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# Transforming agri-food systems for Agroecology development: exploring conditions of success in European case studies

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**Abstract:** *In Europe, developing Agroecology requires a redesign of production systems towards agroecology, to provide a scope of environmental, economic and social benefits at local and global level. We studied the combination of resources that farmers or groups of stakeholders mobilize for developing agroecological farming systems integrated in sustainable food systems, focusing in particular on the resources brought by collective dynamics. We identified fifteen case studies across Europe, selected in various environmental and social contexts and covering the main productions, and studied their functioning and performances. Three case studies are detailed in Denmark, Portugal and Belgium. They all face sustainability challenges such as soil fertility management, biodiversity conservation, and necessity to increase the added-value of their products to remain economically viable. From the case studies, we conclude that agroecological farming systems are diverse and can provide altogether sufficient production levels, acceptable farm viability, and positive impacts on biodiversity ranging from low to very high while guaranteeing accessible, more or less expensive but healthier products for the consumer. Collective action and mobilization of supporting stakeholders (scientists, consumers and local authorities) appear to be determinant for the development of these systems. The most promising case studies rely on adequate combinations of material, cognitive, technical and socioeconomic resources. Enhancing these resources at local and regional level through adequate development policies and stakeholders' mobilization can strongly support the development of agroecology.*

***Keywords:*** *Agroecology, High Nature Value, Supply chains, ecosystem services, grassroots innovation.*

## Introduction

The development of Agroecology in Europe requires changes in farming practices to mobilize natural processes in production reducing the use of inputs, and to diversify the farming systems to preserve ecosystems and biodiversity. The project Ten Years For Agroecology (TYFA), led by the Institut pour le Développement Durable et les Relations Internationales (IDDRI) and the European Forum for Nature Conservation and Pastoralism (EFNCP), aims at designing a prospective scenario assuming the generalisation of agroecology in Europe, and assess its consequences for food security and food sovereignty of European consumers, impacts on ecosystems and environmental issues, economic performances and territory development. This paper presents the investigation of Case Studies (CS) of agroecological farming systems embedded in sustainable food systems and their multicriteria analysis. The objective is to identify the key factors that explain how they were able to develop despite lock-ins and opposing power structures, in order to propose pathways of agroecological transition for a wide range of production systems in Europe. Our analysis reveals a wide range of resources on which the initiatives rely. In this paper we focus in particular on the resources brought by the collective dynamics and the building of networks with various stakeholders. We identified 15 case studies in a diversity of contexts and production types (Table 1). This paper presents in a first part the method of analysis of agroecological CS. Then we illustrate the inspiring potential of the CS through three contrasting cases. We propose a transversal analysis of the functioning and performance of the CS, focusing on the

combination of different resources that are mobilized in the CS. Based on this analysis, we make recommendations for the support of agroecological transitions in Europe.

## Methodology: tracking and assessing agroecology in Europe

### Analytical framework and identification of transition pathways

Like Gliessman and Engles (2014), we consider that agroecological systems must be approached through a holistic perspective, taking into account the ecological, human, technical, social dimensions of agroecology, defined by Wezel et al. (2009) as a science, but also a movement embedded in socio-political dynamics and a practice with technical issues. Our analysis focuses *on Agroecological Farming Systems (AEFS), that we here define as low- or no-external-input production systems preserving local biodiversity and natural resources, embedded in sustainable food chains*.

An *ad hoc* analytical framework is developed to look at the diversity of AEFS and select CS within this diversity. In addition to geographical context and farm structures, we focused on functional elements in production systems and marketing channels.

The production systems are defined as combinations of technical practices (cropping systems, livestock systems) and their interactions with local environment (ecosystems, resources, other farms). We categorized this „horizontal dimension“ of AEFS in three types: preserved, adapted and redesigned farming systems. Preserved farming systems correspond to the traditional practices, with very little use of chemical inputs or machinery. Adapted farming systems correspond to partly modernized practices or equipment, e.g. using tractors or machinery for technical work but preserving the crop management, land use and landscape close to traditional ones. Redesigned farming systems correspond to formerly intensive systems that switched to agroecological practices by re-diversifying crop patterns, changing animal breed for more rustic ones, and re-introducing grazing or crop-livestock interactions. This typology was set to better assess the needs of agroecological transition at large scale: this is not only a matter of redesigning some existing farming systems, as frequently perceived, but also a matter of conserving the already existing preserved ones and changing some practices in adapted ones.

The marketing channels are defined as the way farms commercialize their products, with or without intermediaries, locally or on national or international markets. It distinguishes between long conventional supply chains and local short supply chains, also merged with highly differentiated “niche” marketing strategies.

Once this diversity of AEFS was identified, we assessed, for each of them, their *multicriteria performances*, their *functioning* and their *impacts on local territory, food chain and societal challenges*.

#### *Multicriteria assessment of AEFS*

The first level of analysis aimed at assessing the performance of the case studies. The CS were assessed using an assessment grid that crossed scientific literature on sustainability assessment (Bockstaller et al. 2008; Olde et al. 2016), the modelling of farming systems as done in agrarian diagnosis (Cochet and Devienne, 2006) and the analysis of agroecological transitions in territories (Duru et al., 2015).

The resulting assessment grid (Table 2) includes six main criteria: production (nature, yields and estimation of quality of products); inputs self-sufficiency; domestic biodiversity; landscape diversity; work management; farm autonomy and economic performance. For each criterion, indicators are selected and informed either with quantitative data (yields, average use of mineral fertilizer on crops, etc.) or qualitative (expert judgement of how far the AEFS impacts the criterion). This assessment is a comparison of the AEFS with the „baseline“, i.e. the conventional farming systems in the area, which is also described using

specific data. We also estimated the life standard of farmers in the studied AEFS. Details of the assessment method and corresponding data for each CS can be found in Moraine et al. (2016).

**Table 2.** Criteria for assessment of the Agroecological Farming Systems.

| Criteria | Indicator, unit of measure and nature of information |
|---|---|
| Production | Yields: production/ha (/Ref) |
| | Quality: level of food quality (qualitative) |
| Inputs self-sufficiency | Mineral N input: kg N/ha (/Ref) |
| | Pesticides use: Treatment Frequency Index (/Ref) |
| Domestic biodiversity | Abundancy and local adaptation of crop varieties and animal breed (qualitative) |
| Landscape diversity | High Nature Value type |
| Work management | Workload and complexity (qualitative) |
| Farm autonomy | Dependency on external funds, farm investment capacity, debts (/Ref or qualitative) |
| | Public or private subsidies |
| Economic performance | Added value of products (/Ref or qualitative) |

(/Ref) : compared to local references when available

*Functioning and resources mobilized in AEFS*

The second level of analysis aimed at describing the type of resources that are essential to make the AEFS possible, in order to identify pathways for enhancing the development of agroecology.

We identified four types of resources mobilized during transitions towards agroecology:

(i) *material resources* such as land, water, local ecosystems;

(ii) *cognitive resources*, e.g. the ability of farmers or local leaders to integrate pieces of knowledge in systemic approaches, manage complexity and trade-offs between short vs. long term benefits;

(iii) *technical resources* such as qualified workforce, specific equipments, adapted breed or crop varieties including local ones;

(iv) *socio-economic resources*, such as specific marketing channels, subsidies or social networks.

These four types of resources can be strengthened at local or regional level through adequate development policies, local stakeholders' mobilization and innovative networks for resource sharing.

It must be outlined that our analysis in TYFA is not about comparing CS to one another, considering that the biophysical and socioeconomic contexts of each CS are very different and that the nature of productions are also different, making meaningless the direct comparison of grass beef production with vegetable production on biodiversity for example. However, we aim at demonstrating that some factors of success of agroecology development, i.e. factors of performance of AEFS, can be of the same nature. Limiting factors can also be identified. We assumed that AEFS functions depend on an adequate combination of resources that are possible only in specific geographic, historic and socioeconomic contexts. And that identifying these good combinations of resources is a strong lever for the outscaling of agroecology.

*Impacts of AEFS on local territory and beyond*

The third level of analysis aims at observing the „horizontal“ and „vertical“ impacts of AEFS. Horizontal impacts mean the potential or proved ecosystem services occurring at the local and regional level, both on ecosystems (e.g. water cycle regulation) and on rural communities (e.g. cultural landscape preservation). Vertical impacts mean the consequences of AEFS on the food chain, from the farm (e.g. distribution of added value) to the consumers (e.g. final price of the products).

Looking at all the CS as a whole, we tried to estimate the consequences of AE systems on market issues (the price of products and accessibility for consumer), conservation issues (defined by the quality of habitat provided by production systems and the scale of spreading) and society issues (production services, i.e. food supply, local identity, rural dynamism, cultural services for local people).

### Data collection: tracking and selecting agroecology CS

In the absence of existing database at the European level, case studies have been investigated by open research on the Internet. Investigated websites were not restricted to academic research and databases in order to capture initiatives that were not in research area. Out of fifteen CS finally selected, 5 were through research projects, 4 through professional networks, 3 through NGOs or institutional networks, 3 through individual websites whom knowledge came from partners of the project.

Each AE initiative was synthesized in 2 pages presenting the general context, the content of AE projects compared to typical farming systems, and the analysis of AE project functioning, performance and impacts.

The context presents the general description of AE projects with location, climate, landscape features, agronomic potential of the area, and the socioeconomic context describing the importance of farming activity in the territory, its social acceptability (e.g. the existence of controversies or social tension around environmental issues), the structure and strength of local markets and supply chains, the land tenure conditions.

A baseline is described, presenting the ‘counterfactual’ (to agroecology) farming systems for the corresponding production, the professional identity of farmers of the area, the typical supply chains and consumer habits. The sustainability issues corresponding to this baseline are described to identify the main issues, the level of change needed (with reference to the “preserved/adapted/redesigned” above typology) and how far the AE project presents solutions.

The AE project is presented in four main rubrics: initial steps (the origin and main steps structuring the current project), farming systems (the farm structure and resources), practices and performance and marketing strategies.

The selection of CS was made upon three criteria prioritized as follow: (1) the interest of the AE project both in vertical and horizontal dimensions, (2) the complementarities of productions, production system, socioeconomic and ecological context to complete the scope of investigation, (3) the ability to obtain data of sufficient quality. Three case studies are detailed in this article, presenting, in various contexts (Belgium, Portugal, Denmark), AEFS developed thanks to complementary sets of resources in terms of networks and supporting stakeholders.

The information on CS was gathered by analysing study reports, farm presentations, and compared with local technical references when available. Four CS (1,2,4,11) were completed by interviews with experts of these specific CS: 1 researcher, 1 postdoctoral student, 1 graduate student, 1 professional.

## Results: pluralising pathways for agroecology development in Europe

## Types and diversity of agroecological initiatives

The diversity of CS is much focused on Western Europe, with an over-representation of France (7/15) and 8 other countries with only one CS each.

Farming systems were intended to represent a diversity of productions: 3 CS in beef meat, 2 in milk, 3 in pig and/or poultry (including 1 mixed with dairy cows), 2 in cereals, 1 vine, 1 olive, 3 diversified including cereals, fruits and vegetables.

Blindspots might be cereal production in South context, specialized vegetable production (notably in North of Europe as South could be inspired by diversified territory CS) and most of the production systems in central and Eastern Europe, where it was difficult to identify CS with sufficient level of information.

Scale of CS is balanced between farm CS (n=5), network CS (i.e. networks of farms under the same type of production systems, management strategies and labels; n=3) and territory CS (i.e. large areas under the same type of production systems and organization; n=7). Nine out of 15 CS are organic farming.

The distribution of CS within the analytical framework is quite good, considering that all dimensions are addressed. Strategies of commercialization in short supply chains are less represented than longer ones (6 vs. 9), which is consistent with the current consumer habits. Regarding production systems, redesigned (n=7) are more represented than adapted (n=5) and preserved (n=3) in relation with the necessity to build transition pathways for intensive farming systems.

## Illustrations of agroecological farming systems in Belgium, Denmark and Portugal

*Gaume Beef: New production to value Natura 2000 grasslands and maintain local activity in Belgium*

In Gaume territory, Natura 2000 areas cover 37% of the land, because of a high biodiversity in wet grasslands, which are subject to abandonment or intensification. This intensification of livestock systems, with more productive breeds and higher stocking rates, threatens also water quality. Traditional small dairy farms are disappearing, the competition on milk production making them less competitive, and the conventional supply chains refuse to buy small quantity of milk from remote farms. These small farms need either to get bigger and intensify their production systems or to find alternatives in pluriactivity.

The Gaume Grassland Beef project was developed to maintain extensive grassland management and grazing in areas where dairy farming was decreasing due to difficult natural conditions. Researchers involved in agroecology research (GIRAF group; Stassart and Stilmant, 2012) looked for an innovative approach for N2000 area management. Beef production was seen as a good alternative but could not be based on intensive production systems such as Blanc Bleu Belge breed. Alternative beef systems based on grass were then adapted from dairy systems.

In the Gaume Beef production systems, Natura 2000 grasslands are primarily for hay making, and farms contract agri-environmental schemes on grassland management: grazing half of the year, hay making as late as possible to favor grassland diversity and flowering of plants. For winter diet, beef cattle are fed on hay coming from late-harvested grasslands, complemented with concentrates up to 10% of the total feed, and up to 30% the last months of fattening. Concentrates are either produced on farm or purchased in the area and must come from local production (linen, potatoes, rapeseed, alfalfa, etc.).

A local cooperative developed the label "*Boeuf des prairies gaumaises*" (beef from Gaume grasslands), sold in local shops developed by the cooperative and in local partners' shops (butchers commited to promoting local products), restaurants and schools.

The AEFS estimated performances (Table 2) shows the main benefits of the CS for local development: maintenance of biodiversity-rich extensive grasslands and development of a viable, farmer-supportive supply chain around meat production.

The resources mobilized to make this AEFS possible (Table 3) show a strong mobilization of different stakeholders around the development of the AEFS: farmers above all, who committed themselves to the collective action, but also local citizens, public authorities and researchers.

The benefits of the CS for the territory are on local environment (water regulation in which wet grasslands play a key role), local development (development of a local supply chain including a common hall for meat processing, conditioning and storage), and consumers (access to local products with different taste and quality).

As a whole, the Gaume Beef CS shows a good combination of biodiversity conservation, innovative farming practices and collective organization of a variety of stakeholders for sustainable rural development.

**Table 3**. Multicriteria assessment of three illustrative case studies.

| | Gaume Beef - BEL | | Troldgaarden farm - DEN | | Freixo Do Meio - PT | |
|---|---|---|---|---|---|---|
| Criteria | Score | Comment | Score | Comment | Score | Comment |
| Production | = | Slower beef production (26 months vs. 12) Higher quality | = | Less production per surface unit but more diversified | + | Wide diversity of products. High quality. |
| Inputs self-sufficiency | + | No N nore pesticides on grasslands, few on cereals | ++ | No N, no pesticide, no exogenous animal feed. | ++ | Very few inputs, no mineral N, no pesticides. |
| Domestic biodiversity | + | Diversified grasslands. Locally adapted breed. | ++ | Diverse, adapted crop varieties. Rare animal breed. | ++ | Diversity of cultivated trees, crops and raised animals. |
| Landscape diversity | ++ | Large N2000 sites preserved. HNV Type 1. | + | Important diversity at farm level but spatially restricted. | ++ | Extensive ecosystem management on a large scale (*montado*) |
| Work management | = | Neutral | - | Workload and complexity are high | ++ | Collective organisation, sharing of information and collaborative governance. |
| Farm autonomy | + | Low feed costs, dependency on grass resources mainly. Collective organisation facilitates farmer empowerment. | + | Very limited investments. High self-sufficiency for production. | ++ | Few investments. Own commercialization channels. |
| Economic performance | + | Good added value of the products. Public subsidies. | = | High added value of products but very small production. Public subsidies (organic). | + | Few public subsidies, diversified income from leisure activities, direct sales of products.<br>Inherited capital in land and buildings helps the economic performance of the system. |

*Troldgaarden: diversified small-scale farm valuing agroforestry and crop-livestock interactions in Denmark*

Troldgaarden is a small farm located in Jutland, a densely populated area of Denmark (133 persons/km$^2$) where farming systems are mostly intensive in inputs, with high productivity

and competitiveness on international markets, but generate important environmental issues (nitrate pollution due to concentrated livestock systems, pesticides pollution, biodiversity). The price of land makes large farms extremely difficult to pass to new generations. The farm area is 2 ha. It is certified organic and based on a diversity of production, very few investments in equipment and inputs. The smallholding, which involves pig and poultry production, is part of the concept 'welfare delicacies', a network in organic meat production in Denmark which promotes natural and diverse livestock production on small organic farms and was initiated by the Danish Animal Protection Association together with organic farmers (Kongsted, 2014).

On Troldgaarden farm, the animals are full-time outside and have access to tents to protect them from cold and rain. The pigs are weaned at 'natural weaning age' at around 12-17 weeks. They are slaughtered at around 5-6 months of age and approximately 50 kg liveweight. One tent is placed in an agroforestry system with fruit trees (450 trees, primarily apple), shrubs (700 gooseberry plants) and vegetables. After harvesting of the vegetables (e.g. pumpkins, squash and Jerusalem artichokes) in autumn and early winter, sows gain access to the area to forage on leftovers.

All fruits and vegetables are sold locally. The meat is sold in diversified and distinctive cuts directly to consumers and the production is based on seasonal production with farrowing in spring and mating in December-January.

The AEFS performance (Table 2) shows the strong level of diversity of production and the high self-sufficiency obtained by the farmer. The amount and complexity of the work required by this system questions its sustainability, despite the interest and satisfaction of the farmer. The added value of the products is very high thanks to direct sales only and consumers willing to pay for the specific quality. This added value makes the system viable despite a low production level.

The resources mobilized to make this AEFS possible (Table 3) combine high agronomic potential of soils, an important workforce and the ability of the farmer to innovate and manage complexity, and a strong support of citizens and network to guarantee the acknowledgement and added value of the products of the farm.

The farm itself has little impact on the territory but demonstrates the possibility to produce meat and other products almost without inputs, on a small scale and using animal-friendly practices. At the food-chain level, the model of direct sales and seasonal variability represents a strong break away from conventional food systems. It requires a strong shift in consumption practices but allows a connection between consumers and farmers.

Troldgaarden farm combines technical and social innovations to produce meat in an animal-friendly manner within an integrated agro-sylvo-pastoralist system. Despite being dedicated to a niche market, it could represent an alternative to conventional livestock systems in Denmark, under the conditions of a larger development of such systems, supported by public policies and a change in consumers' habits.

**Table 4**. Resources mobilized in case studies.

| Resources | Gaume Beef - BEL | Troldgaarden farm - DEN | Freixo Do Meio - PT |
|---|---|---|---|
| Material | Adequate climate and soils for beef production on grasslands Rich domestic biodiversity | Very high soil potential<br>Proximity to cities | Climatic and soil constraints but large available inherited land |
| Technical | Exchanges of practices for grassland management | Important workforce. Adapted breed and crop varieties. | Qualified workforce, skill acquisition. Adapted breed and crop varieties. |

| | | | |
|---|---|---|---|
| Cognitive | Collective organisation for the management of the supply chain, education of local consumers, partnership development. Strong support of researchers. | Farmer's capacity to test and adapt practices to local conditions, and manage complex systems. | Farm manager's capacity to deal with and communicate complex systems, federate different stakeholders and partners. Connected research projects and hosting of interns. |
| Socio-economic | Support of local citizen. Access to the public market (schools), administrative restaurants. Public subsidies. | Support of consumers paying for high-quality meat. Network Welfare delicacies labelling the products. | Direct sales, shop in town, inherited housing capacity on farm. Few subsidies. |

*Freixo Do Meio farm in Montado: a diversified farm managing agroecosystem to optimize the use of local resources and biodiversity in Portugal*

In Montado, extensive farming is the traditional activity but is nowadays threatened by both desertification and intensification of remaining cultivated lands. The Montado ecosystem is a rare combination of extensive livestock and Mediterranean forest under dry climate, resulting in habitats of high interest for biodiversity (Natura 2000 programs). The balance of the ecosystem is determinant for regulation of the water cycle and protection against erosion and forest fires.

However, the CAP-coupled payment has led to intensification of many farming systems of the area, which currently threatens the maintenance of a cultural landscape and traditional practices.

After being confiscated in 1974 during the revolution, Herdade do Freixo do Meio (HFM) was returned to the former owners in 1990 and since then tried to bring a new way of managing this heritage guided by the ethics of respect for the people and for the environment, with organic conversion in 2001. The project was to make the best use of the inherited large farm, typical of the local farm structure, showing a combination of small and large farms.

The farm covers 440 ha, mainly constituted of cork oak and holm oak Montado agroforestry systems. Portions of irrigated land, vineyards, olive groves and biodiverse pastures enables production of nearly all the ingredients of the Mediterranean diet with the exceptions of milk and fish. Since 2008, HFM acts also as an economic active agent by embracing autonomous but complementary projects that strengthen the system as a whole and increase the amount of products available from the farm. The independent projects include 4.5 ha aromatic and medicinal garden (2011), 2 ha of a horticulture garden and 5 ha of orchards (2011), free-range chicken production with a movable poultry house (2012).

The management principle is to take advantage of the diversity of local resources: 3 levels agroforestry: trees, shrubs, pastures. It is organized around sequential grazing: cows / sheep / poultry. Making compost out of processing byproducts is a pillar of the system. It is dug by pigs who feed on it and fulfill their natural behaviour of digging. Biodynamic preparations are used to improve soil fertility, crops and animals' health. Thanks to the use of wastes, olive pulp, etc. to feed animals, the self sufficiency is very high, the only input being fish powder as complement for feed. HFM produces around 300 different products and employs 12 workers directly and 8 through the associated projects – four times more than the surrounding farms dedicated to intensive agriculture.

The commercialization of the products is done integrally in direct sales, on farm, on local markets and in the farm's shop in Lisbon, 100 km away from the farm.

The AEFS performance (Table 2) shows the successful strategy of complex management of the Montado ecosystem, together with a good management of business activities (processing, commercialization, leisure activities). The HFM farm appears to manage a very wide diversity of production, while protecting local biodiversity (wild cat, eagles and a diversity of endangered flora) and favoring employment and economic performance.

This strategy is adequately supported by a good combination of resources (Table 3), in first place the technical and managerial skills that are distributed among employees, and the process of continual improvement and learning through on-farm research projects (e.g. research on the nutritional value of acorn flour), hosting of students, etc.

As a whole, the HFM farm seems to benefit strongly to the local territory by generating employment, favoring tourism, preserving landscape, biodiversity and services linked to the Montado ecosystem (water regulation, erosion control). The food chain is fully internalized in the farm, making a large diversity of products accessible to local consumers and to urban consumers through the farm shop. The HFM farm also hosts educational programs on rural life and sustainable agriculture, training sessions for students or volunteers, farm visit and tour (pedestrian pathways across the farm).

## Transversal analysis: Modifying power relationships to make agroecological transition happen

The analysis of the 15 CS shows different pathways to reinforce the AEFS in terms of power structures and the position they occupy in sociotechnical systems, through the marketing strategies implemented in AEFS, the way they deal with biodiversity conservation issues and other societal challenges, and finally the type of collective dynamics and networks that are at the origin of the case studies (Table 5).

*Strategies to position AEFS along the value chains*

We distinguish three profiles.

« Redesigned farming systems, specialized, productive » are AEFS that are structurally close to conventional farming systems, but the practices are much less intensive, notably regarding the use of inputs. The decrease in yields ranges from 0 to 50% with an average of 20%. Seven CS belong to this category (including Gaume Beef), in which the food chain is not much impacted (long supply chains, supermarkets) and the price of products is raised between 10 and 30%.

« Niche, high quality/low productivity » are AEFS producing niche or at least high-quality products. The yields are often low (around 50% less than “baseline” systems in average), and the price of products much higher than conventional (50%). Products are distributed in specific channels: specialized shops, direct sales, specialized markets. Four CS belong to this category (including Troldgaarden) in which food chains and consumers’ habits are strongly impacted.

« Re-localized food systems »: diversified production in which the evaluation of yields is not relevant in itself as the farming system stands on a variety of productions. Commercialization includes farmers’ shops, direct sales, markets but also some share of local supermarkets who develop partnerships with local farms. The price of products rises between 0 and 30%. Four CS belong to this category (including HFM) which requires a partial change in consumers’ habits.

*Biodiversity conservation*

For the conservation issues, we distinguished three main categories of AEFS depending on their impact on the quality of habitat provided to local biodiversity and the scale of impact of changes (small, local or regional).

The first, “*Greenest*” (n=7) shows high-quality habitats on large areas; consequences for biodiversity conservation can then be very good: HFM in Montado ecosystem and Gaume beef preserving grassland of high nature value belong to this class.

The second, “*Greener*” (n=7) shows medium-quality habitats on small or local areas. Conservation of biodiversity would be improved but need to be reinforced or developed, as in Troldgaarden farm which is very limited in area.

The last one, "*Impactless*" corresponds to a reduction of impact of intensive pig production (CS9) on the environment, at a small scale. Consequences for biodiversity conservation are then very restricted and clearly not a strength of the CS.

*Societal challenges*

Societal challenges gather local issues (culture, traditional systems, landscapes), general issues (animal welfare) or intermediaries (employment, food sovereignty). We distinguish four categories of AE initiatives depending on their impact on the food production levels and the services for rural communities.

The first (P+/T+; n=6) shows good production levels and territory services and are then highly acceptable at local and global levels.

The second (P+/T0 or P0/T+; n=7) shows either high production level with little territory services or medium production levels and moderate territory services. Those CS are interesting but should be combined with other profiles of performance to fulfil societal objectives.

The third (P0/T0; n=2), Troldgaarden CS and CS3 in wine production show low production levels and moderate services at local level (small surface and few local employment), which signifies that they represent some other interesting characteristics but must be combined with other types of performance profiles.

Another societal issue is the quality of products obtained from these production systems for health and taste criteria, assessed through the labels that certifies specific qualities of the products. Twelve of the 15 CS are labelled for their quality, for criteria regarding health (low pesticide use, higher vitamins contents such as the meat products of HFM, well-balanced fatty acids, etc.) and taste (specific typicity or gastronomy label such as Gaume beef).

*The social factor: a matter of collective dynamics*

Agroecological CS show the importance of collective dynamics as a success factor. Individual adventures can also be encountered but they are reinforced and supported by relay actors such as groups of farmers or citizen. The origin of collective action in AE projects appears to be of three types.

The first, "Individual", gathers 6 CS in which individuals have initiated the projects, and developed it until it has been acknowledged by citizens, institutions and consumers. Troldgaarden and HFM are part of this category, with strong commitment of the farms' leaders. Another example is the CS10 in which the farmer, after transitioning its own farm to agroecology, developed a network of farmers to collectively exchange practices and commercialize the milk products under a common brand which belongs to him.

The second, "Collective", gathers 5 CS in which groups of local stakeholders, mainly farmers, organize among themselves the development of AEFS, organize complementarities and design the alternative production system as a whole. Necessary development of common rules, governance framework, appears to be factors of reinforcement of such collective initiatives: charts for production, cooperation rules among farmers, discussion arenas for strategic decision-making. Exchange of knowledge is also very active through these cooperation rooms. Such initiatives organize self-promotion for marketing (advertisement, demonstration events) and to get supports from public authorities (application for public subsidies for innovative projects, recognition as "public interest" initiatives).

The third, "External", gathers 4 CS based on the recognition of virtuous systems by external actors, e.g. in Gaume Beef CS. These AE initiatives rely on the external intervention of research or environmental institutions who seek their preservation in close cooperation with farms. Researchers and experts have crucial roles as partners for identifying the natural

resources and ecological processes to manage. It can also be local authorities willing to value their agroecological assets (CS4). Such actors invest time and skills in the co-building of innovative systems or solutions for preserving traditional systems. The identification of local leaders and transfer of the animation of the projects are very crucial phases for the success and longevity of the AE initiatives.

**Table 5**. Transversal analysis of Case studies categorization. In "societal challenges", P means "Production" and T means "Territory", "+" means "benefic", "0" means "neutral"; categories show the type of services provided by the AEFS, either dedicated to food production (P+), Territory development (T+) or else (P0/T0).

| CS N°-Country | Type of production | Strategies vs. value chain | Biodiversity conservation | Societal challenges | Origin of collective action |
|---|---|---|---|---|---|
| CS1 ROM | Diversified | Relocalized | Greenest | P+/T+ | External |
| CS2 UK | Crops, sheep, beef | Redesigned | Greener | P+/T0 | Individual |
| CS3 FR | Wine | Niche | Greener | P0/T0 | Individual |
| CS4 FR | Diversified | Redesigned | Greenest | P+/T+ | Collective |
| CS5 BE | Beef | Redesigned | Greenest | P0/T+ | External |
| CS6 IR | Beef | Niche | Greenest | P0/T+ | External |
| CS7 FR | Crops | Redesigned | Greener | P+/T0 | External |
| CS8 FR | Crops | Redesigned | Greener | P+/T0 | Collective |
| CS9 FR | Pig | Redesigned | Impactless | P+/T0 | Collective |
| CS10 FR | Milk | Niche | Greener | P0/T+ | Individual |
| CS11 AT | Milk | Redesigned | Greenest | P+/T+ | Collective |
| CS12 ES | Olive, sheep | Relocalized | Greenest | P+/T+ | Collective |
| CS13 PT | Diversified | Relocalized | Greenest | P+/T+ | Individual |
| CS14 FR | Milk, poultry | Relocalized | Greener | P+/T+ | Individual |
| CS15 DK | Pig, poultry | Niche | Greener | P0/T0 | Individual |

## Discussion and perspectives: from cases' limits to outscaling of agroecology

### Limits of the study

The impacts and performance of AEFS are difficult to assess objectively. First, the comparability of data and results is debatable due to non-homogeneous data, qualitative assessment and very different structures of CS (individual vine farm vs. diversified territory are difficult to compare), different degree of achievement of AE transitions (some are quite young projects). Second, the CS themselves are not supposed to be generalized as it is in a "copy – paste" rationale. Due to its specificities and the specificities of all other farming systems and contexts around it, an AE project should not be transposed but combined with others at local or regional levels because diversity is needed at many scales. Third, our analytical framework has necessarily a normative dimension and needs to better take into account the consistency of each CS in its local context, including social background of farming communities and individuals. For these reasons, it makes no sense to assert in a definitive way that one CS would be more interesting than another, or that one should be generalized and the other abandoned. Each show some interesting performances, and represent knowledge resources and inspiring practices.

### Limits of agroecological case studies

As it can be observed in the transversal analysis, the presented CS are often unfulfilled or unable to answer to each sustainability issues emerging at local or global level. Regarding the strategies of positioning of AEFS along the value chain, several niche strategies appear, meaning that the access to these food products for random consumer will be difficult. On the

other hand, the CS which are close to the conventional farming systems, selling products in long supply chains and supermarkets, do not represent a strong alternative to the dominant food production regime.

An alternative system such as Troldgaarden is very limited in terms of impacts on food production, number of consumers that can be reached and areas managed under agroecology practices. Moreover, it relies on the individual commitment of the farmer leading the project, as the 6 others CS of the “Individually-driven” category. The longevity of such projects can be threatened by governance issues, and their outscaling raises new problems of transfer of leadership.

### Resources and development pathways

Analysing the mobilized resources in AEFS shows that a combination of material, technical, cognitive and socioeconomic resources is necessary for the development of performing AEFS.

As an example, CS8 in France stands on the combination of material resources (very high potential of soils and favourable climate), technical resources (equipment and skills), cognitive resources (ability to anticipate and adapt to changing conditions, knowledge exchange groups), but few socioeconomic resources (few public subsidies, no specific commercialization channel). On the contrary, CS1 in Romania shows a combination of few material resources (topographic constraints and harsh climate), but high technical (well adapted crops and animals), cognitive (local knowledge) and socioeconomic (mutual-aid system, support by research and policies) resources.

Conducting this analysis for each CS allowed us to identify crucial resources to support agroecological transitions. Where material resources cannot really be improved, the technical resources can benefit from local variety development (e.g. through participatory seed selection), local adaptation of tools (e.g. the « paesant workshop » in France) and the sharing of practices among farmers.

Training, education, empowerment of farmers and partnerships with local stakeholders and researchers can be levers for improving the cognitive resources. Also, simple tools such as the following of practices and technical results on the long run (5 to 10 years) and discussing the trajectories with technical advisors or other farmers can be a way to favour learning.

Other trainings on the development of new business activities, or commercialization strategies in order to increase the added value of products, may improve the socioeconomic resources. Investments in processing structures or local development policies (tourism, education of consumers) can be of major interest also.

## Conclusion

After studying 15 CS of agroecology development in Europe, it appears that the performance and consistency of the AEFS lie in a combination of material, technical, cognitive and socioeconomic resources. In some CS a synergetic effect can be observed, which explains the good performance of AEFS for most of the criteria. These good conditions or success factors could be developed elsewhere by upgrading the resources at farm or territory level. This resource-oriented approach could avoid a normative perspective of agroecology development, valuing the diversity of trajectories, preferences of farmers and local stakeholders. Under these conditions, promising pathways of agroecology development can be identified. The diversity of AEFS also corresponds to diverse performance profiles, some being focussed on local development and territory services, others on high-quality products.

To make this outscaling of agroecology possible, the learnings that can be drawn from the investigated AEFS are that changes must also occur at different levels of the agrifood systems. New food chains with alternative long supply chains and more local ones, with good balance of both; new consumption habits, consumers spending a bit more time and money

on their food supply, gaining in quality of their food; new territorial projects to set collective dynamics around AE transition. Such transition pathways are not all new; some of them exist in our CS but should be reinvented every time it is discussed outside of its initial context.

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**Table 1**: Characterization of ecological, socioeconomic and political contexts of case studies.

Abbreviations: Climate: "Oc.": Oceanic; "Cont.": Continental; "Med.": Mediterranean; "Temp.": Temperate; "Mount.": Mountainous. Presence of advisory services: "Imp.": Important; "W. Struct.": well structured. Public policies: "Org.": organic; "Wat.": water; "Prot.": protection; "Biod.": biodiversity. "Reg.": region or regional. ROM: Romania; UK: United Kingdom; FR: France; IR: Ireland; BE: Belgium; AT: Austria; DK: Denmark; ES: Spain; PT: Portugal.

| CS N°- Country | Type of production | Type of system | Scale | Climate - topography | Pop. Dens. (hab./ km2) | Public policies - targeted issues | Presence of advisory services | Proximity to consumption areas (cities, tourism) | Wider socio- economic and cultural contexts |
|---|---|---|---|---|---|---|---|---|---|
| CS1 ROM | Diversified | Preserved | Territory | Cont. Hills | 30 | Biod. / rural development | Low | Medium: local markets, few tourism | Aging communities, risk of desertification |
| CS2 UK | Crops, sheep, beef | Redesigned | Farm | Oc.-Temp. Plain / hills | 190 | Landscape | Low | High: close cities, tourism activities | Patrimonial landscape and cultural heritage |
| CS3 FR | Wine | Redesigned | Farm | Med. Plain | 240 | Wat. Prot. | Strong, w. struct. | High: close cities, oenotourism | Critical unemployment in the area; importance of the winegrowing activities in the local economy |
| CS4 FR | Diversified | Adapted | Territory | Med.-Mount. Hills | 30 | Org. farming | Medium | High: local market, tourism | Risk of decline of farming activities |
| CS5 BE | Beef | Adapted | Territory | Oc.-Cont. Hills | 90 | National park, N2000 conservation policies | Strong, w. struct. | High: close cities, tourism activities | Disappearing milk supply chains, risk of decline of farming activities |
| CS6 IR | Beef | Preserved | Territory | Oc.-Temp. Hills | 10 | National park, N2000 conservation policies | Low | Medium: few local markets, few tourism | Risk of desertification |
| CS7 FR | Crops | Redesigned | Territory | Oc.-Temp. Plain | 36 | Biod. / Wat. Prot. | Strong, w. struct. | Medium: close cities | Tensions around urbanization of land |
| CS8 FR | Crops | Redesigned | Network | Cont.-Temp. Plain | 15 | Wat. Prot. / biod. | Strong, w. struct. | Low: far from city, no local market, no tourism | Importance of farming in local economy; strong conventional supply chains |
| CS9 FR | Pig | Redesigned | Network | Oc.-Temp. Plain | 65 | Wat. Prot. / nitrates reduction | Strong, w. struct. | High: close cities, high population density | Crisis in pig production: profitability, environmental impact, animal welfare |
| CS10 FR | Milk | Adapted | Network | Oc.-Temp. Plain | 95 | Org. farming | Strong, w. struct. | Medium: close cities, few local markets | Local interest for environment and org. farming |
| CS11 AT | Milk | Adapted | Territory | Mount.-Cont. Mountains | 75 | Org. farming | Medium | High: local markets, tourism activities | Risk of decline or intensificationof farming impacting traditions and lifestyle |
| CS12 ES | Olive, sheep | Preserved | Territory | Med. Hills | 15 | / | Struct. by the local cooperative | High: local markets, tourism activities | Risk of decline or intensificationof farming impacting traditions and lifestyle |
| CS13 PT | Diversified | Adapted | Farm | Med. Plain | 15 | / | Low | Medium: far from city, few local markets, few tourism | Importance of farming in local economy; importance of cultural heritage |
| CS14 FR | Milk, poultry | Redesigned | Farm | Oc.-Temp. Plain | 25 | Org. farming / Wat. Prot. | Strong, w. struct. | Low: far from city, no tourism | Importance of farming in local economy; strong conventional supply chains |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| CS15 DK | Pig, poultry | Redesigned | Farm | Oc./ Cold. Plain | 133 | Wat. Prot. / nitrates reduction | Medium | High: close cities, high population density | Tensions between rural and urban; strong conventional supply chains |