the west of the country and more dry in the eastern region, a rather flat landscape, and fertile soils. The farms have an average size of 83 ha, and more than 20% of the farms exceed 100 ha of land. Many farms produce crops, but a large proportion have livestock, and especially meat and dairy products are main export goods from Danish agriculture. The dominating field crops are cereals. Most of the cereals, 85%, are used for animal feed and the rest is consumed as food products.

Around 12% of Danish farmland is cultivated organically (over 300,000 ha) and the farmers involved in DIVINFOOD the living labs do not differ from typical organic farmers. Organic agriculture and food products are popular in Denmark and Danish consumers buy more organic food items than any other European country. In 2020, 12.8% of Danes' food purchases were organic products.

The market for plant-based food products has also experienced a rapid growth in Denmark, as the demand for more plant-rich diets has emerged. As a result, the agricultural production of high-quality protein-rich plant crops for plant-based food products has increased greatly. Namely, the area for protein-rich plant crops production has doubled from 2017 to 2022, employing 13,400 employees and creating economic value of 1.15 billion DKK. Like in Sweden, the production area of faba bean is around 20,000 ha in Denmark, but the main use is as animal feed. Farmers in the LL are familiar with growing faba beans but introducing them as food products is a new aspect.

All legumes for human consumption except yellow dry pea and frozen green pea are considered to be NUCs in the broad sense in the LL Leg-Nord and LL Faba-Nord. Narrow-leaved lupin, grey, old and landrace pea varieties, lentils, soy bean, and common bean for LL Leg-Nord, and faba bean for human consumption for LL Faba-Nord as NUCs in the narrow sense or LL specific.

2.7 LL Leg-Hung – Legumes in Hungary

The agricultural land in Hungary covers an area of 5,081,000 hectares, encompassing arable land, vegetable gardens, orchards, vineyards, pastures, and permanent grasslands. This area represents nearly 55% of the country's total territory. In 2022, the arable land extended over 4.16 million hectares, accounting for 45% of the country's territory and constituting 82% of the agricultural zone. The primary crops cultivated are oilseed plants and cereals, and their proportion has been increasing over the past three years. Conversely, the cultivation of industrial crops, fodder crops, and vegetables has experienced a decrease in proportion. Among vegetables, sweet corn and green peas boast the largest planting areas, followed by fennel in the third position. Aligning with soil and land characteristics, agricultural activities predominantly concentrate in the Great

Hungarian Plain (Alföld), where 5.8% (equivalent to 293,600 hectares) of the agricultural land was dedicated to organic cultivation in 2021. Within this context, 61% constituted meadows and pastures, while 31% comprised arable land (Kezena et al., 2022).

In Hungary, the extent of agricultural land engaged in organic farming surpassed 303,000 hectares for the first time in 2019, positioning this country within the mid-range of Europe in terms of territorial proportion. Between 2018 and 2019, the size of converted areas increased from 38,271 hectares to 117,963 hectares, exceeding the 300,000-hectare threshold for organically managed land in 2019. (In 2018, the area was merely 209,000 hectares.) The size of organic areas expanded by a third, among which meadows and pastures experienced the most substantial growth (Központi Statisztikai Hivatal, 2023).

By 2022, the cultivated area for cereal crops encompassed 47,374 hectares, of which 14,077 hectares were in the process of conversion, and 33,297 hectares were under organic cultivation. The total cultivated area for field crops reached 129,097 hectares, with the combined size of organic areas reaching 325,729 hectares, of which 169,437 hectares were meadows and pastures. Legumes were grown on 3,865 hectares (Központi Statisztikai Hivatal, 2022).

The cultivation of four main crops (wheat, maize, rape and sunflower) is dominant, with only a very small proportion of dry pulses (0.5%) and vegetables (less than 1%), including green beans and peas. The three most typical grain legumes for which we have comprehensive long-term data are beans, peas and lentils. Other grain legume species appear in the statistics only sporadically and/or in negligible quantities. Historically, green peas and dry peas are grown in the largest quantities, followed by green beans and then dry beans in much smaller quantities. Lentil production has never been significant, but since the early 1990s it has disappeared from the national statistics and almost 100% of the lentils consumed in Hungary are imported.
However, there have been significant fluctuations in Hungarian pulses production since it was recorded. The last and highest production peak, both in terms of area and yield, was at the end of the 1980s, when all cultivated legume species accounted for approx. 3.5% of the total Hungarian arable land. Since the 1990s there has been a steady decline in area, which currently stands at 0.5%, and unsurprisingly total yields have also been declining steadily, with minor fluctuations.
It is important to emphasise that while in Hungary there has been a downward trend since the late 1980s for the three main traditional legume species, the area of soybean has doubled between 1976 and 2015, in parallel with the global spread of soybean. The soybean area in Hungary is 77,270 ha and the production is almost 185,000 tonnes (2017).

In LL Leg-Hung, all grain legumes for human consumption can be considered as NUCs in a broad sense and beans, chickpea and autumn lentil in a narrow sense or LL specific NUCs.

2.8 LL Cer-Hung – Emmer and Einkorn in Hungary

The main cereals grown in Hungary are wheat, barley, rye, triticale and oat, but among the species belonging to the *Triticum* genus, spelt has also significant area sown.

Over the last ten years, the cultivation area of bread wheat and barley can be considered relatively constant, and they are the two largest cultivated cereal crops in terms of area. Their average annual cultivation areas are 1,000,000 ha and 280,000 ha, respectively. Data on spelt, einkorn and

emmer derived from the Hungarian State Treasury Office for the period 2017-2022 characterise the cultivation of ancient cereals in Hungary: Spelt, considered to be a NUC in the broad sense, averages around 12.000 hectares; nevertheless, its harvested area fluctuates significantly (8.600 ha in 2017, 16.400 ha in 2022). The cultivation areas of emmer and einkorn, considered LL specific NUCs, are significantly smaller in magnitude compared to other cereal types. The cultivation area of einkorn slightly exceeds that of emmer, but neither reaches one thousand hectares. Between 2017 and 2022, the average cultivation area for einkorn was 449 ha (min 107 ha, max 873 ha), and for emmer, it was 191 ha (min. 40 ha, max 583 ha). Overall, the majority of spelt, emmer and einkorn are produced according to organic guidelines, the area compared with wheat, barley oat and rye is relatively small for spelt and marginal for the other two species, emmer and einkorn.

In LL Cer-Hung ancient or hulled cereals including spelt can be considered as NUCs in the broad sense and emmer and einkorn in the narrow sense or LL specific.

3. The Neglected and Underutilised Crops (NUCs) in DIVINFOOD

3.1 Common bean *(Phaseolus vulgaris)* - Meat bean and Lingot bean

Common bean, member of the family Fabaceae, is a self-pollinated, diploid (2n = 2x = 22) legume crop independently domesticated in Mexico and South America nearly 8,000 years ago. Common synonyms are French bean, haricot bean, salad bean, snap bean and string bean. Today it is cultivated throughout the world for its green pods as well as for dry seeds and it is the most important legume produced for direct human consumption, with a commercial value exceeding that of all other legume crops combined. Like other legumes, common bean also associates with *Rhizobium* bacteria in the soil that makes beans important in conservation of soil quality due to their ability to fix atmospheric nitrogen in soil (Jan et al., 2021).

Common beans are low in lipids and sodium and are a significant source of protein, dietary fibres, carbohydrates, vitamins and minerals and are also rich in unsaturated fatty acids, such as linoleic and oleic acids. Dry beans are typically processed before consumption, usually by cooking in water, but some beans are consumed after roasting or after milling into flour. Immature seed pods, called snap beans, are consumed as vegetables in some regions, and straw from the plants is used as forage (Los et al., 2018).

Due to extensive plant-breeding efforts, common bean comprises numerous cultivars with a wide range of morphological and agronomic characteristics, including differences in seed size and colour as well as growth habits. Nevertheless, landraces and local varieties of common beans are an important component of plant biodiversity and source of quality and flavour traits (Celmeli et al., 2018). Different varieties vary with respect to their physical and chemical aspects making them key ingredients in many traditional or local dishes.

DIVINFOOD NUC Common bean (*Phaseolus vulgaris*) varieties:

- **Meat bean**, **Bean of Bresse or "Chartreuse and Oisan bean"** is an old small white bean variety traditionally cultivated in the Chartreuse mountainous region**,** near Lyon (France) and also called "small rice". It is a climbing type bean and produces in late summer a delicious grain that renowned as local dishes.
- **Lingot bean** is a small white oval bean with curved appearance. It has a tender and thin outer skin with a soft, creamy texture and a rich, buttery flavour. It requires no pre-soaking and cooks tender in an hour with a guaranteed softness. 69 municipalities cultivate it in a growing area of 200 hectares with more than 200 tons produced per year. Lingot beans are used as a garnish in traditional French dishes and are one of the traditional white beans used in French or Castelnaudary Cassoulet (Office de Tourisme de Castelnaudary, 2024).

3.2 White lupin (*Lupinus albus)* for human consumption

White lupin is a legume whose grain and seed have gained increasing interest but it is a different botanical species to narrow-leaved (*Lupinus angustifolius*). Its recognized nutritional properties, namely a high content of proteins, dietary fibres and its low fat content, make lupin a suitable alternative not only for animal proteins, but also as a substitute for more processed and less balanced flours from a nutritional point of view, used in the preparation of bread, cakes and cookies, among others (Pereira et al., 2022). White lupin is a species of the family Fabaceae, and like most of the members of their family, it can fix the nitrogen.

White lupin is an annual legume that can reach a height of approximately 120 cm, with strong stem and roots that can penetrate the soil to a depth of 1.5 m. White lupin flowers from April to June, the flowers are white to violet. The seeds are large, cream in colour with a 1000-seed-weight of 350–400g. White lupin originates from the Mediterranean basin and is thus suited to relatively mild winter and warm, humid spring but sensitive to cold and to spring freeze. It requires cool temperatures until the beginning of extended growth and good water supply for flowering. Harvest occurs in June-July with dried out plants. It tolerates heavier soils and has a higher yield potential, but does not ripen until August - September.

In Switzerland, important cultivation practices include the use of healthy, certified seeds, sowing as early as possible and using the right cultivar to reduce the impact of the fungal disease anthracnose, which is spread through the seed. Potentially, white lupin is the most valuable protein crop after soybean for animal feed and human nutrition due to the high protein content and good amino acid profile. The yields are usually around 3 t/ha, typically varying from 2 to 4 t/ha. Advantages over soybeans include above all the possibility of sowing in March (frost down to -5 °C is no problem), a better preceding-crop or break-crop effect, and clearly visible flowers which are attractive for pollinators. Lupin thrives well in acidic, low phosphorus soils. Disadvantages of white lupin are the risk of losses due to anthracnose, problems with late weed infestations, relatively late harvest (mid to late August) and alkaloid content (Arncken et al., 2020).

3.3 Narrow-leaved lupin (*Lupinus angustifolius*) for human consumption

Narrow-leaved lupin is an annual plant native to the Mediterranean regions of Europe, Asia and Africa. It has been widely introduced for use as green manure, forage and as a grain legume and soil improver. The nutritional value of narrow-leaved lupin is determined by its high content of protein (30–40 %), carbohydrates (40 %), oil (6 %), numerous minerals, vitamins, and other health-promoting constituents (Lemus-Conejo, 2023).

3.4 Grass pea (*Lathyrus sativus*)

It is a winter-season legume crop adapted to areas with arid or semi-arid conditions. It is grown predominantly under rainfed conditions and on marginal and submarginal lands that are generally characterized by poor soil health/fertility. In Portugal, grass pea is a traditional grain legume that was recovered by the local authorities. Due to the effort done in order to promote this grain legume, grass pea cultivation has gained a new strength. Consumer demand increased, therefore grass pea became a profitable crop. Moreover, grass pea is a very low-input crop and undemanding in labour. One of the main limitations in Portugal consist of a lack of adjusted machinery to harvest and sorting.

3.5 Einkorn (*Triticum monococcum*)

The name einkorn ("single seed" in German), is derived from the presence of a single grain in each spike or from the husk surrounding the grain. Einkorn, which was already cultivated about 12,000 years ago, is known as the ancestor of wheat, originating from the Fertile Crescent region. It is mostly produced in marginal areas and adapted to poor soil and it has regained importance regarding sustainable agriculture and its nutritional values. Einkorn (and emmer also) is considered to be more resistant to diseases than modern wheats. Certain accessions have been identified as resistance sources against fungal diseases, including powdery mildew, stem, yellow and leaf rusts, tan spot, *Septoria* blotch, bunts, and *Fusarium.* Einkorn is much less valued than spelt, although considered as a healthy cereal (Bencze et al., 2020).

3.6 Emmer (*Triticum dicoccum*)

Emmer which is also an ancient hulled wheat, is among the early cereals that were domesticated in the Fertile Crescent region. Emmer wheat possesses valuable traits of resistance to pests and diseases and tolerance to abiotic stresses and is increasingly used as a reservoir of useful genes in wheat breeding. In some parts of the world, certain traditional foods prepared with dicoccum wheat are preferred due to their better taste, texture, and flavour. It is rich in bioactive compounds, furthermore its starch has been reported to have slow digestibility (Dhanavath et al, 2017).

3.7 Rivet wheat (*Triticum turgidum*)

Rivet wheat - also named Poulard, Cone or English wheat - is a free-threshing tetraploid winter cereal, which was differentiated throughout the Neolithic era from other descendants of domesticated emmer (*Triticum dicoccum*) like Durum, Polish, Khorasan and Persian wheat. Archaeological findings suggest that Rivet wheat has spread from Fertile Crescent and arrived in Europe by the Mediterranean route. Across its evolutionary process in cold and mountainous environments, Rivet wheat acquired a good tolerance to frost, wind and humidity. It has the capacity to grow in poor soils, shows a strong weed competitiveness and a good resistance to diseases. Consistently with the hardness of the kernel, it has been traditionally used for pasta and biscuit production (Chable et al. 2018).

3.8 Faba bean (*Vicia Faba*) for human consumption

Faba bean is grown worldwide under different cropping systems as a dry grain (pulse), green grains/pods and a green-manure legume. Faba bean contributes to the sustainability of cropping systems through its ability to provide nitrogen (N) to the system by biologically fixing N_2; diversification of production systems leading to decreased diseases, pests and weed build-up, potentially increased biodiversity. Faba bean is cultivated under rainfed and irrigated conditions and is distributed in more than 55 countries but its introduction in food products is a new concept.

3.9 Lentil (*Lens culinaris*)

Lentil is a cool season legume crop belonging to the Fabaceae family. It is an excellent food source to provide energy, proteins and iron in the human diet. During the last two decades (2001–2020), world production of lentils increased by 107%, from 3.15 to 6.54 million metric tons (Kaale et al., 2023). Lentil is an annual herb, erect in growth form, much branched with a slender stem; Agronomic requirements for lentil differ from region to region depending on the climatic conditions, cropping system, and variety. Dehulling and splitting of lentils are the most-commonly used basic processing methods (Laskar et al., 2019).

3.10 Chickpea (*Cicer arietinum*)

Chickpea belongs to the Fabaceae family and is the second most grown food legume worldwide after the common beans. It was domesticated in the Fertile Crescent, and chickpea cultivation has spread throughout the Mediterranean Basin, central Asia, and Africa (Rocchetti et al., 2020).

There are two main cultivated types of chickpea: the 'Desi' type, which is characterized by purple flowers and small dark seeds, and is mostly grown in the Indian sub-continent and Ethiopia; and the 'Kabuli' type, which has white flowers and large light seeds, and is mainly consumed in the Mediterranean Basin (Boukid, 2021).

In the Mediterranean area, chickpea is usually grown in the spring–summer season, relying on the residual moisture of the soil. However, many studies conducted in Mediterranean countries have shown that the mild winter conditions of this area offer the possibility to sow chickpea in autumn, with increased yield and yield stability (Iliadis, 2001).
However, breeding efforts to develop novel chickpea varieties that are better adapted to European agro-ecosystems are still lacking although national activities and recent projects are now growing due to the stimulus of consumer demand and market trends (Bellucci et al., 2021).
It is traditionally commercialised as seeds, flour or canned foods. In the frame of alternative protein sources, chickpea emerged as a rich source of dietary proteins (17–22%) that can be dry- or wet-extracted.

3.11 Grey pea (*Pisum sativum* ssp. *arvense)*

The grey pea has historically been a staple for northerners, but has been phased out and completely lost ground in Sweden from the 19th century till today. Grey pea was used in everything from soups to bread and it has even been said that each parish in Sweden had its own grey pea variety before it was phased out as the yellow and green peas were refined and gave better yields.

However, thanks to The Nordic Genetic Resource Centre, several grey pea varieties of Swedish origin have been preserved. The company Nordisk Råvara has cultivated many varieties, one being the much appreciated “Rättviks gråärt”, which today is sold to Suede’s best restaurants.

Farmers in Latvia, unlike in Sweden, have never stopped growing grey peas, but have instead continued to develop it. They have gone even further and have had the finest variety, Retrija, protected through the EU’s Protected Geographical Indication (Andersson, 2020).

Conservation varieties are commercially grown in Sweden (e.g. Rättviksärt, Stäme) as well as other types of grey pea (Stor gråärt) and older yellow pea varieties (Vreta gulärt) and autumn sown pea. As the category grey peas generally overlaps with the category of forage peas it is also possible to obtain some grey pea varieties from some smaller seed companies and they are occasionally grown. Yield is lower in grey peas than in peas for feed and some varieties of yellow and green pea used for food.

3.12 Peas *(Pisum sativum)* - Dry yellow or green pea

Peas are legumes which are native to the Mediterranean region, very widely grown and popular vegetable crop. It is a rich source of proteins, amino acids, and carbohydrates. It is an annual herbaceous plant with racemose inflorescences arising from the leaf axils; it is single to multiple podded, and the pods have 5 to 10 seeds. Peas are a cool-season crop grown for their edible seed or seed pods. Different types of peas are grown for various purposes. Garden or green peas are harvested before the seed is mature for the fresh or fresh-pack market. Sugar snap peas and snow peas lack the inner pod fibre and are also harvested early for the fresh or fresh-pack market. Dry peas are harvested when they reach maturity and the pods have dried up and turned brown. At this stage, the peas inside are fully mature and have a hard texture, which makes them ideal for drying and storage.

Peas are grown alone or mixed cereals for silage and green fodder. Peas and other legumes are desirable in crop rotations because they break up diseases and pest cycles, provide nitrogen, improve soil microbe diversity and activity, improve soil aggregation, conserve soil water, and provide economic diversity.

3.13 Cowpea *(Vigna unguiculata)*

Cowpea, also known as black eyed pea, is an herbaceous annual crop belonging to the Fabaceae family. Due to its tolerance for sandy soil and low rainfall, it is an important crop in the semiarid regions but it could become increasingly popular in Europe as well. It requires very few inputs, as the plant's root nodules are able to fix atmospheric nitrogen, making it a valuable crop for resource-poor farmers and well-suited to intercropping with other crops. Cowpeas are grown mostly for their edible beans, although the leaves, green seeds and pods can also be consumed. Grains are rich in protein with most improved varieties containing between 20-25% protein on a dry weight basis.

4. Motivations and limitations of NUC production at territorial level

Across the LLs, 6 main categories can be determined as main motivations for NUC cultivation. However, it is important to emphasize that these categories are not clear-cut and there are overlaps among them. Moreover, most farmers mentioned several different reasons for starting NUC cultivation and their motivations are usually a mix of the different categories.

Category 1: NUC cultivation driven by agronomic reasons or agricultural practices

Most farmers mentioned different agronomic benefits of cultivating NUC legumes, such as nitrogen fixation capacity, good cover crops, drought-resistance, diversifying crop rotation and for several farmers, these were the primary motivations in starting NUC cultivation.

A large number of farmers are also looking for crops that are productive and profitable under extensive or poor soil conditions. Organic farmers are also motivated to look for species that are easy to cultivate under low input conditions. Some traditional NUC varieties (specially in case of grass pea) are well adapted to local conditions, therefore the investment to produce them is not very high and the farmers have a good knowledge of agricultural practices to obtain reasonable yield. NUC grain legumes serve as a good precedent for the following crop and allow for nitrogen residue, which reduces the cost of fertilization and there is a special interest due to their fixation of nitrogen. The need for crop rotations also makes the way for new legume crops and the potential to grow high value crops is always of interest.

Whilst some farmers highlight that these qualities of NUC legumes are also beneficial for the environment and for combating climate change, they put the emphasis on the mentioned practical reasons/motivations, instead of an environmental motivation.

The cultivation of NUC species can also be motivated by less stringent quality parameters compared to common wheat or even spelt. Quality parameters are closely linked to the agricultural practices used, and in organic farming or low-input practices, achieving food-grade quality is possibly easier with these grains, and they have lower expectations for baking quality compared to common wheat. Organic farmers are also motivated to look for cereal species, like NUC cereals, that are easy to cultivate under low input conditions, due to their weed suppression capacity, resistance to biotic or tolerance to abiotic stresses.

Category 2: NUC cultivation driven by market need or economic reasons

Several farmers started to cultivate different types of NUCs because they realized that there is a market need for these products, and consumer demand also increased for product diversification. It has also been mandatory to include legumes in their field crop rotation since the latest CAP plan (2023-2027), in order to benefit for coupled subsidies per hectare. In the case of lupin growing Living Labs, the Swiss organic certification body (BioSuisse) is even encouraging lupin cultivation by giving a "subsidy" on feed lupin and soybean at sale price level. This promotional contribution is rather important and contributes to increase profitability of lupin production for organic farmers.

In case of cereals growing farmers it is important to get a higher price for NUC compared to main crop, which will compensate the yield gap between NUC and main crop. Certified organic farmers view these grains as alternative products, diversification options, and breakthrough points in a market saturated with spelt. They believe that the market will develop soon, allowing them to sell the grains they've already produced (pertains to einkorn).

In case of farms coupled with an own shop or webshop, alternative or "rare" cultivars (NUCs) that are not reaching the yields of main crops can also be beneficial as the exclusivity or other attributes such as taste or historical associations can generate a higher revenue per weight unit. In other words, if a farmer can reach an alternative value chain with a niche variety, he/she can compensate for lower yields with a higher revenue associated to other quality traits, sustainability, or cultural associations.

Category 3: NUC cultivation driven by the personal interest or curiosity of the farmer

Some of the farmers' key motivation for NUC cultivation was a certain kind of personal curiosity or interest. Most of these farmers come from an academic or research background who moved to the countryside or started farming because they wanted to gain practical experience in the field as well. They grow legumes because they want to experiment with different varieties in different settings and are also interested in the science behind it. They are curious and have a pioneer mentality. Many have their main incomes from other jobs or other productions on the farm (crops/animals) and use NUCs because they find it interesting to grow something different. Some farmers are mainly interested in NUCs for cultural and patrimonial aspects, for example through landrace conservation, or would like to keep and preserve the cultural heritage (PDO) of a historic crop, such as the Puy lentil variety which was defined in 1935.

Category 4: NUC cultivation driven by nutrition-based and health motivations

Some farmers growing minor cereals started production for health reasons (e.g., einkorn is recommended for diabetes, intestinal and digestive problems) or due to the demand for healthier grains with better nutritional values. Common perception holds that both emmer and einkorn are healthier alternatives to common wheat, with emmer being less familiar.
Vegetable farmers mention that customers search for legumes because they believe that they are tasty, healthy and a good protein alternative. We can say that generally, farmers share the same motivation for cultivating plants, often selecting various vegetable varieties based on their belief that customers will appreciate them, thereby making financial sense to cultivate. There are farmers who were already producing crops for food, and the motivation for growing NUCs came though cooperation with smaller companies selling organic products. These companies normally have a group of farmers growing the crops and have a goal of producing healthy food in close cooperation and in short value chains. In some cases, the motivation came from the farmer's desire to switch from feed production to food production. Nutraceutical potential of some NUCs can be also considered in relation to non-communicable diseases such as diabetes, cholesterolemia, and hypertension: it was also mentioned by some farmers, especially in case of einkorn and lupin.

Category 5: NUC cultivation driven by a sense of calling, environmental or moral consciousness

There are many farmers who feel that they have a sense of calling and an environmental or moral consciousness and thus they have to do their best in contributing to the fight against climate change and biodiversity loss. In Sweden many farmers are aware of issues related to the agro-chemical-seed-industry and agrobiodiversity loss and are motivated to grow more diversity and help creating a market for that.

Category 6: NUC cultivation driven by innovation or knowledge challenge

Organic farmers are in general more innovative than conventional farmers when it comes to choosing crops. NUC species can represent an interesting challenge for them to innovate their production, and acquire more knowledge and technical skills on these crops.

5. European and national regulatory framework on DIVINFOOD NUCs

NUCs performances depend on the context in which they are cultivated. This context includes the regulations (R) applied to NUCs seeds and NUCs cultivation.

5.1 Regulation for NUC seed production

At **European level**, the CPVO[1] is a European Union agency, which manages the European Union system of plant variety rights covering the 27 Member States. In the case of cultivars that do not

[1] Community Plant Variety Office of the European Union.

have variety protection (see *UPOV*[2] convention for the protection of new plant varieties (UPOV, 2024)), like cultivars of species with low economic value that does not fall under the UPOV convention, or landraces, and amateur varieties, there is no license fee, and anyone who has propagating material of the given cultivar can register as a variety maintainer.

There are different levels of intervention from each law state into the regulation of seeds. More details are presented in **Annex 3**.

5.2. Inventory of public subsidies related to NUC cultivation

At European level, the latest Common Agriculture Policy (CAP) plan (2023-2027) grants aid within the first and second pillars targeted on legumes (including NUCs). Within the first pillar, to support agricultural markets and incomes, farmers can benefit from direct aid in the form of basic payments (per hectare), and green payments, accessible if and only if there is diversification of the crop rotation with legumes.

In France, there are different levels of support available for the development of the legumes sector. The French state create a legislative framework and regulations for the general development of legume agricultural production, while smaller territorial entities grant more specific aids according to the needs identified locally and the objectives set up to respond to the more general regulations on a national level. More details are presented in **Annex 4.**

In Switzerland, farmers get direct payments for growing legumes for feed purposes. As of the first of January 2023, farmers will get this direct payment also for legumes, including lupins, grown for food purposes (1000 CHF/ha). For the organic sector, BioSuisse produces every year a report of the market situation of various arable crops and provides information on current target or market prices. In 2023 the market price for lupins for feed use was set at 117 CHF/dt plus 27 CHF/dt of subsidy to sale price (for a total price of 144 CHF/dt). No price definition is provided for lupin grain for human consumption as the marketing for human consumption is not developed yet. There are also landscape quality contributions (Landschaftsqualitätsbeiträge), in order to preserve, promote and further develop attractive landscapes, such as the preservation of forest pastures, the maintenance of chestnut meadows or the promotion of mountain agriculture and the Confederation allocated landscape quality contributions to the Cantons. In some Cantons (e.g. Schaffhausen) this measure includes a contribute to the cultivation of lupins because of the landscape beauty/quality provided at flowering.

In Italy, grain legume crops (explicitly including lupins) are subsidised as coupled payment with a different amount depending on regions (ranging from 48,35€/ha in Central Italy to 25,99€/ha in Southern Italy) and no subsidies seem to be available in Northern Italian regions. Overall, 39,15 MLN € for the whole CAP planning period are allocated for an estimated 40€/ha. Notably, use of certified seeds is not compulsory for applying for subsidies. In Veneto a specific RDP Measure supports new crops introduction to enrich rotations. No reference is made yet to lupins. For conservation varieties, custodian farmers benefit from a subsidy for on-farm conservation. They are also eligible for R&I regional projects to test agronomic practices for their improvement.

[2] Union for the Protection of New Varieties of Plants.

In Portugal, there are public subsidies for the management practices of some NUC such as common bean (*Phaseolus vulgaris*), black eye peas (*Vigna unguiculata*), white lupins (*Lupinus albus*), chickpea (*Cicer arietinum*) and grass pea (*Lathyrus sativus*) under the scope of the European regulation, Reg. (EU) nº 1307/2013. This regulation states the subsidies farmers can apply for crop diversification, in order to increase the introduction of agricultural practices that can benefit the environment (Greening). The Portuguese legislation, namely the Portaria nº 131/2022 states an exceptional and temporary regime for the payment of agricultural practices that benefit the environment and climate. The introduction of grain legumes into the agricultural systems is a valuable contribution for crop diversification and, therefore to more sustainable agricultural systems.

However, in **Hungary, Denmark and Sweden** no specific public subsidy (except CAP) has been identified at national scale that supports NUC value chains.

6. Agroecological practices observed on NUC farms in the LL regions, and performances

Agroecology as a practice is one of three major interpretations of agroecology, the others being a scientific discipline and a social movement. According to Wezel *et al*. (2014) "agroecological practices (AEP) are agricultural practices aiming to produce significant amounts of food, which valorise in the best way ecological processes and ecosystem services (ES) in integrating them as fundamental elements in the development of the practices, and not simply relying on ordinary techniques, such as chemical fertilisers and synthetic pesticides application or technological solutions, such as genetically modified organisms. Agroecological practices contribute to improving the sustainability of agroecosystems while being based on various ecological processes and ecosystem services such as nutrient cycling, biological N fixation, natural regulation of pests, soil and water conservation, biodiversity conservation, and carbon sequestration. Some of these practices have already been applied in varying degrees in different regions of the world for years or decades, while others were more recently developed and still have a limited rate of application."

In this report we distinguish between agroecological practices applied on NUC farms that are either related to the crop management (1) or management of landscape elements (2) (**see Figure 3**).

1. Regarding the agroecological practices related to crop management we differentiate practices on **crop choice and distribution, fertilization, tillage, weed, water, pest and disease management.**
2. In the case of landscape elements, practices at the field/farm level and landscape level can be distinguished. **Farm level practices** for managing landscape elements can be identified as **production systems** or **agro-ecological infrastructures**. The earlier includes farms applying organic farming practices as defined in Regulation (EU) 2018/848 and more restrictive national regulations or international certification (biodynamic). **Agroecological infrastructures** include management of hedges, grass or flower strips and integration of (semi) natural landscape elements at field or farm scale.

Furthermore, **agroecological infrastructures at territory or landscape scale** includes diversified landscapes (mosaic landscapes), management of hedges, vegetation strips and other landscape elements at territory scale, management of landscape elements by regulation (national land use regulations or agricultural practices that could be supported by eco-schemes (CAP 2023-27), and natural habitats or protected area (like Natura 2000 ecological network)).

In general, we are focusing on farm or field level practices but in some cases, we were also able to collect information on practices applied at territorial or at landscape level. The detailed analysis of the agroecological cropping practices applied in the 9 LL regions of DIVINFOOD are presented in the following subsections, in accordance with the grouping above.

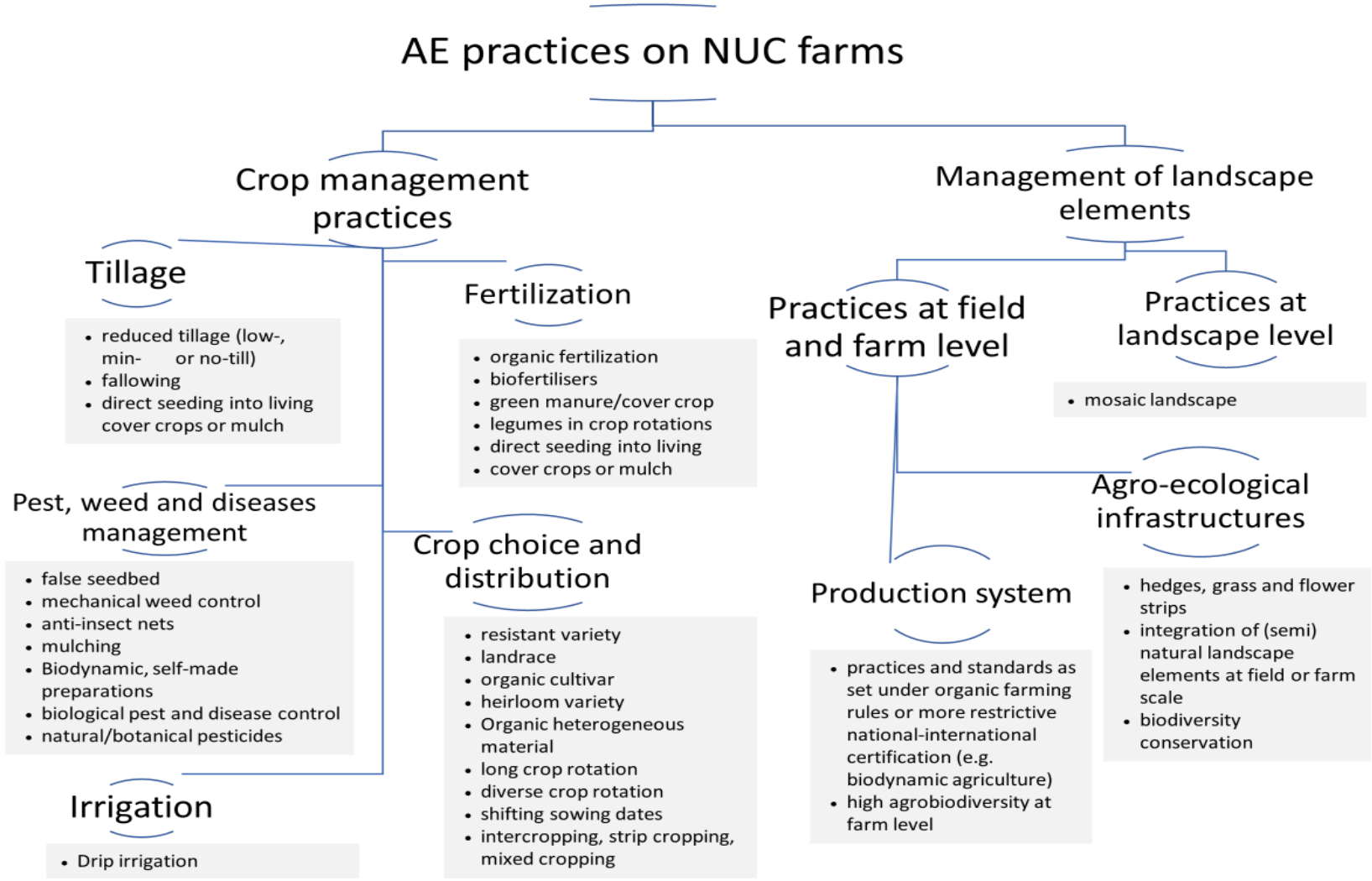

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Figure 3. Agroecological practices considered at DIVINFOOD NUC farms

6.1. Crop management practices

6.1.1 Crop choice and spatial or temporal distribution

INTER- AND MIXED CROPPING

In Switzerland, agroecological practices in **lupin** cultivation are adapted from other grain legumes. For example, intercropping is well established in protein pea production and it inspired research and farmer-experiences with this practice. Currently, this practice suggested for weed control in blue lupin, such as intercrop with oats. However, no suitable companion crop for white lupin has yet been defined for Swiss conditions. **In Italy**, unlike Switzerland, **lupins** are generally cultivated in rotation with cereals as it is a good precession for wheat in terms of yields and protein content. **In Denmark** a practice is to grow narrow-leaved lupin with a small amount of spring wheat to get earlier maturity of the lupins. **In Sweden and Denmark,** the standard organic farming practice for grey pea cultivation is to intercrop them with oats, wheat or barley. Some farmers grow lentils not as a sole crop but mixed with oat to reduce weed pressure and lodging. Estimated yield ranges from 0,7 to 2 t/ha and the yield of lentils is lower when grown together with cereals. Farmers of LL Leg-Hung also experience bi-cropping or intercropping as beneficial for weed control and nutrient supplementation too, these practices are also used by some farmers.

CROPPING AMONG TREES

Olive trees alone, or in orchards are found in the region Alvaiazeire, **Portugal** that have Mediterranean climate. The olive tree is considered to be one of the least demanding cultivated trees in terms of soil nutrients and intercropping of olive trees and grass pea could be a valuable addition to the ecosystem. It provides new products and offers environmental benefits, such as increased biodiversity and soil conservation. Based on initial trials, farmers in LL GPea-Port has gained encouraging experiences with **grass-pea and olive tree intercropping**.

EARLY SOWING

In Switzerland, early sowing as an agroecological practice is adapted from pea cultivation then **lupins** are sown in February instead of end of March.

LONG CROP ROTATION

As an agroecological practice for faba bean and grey pea cultivation in Nordic countries, crop rotation with minimum five years without faba bean and pea is suggested to prevent soil borne diseases. Longer crops rotation are applied in Sweden than in Denmark. Organic farms in the region of LL Cer-Occ are mainly using registered organic cereal cultivars or heirloom cultivars, with 3 - 5 years' rotations. In LL Leg-Hung, a 4 years long crop rotation is used, in general. In Switzerland, the crop rotation of the lupin farmers can be very diverse and complex and even seven crops can be included in the arable part of the farms. A typical example can be described as a cereal followed by green manure and lupin. In this case buckwheat is cultivated as cover crop or green manure before lupin for weed control. In the Nordic LLs (LL Faba-Nord, LL Leg-Nord) crop rotation is about 5 or 6 years minimum between same crop. There is a farm where faba bean was originally introduced to the crop rotation because of large residues of straw (65 tons/ha) after having carrots stored in field over winter. Faba bean was needed due to nitrogen-mobilisation of

the straw. There is also an example for fields swaps with the neighbours, they exchange 5-8 ha per year to prevent soil born disease and to get suitable field for vegetable cultivation.

USE OF CONSERVATION, LANDRACE OR HEIRLOOM VARIETIES

Two conservation grey pea varieties (‘**Rättviksärt**’ and ‘**Stäme’**) and one lentil variety (‘**Gotlandslins**’) for human consumption are commercially grown in Sweden. These conservation grey pea varieties can only be grown under contract with Nordisk Råvara, the Swedish LL-member of the DIVINFOOD project. The ‘Gotlandslins’ lentil is expected to be awarded the Protected Designation of Origin label and cultivated on around 50-60 hectares on the island Gotland. ‘Rättviksärt’ is a landrace grey pea from Rättvik in Sweden and this pea has recently been multiplied and brought back into larger scale (although still small scale) production again. ‘Rättviksärt’ is very popular and is now served in the best restaurants in the country. The first year of production for ‘Stäme’ grey peas was 2023, with about 3 hectares. In Denmark, there are also two landrace grey pea varieties in use ‘Lollansk Rosin’ and ‘Brunært fra Nakskov’. The seeds of these variety are propagated organic.

In Portugal, the **grass pea** cultivation is also based on landrace varieties.

In France and more particularly in the Auvergne-Rhône-Alpes region (close to LL Bean-Lyon), the lentil has been present since Roman times. The **Green Lentil of le Puy** (La Lentille Verte du Puy) was the first legume with protected designation of origin in France and its cultivation area is varying between 3,000 and 4,000 hectares. Its appellation area is limited to the Haute-Loire region and located in a mountainous zone with an average altitude of 1,000 meters. The sector applies the principle of sustainable agriculture throughout the crop cycle. The lentil cultivation is not a main crop: at the farm level, it is complementary to their main activity, and the vast majority of lentil producers are livestock farmers[3].

Until the mid-1960s, **The Blonde lentil of Saint-Flour** (La Lentille Blonde de Saint-Flour) was widely cultivated on the volcanic plateau of the Planèze, in Cantal. But gradually, farmers have turned away from this non-mechanised crop to dairy farming. In the early 1990s, after an inactivity of more than 30 years, the mayor of Saint-Flour decided to revive this lentil cultivar. After numerous experiments, two varieties of blond lentils had finally been retained, Flora and Santa. Today, more than 40 producers cultivate the blonde lens on 170 hectares, i.e. more than 150 tonnes harvested each year (compared to the 4,000 tonnes of Green Lentil of le Puy) The Saint-Flour blonde lentil is provided with the *red label* and is one of the "sentinel" products of the international "Slow Food" movement. It is also in the process of PDO recognition[4].

‘Rouge de Bordeaux’ is a French **heirloom landrace wheat** from the 19th century and it was the favorite of French bakers for generations. Farms in the region of LL Cer-Occ are still cultivating this variety that makes an excellent bread with a rich brown color, mellow flavor, and baking spice aroma. The ‘Florence Aurore’, an **old French drought-hardy wheat variety** (1920), is also grown sporadically in this region.

Szarvasgedei alakor previously known as Bözödi alakor, is a historic Hungarian einkorn variety originating from the flooded area of Bözödújfalu in Transylvania. It holds archaeological and genetic significance and has gained large popularity in Hungary (LL Cer-Hung). It is officially

[3] http://www.lalentillevertedupuy.com/en/in-figures/
[4] https://www.lentille-blonde.fr/

registered as a variety since 2022. It's recognized for its unique characteristics and is cherished by numerous producers and processors.

CERTIFIED ORGANIC SEEDS

Spelt is considered to be a NUC in the broad sense in LL Cer-Hung and Franckenkorn and Oberkulmer Rotkorn are the two most commonly grown varieties under organic farming conditions. They are mostly cultivated under contractual arrangements and the production and market success of these varieties are anticipated, especially coming from certified organic farms, with the certificate for the specific cultivar.

6.1.2 Fertilization practices

LEGUMES IN CROP ROTATION

Legume NUCs (like legumes in general) are **commonly rotated with cereals** on the area of all DIVINFOOD's LLs to reduce nitrogen fertilizers use while offering plant-based protein source for human consumption. Growing pulse crops in cropping systems is known to improve soil nitrogen (N) supplies through biological N fixation and the return of crops residues to the soil (Herridge et al., 2008). However, the N fixation capacity of pulse crops varies depending on species and environmental conditions (Liu et al., 2020).

LOW INPUT CEREALS

Emmer and einkorn wheats are classified as hulled minor or ancient cereals, due to their generally small production areas and their cultural-historical significance going back thousands of years. One of the most important agroecological cropping practice related to NUC cereals is that they are well adapted to low-input conditions. These varieties can typically be cultivated on poor quality soils and under extensive or low input condition with less operations compared to the main cereal crops (wheat) in the region (LL Cer-Hung and LL Cer-Occ). **Rivet wheat**, a free-threshing tetraploid cereal, has also the capacity to grow in poor soils and shows a strong weed competitiveness and a good resistance to diseases.

ORGANIC FERTILIZERS AND GREEN MANURE

Organic fertilisation is a way of substituting inorganic fertilisers and improving the efficiency of fertilisation by improving general soil fertility. Use of cover crops and green manure is also a widely applied agroecological practice at NUC farms to limit fertiliser inputs and/or control weeds. Integration of cover crops into the rotation automatically incurs crop diversification. Based on interviews, the clover, vetch, alfalfa and mustard are the most commonly used green manure plants at arable NUC farms. Beside green manure, organic fertilisers such as compost, manure from own-production or from outside of the farm, cattle slurry, soil bacteria, vinasse, pig slurry, biogas slurry, organic and conventional slurry, foliar fertilizers and micronutrient fertilizers are also the types of organic fertilisers frequently applied in NUC farms.

6.1.3 Tillage

Small vegetable farms cultivating NUCs in LL Bean-Lyon are organic certified and apply low till management, using mulching and/or organic fertilization like horse manure, compost or

fragmented ramial wood. Grass pea farmers in Portugal also tend to use low till in general. However, farms and agroecological farming practices on tillage show more diverse picture in other LLs. In general, NUC farmers seem quite open for sustainable tillage practices and most of the NUC farmers, regardless of the country, introduced new agroecological practices at least one of the following: shallow, low or reduced tillage, or less frequent ploughing. Like fertilization practices, number of variations in tillage practices varies from farm to farm and from crop to crop : Therefore, it is not possible to classify farms into distinct subcategories but NUC farmers in general tend to use reduced or superficial tillage without soil inversion.

6.1.4 Weed, pest and disease management

MECHANICAL WEED MANAGEMENT

Weed management is the most critical input requiring task in **lupin** cultivation both in LL Leg-ItSwitz and LL Leg-Nord and might be very intensive in cultivation for human consumption. For example, in some cases, **manual weeding** might be needed in addition to **mechanical weeding** which makes the cultivation more expensive compared to wheat. In Switzerland, in organic lupin cultivation **narrow row spacing** is mostly used like for cereals and **harrowing** is done once or twice. In general, white lupin is managed as sole crop and based on the trials and farmer-experiences **tillage with a plough,** harrowing twice and if possible, **hoeing** is recommended.
In Italy, sowing also occurs in narrow rows (12-18 cm) with cereal seeder, but cases exist of broadcast with a manure spreader. Typical target seedling rates are 50-70 seeds/m^2 for white lupin. In Sweden, some farmers intercrop narrow-leaved lupin with cereals to reduce weeds, but the majority of lupin cultivation is as sole crop.
Lentils are weak in weed competition and tend to lodge, therefore management must be focused on this. Growing of organic lentils is only suitable for fields with a low weed pressure and some farmers use **false seedbed** or swarding before harvest as an agroecological practice to reduce weed pressure.

In the area of LL GPea-Port agroecological management practices are being successfully applied to **grass peas**, which are also related to weed control. If **less than 40 cm inter-row spacing** is used, the grass pea plants will be able to grow properly and cover the soil, so most of the weeds will not be able to emerge.

In case **of bean** production **mechanical weed control and hoeing** are also used in the area of LL Bean-Cast. For the chickpea, the crops require to be planted in wider rows, allowing easier hoeing and more air between plants to avoid fungal diseases related to soil humidity. The main challenge for mechanical weed management, however, is dependence on weather conditions, with limits in the time window of application (particularly at harvest time).

Most of the organic and conventional farmers who grow cowpea varieties and chickpeas in LL Leg-Hung use mechanical weed management but all mentioned it as a critical issue in cultivation. Organic farmers also mentioned labour shortages, which makes different tasks, especially weeding, really difficult to manage.

BIOLOGICAL PEST AND DISEASE CONTROL

In organic farming, prevention and **selection of suitable varieties** adapted to local cropping practices and environment conditions are the key elements for biological pest and disease control

(Radzikowski et al, 2023). In wheat and related NUC cereals, common bunt can cause considerable damage in yield and grain quality. The disease is caused by seed-borne fungi, which can persist in soils as well. **Seed treatments** are essential to prevent and control common bunt and application of vinegar is reported in LL Cer-Occ. Fusarium infection can also be critical in wheat production but no significant issue for spelt or other NUC cereals (emmer, einkorn and rivet wheat) were reported by farmers interviewed.
According to individual farm interviews, there are several minor cases reported on pest and disease problems in legumes, in the majority of cases the extend of the infection would not cause significant yield loss or quality problems therefore pesticides are not commonly used even in the conventional farming systems. Early sowing (grass pea) or sowing at the most appropriate time (lentil) is also frequently applied as agroecological practices that decrease the risk of infection. Potassium soap is also used in horticulture as a natural insecticide (LL Leg-Hung).

6.1.5 Irrigation and water management

Small vegetable farmers apply drip irrigation both in France and Hungary for bean and legume cultivation. In LL Leg-Hung many farmers use **mulching as a suitable practice for retaining water**, but also suitable for enriching the soil with nutrients. No-till or minimum till is also widely used, this is also suitable for retaining water, keeping nutrients in the soil, and good for weed control too. **Growing beans in polytunnels, or under raschel netting** are innovations used by some farmers in Hungary for the purpose of retaining water and **protecting the plants from drought**. Additionally, all farmers mentioned severe droughts as critical hindering factor and there is a shared opinion that there is a need for more elaborated agroecological practices on cultivation technology of legumes in Hungary.
In Sweden and Denmark not all farmers have the right infrastructure to irrigate NUC legumes but some farmers reported about it or at least would like to have irrigation facility. According to their opinion, faba beans must be irrigated and lupin also perform better if irrigation is possible and applied at the right time. Normally there is a drought 'late' in the season, which usually don't cause any problem as the crop is around maturity. However, in 2023, there was an 'early drought' and lot of rain later on, which had an adverse effect.
In LLs dealing with NUC cereals or grass pea farmers do not use irrigation nor it is necessary for successful cultivation except areas like the Homokhátság region in Hungary, that is now officially labelled as a semi-desert. Farmers are facing various challenges in this region, primarily concerning water management and conservation due to heavily droughts as well as other negative effects of climate change. There's a focus on developing technologies to minimize soil disruption, with a potential improvement in machinery for small farms. Furthermore, there's a need to explore the impact of water retention on arable crops, which may necessitate closer collaboration with concerned authorities.

6.2 Management of landscape elements

6.2.1 Practices at field and farm level

PRACTICES ON PRODUCTION SYSTEM

Based on the information collected we can state that interest for growing NUC legumes for human consumption (faba bean, lentil, grey pea, white and narrow-leaved lupin) or NUC cereals (emmer,

einkorn, rivet wheat) are coming mainly from farmers either committed to integrated management (IP-Suiss, Global GAP) or to **organic agriculture** (especially in the case of LL Faba-Nord, LL Leg-Nord, LL Cer-Hung) even if they are not certified.

NUC cultivation itself can be considered a distinct agroecological practice, as the integration of these plant species and their varieties into the cropping system increases agrobiodiversity at farm and territorial level and provides higher biodiversity at ecosystem level.

PRACTICES ON AGRO-ECOLOGICAL INFRASTRUCTURES

In the area covered by LL Bean-Lyon famers do not integrate land-based body of water (**pond**) and small group of trees like **copses** into their cultivation area but treat them as support for beneficial fauna and flora. In LL Leg-Hung flower stripes, flower seed mix, T-shaped bird seat and wide variety of plants for pollinators placed to support beneficial fauna and flora. In Switzerland, NUC famers keep a lot of **natural areas** out of cultivation (far over the required area) and biodiversity is an important topic on their farm and naturally enhanced whenever possible. In Sweden, France and Hungary **hedges and hedgerows** are the most important agro-ecological infrastructure elements of NUC farms.

6.2.2 Practices at landscape level

By collecting information on NUCs-growing farms we were focusing on farm or field level practices but we were also able to collect information on practices that concerned NUC farms at territorial or landscape level in some cases. In Switzerland, farmers have to convert 7% of the arable land into ecological compensation areas (ECA) like grassland and agroforestry in order to enhance biodiversity and low-input grassland making up the major part of ECA. On some NUC farms extensive meadow or flower strips cover around 16% of the arable land that is much higher than mandatory rate. In Hungary some NUC farms also have Natura 2000 protected area while in Sweden some farms have a protected area according to the Swedish Environmental Code § 3 that categorises agricultural land as of national importance and contains special provisions concerning land and water management in certain areas in Sweden.

7. Repertoire of local farms and farming systems using NUCs in agroecology

In each LL region, we elaborated a repertoire encompassing the different types of farms using NUCs in the broad sense. These types weree constructed on the basis of several criteria presented above: practices applied to NUCs in 4 domains (production, processing, marketing, organisation) and motivations for growing NUCs. Information is also provided on the agronomic performance of NUCs in the different farm types.

7.1 LL Bean-Lyon

With the special focus on management practices, the main types of farms producing NUCs in broad sense in the region Auvergne-Rhône-Alpes can be categorized in five main groups:

Livestock farmers benefiting from the PDO crops

Farms in Haute Loire, including PDO and Label Rouge zones (The green lentil of le Puy and the Blonde lentil of Saint-Flour are the PDO crops) laying in high altitude zones (800-1,000 m) on slopes and uplands, with an average size of 52 ha (Agreste, 2023). The soils in this region is rather poor in fertility and consist volcanic rocks with no possibility for tillage. These farms are mainly traditional, managed by farmers with agricultural background and small areas of lentils are integrated into the grassland rotations for livestock. The interest in NUCs is due to the PDO labelling as these products can be sold at a higher price (3 times higher) than NUCs outside the PDO zones. The main agricultural activity of these farms is cattle rearing but not arable farming. These farms often have problems with soil diseases, mainly linked to the short crop rotation but lack of knowledge on arable farming and time pressure of livestock farming also hinder the crop production. The raw material of the PDO NUC is sold to agricultural cooperatives on long distribution chains, without sorting or pre-processing. In 2021, the PDO lentils were produced on 3,800 ha including 2,800 ha in the Haute Loire. This represents 9% of the total area of lentil grown in France.

Mixed-farms with livestock and vegetables production

These farms are mainly located on the borders of the Limagne plain, on slopes, hillsides and uplands, in the Puy de Dôme, Drôme, Savoie, Haute Savoie and Isère department and they are not beneficiaries of the PDO zones. These farms can be considered "small" with an average size of 47 hectares.

They are mostly organic farmers, but not exclusively and motivated by crop diversification and low input requirements for pulses and CAP subsidies. They are working in close collaboration with technicians and advisors from public technical institutes, such as GIEE, GEDA, Chambers of Agriculture and Déphybio groups. Open sorting lines (densimetric tables and optical sorter) are often shared among farms as services to increase the added value of different crops. Packaging is often done in big bags and bulk sachets for sale to short value chains, storage platforms for collective catering or directly to producers' stores after processing (canned and soaked pulses).

Arable farms on irrigated plains

Arable farms mainly cultivating cereals in conventional farming on the plains of the Rhône, Isère and Ain departments with the possibility of irrigation and including NUCs in broad sense context like soybeans, chickpeas and lentils into crop rotation. They are farming on larger plots with the help of advisors of private technical institutes like Limagrain or Terres Innovia. The average farm size is between 80-150 ha. The raw material is mainly sold to long distribution chain to cooperatives, which take care of storage, sorting and packaging. The main driver of production is the volume produced, not the level of on-farm (pre)processing.

Diversified arable farms in advanced agroecology

Arable farms located mainly in the Rhône and Ain regions diversify the cereal production by using ancient varieties of cereals and including pulses in crop rotation. They are mostly organic farms or farms without organic certification using agroecological practices. They usually own a collective tool for storage, sorting, milling often into legume flour and for packaging (flour or bulk pulses), then sales to all kind of channels. Farmers often together have a processing unit and registered trademark, such as "Les Robins des Champs", "Graines de l'Ain" or "Graines de Lyon". As far as sales channels are concerned, they mainly turn to producers' stores and markets, but can also sell to supermarkets and hypermarkets.

Small scale vegetable farms in advanced agroecology

Across the region, there are also vegetable farms that diversify the cultivation with a few rows of lentils and beans. The size of these farms are between 2 and 5 hectares and dealing with the production of dozens of different species including a few hundred square metres of legumes or lentils and they prefer to focus on on-farm processing and direct sales.

7.2 LL Bean-Cast and LL Cer-Occ

The main types of farms producing NUCs in broad sense context in the region Occitanie can be categorized in three main groups:

Artisanal peasant processors

These small farms with the size under 30 ha mainly grow a diversity of cereals and the main economic activity is cereal processing: they also process raw material from outside of their farms. The farmers can own all the agricultural equipment, or just part of it and have informal arrangements for common harvests. They are interested in producing products with high added value, like bread and pasta both for cereals and legumes including NUCs and they are advanced in agroecological practices. They mainly grow pulses for economic interests in diversifying their production and sell them directly to their established consumers. Their sorting and cleaning tools are usually on the farm or close-by and pre-processing is mainly performed in the frame of an informal arrangement with peers, or done by specialist services. The products are sold in short food supply chains. Most of the 'NIMA' (non issus du milieu agricole - new farmers without a family farm) are in this category.

Farms in collective organisations or linked to local patrimonial network

These farms are growing NUCs for innovative or cultural purposes. The size of the farms in this group is quite diverse from few hectares to hundreds. They cultivate cereals as main crop but includes NUCs for diversifying the production for agronomical interests, for a local organization demand, due to personal curiosity or for patrimonial purposes. They are mainly technically skilled farmers and the farming system can be either organic or conventional but include some agro-ecological practices. The farmers usually do not own processing facilities but are sharing the tools with others in a structured organization. Farmers sell most of their production in a collective chain or to local cooperative and are engaged in the governance with their peers, so particularly integrated to local farmers' networks. In the case of cultural motivations for growing NUCs,

farmers are generally anchored in the territorial system and linked to the local heritage.

Innovative arable farms

These farms large in size and historically cultivating a few number of crops, mainly with conventional practices but diversifying their production with NUCs cereals or NUC pulses.
The farmers can own all the agronomic equipment, or just part of it and have formal arrangements with the cooperative for some activities (i.e. common for harvests). The farm system integrates different NUCs (cereals and legumes) because of market or economic opportunities within their usual selling channels, that are mainly the cooperatives. The agronomic practices are conventional but tend to be innovative. The farmer is focusing on cultivating the cereals and sell the raw unsorted material directly after harvests. Even if the tracking should be assured in the long supply chain market, the farmers do not usually know what is done with their production. This category seems to include the more isolated farmers.

7.3 LL Leg-ItSwitz

SWITZERLAND

In Switzerland, white lupins are in demand in the organic protein feed market and are increasingly being recognised by food processors. They can contribute to diversity in the cultivation of grain legumes with a satisfactory yield potential if they have increased resistance to the aggressive fungal disease anthracnose. Since the introduction of the two varieties Frieda and Celina with increased resistance, a major step has been taken towards yield security in Switzerland. Taking into consideration specific charecteristics of lupin value chains in Switzerland, farms can be categorized in four main groups:

Farms linked to food processors

This group includes farms that are in close collaboration with food processors and from whom the food processors directly request the cultivation of white lupins. Hovewer, the market for food products from lupins produced in Switzerland is at the very early stages and there are no consolidated value chains at the moment. There are relatively new small-scale initiatives (single farms and startups) trying to develop such products. The main products from such initiatives are coffee, yogurt, flour, flakes, “bulgur”, hummus-like spread and fermented sauces. These are products that target the market of niche and premium products and can be characterised as ‘plant-based’, ‘swiss origin’, or ‘nutritious and healty’.

Organic farms with feed production

This category encompasses organic farms who cultivated lupins for feed as there is a high request of swiss produced protein feed for organic farms in Switzerland. However, it is common to bring grain lots above 3 tons (sometimes possible already above 2 tons) to collection points for cleaning and drying, even if the farm would afterward buy the feedstuff from the same miller. BioSuisse is even encouraging lupin cultivation by giving a “subsidy” on feed lupin and soybean at sale price level. This promotional contribution is rather important and contributes to increase profitability of lupin production for organic farmers.

According to expert opinions, these farms are not interested to produce lupin for human consumption therefore they are not relevant for DIVINFOOD project.

Innovative pioneer farms

This category includes very diversified farms including vegetable and arable farms. They are often organic and interested in "special" products and crops in order to increase and diversify the offer of products for direct sale at the farm shops and have a strong focus on direct marketing.

Most of lupin growers are single pioneers' farmers, often not connected with each other. Hovewer, FiBL (LL member of LL Leg-ItSwitz) has set-up a professional network for exchange of knowledge and practices in order to support the market development of lupins and other underutilised grain legumes (Swiss Legumes Hub, 2024).

Diversified arable or mixed farms

These farms have a focus on management innovation and want to try new options and crops to diversify the crop rotation and increase ecological benefits compared to cereal production. They can be very old organic farms taking care about crop diversification.

ITALY

Lupin growers in Italy are restricted to few types, particularly if targeting food products. Farms tend to be low-input, with limited scale of lupin cultivation, often lupin-lovers, having limited connections to industry and to long value chains (or even prejudicially neglecting industries). Lupin valorisation is key in all categories in relation to either (mostly traditional) food products or non-market values (tradition of cultivation, aesthetic potential, territorial networks).

Custodian growers

These farms are generally interested in small scale farming and dynamic conservation of local landraces that is often not limited to lupin. In case of lupin, *Maremma sweet lupin* landrace is included in the Tuscan regional repertoire as a genotype at risk of genetic erosion. It is safeguarded by the Tuscan germplasm bank and entrusted for cultivation to custodian growers. Seeds dissemination is managed by the germplasm bank; it can be marketed directly by the custodians but only in limited quantities. The same applies to the *Recanati white lupin* in the Marche region.

Small scale farms in advanced agroecology

These farms are generally interested in high agro-biodiversity and agroecological approaches. They are mainly cultivating according to the rules of organic agriculture even if they are not necessarily certificated. They are selling their products to short value chains to promote territorial development. They hardly have connections with processing industry or retailers and sell on-farm or through local markets and fairs. They tend to lever local traditions and act as local heroes.

Diversified mixed or arable farms

They are mainly organic farmers (small-medium scale and certified and non-certified organic) with marked inclination for the adoption of agroecological approaches, on-farm processing and

short/local value chains and motivated by the lupin role in rotation and its general good performances compared to other leguminous crops.

The barriers may act at processing level for difficulties with alkaloids and lupin debittering processing. Untargeted equipment, particularly in relation to machinery that sometime has to be adapted (e.g. for sorting). In the Padana plain (Northern Italy) farms tend to be bigger, notably in case of arable farms, with simplified rotations. Lupin introduction might represent a useful novelty for value chains innovation and to provide income opportunities, yet this seems to be a wishful thinking of some key informants, rather than a concrete business option. No large-scale cultivation of lupin is noted if targeting food use; greater extensions is yet limited to few farms in case of use as living mulch.

7.4 LL GPea-Port

In Portugal, the average farm size is around 14 hectares and the cultivation of NUCs (broad sense) is traditional in small farms since these crops grow well in small plots of land. Grass pea (*Lathyrus sativus*) is a traditional grain legume that was recovered by the local authorities (Municipality) and there is no doubt that grass pea is a strategic grain legume for the local economy. Due to the effort done in order to promote this grain legume, grass pea cultivation has gained a new strength. Consumer demand increased, therefore grass pea became a profitable crop. Moreover, grass pea is a very low-input crop and undemanding in labour. One of the main limitations consist of a lack of adjusted machinery to harvest and sorting. Based on this, three main types of farmers and associated farm types are found in relation to grass pea cultivation.

Traditional low imput farms

NUC traditional varieties are well adapted to the local land therefore, the investment to produce them is not very high. The farmers have a good knowledge of cultural practices to obtain reasonable NUC yield. The main crops are mainly olive oil and wine, potatoes and corn cultivated according to traditional practices (low-input, low till, incorporation of manure in the soil). The farmers cultivate several NUCs, mainly grain legumes such as: common bean (Phaseolus vulgaris), black eye peas (Vigna unguiculata), white lupins (Lupinus albus), chickpeas (Cicer arietinum) and grass pea (Lathyrus sativus). Farms in this category are family based, working on an individual basis and mainly organic but not certified. Pre-processing (including cleaning and sorting) and storage is done on-farm and they are selling their product in short value chains. They prefer to sale the raw material directly to final consumers, bakers and wholesalers, but no communication or promotion is done by the farmer. The NUC sowing and harvest are still done manually.

Innovative grass pea farms

These farms are mainly conventional or integrated production system and doing pre-processing on-farm but the grass pea is the most important NUC for these farmers. The farm size ranges from 7 to 10 ha, and the majority of the land was inherited from the parents. The main crops are mainly olive oil and wine cultivated according to traditional practices (low-input, low till, incorporation of manure in the soil). In the control of pests and diseases of the main crops, farmers use some pesticides. They are collaborating with other farmers in crop management and the sowing and harvest are done with tractor and machinery. One farmer of this type sells the raw material,

packaged, in local markets and /or local shops outside the farm and created his own seed brand with marketing activity as a local innovation.

Grass pea farms with innovative food products

These farms are quite similar to innovative grass pea farms in relation to crop management practices but they are using proper machinery (harvester and threshing machine) and the storage is outside the farm in a warehouse or in a cool room. In addition, they are processing the raw material outside the farm to produce innovative food products and some farmers created their own food products brand. The farmer processes and mills the grains and uses the flour to produce pastry. In other cases, the farmer uses the cleaned raw material to obtain other NUC-based products such as liquors.

7.5 LL Faba-Nord and LL Leg-Nord

In general, the farmers in the living labs do not differ from the general organic farmers in Denmark and Sweden. The age of farmers in Denmark and Sweden is relatively high and most farmers have an educational background in farming. For some of the smaller farms, the farmer has a job outside the farm as well. The NUC legumes are grown at arable land that are suited for main crops as well. Many NUC farmers are curious and well aware of sustainability issues. In the two Nordic living labs, that both covering the same area, four types of NUC farms can be identified. However, faba beans are slightly complicated in their NUC definition as they are commonly cultivated for feed where we do not really consider them NUCs. However, when the faba bean is used as food it becomes a NUC. The production of faba beans is therefore less tied to alternative value chains compared to many other NUCs. All the below categories could apply to faba beans, but none of them is very common.

Innovative organic farms with direct sales

This category of organic farmers is usually entrepreneurial, innovative and curious. They might have a small farm shop and sell their NUCs directly to restaurants or end consumers via farm- or webshop. In some cases, these farms could send the harvest to a processor (for peeling or milling) and get it back to sell it through previously mentioned channels.

In Sweden many of these farmers are aware of issues related to conventional agriculture and agrobiodiversity loss and are motivated to grow more diversity and help creating a market for that. They are curious and have a pioneer mentality. Many have their main incomes from other jobs or other crops/animals and have the NUCs because they find it interesting to grow something different, despite these varieties are not reaching maximum yields but the exclusivity or other attributes such as taste or historical associations. If a farmer can reach and alternative value chain with a niche variety they can compensate for lowers yields with a higher revenue associated to other quality traits, sustainability, or cultural associations.

Organic farms under contract with intermediaries

Commonly these farmers get the seeds from a company with a contract that inhibits them to share the seeds with other farmers. The company they have the contract with is the only buyer of the harvest. These companies normally have a group of farmers growing the crops and have a goal of

producing good food in close cooperation. Some have been producing NUCs (grain legume) for some time (Nordisk Råvara, Linser for livet), others have been producing NUCs cereals and have now started to produce grain legumes as well (Aurion), some have started within the last couple of years (Food Borholm). The farmers in this category are often experienced and good farmers, hence the companies reach out to them as they often rely on a few good growers for their NUCs. These growers are usually pleased with the price they get for their crop, which is a motivation for them.

Sales and processing is handled by the contracted company or other companies who process the raw material further. There is a small overlap between Innovative organic farms with direct sales as some farmers also sell the products in their farm shops, but most of the farmers do not have direct sales and therefore sell their dry and clean raw material to the company they have a contract with.

Diversified organic farms cultivating modern legume cultivars

For cereals NUCs this is a more common category, however due to the lack of alternative NUC legume varieties this category is not as common with the exemption for legume crops where modern cultivars of species commonly used for feed and being sold for food such as faba beans and lupins. As there is an established feed production of these crops (mainly faba beans) food companies might reach out to buy seeds from these farms for food production. These farms are mainly medium-large organic farms (100-500 ha) specialized in arable production and growing high value or niche crop, or to have legume crops in the rotation and mainly selling faba bean for feed (better price). In general, on-farm de-hulling and milling are not well developed. Success stories are experienced with the cultivar of lupin named 'Frieda'. It has a very good vegetative growth, a bit like faba bean. Some started growing faba beans because they needed nitrogen in the field after a season with carrots. They found out that there was a very good economy in growing faba beans, so they have continued since.

Conventional farmers growing legume NUCs for companies

These growers are sometimes associated to bigger conventional companies but not limited to those. In Sweden there are conventional growers of common beans, faba beans, lentils and peas (mainly yellow peas). In general, on-farm de-hulling and milling are not well developed.

7.6 LL Leg-Hung

Small-scale vegetable gardens in advanced agroecology

The overall size of these farms are less than 5000 m2 with an experimental, progressive approach in farm practices, marketing, and sales. The diversity of species/varieties is generally high, with many unique, less-common crops - including legume species, as NUCs grow on a few percent of the total cultivated area. Farms are mostly certified organic with agroecological practices. The experimental character is also reflected in the choice of species: environmental and climate adaptation aspects, as well as farmers' personal curiosity or conviction play an important role. Due to the agroecological approach, innovative solutions for weed control, water management and nutrient supply are commonly used - such as no-till, mulching and water retention. Farmers mostly try to find their market niche themselves, preferring direct sales or alternative channels

(Community-Supported Agriculture, growing for restaurants), where the unique range and high quality of produce are kept on display. To varying degrees, the goods produced also serve the farmer's subsistence.

Vegetable farms

This category encompasses larger scale commercial horticultures, driven predominantly by economic considerations. The picture is mixed: both conventional and/or progressive/organic farming, depending on the farmers' education and the market positioning of the products. The main motivation for growing NUC legumes is to supply a well-established market (e.g., a restaurant, or a fixed retailer) and to meet the (presumably) growing market demand for healthy food and protein alternatives. Agronomic benefits of legumes, such as N-fixation, soil cover, and drought tolerance also play an important role. The diversity of crops is lower, but leguminous crops still do not occupy more than 5-10% of the area. Variety selection is based on yield, yield security and marketability, so preference is given to proven and/or sought-after species and varieties. Produce is sold directly (e.g., to restaurants) or through intermediaries, typically in short supply chains. Processing of produce beyond cleaning and drying is rare, in some cases canning/jarring.

Small scale arable farms in advanced agroecology

The overall farm size in this group is below the national average (17 ha). Generally younger or mid-age (under 50) and more highly skilled farmers, with an experimental, progressive approach. Farms are mostly organic and/or are using agroecological or regenerative practices. Small farm size is less suitable for the mass production of conventional arable crops, hence farms are usually experimenting or specializing in unconventional, less common crop varieties (incl. NUCs) such as arable vegetable farming, and organic seed production. The share of legumes varies but can reach up to 40%, in line with the specialization of the farm. Produce is sold directly (e.g., to restaurants) or through intermediaries, typically in short supply chains. Pre-processing usually does not go beyond basic cleaning, drying and pest (weevil) control.

Medium-sized arable or mixed farms in advanced agroecology

This group includes farms with size of up to 200 ha: arable-dominated farms or mixed farms where arable is less than 50% of the total utilized area. In most cases, legume production affects only a small part of the arable area, as a complementary activity to large-scale arable cropping of conventional crops, but in rare cases, it can become the main cash crop. Usually, a smaller range of cultivated species-varieties is cultivated, mostly tried and tested crops. Even these larger farms have a certain degree of experimental and progressive approach, farms are mostly certified organic or using regenerative methods. Pre-processing of crops usually does not go beyond cleaning, drying/dry freezing and pest (weevil) control. Produce is sold through intermediaries, typically in a short- or mid-tier supply chain.

7.7 LL Cer-Hung

In Hungary, the best-known ancient grain species, also known as husked grains is spelt, while emmer, and einkorn have only recently begun to enjoy a renaissance. The list of ancient cereals

for human consumption in Hungary includes: spelt (as broad sense NUC), einkorn and emmer and farms producing NUCs can be categorised in three main groups.

Organic farms under contract with an intermediary

They are organic farmers under contract with an intermediary company (Naturgold) and growing emmer cultivar MV Alkor and/or spelt with no intention for processing. Naturgold sells the organic seeds to organic farmers and buys back the product they produce. This reduces the financial risk for the farmers. The cultivation and processing of the grains occur entirely under certified organic conditions and the farmers typically involve land areas for NUC cultivation ranging from 1 to 20 hectares and manage farms of 30 to 200 hectares. The intermediary company covers the entire value chain and works together with the farmers in a closed system. They have a nationwide presence in the food chain and organic stores. They started with introducing spelt and also work with einkorn, but the focus on emmer is not significant, and they mainly export their products abroad.

Diversified organic farms connected to local food networks

These organic farmers and producers have their own processing capacity and in some cases either have or aim to have their own bakery too. They have already established direct connections with consumers or artisanal bakers and manage total areas from 50 to 300 hectares. Personal relationships are strong among collaborating actors and it is common for a farmer to supply multiple bakeries, while a single bakery may source ingredients from multiple farmers.

This group includes both the new-wave, strong-brand-building farmers with a visible and well-known innovative network of millers and bakers and small and medium size individual farmers who grow NUC for diversification or other reasons, and see it as a way out/survival opportunity and try to enlarge their own domestic market and try to sell the grain in more processed form. Some producers exclusively process NUCs, though it is more common to find farmers who cultivate both emmer and einkorn alongside bread wheat and spelt. Having their own stone mill is a distinctive feature.

Diversified organic farms with occasional market outlets

This category includes small organic and individual producers (30-100 ha) with permanent or occasional market outlets, but without their own storage capacity. They sell their grain to buyers (mostly for export) without processing and do not intend to process it.

This group includes mainly individual farmers with an average farm size between 30 and 100 ha. These farmers aim to sell their produce unprocessed, with no intention of processing. They try to sell their bulk produce through personal contacts, online platforms and social media groups. They do not engage in marketing activities, do not have their own brand and form a group of individual farmers.

Occasionally, conventional farmers seeking to convert to organic practices, or self-sufficient individuals seeking to change their lifestyles, may also grow NUC cereals, but their relevance is so far marginal, according to the experts interviewed.

8. Conclusion

The Repertoire of local farms and farming systems using NUCs in agroecology presented in this report is summarized in Table 3. It considers biodiversity in action throughout Genotype-Environment interactions (GxE) where the Environment is no longer limited to the Biophysical environment (Be) (soil, climate), but enlarged or extended also to agricultural Management practices (M), processing/cooking technologies (T), marketing Channels (Ch), Social organisations (S) and regulations (R).

Although there may be significant differences between the farm types identified in each LL, we have identified common characteristics and clustering factors that allow farms dealing with NUCs to be classified into LL-independent categories and in parallel, to be included in the extended GxE interaction model. Qualitative and quantitative data, especially on NUCs agronomic performances in specific environments, have been produced and will feed the GxE database.

This repertoire also ensures that the legume and minor cereal NUCs farms involved in on-farm studies and trials can be extended to cover and include the widest possible range of farm types existing in the LLs regions.

Table 3. NUCs farm repertoire of DIVINFOOD - Farm types producing NUCs in the LL regions
Farm types that are active partners of the LLs are marked with grey and bold and farm types whose members we interviewed are marked with star (*). Figures {in bracket} represent the number of farms interviewed in each LLs.

	Main clustering factors					
Living Lab (GXE)	**Genotype (G)**	**Legal contract (R)**	**Farm scale (M)**	**Mixed farming system (M)**	**Diversification or AE innovation (M)**	**Local or territorial network (S)**
LL Bean-Lyon {8}	Livestock farmers benefiting from PDO		***Small scale vegetable farms in advanced agroecology**	***Mixed-farms with livestock and vegetables production**	*Arable farms on irrigated plains *Diversified arable farms in advanced agroecology	***Diversified arable farms in advanced agroecology and with registered trademark**
LL Bean-Cast { 1} and LL Cer-Occ {2}			**Artisanal peasant processors**		*Innovative arable farms	**Farms in collective organisations or linked to local patrimonial networks**
LL4 Italian-sub-LL {3}	*Custodian growers		Small scale farmers in advanced agroecology		* **Diversified mixed or arable farms**	
LL4 Swiss sub-LL {3}		*Farms linked to food processors	***Innovative pioneer farms**		* Diversified arable or mixed farms Organic farmers with feed production	
	*Traditional farms		* **Innovative grass pea farms**			

LL5 GPea-Port{5}		* **Innovative grass pea farms with food product**			
LL6 Faba-Nord & LL7 Leg-Nord {8}	Organic farms contracted to intermediaries Conventional farmers growing legume NUCs for companies	*__Innovative organic farms with direct sales__		* Diversified organic farms cultivating modern legume cultivars	
LL8 Leg-Hung {4}		*__Small-scale vegetable gardens in advanced agroecology__ *Small scale arable farms in advanced agroecology	*Medium-sized arable or mixed farms in advanced agroecology	*__Vegetable farms__	
LL9 Cer-Hung {4}	* Organic farms contracted to intermediary			* **Diversified organic farms with occasional market outlets**	*__Diversified organic farms connected to local food network__

	Conventional farmers aiming for conversion to organic practices

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Annexes

Annex 1 - List of key informants and experts

Annex 2 – Internal reporting template for LLs and interview questions for farm interview

Annex 3 – Regulation for NUC seed production.

Annex 4 – Inventory of public subsidies related to NUC cultivation – Focus on France

Annex 1 - List of the key informants and secondary sources

KEY INFORMANTS

- 36 individual farm interviews across the LLs
- Organic breeder, researcher, ELKH ATK, Martonvásár, Hungary
- Hungarian organic certification bodies
- Organic seed supplier
- Members of ÖMKi on-farm network
- Members of the Farmer-Miller-Baker network
- French Agriculture Minister Observatory (AGRESTE)
- French Chambre d'Agriculture 11 technicians (conventional agriculture support institute), Biologic Agriculture Support network (French) technicians from dept. 81, 31, 09, 32, 34.
- FILEG, legumes inter-profession in Occitania, French
- Researcherd at FiBL
- Agricola Grains
- Professor at University of Pisa, Italy
- PSB Sementi
- researcher at RSR – Italy
- Secretary of Comunità del Cibo della Maremma (Maremma's Food Community)
- Researcher at CREA – Acireale, CT, Sicily
- Professor and researcher at SLU and ICOEL
- Nordisk Råvara
- Local food project manager, Auvergne-Rhône Alpes Regional Chamber of Agriculture (CRA AURA)
- Field Crops Project Manager, Puy de Dôme Chamber of Agriculture (CA 63)
- Coordinator for the organic farmers' group of 63, Groupement en Agriculture Biologique du Puy de Dôme (GAB 63)
- Head of Research, Innovation and Development at the Auvergne-Rhône Alpes Regional Chamber of Agriculture (CRA AURA).
- Development engineer for pulses and organic correspondent for Auvergne Rhône-Alpes, Terres Inovia.
- Adviser on local distribution channels - Territories, Environment and Society Department - Rhône Chamber of Agriculture (CA 69).
- LegSecAuRA Regional Technical Advisor
- Organic Field Crops Advisor, Organic Field Crops Regional Technical Advisor, Isère Chamber of Agriculture (CA 38)
- Technical advisors at ADECA
- Stakholders of the LLs

KEY EVENTS ATTENDED (in which information was collected)

- Cer-Hung LL Kick off meeting February 2023, Kecskemét, Hungary
- Soul of Bread Festival, August 2023, Budapest, Hungary
- Network workshop in French Speaking Switzerland, Lausanne, February 2023

- Protein Power Network event, Strickhof, Zurich, March 2023
- Legume Day, Grünhölzli, Zurich, May 2023
- International Lupin Conference, Rostock, June 2023

ADDITIONAL REFERENCES AND DATA SOURCES

- **HealthyMinorCereals (GA Number 613609) -** Report on the market potential of minor cereal crops and consumers' perceptions about them in different European regions: **http://healthyminorcereals.eu/en/publications/report-on-the-market-potential-of-minor-cereals**
- **Farmer-Miller-Baker database: https://biokutatas.hu/hu/page/show/gabona-adatbazis**
- **Members of ÖMKi on-farm network**
- **Hungarian State Treasury** (land-use database, income support based on farm size)
- **Hungarian Central Statistical Office**
  https://www.ksh.hu/stadat_files/mez/hu/mez0038.html (organic agriculture)
  https://www.ksh.hu/stadat_files/mez/hu/mez0008.html (land area by types of farming)
  https://www.ksh.hu/stadat_files/mez/hu/mez0018.html (crop yield)
  https://www.ksh.hu/stadat_files/mez/hu/mez0021.html (export)
- https://www.agrarszektor.hu/noveny/20210415/egyre-tobb-gazda-termeszti-ezt-a-buzafajtat-magyarorszagon-ezert-ilyen-nepszeru-29134
- https://webshop/ite /www.biokutatas.hu/hu m/86/tonke-es-alakor-tajfajtak-termesztese-okologiai-gazdalkodasban
- https://www.biokontroll.hu/alakorfajtak-az-oekologiai-gazdalkodasban/
- Cultivation of white lupin - A cool-season and environmentally friendly protein crop, **https://orgprints.org/id/eprint/38740/**
- FactSheet, Alkaloidanalyse bei Lupinen, https://www.fibl.org/fileadmin/documents/shop/1363-alkaloidanalyse-lupinen.pdf
- Lupins. Cultivation and uses; Gesellschaft zur Förderung der Lupine e.V. , https://www.legumehub.eu/is_article/lupins-cultivation-and-uses/
- The Food and Feed Value Chain of Lupin in Switzerland, CROPDIVA – Deliverable 5.1, https://www.agroscope.admin.ch/agroscope/en/home/news/newsroom/2023/02-13_cropdiva.html
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- **https://www.bioaktuell.ch/markt/produkte/ackerkulturen/marktuebersicht**
- **Landwirtschaftsamt Kanton Schaffhausen, Landschaftsqualität, https://sh.ch/CMS/get/file/cfd88f4e-b3e4-4de0-bd6c-df87a46da668**
- ASSAM (2019) Lupino bianco di Recanati, ASSAM
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- Gresta F., Wink M., Prins U., Abberton M., Capraro J., Scarafoni A., Hill G. (2017) Lupins in European Cropping Systems; CAB International
- ISTAT: statistical yearbooks (http://dati.istat.it/Index.aspx?QueryId=37850) (same figures as for FAO https://www.fao.org/statistics/en/)

- Liberto M. (2020) Legumi sostenibili. Buoni per buongustai, vegetariani e vegani; Ed. Momenti
- Murphy-Bokern D., Stoddard F., Watson C. (Editors) (2017) Legumes in Cropping Systems Illustrated Edition; CABI
- Ranalli P., Spina A., Parisi B., Torricelli E. (2018) Leguminose minori. Lupino, cicerchia, roveja; Edagricole
- Regione Campania (2022) Lupino - Scheda coltivazione per disciplinare di agricoltura integrata
- Agreste. 2022. Chiffres et données, statistique agricole annuelle 2020, mai 2022.
- Gran'AURA : Structuration des filières protéines végétales à destination de l'alimentation humaine en Auvergne Rhône-Alpes Panorama des filières protéines végétales en Auvergne Rhône-Alpes, LESNE-SEFTEN Pauline, 60 pages,
- LegSecAura Projet PEPIT, Reports and technical data sheets.
- « Analyse technico-économique des cultures de légumes secs sur la région Auvergne Rhône-Alpes », CA63, LAUGIER Maurin, 2020, 156p.
- FNLS - Fédération nationale des légumes secs. Régions de production. [en ligne]. Disponible sur http://www.legume-sec.com/regions-de-production/.
- Fiches filières légumes secs du réseau GAB/FRAB AuRA, 2022, Yanis ESSAOUDI-CARRA (FRAB AuRA), 4p.
- GNIS, INRAE, 2020, « L'avenir des filières semences en légumineuses », Compte-rendu du colloque du 11 février 2020.

Annex 2 – Reporting template

I. Expert interviews and literature review

1. **Name of the LL:**

2. **Name, role and institute of the respondent:** (who is filling in this form)

3. **Source of data: please, list the key informants which have been interviewed and the secondary sources (links, references) which have been used.**

4. **Please describe the regulatory framework (variety registration, seed marketing, NUC marketing) on seed production and protected designation of origin for NUCs (if there are any) in your country:**

5. **Are there any types of public subsidy (management practice, cultivar use, farm infrastructure, cooperatives, etc.) to support NUC value chains in your country?**

6. **Please describe the main characteristics of NUC (broad sense NUC) farmers and farms.**
   Please identify and describe the main profile and trends by grouping them into 2-4 categories.
   (Who are the farmers growing NUCs in the LL region (age, social origin (farming parent, newcomers), education background, etc.) and what kind of the farms are they running (size of farm, main production (specialized on NUCs or mixture of NUC and main crop), equipment, type of soils (is it suitable for main crop production or only NUCs can be cultivated), altitude etc.). Note that the typology is based on practices, and not on structural or socio-demographic data, and same practices can be developed by a diversity of farmers and farms.) Where possible, please make a comparison with main crops.

   General description

   Category1

   Category2

   Category3
   …

7. Please describe the main motivations of NUC (broad sense) cultivation.

Please identify and describe the main profile and trends, considering the points listed below and grouping them into 2-4 categories.

What are the motivations to produce NUCs, what triggered and when did they start cultivating them, are these factors still present? Where possible, please make a comparison with main crops.

What are the general advantages, limitations, and difficulties related to NUCs comparing with main crops (+ / -)

General description

Category 1

Category 2

Category 3

8. Please describe the main ways (<u>focusing on management practices) farms produce NUCs (broad sense)</u> in the LL region.

Please identify and describe the main profile and trends, considering the points listed below and grouping them into 2-4 categories. In case of each aspect, where possible, please compare NUCs with main crops.

- *Input: NUC species and varieties, types of seeds, inputs (conventional, organic) which are used*
- *Management practices: conventional, integrated, agroecological practices: (cropping practices e.g. intercropping, mixed cropping, crop rotation etc., soil management practices, support of beneficial flora and fauna)*
- *Motivation to use certain (agroecological) management practices. Management practices that changed/were newly introduced due to NUCs.*
- *Performance: yield, resistance, nutritional quality, ecosystem services etc.*
- *Advantages, limitations, difficulties regarding NUC related(agroecological) management practices.*
- *Costs, subsidies*
- *Innovations regarding production (management practices, cultivar use, etc.)*

General description

Category 1

Category 2

Category 3

…

9. Please describe the practices of <u>pre-processing</u> and processing **of NUCs (broad sense).**

Please identify and describe the main profile and trends, considering the points listed below and grouping them into 2-4 categories. In case of each aspect, where possible, please compare NUCs with main crops.

- *Practices: on-farm or industrial (pre)processing, mild processing or conventional (pre)processing, which step is done on-farm and which outside of the farm (where) storage, cleaning, sorting, dehulling, milling, anti-insect treatment, etc.*
- *Performances*
- *Costs, subsidies*
- *Advantages, limitations and difficulties*
- *Organisation (individual/collective, contracts, etc.)*
- *Innovations*
- *Type and localisation of farms and farmers*
- *Motivations*

General description

Category1

Category2

Category3

…

10. Please describe the marketing practices used in case of NUCs as i) raw material, ii) as pre-processed food (e.g. flour) as well as iii) NUCs-based fully processed products? (broad sense NUCs)

Please identify and describe the main profile and trends, considering the points listed below and grouping them into 2-4 categories. In case of each aspect, where possible, please compare NUCs with main crops.

- *Practices (Who they are selling their raw or processed products to, what do they do to promote it (label, communication, etc.)) direct sale of raw materials and/or (pre)processed products, sale to millers/bakers, wholesalers, cooperatives, etc..*
- *Performances: price, etc.*
- *Costs, subsidies*
- *Advantages, limitations and difficulties*
- *Organisation (individual/collective, contracts, etc.)*
- *Innovations*
- *Type and localisation of farms and farmers*
- *Motivations*

General description

Category1

Category2

Category3

…

11. Please describe the organisational practices concerning broad sense NUCs of your LL region.

Please identify and describe the main profile and trends regarding the professional network integration of farms/farmers (individual/collective, with subsidies or not), by

grouping them into 2-4 categories. Where possible, please compare them with practices related to the main crops.

General description

Category1

Category2

Category3
…

12. Overall NUC farms repertoire in the LL region.
Based on the categories identified above, representing the main trends in the country/region, please group the observed profiles: e.g., type 1: farms in advanced agroecology, doing pre-processing and processing on-farm, mild processing, marketing in short chains, and collaborating with other farms; type 2: farms in conventional agriculture, selling NUCs to a cooperative; type 3, etc.

Type 1

Type 2

Type 3
…

13. Please identify the farm types producing the specific NUCs (defined in the proposal) of your LL.
Please complete this part after the individual farm interviews.

Type 1

Type 2

Type 3
…

14. Please write here success and failure stories of agroecology management practices and pre-processing related to the specific NUCs of your LL (defined in the proposal).
Please fill out this part after the individual farm interviews.

II. Questionnaire for individual farm interviews

I. Farm - basic information

1. **Farm ID, name**:
2. **Country:**
3. **Location:**
4. **Is the farm part of the DIVINFOOD Living Lab** or any type of practice-oriented research project, own innovation or other LL? In case yes, for how long and what is the experience? In case not, would like to join or at least be part of an on-farm experimentation network?
5. **Farm size** (ha):
6. **Farming system** at farm level or applied on the NUC areas if there are more types at farm level (Conventional/Organic- certified/Organic-uncertified):
7. **Age of farming system:**
8. **Which are the main products that are produced** (Arable crops, Livestock, Vegetables, Horticulture, Permanent crops-trees, Other):
9. **Farm type** (based on the typology exercise):
10. **Number of full-time equivalent employees (paid and not paid):**

II. Farmer - Socio-economic characteristics

1. **Proportion of land owned by the farmer (%)**
2. **Age of the farmer**, operative leader or the person that takes care of the NUC
3. **Education's level of the farmer**, operative leader or the person that takes care of the NUC:
4. **Social background of the farmer** (farming parents, newcomer, etc)
5. **Is the farmer a full time or part-time farmer?**
6. **Is the farmer member of any farmers' organisation and/or cooperative?** If yes please give details.
7. **On which channels do the farmer get professional and market information?** (advisory services, agency, magazine, newsletter, social media, YouTube, etc.)
8. **Reason to start farming** (family tradition, marriage, self-provisioning, lifestyle change, secure livelihood, business interest):

III. Biophysical environment

1. **Soil type:**
2. **Soil fertility (according to the farmer) (**high/medium/low):
3. **Annual precipitation (mm**):
4. **Soil pH / area in which NUC is produced** (rather basic, rather acidic, rather neutral):
5. **Topography area in which NUC is produced** (plain, coastline, medium mountains, mountains, Is the area affected by erosion):
6. **Biogeographical regions of Europe** ((European Environment Agency) https://en.wikipedia.org/wiki/Biogeographic_regions_of_Europe):

IV. NUC use - Agronomic details

1. **Area of NUC at farm level** (%):
2. **NUC species (if possible Latin name as well) and name of the NUC cultivar**(s):
3. **Type of NUC cultivar** (DUS variety, landraces, amateur variety, OHM, organic variety):
4. **Is the NUC cultivar(s) registered variety?** (Yes/No):
5. **Seed source** (own production, exchanged farm seed, purchased farm seed, certified conventional seed, certified organic seed, certified untreated, other):
6. **If own seed production, what are the main bottlenecks?** (disease e.g. common bunt, weed seed contamination, seed cleaning, storage pests, etc.):

7. **Cultivar choice**: **what has the most impact on your decision?** e.g. only this specific cultivars is growing well in my area, it's ornamental characteristics (nice colour), processing quality, etc:
8. **Purpose and motivation to cultivate NUC** and the specific cultivar (For own production or for sale, where came the idea to cultivate NUC and the specific cultivar(s)? Were there other NUCs in the past that were cultivated but abandoned for a reason? If yes, what reason?
9. **Yield** range (data from the last 2 years/cropping seasons) in t/ha
10. **Disease resistance** (poor/medium/good, or any experiences based on at least 2 seasons):
11. **Lodging** (poor/medium/good, or any experiences based on at least 2 seasons):
12. **Weed suppression** (poor/medium/good, or any experiences based on at least 2 seasons):
13. **Any crop specific quality**:
14. **Processing quality:**
15. **Type and use (kg/ha) of input material(s):**
16. **Where do you find technical info on growing this crop?** Are you satisfied?
17. **Cite 3 main problems the farmer encountered in NUC production:**
18. **Cite innovative solutions the farmer introduced in NUC production:**

V. Main crop - Agronomic details

1. **Area of main crop at farm level** (%):
2. **Main crop species (if possible Latin name as well) and name of the cultivar**(s):
3. **Type of cultivar** (DUS variety, landraces, amateur variety, OHM, organic variety):
4. **Is the cultivar(s) registered variety?** (Yes/No):
5. **Seed source** (own production, exchanged farm seed, purchased farm seed, certified conventional seed, certified organic seed, certified untreated, other):
6. **Yield** range (data from the last 2 years/cropping seasons) in t/ha
7. **Disease resistance** (poor/medium/good, or any experiences based on at least 2 seasons):
8. **Lodging** (poor/medium/good, or any experiences based on at least 2 seasons):
9. **Weed suppression** (poor/medium/good, or any experiences based on at least 2 seasons):
10. **Any crop specific quality**:
11. **Processing quality:**
12. **Type and use (kg/ha) of input material(s):**

VI. NUC use - Agroecology practices on NUC areas of the farm

1. **Soil management on NUC area** (low till, no till, cover crop, living mulch, dead mulch, ploughing):
2. **Machinery used for soil management and cultivation**: type, own or rented, high-low impact, use of animal force
3. **Nutrient management on NUC area** (low-input, green manure, organic fertilisation, biodynamic preparates (purchased or self-made), nitrogen fixation (own production-external purchase):
4. **Cropping practices applied on NUC area:** (intercropping, mixed cropping, agroforestry, crop rotation and its composition, list of crops cultivated in the last 2 seasons, leave fields to lay fallow)
5. **Pest and disease management on NUC area** (type, administration):
6. **Weed management on NUC area** (type, which weed species are the most problematic, how do you solve it, hoeing, harrowing-manual, animal, tractor):

7. **Water management on NUC area** (rainwater harvesting, irrigation (drip irrigation, other), etc.):
8. **Permanent grassland** (yes, no, intensity), if yes, grassland management:
9. **Support of beneficial fauna and flora** (flower stripes (composition), attract birds of prey, installing artificial nest, insect hotel, landscape features):
10. **Type of protection against wild animals on NUC areas** (electric fence, dog, etc…)
11. **Area of ecological importance**
12. **In case of having livestock, is agroecological livestock management applied?**
13. **In case having livestock, is the farm self-sufficient in feed/fodder production?**
14. **Which practices were changed due to NUC cultivation and why?**

VII. NUC use – Pre-processing/processing technologies

1. **At what level of pre-processing/processing does the farmer sell the NUC? (**As raw material, cleaned, pre-processed, processed (as flour in case of cereals) or as bread)
2. **Is there any NUC pre-processing/processing done at on farm level?** (Yes/No, If yes description)
3. In case of no, **where and how is the NUC pre-processed/processed**, if it is known? Please give some details on type of (pre)processing.
4. **Where is the NUC stored?** (On farm, or elsewhere? Is it similar to where and how the main crop is stored?)
5. **Type of storage at on-farm level**, if they have on farm storage (silo/big-bag). Is it similar to how the main crop is stored?)
6. **What are the main challenges regarding storage**?
7. **Are there innovative solutions/success stories regarding storage?** Please describe
8. **Type of main sorting machine** if they have any (Rotating / plan sorting / Alveolar):
9. **Type of dehuller,** if they have any (Impact / friction)
10. **Other pre-processing/processing machine**, if they have any
11. **Are there any post harvest issues?**
12. **What are the main challenges regarding pre-processing**?
13. **Are there innovative solutions/success stories regarding pre-processing of NUCs**? Please describe.

VIII. Main crop – Pre-processing/processing technologies

1. **At what level of pre-processing/processing does the farmer sell the main crop? (**As raw material, cleaned, pre-processed, processed (as flour in case of cereals) or as bread)
2. W**here and how is the main crop pre-processed/processed**, if it is known? If yes, please give some details on type of processing at on-farm and at out-farm level.
3. **Where is the main crop stored?** (On farm, or elsewhere?)
4. **What are the main challenges regarding pre-processing of the main crop**?

IX. NUC use – sales channels, value chain, marketing

1. **How is the NUC raw material sold?** Channels and proportion (%) (cooperative, wholesaler, small-scale processor, big firm, barter, self use, for animal retailer) Is it different to the way how main crop sold?
2. **Is it done on a contract base?** (yes/no, for each channel; annual or multi-year contract):
3. **Are NUC-based products sold by the farm** (or raw material only)**?** If yes, what kind and how are NUC-based products sold? (supermarket, groceries, hard discount, specialty shop, frozen food shop, organic shop, open-air/farmer market, on farm, collective farmer shop, CSA online platform for local, organic food online platform for ready-to-use meals, purchasing group, food coop, restaurant) Is it different to the way how main crop sold?
4. **Are by-products sold/valued** (straw, etc) **and how?**

5. Is there any type of **marketing activity at farm level related to NUC?** (if yes, what and how, FB, conference, fairs, open farm day, etc)

X. Main crop – sales channels, value chain, marketing

1. **How is the main crop raw material sold?** Channels and proportion (%) (cooperative, wholesaler, small-scale processor, big firm, barter, self use, for animal retailer) Is it different to the way how main crop sold?
2. **Is it done on a contract base?** (yes/no, for each channel; annual or multi-year contract):
3. **Are main crop products sold by the farm** (or raw material only)**?** If yes, what kind and how are NUC-based products sold? (supermarket, groceries, hard discount, specialty shop, frozen food shop, organic shop, open-air/farmer market, on farm, collective farmer shop, CSA online platform for local, organic food online platform for ready-to-use meals, purchasing group, food coop, restaurant) Is it different to the way how main crop sold?
4. **Are by-products sold/valued** (straw, etc) **and how?**

Annex 3 – Regulation for NUCs seed production

At **European level**, the CPVO[5] is a European Union agency, which manages the European Union system of plant variety rights covering the 27 Member States. In the case of cultivars that do not have variety protection (see *UPOV*[6] convention for the protection of new plant varieties (UPOV, 2024)), like cultivars of species with low economic value that does not fall under the UPOV convention, or landraces, and amateur varieties, there is no license fee, and anyone who has propagating material of the given cultivar can register as a variety maintainer.

In France, seeds may be subject to individual and intellectual property rights (IPR) through two tools: the plant variety certificate (COV) and the patent. In these cases, seeds are registered in the national official catalog and the GEVES (Groupe d'Etude et de Contrôle des Variétés Et des Semences - study and control group for varieties and seeds).

- The Plant Variety Certificate (COV) is an industrial intellectual property that protects only the use of plant varieties. The COV breeder guarantees its exclusive use for 20 to 30 years. It can be individual or community-based. The laws governing COVs are governed by UPOV
- When there is no intellectual title, the seed belongs to the public domain, known as "royalty-free seeds", like those belonging to network "Réseau Semences Paysannes". These seeds do neither belong to any list nor included in the official catalog. It is possible to reproduce a variety not listed in the official catalog and then market the seed.

Nevertheless, in France, there are special cases for the use and exchange of seeds of non-registered varieties? (for the reproduction of seeds for non-commercial purposes):

- Agricultural mutual aid, in accordance with L.315-5 of the French Rural Code. It is authorized to grow and multiply seeds for exchange purposes only, and not for sale or other economic interest. For example, it is not permitted to multiply seeds and then sell them privately to a seed company.
- It is authorized to grow and multiply seeds for conservation, selection and research, in "small quantities only", according to article 1-3 of decree 81-605 "Commerce des semences et plants / Trade in seeds and plants".
- In association or club, for seed exchanges only, according to article L.661-8 of the Rural Code modified in 2016.

In Hungary the FVM Decree 48/2004 (IV.21.) declares that varieties not included in the National List of Varieties, non-protected varieties, as well as seeds of species not named in the Decree, can be marketed without certification. Furthermore, re-sowing and exchange between farmers is also permitted. However, the varieties covered by the Decree can only be resown by the farmers themselves; everything else is considered as seed “marketing”. Regarding NUC cereals, einkorn and emmer are optionally listed plants, as millet or some pseudo cereals like buckwheat, in the national variety database, as they are commercially less important species, therefore the variety registration is optional. The use and exchange of farm saved seeds and other propagating materials are permitted in compliance with current seed regulations. Such farm saved seeds (propagating materials) produced on certified organic land are considered as certified organic,

[5] Community Plant Variety Office of the European Union
[6] Union for the Protection of New Varieties of Plants

and do not require an exemption (derogation). The Section D of the Regulation No. 48/2004 (April 21) issued by the Ministry of Agriculture and Rural Development mentions einkorn and emmer wheat. According to this regulation, the seeds of species listed there can be subject to certification, but it is not obligatory, meaning they can be placed on the market without being certified (although in case of a complaint, an official investigation might not be feasible due to the lack of traceability). For the seeds of species not subject to certification as listed in Section D, actions like resowing, exchange, and sale are allowed.

In Switzerland, DUS tests for white lupin are not conducted in Switzerland. According to UPOV, in cases where a DUS test report is not available from a member of the Union, the Office of Plant Variety Protection will request an appropriate authority or testing of a member of the Union to perform a DUS test on its behalf. Currently no application of variety registration has been submitted in Switzerland, so it is not clear how the national examination office would react.

An alternative is to register the variety in a CPVO member as there is an automatic mutual recognition of the Swiss and European catalogues. White lupin seeds are sold by seed traders. In Switzerland, some seed producers affiliated to a seed production organisation are producing lupin seeds. Seed traders make the link between seed producers (foreign and Swiss) and farmers. Farmers in Switzerland do not use farm-saved seeds.

The EU regulation on Heterogeneous Material has not been taken up in Switzerland and it is not clear how this type of material will be treated in Switzerland.

In **Switzerland** is in place a specific regulation for the registration of "niche varieties". The regulation on niche varieties (FAO, 2019) has been implemented by the Swiss Federal Office for Agriculture (FOAG) and aims at the release of varieties of niche status, complementing the regulation on commercial varieties. Through this measure, small-scale breeders, producer-communities (1-5 farmers), and Non profit-organisations (>5 farmers) can save and use seeds of non-commercial varieties through "Niche varieties". These niche varieties benefit from a simplified admission to the market which does not require the official registration of the variety and the certification of seeds or planting material. The simplified regulation has been established by the amendment of article 29 of the regulation of seed and planting material in 2010, with the objective to enable the sustainable use of PGRFA (Plant Genetic Resources for Food and Agriculture) and to reduce technical barriers for small-scale value chains. The regulation is composed of three measures: firstly, the authorization of a person / enterprise for the marketing of other seed than specified in the marketing regulation for seed and propagating material, secondly, the definition and control of the size of the niche (annually maximum amount of seed production), and lastly, the implementation of plant health measures. These measures allow for complementary seed supply to the highly formalised system of commercial varieties, and enables the sustainable use and further development of about 40 common vegetable varieties, several old varieties of crops with special characteristics, and for particular markets even new varieties which failed the admission as commercial varieties.

The main Swiss agricultural markets are mostly protected by tariffs. This also applies to seed imports. One major entry barrier for seed producers is, besides the current low market size, the absence of tariff protection on lupin seeds. Without such protection, lupin seeds are much cheaper to import. According to "tares" - Swiss customs tariff -, there is no tariff protection on lupin (BAZG,

2022). Lupin is listed together with vetch und the category “Seeds, fruit and spores, of a kind used for sowing”. There is no explicit category for grain-legumes or for lupin for food production.

In Italy white lupin is considered an agriculture crop and not a vegetable for the variety registration process, differently from chickpeas and lentils that are considered horticultural crops. The variety registration requires the DUS test also required for vegetables, as well as the VCU (value for cultivation and use) agronomic test. This test must be carried out for two growing seasons in several locations to assess yield and other agronomic parameters (e.g. resistance to diseases). Lupin seeds are mainly sold by seed companies to farmers through seed sellers (Consorzi Agrari or other private entities). The market for lupin seeds is very limited and few cultivars are available.

Terms are regulated by the national Law 194/2015. Art. 11: “Marketing of seeds of conservation varieties 1. Farmers who produce the seeds of varieties listed in the National Register of Conservation Varieties, in the territories where these varieties have evolved their characteristic features, are granted the right to direct and local sale of seeds or propagating material related to these varieties and produced on the farm, as well as the right to free exchange within the National Network of Biodiversity of Agricultural and Food Interest, in accordance with the provisions of Legislative Decree No 149 of 29 October 2009 and Legislative Decree No 267 of 30 December 2010, “without prejudice to the provisions of the current phytosanitary regulations".

In Sweden and Denmark, there are limitations in the seed categories related to legumes NUCs as landraces and old cultivars that are not on the common variety list. There is the conservation variety list that could accommodate many of the legume NUCs, however, that list has quantitative limitations and is poorly communicated to relevant stakeholders. The OHM category has not yet been officially introduced in Sweden and the ministry of agriculture has not facilitated any OHM related progress. In Denmark two cereal populations have been introduced in the conservation variety list? but no legumes. The general situation for legumes NUCs in the Nordic countries is that farmers or small companies find and multiply the seeds themselves, which makes seed marketing and variety registrations obsolete. The only exception is when the larger seed companies want to start producing legumes and they use foreign cultivars, which are on the EU variety list and sell the seeds to farmers.

In Portugal, the regulatory framework for NUC is based on the Portuguese regulatory law, Decreto-Lei 257/2009. This regulation represents the transposition of the European directives, Directivas da C.E. nº 2008/62/CE and 2009/145/CE. Accordingly, the NUC varieties must be registered in the National Catalogue of Varieties and their commercialization is restricted to short chains.

In addition, the Portuguese regulatory law Decreto-Lei nº 54/2011 introduced modifications to the original 257/2009. The Decreto-lei nº 54/2011 provides for derogations from the admission of landraces of vegetables and other varieties traditionally cultivated in certain localities and regions and threatened by genetic erosion, and of varieties of vegetables with no intrinsic value for commercial plant production, but developed for cultivation in certain conditions, and the commercialization of seeds of these native varieties and other varieties.

Annex 4 – Inventory of public subsidies related to NUC cultivation – Focus on France

1. European level

At the European level, the latest Common Agricultural Policy (CAP) plan (2023-2027) grants aid for pulses (including NUCs) within the first and second pillars targeted.).

In the first pillar, farmers can receive direct aid in the form of basic payments (per hectare), and green payments to support agricultural markets and incomes. There are only accessible if and only if there crop rotation is diversified with pulses. To obtain CAP first pillar aid (excluding organic farms, farms of less than 10ha, or multi-crop and breeding farms with 75% of the arable area in grassland), arable land farms must adhere to compulsory conditions of crop rotation(GAEC7). This involves an annual rotation of 35% of the total area with a different main crop or a secondary crop (cover crop), or a minimum 4-year plot rotation (Annex 13, MinAgri, 2023) with minimum 5% of pulses (area-based) in the 2nd year, or more than 5ha - Level 1 or minimum 10% of pulses for Level 2. Coupled aids for plant proteins are also available, with the aim of doubling the area under pulses to 2Mha by 2030 (8% of the French agricultural surface). The coupled aid will increase by over €100 million in coupled aid in 2027 compared to the previous CAP plan. These coupled aids reach 99€ or 104€ /ha (depending on the year), for seed pulses (or dehydrated forage pulses or pulses intended for seed production) or for a protein crop mix > 50% in the implanted seed mix) (MinAgri, 2023).

The second pillar of the CAP includes rural development policy, which offers two types of funds that can be applied for pulse production: FEADER (European Agricultural Fund for Rural Development) and FEDER (Agricultural Fund for Rural Development). These funds are then distributed by region according to specific guidelines for investment projects based on local needs. Pulses are not explicitly mentioned as in the first pillar of the CAP, but they often correspond to low-input crops, and thus respond to investments in areas subject to specific or natural constraints, or water framework directives.

There are different levels of support available for the development of the pulse sector. French state creates a legislative framework and regulations for the general development of pulse agricultural production, while smaller territorial entities grant more specific aids according to the needs identified locally and the objectives set up to respond to the more general regulations on a national level (**Table 1**).

	Management practice	Cultivar use	Farm infrastructure	Cooperatives	Market opportunities
Europe	CAP (2023-2027) FEADER (low-input crops)	CAP (2023-2027)			
State	Cap Protéines Law Climate & Resilience	Cap Protéines Law EGalim	National strategy for plant proteins	National strategy for plant proteins	Law Climate & Resilience
Region/ Watershed area	Inter-profession	Inter-profession		Inter-profession	Inter-profession
Department			Investment subsidies	Investment subsidies	
Community of municipalities		Law EGalim			PAT
City	Low-input crops				PAT

Table 1. Summarizing the different scales of public subsidy for the development of pulse chains in France.

2. National scale

2.1. Technical and logistical support

On a national scale, France has mainly invested in the development of pulses as part of the Plan "France Relance" - Proteines Cap (January 2021-December 2022). This two-year project was designed to increase plant protein production in France, and applies to oilseed and protein crops for human and animal consumption.

The research, development and innovation section (RDI) of the protein plan (January 2021-December 2022), with a budget of 55.5 million euros including 20 million euros from the Ministry of Agriculture and Food as part of the recovery plan, will provide technical support in each of these territories.

The project has 5 components :

- Evaluate and disseminate new high-protein pulse and oilseed varieties;
- Increase the competitiveness and sustainability of oilseed and protein crop production;
- Respond to the food transition with local, sustainable and diversified products;
- Develop the protein autonomy of livestock farms;
- Sharing information from producer to consumer;

The focus here is on the objective of covering the deficit in vegetable proteins from pulses destined for human consumption, in response to the growing demand.

The pulse sector has been identified as being locked in by the lack of improvement and work on genetic progress and new variety proposals for pulses. In particular, work has been carried out on soybean, pea, faba bean, lentil and chickpea. A 3-year project (2023-2026) between research

institutes (Icarda and Terres Inovia) and lentil and chickpea breeding companies was signed in december 2022.

In addition, the creation of a lentil varietal evaluation network (13 trials per year and 10 varieties studied), and the reinforcement of the chickpea varietal evaluation network (16 trials per year and 11 varieties studied) will improve the choice of lentil and chickpea varieties, which is currently limited. The technical institute for oilseed and protein crops -Terres Univia- is also proposing a new classification of the varieties already present in the gene pool, as well as the implementation of a varietal selection advice tool for farmers belonging to Terres Univia: MyVar. Cap Protéines has also enabled an increase in the number of varietal improvement projects, with a first specific focus on the management of biotic and abiotic stresses (LEGHIVER on climate change, PHENOLAG on disease behavior), and a second focus on production quality to improve marketing and outlets of pulses (GPS4PEA, SOYFOOD+, CREAPULS).

The Plan Relance also works on the lack of technical and economic information on market prices and outlets, as well as on technical itineraries.

3 tools have been set up to respond to the problems linked to the downstream part of pulse production and the lack of market opportunities and an attractive remuneration for farmers:

- OleoProteines: An observatory of the vegetable protein market for human consumption (since 2022). The 2022 edition, financed as part of the Cap Protéines program, took a closer look at the production and consumption of the seven pulses most widely used for human consumption: lentils, peas, soybeans, chickpeas, field beans, dry beans and lupins, by market and production method.
- Observatory of oil protein prices (since 2022): Monthly analysis of price comparisons between major crops (wheat/corn) and an equivalent protein crop, according to soil type (and possibility of irrigation).
- Note to operators on production and markets for protein-rich plants, to help farmers better understand the market they are entering.
- Letter from the “OleoPro”, to develop and structure the various pulse sectors at regional level, in parallel with the technical actions carried out by Cap Protéines.

On the more production-related side of the project and problems met on the technical itinerary, the relance Cap Protéines plan aims to provide new and more technical support for pulse crops. This will encourage and assist farmers to grow new crops, not necessarily already established in the region, but which can now be grown in new areas as a result of climate changes (e.g. soybean production in the Hauts-de-France region). These kinds of initiatives include:

- Landfiles: Implementation of a tool to support farmers during the growing season, enabling them to enter their technical itineraries. This tool enables all those involved in the project - advisors and farmers - to enter observations directly in the field, on all crops and for a very wide range of indicators, as well as soil fertility parameters. These different outputs enable the advisor to discuss the current campaign with the farmer, and to animate the network by bringing together the various results.
- Systerre: Setting up pilot farms to obtain reference datas for the neighbouring farms of the Systerre project. This powerful tool provides indicators on economic aspects, input use and environmental impacts and socio-technical aspects.

- A crop rotation simulation tool, to calculate a farm's economic performance on a rotation scale and highlight the effects of precedents linked to pulses in the crop rotation.
- A methodology for conducting agronomic sector diagnostics: soybeans, peas, chickpeas.

Also, the Syppre project financed by Cap Protéines (Arvalis - Institut technique de la betterave - Terres Inovia), is also working on phytosanitary risks linked to diseases, viruses and pests (aphids, bruchids) in pulses. These projects include

- Identification of the main viruses transmitted by aphids.
- Technical meetings with farmers on agroecological pest management in field crops (Projet R2D2: Agronomy and Auxiliary Insects).
- Work on the control and verification of seed quality, mainly linked to pests during packaging and storage, such as bruchid.

National strategy for plant proteins (2021) (French Ministry of the Economy - 2021) – included into the Recovery Plan - support for research and innovation; assistance with material investments, support for the structuring of plant protein chains; support for the promotion of pulses to consumers. This plan applies to : (i) farms, CUMAs and GIEEs wishing to acquire the equipment needed to introduce protein crops into rotations; (ii) downstream companies in the sector to have access to subsidies for equipment investment, structuring sectors or promoting new products; (iii) research organizations and technical institutes carrying out R&D or applied research projects; (iv) managers and cooks in collective catering.

For example, there is support for investment in specific equipment for growing, harvesting and drying species rich in plant proteins, and for the development of forage pulse overseeding (between €1000-40,000/agri, and €150,000/ CUMA).

Plan protéines végétales : ouverture d'un second dispositif d'aides à l'acquisition d'agroéquipements Ministère de l'Agriculture et de la Souveraineté alimentaire

Stratégie nationale sur les protéines végétales | economie.gouv.fr

2.2 Legislative support

The French government also supports the production and consumption of pulses through: :

- The EGAlim law (2019,2021), which aims to improve nutrition.

  - Law EGalim 1, 2019: Also named "law for balanced trade relations in the agricultural and food sector and healthy, sustainable food accessible to all". The law is the result of the 2017 " States Generals of Food ". The main measures concern collective catering, with contract terms ensuring a better income for farmers, and a target of 50% quality products in menus. The regulatory framework includes the notion of "quality" products, SIQO or value-adding labels (HVE levels 2 and 3, " farm", " farm product" or " farm produce").
  - Law EGalim 2, 2021: this law introduces a number of measures, including fair remuneration for farmers, mandatory contractualization and collective grouping of farmers, and a requirement for collective catering supplies to include at least 50% quality and sustainable products, including 20% organic produce, as well as user information.

- Aide à l'investissement dans des équipements spécifiques permettant la culture, la récolte et le séchage d'espèces riches en protéines végétales et... | FranceAgriMer - établissement national des produits de l'agriculture et de la mer

- The Climate and Resilience Law, 2021. The result of the work of the Citizens' Climate Convention, this law is dedicated to combating climate change and strengthening resilience. In particular, it includes a framework that can help the cultivation of pulses:

- Synthetic fertilizers (art.269): An annual trajectory for reducing emissions from nitrogen fertilizers will be defined by decree and an action plan put in place, with a tax triggered from 2024 if targets are not met.

- Vegetarian menus and school catering (art.252 and 254): Since the start of the school year in 2021, public and private school canteens must offer a weekly vegetarian menu. From 2023, state and university canteens offering a choice of multiple menus will have to offer a daily vegetarian option. Voluntary local authorities will be able to experiment with a daily vegetarian menu.

- The National Nutrition and Health Plan (PNNS) promotes pulses to consumers. It Influences the main orientations of the EGalim law on the "menu design" aspect.

3. Territorial scale

3.1. Aids on the scale of several regions:

There are various types of subsidies specific to territories, with different scales: administrative such as regions and departments, but also "natural" definition in relation to the territory, such as watersheds, terroirs or small agricultural regions that follow specific microclimates and pedoclimatic contexts.

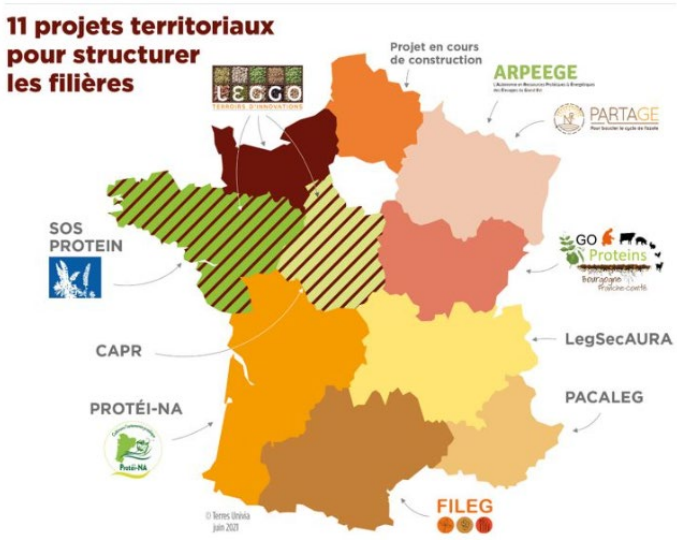
Research funding enabled to finance the LEGITIMES project: LEGume Insertion in Territories to Induce Main Ecosystem Services between 2013 and 2018. It focuses on the construction and evaluation of territorial scenarios for integrating pulses into cropping systems in response to global change in 3 former administrative regions: Poitou-Charentes, Bourgogne and Midi-Pyrénées. (https://www6.inrae.fr/legitimes)

(Crossed viewpoints on socio-economic analyses of levers for unlocking the agricultural system to promote pulses, Quantification of services provided by different pulses in cropping systems, Construction of cropping systems and agronomic scenarios for their organization on a territorial scale, and evaluation of their performance.

3.2. Regional or watershed scale

On a regional or watershed scale, there are various institutions and organizations working on the development of pulses: the DRAAF (Regional Department of Food, Agriculture and Forestry), the Region, the Regional Chambers of Agriculture (CRA), the Water Agencies.

There are also 11 inter-professional territorial projects to promote regional resilience and protein autonomy, financed by the regional Chambers of Agriculture.



Source : Terres Univia, 2022

3.3. At departmental and chamber of agriculture scale

There are more specific projects that respond to local needs, focusing more on support for processing facilities and cooperatives. For example, many departments support on-farm processing, and have enabled some farmers to buy mills and sorters to add value to their cereal and pulse productions. There is also a support for the creation of vegetable and canning factories to add value and ensure better preservation of food products through time.

3.4. At the scale of communities of municipalities and cities

Within communities of municipalities and cities, the French government - through article L-111-2-2 of the rural and maritime fishing code - supports Territory Food Projects (430 recognized in France by the Ministry on April 1, 2023) that promote local and a raise of plant-based food use in collective catering (according to the EGalim laws).

Cities are also supporting low-input sectors, such as the FIBANI project within the Montpellier Metropolitan Council and in partnership with the Water Agency (Rhône-Méditerranée-Corse), which guides and supports farmers in the use of low-input crops, which include pulses.

As far as public subsidies are concerned, the situation is more favorable now, and there is a clear synergy to support more crops diversification with pulses, but the genetic research for these crops is too slow. It takes 4 to 5 years to develop a new variety after laboratory and field trials. There's therefore a time gap with public policy.