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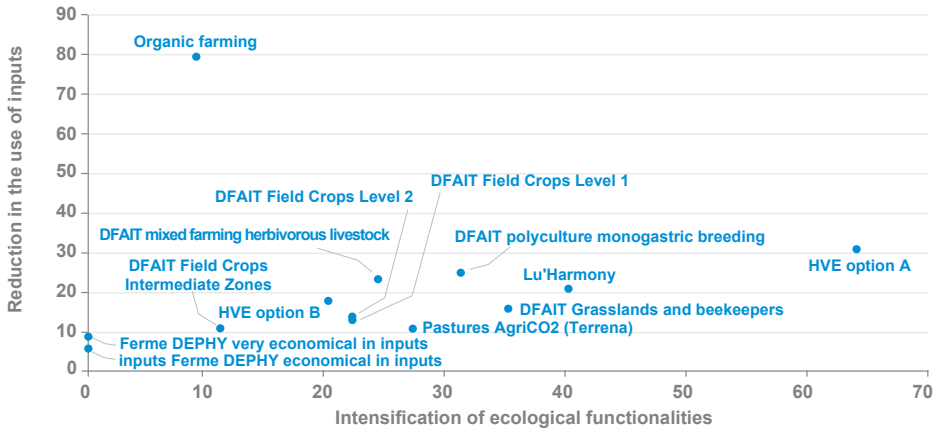
The economic and environmental performance of agroecology

Faced with the dual observation of agriculture's negative effects on the environment and the low income of farmers, agroecology is one of the solutions promoted by the public authorities to ensure the transition of agriculture towards sustainability. But is agroecology profitable for farmers? Agroecology encompasses all agricultural practices based on the optimal use of natural resources to minimize the use of synthetic inputs - chemical fertilizers and plant protection products - and increase the resilience and autonomy of farms. Numerous public or private standards are related to these practices or claim to be based on them: organic agriculture ("agriculture biologique" - AB), agro-environmental and climatic systems measures (MAEC), high environmental value ("haute valeur environnementale" - HVE), Dephy farms, etc. We have chosen to analyze all of these specifications, despite the diversity of the methods of their application and control. Some imply rethinking the entire production system, while others only require the evolution of a few practices, with more or less demanding specifications; some benefit from specific public aid, while others do not.

An analysis of the scientific literature allows us to break down the costs and benefits of these benchmarks[1]. For AB, the reduced use of synthetic inputs certainly leads to a decrease in output and mechanical weeding requires additional manpower. But these costs are compensated by less volatile and higher prices. The agroecological transition therefore appears profitable in the medium term. These results are confirmed by a cereal farm model simulating a change of system: the AB reference frame is the only one among the five tested to bring medium-term benefits.

If the economic profitability of the standards is not always correlated with environmental requirements, organic farming is nevertheless the most efficient from an economic point of view and in terms of environmental requirements. HVE agriculture also has a very high level of environmental requirements. The development of agroecology appears possible and desirable to accelerate the transition of our food system towards sustainability, particularly through the most demanding specifications (AB and HVE). It would therefore be advisable to proportion the public aid allocated to farms – notably aid from the Common Agricultural Policy – to the efforts of farmers to reduce their impact on the environment or to provide environmental services. Public authorities should give priority support to labels with high environmental requirements and economic benefits, such as AB, and better inform both farmers and consumers of these joint benefits.

Typology of the specifications studied



Reading: on the top left, organic agriculture (AB) is by far the most demanding standard in terms of reducing synthetic inputs; on the right, HVE option A certification has specifications that clearly emphasize the preservation of biodiversity, soil and water.

Source: France Stratégie

1. See Grémillet A. and Fosse J. (2020), "Améliorer les performances économiques et environnementales de l'agriculture: les coûts" *Working Paper*, No. 2020-13, France Stratégie, August.

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INTRODUCTION

French agriculture provides our country with relative food self-sufficiency. However, it is also a source of environmental damage and is characterized by the low income of many farmers. These pitfalls call into question the sustainability of the predominant "conventional" agricultural model. Agroecology is one of the solutions promoted by public authorities to ensure the transition of agriculture towards sustainability and thus meet the challenges of climate change and biodiversity collapse. It also meets consumer expectations in terms of sustainable food and the "naturalness" of food. But is this transition profitable for farmers? This note and the accompanying working paper provide some answers by assessing the environmental and economic performance of agroecological farms, based on the analysis of economic data from the scientific literature, supplemented by the development of a model on the scale of a typical cereal farm[2].

A GLOBAL CONCEPT FOR MULTIPLE PRACTICES

Agroecology is based on the optimal use of natural resources to develop a farming system that uses the least amount of synthetic inputs, whether fertilizers, pesticides or antibiotics[3], and thus increase the autonomy of farms[4]. Our study analyzed twenty-three French public and private specifications or reference frameworks that can be linked to these major principles[5]. Agroecology is not limited to these specifications, as some farms can implement agroecological practices without registering for a label or subscribing to a MAEC label. Only the six standards that include the most farms in France are presented here. Their ambitions in terms of intensifying ecosystem services and reducing the use of inputs vary widely. Some of them provide for outdoor farming conditions that contribute to animal welfare, but few explicitly include this issue among their objectives. Only the first two - Organic agriculture ("agriculture biologique" - AB) and agro-environmental and climatic systems measures (MAEC) - benefit from specific public financial support to farms. Some give rise to signs recognizable by the consumers present on the food products (AB, HVE, Lu'Harmony) while others do not (MAEC systems, Dephy).

Organic farming

The AB is a European and national certification that is part of the official quality signs (see box 1). For crop production, the specifications include prohibitions on the use of phytosanitary products and synthetic fertilizers. In practice, these requirements imply changes in the production system to manage fertilization and protect plants from bio-aggressors. For livestock farms, the specifications impose a diet exclusively from organic farming and the limitation of veterinary treatments, as well as outdoor runs in the open air. The transition to organic farming is financed by specific aid from the Common Agricultural Policy (CAP) called "conversion aids" (see Box 2). "This is financed since 2017 by the Regions and the water agencies and implemented in a targeted manner in certain regions, as well as through a tax credit. At the end of 2018, 41,600 farms, representing 2 million hectares, were growing organically, representing 7.5% of the French agricultural land area[6] – up one point per year from the previous year –, about 9.5% of national farms and 14% of national agricultural jobs[7].

Agri-environmental and climate measures

The "agri-environmental and climate measures" (MAEC) are part of the Common Agricultural Policy, with a logic of compensation for costs and loss of earnings. They take the form of multi-year commitment contracts, most often for a period of five years[8]. Some are linked to localized issues such as the preservation of water quality, others to specific issues such as the preservation of genetic resources. We are interested here in the "MAEC systems", intended for farms that wish to engage in agroecological practices by thinking at the scale of their own agroecosystem. Six different specifications[9] focus on the reduction of the use of pesticides and fertilizers or on the food autonomy of livestock farms. The public aid received from the CAP in this context cannot be combined with aid for organic farming (see Box 2). Other MAECs responding to localized issues can nonetheless be combined with assistance for animal production.

2. We chose to model a cereal farm because the environmental impacts of agricultural practices, particularly in terms of fertilizer and pesticide use, are significant and because cereal farms are the primary focus of French farms.
3. Claveirole C. (2016), *La transition agroécologique : défis et enjeux. Opinion presented by the rapporteur on behalf of the Agriculture, Fisheries and Food Section of the Economic, Social and Environmental Council*, November; David C., Wezel A., Bellon S., Doré T. and Malézieux E. (2011), "Agroécologie", article in *Mots de l'agronomie*, November.
4. Schaller N. (2013), " L'agroécologie : des définitions variées, des principes communs ", *Analyse*, n° 59, MAA-SSP, https://agreste.agriculture.gouv.fr/agreste-web/download/publication/publie/Ana59/Ana59.pdf
5. These repositories are detailed in the working document.
6. https://www.agencebio.org/wp-content/uploads/2019/06/DP-AGENCE_BIO-4JUIN2019.pdf
7. Four private repositories - Demeter, Nature and Progress, Biocoherence and Permaculture - add additional constraints to the AB requirements.
8. This is not strictly a transition aid because at the end of the five-year period the farm can return to its previous production mode.
9. http://agriculture.gouv.fr/les-mesures-agroenvironnementales-guide-feader https://info.agriculture.gouv.fr/gedei/site/bo-agri/supima/0a952603-5af4-43ad-ab24-639e09fe8148

Box 1 – Signs of software quality and private certifications

Some food products carry on their packaging an official sign of the quality of the product. Under this term, we group together a set of voluntary approaches, framed by the public authorities. Consumers are thus guaranteed to buy products that meet specific characteristics pre-defined by a set of specifications controlled by the public authorities. These signs are managed by the ministries in charge of agriculture and consumer affairs and by the National Institute of Origin and Quality (INAO), under the supervision of the ministry in charge of agriculture. The use of these quality signs is monitored:

- *at the first level, by certifying bodies working under the responsibility of INAO. These are accredited by the French Accreditation Committee (COFRAC) and approved by INAO. They are responsible for checking compliance with the specifications before the marketing of products registered in France ;*

- *at the second level, by the General Directorate for Competition, Consumer Affairs and Fraud Control (DGCCRF), which monitors products placed on the market.*

There are four official signs of quality framed by European regulations. The first three are defined by Regulation (EU) No. 1151/2012 of November 21, 2012 and relate to the link between a food product, its geographical origin and its typicality:

- *The protected designation of origin (PDO), created in 1992 on the initiative of France, guarantees a very strong link between the product and its terroir. The quality results exclusively from the natural environment and the know-how of men. To benefit from the PDO, the product name must first be recognized at the national level as an* appellation d'origine contrôlée (AOC) *and then registered by the European Commission;*

- *The Protected Geographical Indication (PGI) was also created in 1992. The relationship between the product and its origine is not as strong as for the PDO, but it can be used to confer a characteristic or reputation to a product. The Community registration procedure is the same as for PDOs;*

- *The Traditional Specialty Guaranteed (TSG), created in 1992, certifies that a food product has been manufactured according to a recipe considered traditional;*

- *Organic farming is defined by the European Community Regulation n° 834/2007 of June 28, 2007. It aims to establish a system of sustainable management of agriculture, in particular by improving the quality of soil, water, plants and animals and developing biodiversity.*

In addition to these European signs, there is a national quality sign, the Label Rouge. *Created in the 1960s, the* Label Rouge *is defined in the Rural and Maritime Fishing Code. It certifies that a foodstuff or a non-food and unprocessed agricultural product has specific characteristics, previously set in a specification establishing a level of quality higher than the current product. These products are distinguished from similar products by their particular production and manufacturing conditions. Organoleptic tests – on appearance, taste and consistency – must be carried out to demonstrate the quality of the candidate product. The environmental benefits of agricultural practices related to Label Rouge production are not explicitly included in the specifications, which is why they have not been included in the rest of our analysis. The specifications of a* Label Rouge *are approved by interministerial decree (Ministry in charge of consumption and Ministry in charge of agriculture), on the proposal of the INAO. A certifying body working under the responsibility of the INAO is responsible for ensuring compliance with these specifications. DGCCRF agents carry out a second-level control, by sampling, of the products placed on the market.*

Finally, in addition to the European and national quality signs, there is a product conformity certification (CCP). Created in 1988, this approach can be individual or emanate from a group of professionals. Conformity certification guarantees compliance with certified characteristics (for example, pork fed with 70% cereals). These characteristics must be meaningful, objective and measurable and must distinguish the product from the standard. A set of specifications, drawn up by the operator, specifies how the selected requirements and recommendations are implemented and the main points to be checked. The requirements and recommendations per product are validated by the ministers responsible for agriculture and consumer affairs. The inspection is carried out by a COFRAC-accredited certification body. The DGCCRF agents ensure, by its own means, a second level control on the products placed on the market.

High environmental value ("Haute valeur environnementale" – HVE)

Set up following the Grenelle Environment Round Table to recognize farms that have committed to environmentally friendly approaches, environmental certification is built around four themes: biodiversity, phytosanitary products, fertilization and water. Level 1 consists of compliance with regulations and a commitment to carry out assessments of their implementation. Level 2 corresponds to the application of a set of specifications comprising 16 requirements: approximately 17,500 farms are currently involved in this process[10]. Level 3, « Haute valeur environnementale » which corresponds to environmental certification in the *strict sense*, is an obligation to achieve results in the four themes, which gives the right to certification. The Group had 5,399 HVE[11] or "high environmental value" farms as of January, 2020, compared to 2,772 farms as of July 2019[12].

Operations committed in the environmental certification do not benefit from dedicated public aid but they can obtain aid associated with the other devices, in particular the MAEC and possibly the aids for AB.

Dephy Farms

The Dephy network - a network for demonstration, experimentation and production of references on economical phytosanitary systems – is a major action of the Ecophyto plan, which aims to reduce the use of phytosanitary products while maintaining production. This network aims to share and disseminate successful experiences in this field.

Box 2 – Specific subsidies to organic agriculture and DFAIT systems

Organic farming

Since 2011, during the conversion phase, the farmer can benefit from specific aids in addition to the income aid paid to all farmers (direct aid or basic payment entitlement). After conversion, some farmers can benefit from a specific "maintenance" aid, financed since 2017 by the Regions and the Water Agencies, the management authorities having the possibility of implementing them in a targeted manner, based on criteria for prioritizing applications. Conversion and maintenance aid is financed by the second pillar of the CAP. In addition, since 2017, organic farms in conversion can also benefit from a tax credit from the State. The activities falling within this field are described in Article 63 of the General Tax Code. Farm businesses must have a minimum of 40% of their income from organic production. The tax credit applies to income tax, regardless of the farming system. Its amount has been set for the years 2018- 2020 at 3,500 euros per year. The conversion aid is intended to support the transition phase and the maintenance aid is intended to compensate for any additional post-transi tion costs, i.e. the loss of income due to the change of system.

MAEC systèmes

Farms subscribing to MAEC systems also receive grants from the second pillar of the CAP. By signing a contract with the government, they receive support for five years to compensate for the loss of income related to the fulfillment of the specifications. The aid granted varies according to the system studied (field crops, poly-crop-rearing, grassland farming) and the level required in the specifications or the risks to which the systems are subject. For some systems (arable, grassland and monogastric polyculture-livestock[13]), support levels are defined at the national level by minimum and maximum ceilings. This provides a framework for the aid paid for the regions, which then set the amounts they wish to grant. For other systems, the region has no budgetary room for maneuver and the amount is directly imposed at the national level (arable farming systems in intermediate zones). Finally, for others, the region determines the amount entirely, without a national framework (mixed cropping and herbivore livestock systems).

Other public support for agroecology can be mobilized, notably within the framework of the European Agricultural Fund for Rural Development (EAFRD). Their implementation is nevertheless conditional on co-financing by regional councils. These include, for example, investment aid, increased installation aid for young farmers in the context of agroecology.

10. Numerous approaches have level 2 environmental certification by equivalence, such as the controlled integrated cultivation approach (CRC). See key figures and procedures on the website of the Ministry of Agriculture.
11. HVE can be obtained in two ways. The first is to calculate a score for each of the four themes using several indicators: the operation must score above 10 everywhere. The second is to use global indicators, with two conditions: (i) the percentage of usable agricultural area (UAA) in agro-ecological infrastructure must be greater than or equal to 10 or the percentage of UAA in permanent grassland must be greater than or equal to 50; ii) the weight of inputs in the turnover is less than or equal to 30%. Our analysis considers these two methods as two distinct benchmarks.
12. https://agriculture.gouv.fr/la-haute-valeur-environnementale-une-mention-valorisante-pour-les-agriculteurs-et-leurs-pratiques
13. Monogastric animals are animals with only one stomach (such as pigs or poultry), as opposed to ruminants.

The 3,000 farms in the Dephy network are voluntary partner farms[14]. They are said to be "economical" if their treatment frequency index (TFI) is less than 50% of the regional reference and "very economical" when it is less than 70%[15].

LU'Harmony

The LU'Harmony program is a private initiative launched by the LU brand with 1,700 farmers. It involves compliance with requirements in terms of choice of agricultural plots and crop establishment, biodiversity and landscape, crop nutrition and health.

AgriCO$_2$

Finally, the AgriCO$_2$ approach was set up by the Terrena cooperative. It includes seven levers to achieve greenhouse gas savings, including adapting livestock rations, modifying crop rotation, training in eco-driving tractors and the installation of hedges and plant cover[16]. Approximately 2,800 farmers are involved in this approach.

Typology of specifications

A typology based on the reduction in the use of inputs and on the intensity of practices that are favorable to the preservation of biodiversity, soils and water resources (see Box 3) allows us to distinguish two major families of agroecological farms. The first includes farms where the entire production system has been rethought, with a high level of requirements in terms of reduction of inputs or intensity of environmentally friendly practices. Organic agriculture or HVE certification is the most important. Their specifications benefit from consumer recognition through official labels. The second group includes farms whose production system, despite additional commitments, is still generally based on the principles of conventional agriculture: these are the MAEC systems, Dephy farms, private charters such as Lu'Harmony, etc. (see graph on page 1).

A PROFITABLE AGROECOLOGICAL TRANSITION FOR THE FARMER

The profitability of farms can be assessed using various economic indicators, excluding CAP aid because taking them into account would bias the calculations.

Better economic results

Agroecological farms generally have better medium-term economic results than conventional farms. This is particularly the case for organic (OA) farms, which most often

Box 3 – Methodology for the comparison of reference systems

Comparison of specifications

A keyword search of scientific databases and the Internet enabled us to identify the library of existing methods and indicators for evaluating the environmental performance of operations. We selected the literature related to the evaluation of this type of performance and then we selected the different criteria or indicators used both in these evaluation methods and in the clauses of our standards. We then compared the criteria used in the specifications. These criteria are grouped under four headings: biodiversity of the agro-ecosystem, resource conservation, inputs used in crop production, inputs used in animal production (see Table 1).

Scoring

For each criterion, a score has been assigned to each specification, making it possible to measure the level of requirement imposed for a given criterion. Then we added the scores of the four items to obtain a total score per specification, which allows us to situate them in relation to each other.

Table 1 – Specifications criteria, by heading

BIODIVERSITY	Keep biodiversity natural	Maintain the prairies permanent	Diversity breeding	**Diversify crop use seeds**				Adapted farmhouses to the terroirs and no GMOs	
				Diversify crop rotation		Extend rotations			
RESOURCES		**Ground**				**Water**			
		Limit the work of the ground		Cover the grounds		Preserve water quality and quantity			
CROP PRODUCTIONS INPUTS		**Limit fertilization…**				**Limit use Phytosanitary**			
		Overall		Mineral	Nitrogenous	Organics			
CATTLE INPUTS		**Food**				**Health**			
		Improve autonomy food	Enhance forage		Prohibit some products	Limit the use of antibiotics	Limit the use of pest control	Limit the use of vacciones	Increase the deadline waiting

Source: France Stratégie

14. You can see their location on the Ministry of Agriculture website.
15. http://www.ecophytopic.fr/tr/agenda/colloque-dephy-en-marche-vers-une-agriculture-%C3%A9conome-en-phytosanitaires
16. https://www.terrena.fr/une-innovation-de-terrena-retenue-par-le-pavillon-france/

show an economic gain at the end of their transition from comparable conventional operations. We first analyzed the economic data published in the scientific literature (see Table 2). Then we found that, in most of the contexts studied, AB had important economic benefits (see Table 3). The main reason for the observed profit is the reduction in expenses related to the purchase and use of synthetic fertilizers and phyto-sanitary products, as well as the higher market prices of organic products.

Table 2 – Data used and their characteristics to estimate the costs and benefits post-transition to organic farming

Study	Time scale	Spatial scale	Sector	Data sample	Method: Use of data	Selected indicators	Post-transition results
Ecophyto R&D (INRA)	2006	3 areas: Centre Poitou Midi-Pyrénées, Aquitaine, Languedoc-South-East	Cereals	Economics of break levels 0 (intensive) and 3 (AB) for several rotations and several regions	Average performance over several rotations per region and then calculation of the differential between averages	MB, MD	Benefit
CERFRANCE Agri'Scopie Occitanie	Averages over 4 campaigns 2011-2014	Region Occitanie	Cereals	54 organic farms and 54 conventional farms, some farms in conversion	Calculation of profitability differentials	MB, MD, RC	Depends on the indicator
CERFRANCE The Economic Observatory	2016	Distributions in 11 departments for organic, Champagne Nord-Est Île-de-France conventional	Milk	61 organic farms	Calculation of profitability differentials	MB, MD, EBE, RC	Benefit
		5 departments for organic, conventional Burgundy	Specialized beef and veal	30 organic farms			Cost
		Mainly Burgundy Franche-Comté and 2 structures in the Ardennes	Polyculture breeding beef and veal	29 operations			Benefit
		Departments of the Champagne-Ardenne et Bourgogne regions	Cash crops (including mixed farming, excluding	70 operations, 1,926 conventional			Benefit
INSEE file	2013	Metropolitan France, some details by région	Viticulture	3,861 operations = 3,538 conventional + 323 organic	Calculation of profitability differentials	EBE	Benefit
			Market gardening	646 operations = 527 conventional + 119 organic			Benefit
			Milk	3,357 farms = 3,163 conventional + 194 organic			Benefit
CERFRANCE Adheo	Evolution 2009 à 2016	Meurthe-et-Moselle and Meuse	No distinction but important part of livestock farms	~ 50 organic farms	Calculation of average profitability over the 2009 period to 2016 then calculation of the differential between AB and conventional	EBE	Benefit

MB = gross margin = gross product (excluding CAP aid) - operating costs - **MD = direct margin** = MB – mechanization and labor costs.

EBE = gross operating surplus = MB – fixed costs (rents and rentals) - charges for hired labour - tax. EBITDA represents the profit remaining when all direct costs attributable to production are deducted. It is used to remunerate farmers, repay loan installments, build up a cash flow reserve and a safety margin.

EBITDA = earnings before interest, tax, depreciation and amortization + net financial expense. Obtained after deducting all expenses, including property capital, the RCAI is used to remunerate family work.

Complete references of the mobilized studies :

Brunet N. *et al*. (2009), Ecophyto R&D, Towards cropping systems that are economical in phytosanitary products, part 1, Volume II: Comparative analysis of different field crop systems, Study financed by the Ministry of Agriculture and Fisheries and the Ministry of Ecology, Energy, Sustainable Development and Land Use Planning.

Dubosc N., Glandières A. et Roubière M. (2016), Les dossiers d'Agri'Scopie : "Analyse économique des exploitations en grandes cultures bio", Study carried out by Cerfrance Midi-Pyrénées in collaboration with the Occitanie regional chamber of agriculture with the financial participation of the State credits Animation Bio.

Cerfrance (2018), "Exploitations en agriculture biologique. Résultats 2016, Prévisions 2017-2018", L'Observatoire économique, édition 2018.

Dedieu M.-S., Lorge A., Louveau O. and Marcus V. (2017), "Les exploitations en agriculture biologique : quelles performances économiques ?" *in* "Les acteurs économiques et l'environnement", *Insee Références* - édition 2017, Dossier : Les exploitations en agriculture biologique, p. 35-44.

Cerfrance ADHEO (2018), "Organic farms more resistant to the crisis?", Special Issue on Organic Agriculture, Note de conjoncture agricole, January.

Source: France Stratégie

For organic farming, the benefits observed are usually thought of as the costs incurred. The reduced use of synthesis fertilizers and plant protection products actually leads to lower yields and thus to a lower production volume[17]. In addition, synthetic herbicides are replaced by a greater use of mechanical weeding, which implies additional costs related to mechanization and labor[18]. In addition, the higher final profitability of the AB is most often associated with a lower dispersion and a better stability of the operating result of the agricultural catches within the study samples. This can be explained in particular by a greater regularity of the overall returns, over the entire operation, over the long term and by product prices that are less volatile because they are most often contracted over the medium term. The better overall stability of yields is due to the diversity of production[19] and to the cultivation of hardy varieties that make the system less dependent on climatic conditions and less subject to attacks by pests and diseases - weed growth is particularly favored by the frequent return of the same crop on the same plot of land. The economic results are all the more favorable to AB as the prices of conventional products are low and the climatic situation is difficult.

Table 3 – Estimated costs and benefits after transition to organic farming
(excluding subsidies)

Study	Sector		Costs and benefits €/ha/year MB	MD	EBE	RC
Ecophyto R &D (INRA)	Intensive Cereal	Centre Poitou	398 (+ 96%)	385 (+ 274%)	x	x
		Midi-Pyrénées, Aquitaine, Languedoc	348 (+ 75%)	331 (+ 170%)	x	x
		Southeast	215 (+ 36%)	227 (+ 4%)	x	x
	Mixed Cereal extensive	Centre Poitou	207 (+ 50%)	309 (+ 221%)	x	x
		Midi-Pyrénées, Aquitaine, Languedoc	157 (+ 34%)	255 (+ 131%)	x	x
		Southeast	24 (+ 176%)	151 (+ 51%)	x	x
CERFRANCE Agri'Scopie Occitanie		Cereals	40 (+ 6%)	-30 (- 20%)	x	-70 (- 52%)
CERFRANCE The Economic Observatory		Milk	514 (+ 88%)	241 (+ 225%)	302 (+ 2 517%)	142 (+ 51%)
		Specialized Beef	- 197 (- 36%)	-202 (- 109%)	-178 (- 223%)	-173 (- 124%)
		Polyculture breeding beef and veal	123 (+ 28%)	57 (+ 104%)	177 (+ 5 900%)	124 (+ 54%)
		Cash crops (including mixed farming excluding monogastric livestock)	126 (+ 35%)	97 (+ 86%)	133 (+ 124%)	133 (+ 37%)
INSEE file		Viticulture	x	x	2 506 (+ 72%)	x
		Market gardening	x	x	594 (+ 29%)	x
		Milk (€/VL)	x	x	100 (+ 12%)	x
CERFRANCE Adheo		No distinction but important part of livestock farms	x	x	64 (+ 33%)	x

MB = gross margin **MD = direct margin** **EBE = gross operating surplus** **RC = current result**

Reading: the table presents the estimated overall post-transition benefits or costs in value (€/ha/year) and percentage. The most important benefits in value are estimated from the largest sample (metropolitan France scale) for wineries. This gain in EBITDA is estimated at 2,506 €/ha/year, i.e. more than 4 times that estimated for market gardening and 25 times that estimated for dairy cattle for samples also covering metropolitan France. The lowest benefits in value are estimated for mixed beef and veal farms in Burgundy and Franche-Comté. Some values may seem surprising. For example, an overall profit on EBITDA in €/ha excluding subsidies is calculated for 2016 of 2,517% in milk and 5,900% in mixed farming of beef and veal. This can be explained by the particularly low eco-nomic performance of conventional farms that year, with negative current results before tax: the EBITDA excluding CAP subsidies for 2016 is only 12 €/ha in conventional, compared to 314 €/ha in organic for the dairy farms in the sample. For mixed beef and veal farms, this same indicator reaches 3 €/ha in conventional and 180 €/ha in organic. In other words, excluding CAP aid, these conventional farms from the samples have very little value for managing the farmer, repaying loan installments and building up a reserve for self-financing. Note that this result is related to the year under consideration (2016).

17. A meta-analysis conducted in 2014 estimated that the average decrease in yields observed in organic agriculture compared to conventional agriculture, all crops combined, was 19%.
18. Dedieu M.-S., Lorge A., Louveau O. and Marcus V. (2017), *op. cit*.
19. Chavas J. P., Posner J. and Hedtcke J. L. (2009), "Organic and Conventional Production Systems in the Wisconsin Integrated Cropping Systems Trial: II. Economic and Risk Analysis 1993-2006," *Agronomy Journal*, 101 (2): 288-295. Based on an econometric model using data series from 1993 to 2006 depending on location, this study assesses the impact of the "year" effect on the economic performance of Wisconsin farms via risk exposure. The authors show that more diversified rotations have moderate risk variability (risk premiums not exceeding 5% of estimated profit). However, the rotations practiced in AB are more diversified, which leads us to affirm that farms in AB face a more moderate risk.

The generalization of these results is nevertheless delicate. Not all reference systems have been subject to as many economic analyses as AB. However, we have identified other reference systems that are profitable in the medium term: some MAEC field crop systems, some farms in the Dephy network. Contrary to what is observed for AB, prices do not allow to generate own profits because these references are not associated with brands that can be identified by consumers. In organic agriculture, the savings made on expenses, particularly on inputs, however, make it possible to compensate for yield losses and other costs once the transition is complete.

Finally, the modeling of a typical cereal farm (see box 4) shows that the AB reference frame is the only one among the agroecological reference frames tested – AB, Dephy farms , HVE B, Lu'Harmony - to bring medium-term benefits to the operator (see Table 4). It is also the most demanding benchmark for reducing input use.

Heterogeneous economic benefits

Depending on production and region, the explanatory factor for the gain in the past was either price increases or cost reductions. Thus, according to INSEE, in viticulture[20], the strong profit observed is mainly explained by the differential of the selling price of products. The very good valuation of organic products largely compensates for these additional costs, which are the increase in intermediate costs[21] and the reduction in yield (see table 5). In the case of other products, however, the reduced yield cannot be compensated for by the prices of organic products alone. In market gardening or dairy cattle farming, it is the benefits of reduced operating costs[22] that compensate for production losses and guarantee an overall post-transition profit.

Table 4 – Estimated Direct Margin Costs or Benefits by Modeling for Five Specifications

Specifications	Post-transition MD cost or profit		Comparison with economic data from literature
	Low prices (2006)	High prices	
AB	52 €/ha (+ 26%)	190 €/ha (+ 24%)	Estimated benefits vary between 24 and 398 €/ha depending on the studies (same indicator and same productions)
Dephy thrifty in inputs	0	- 5 €/ha (- 1%)	Lechenet's thesis[23] showed that 67% of Dephy farms do not suffer a loss of profitability by reducing their use of phytosanitary products
Dephy very economical in inputs	0	- 13 €/ha (- 2%)	
HVE option B	- 71 €/ha (- 36%)	- 134 €/ha (- 17%)	No economic data in the literature
LU'Harmony	- 3 €/ha (- 1%)	- 21 €/ha (- 3%)	

Source: France Stratégie, authors' calculations

Table 5 – Details of Calculations for Estimating Post-Transition Costs and Benefits

Indicator economic	Viticulture (€/ha)			%	Market gardening (€/ha)			%	Cattle milk (€/cow)			%
	Conv	Bio	Écart		Conv	Bio	Écart		Conv	Bio	Écarts	
Sales (Gross proceeds)	12,000	17,000	5,000	42	12,500	10,900	-1,600	-13	3,740	3,400	-340	-9
Grants of operations	218	412	194	89	436	642	206	47	582	739	158	27
Consumption intermediaries	5,926	7,111	-1,185	20	8,100	6,300	-1,800	-22	2,640	2,200	-440	-17
EBE WITH AIDS	**3,700**	**6,400**	**2,700**	**73**	**2,500**	**3,300**	**800**	**32**	**1,419**	**1,677**	**258**	**18**
EBE WITH AIDS	**3,482**	**5,988**	**2,506**	**72**	**2,064**	**2,658**	**594**	**29**	**838**	**938**	**100**	**12**

SALES = turnover **EBE** = gross operating profit

Source: France Stratégie, according to Insee Références (2017)

20. Dedieu M.-S., Lorge A., Louveau O. and Marcus V. (2017), *op. cit*.
21. The above-mentioned INSEE study does not allow a breakdown of the different types of expenses (operational and structural). We cannot therefore evaluate the benefit of reducing synthesis inputs. However, the study specifies that personnel costs in AB viticulture are one and a half times higher than those of conventional viticulture.
22. In market gardening in AB compared to conventional: cost of reduction of the gross product = 1 600 €/ha and benefit of reduction of the intermediate consumptions = 1 800 €/ha. The benefit of the reduction in intermediate costs is mainly due to the reduction in phytosanitary products because personnel costs in viticulture are "important regardless of the production method".
23. Lechenet M. (2017), *Can low pesticide use be reconciled with good economic and environmental performance? Analysis of a national network of Ecophyto demonstration farms*, PhD thesis, University of Burgundy.

Box 4 – Economic Modeling of the farm: principles and assumptions

Choice of the type of operation modeled

We chose to model a field crop farm using the conditions of the region "Centre" as an example, which is statistically representative of the entire national production. In France, phytosanitary conditions vary from one sector to another. 68% of total expenditures are attributable to the field crop sector in 2006 (Brunet et al., 2009). Agricultural censuses show that the most numerous farms are those specializing in field crops.

Assumptions

We make the following assumptions: the farmer does not use the market for resources (land, labor); crops are not irrigated; rotations are always the same and plots of the same size, which allows us to impose rotation constraints in a static model in the form of annual upper limit constraints on areas (crop rotation constraint); the farmer is not subject to any institutional constraints; and the prices of agricultural inputs are fixed

Operation of the model in initial conditions (conventional operation)

In initial conditions, our model simulates the behavior of a farmer with a 100-hectare farm, on which he can grow eight different crops: soft winter wheat, rapeseed, winter barley, spring barley, sunflower, triticale, peas, hemp. Each crop can be grown according to five different production methods corresponding to the levels of dis- tinct production (0, 1, 2a, 2c, 3) defined in the INRA's Ecophyto R&D report characterizing five levels of use of phytosanitary products: these include "intensive practices", "sustainable agriculture", "pesticide-saving technical innovation", "integrated cropping systems" and "organic agriculture". The farmer may choose to grow certain crops intensively and others more extensively, or even adopt different cultivation methods for the same crop (meaning that he grows different plots of the same crop).

In the initial situation, based on a certain number of inputs and constraints, the software we use (General Algebric Modeling System) applies the optimization rule of maximizing the global direct margin (MDG) and returns as output the MDG, the cultivated areas per crop and per production technique and the average treatment frequency index (TFI) per hectare. The prices of the products are fixed and we use the model for two price situations (low and high prices). We thus obtain two initial situations, one for each price scenario selected.

Modelling of agroecological repositories

We model the "post-transition" states by introducing into the basic conventional model additional variables and constraints in order to comply with the specifications. The estimated post-transition cost or benefit then corresponds to the difference in the overall direct margin between the two states. The additional variables introduced on which the new constraints are based on: the surface area of agroecological infrastructures, the selling prices of organic products, the total cultivated surface area, the total operating costs, the number of sales. Depending on the agroecological system modeled, one or more of these variables intervene and constrain the model at different levels, specific to each specification.

The total amount of profit, evaluated per year in euros per hectare or per annual work unit, also varies from farm to farm. It depends on the agroecological reference system, the specialization of the farm, its geographical location and the climatic conditions. On the other hand, it does not seem to depend on the level of environmental requirements of the standards. In organic agriculture, an examination of the data in the scientific literature shows direct margin gains[24] that vary greatly depending on the type of production, ranging from -109% to +274%, with an average of +103% (see table 3).

The modeling exercise shows a direct margin gain of around 25% at the end of the transition compared with the initial situation, excluding public aid (see table 4). For the other benchmarks, benefits are only observed at the end of the transition for the agro-environmental and climate system measures, with gains of 10% to 76% depending on the farms studied, as well as for 11% of the farms in the Dephy network.

Benefits that sometimes rely solely on CAP subsidies

Without specific aid from the CAP, some organic farms are not profitable. This is notably the case for beef farms in Burgundy in 2016 and cereal farms in Occitania over the period 2011-2014 (see table 3). These results are affected by unfavorable economic conditions or by the choice of the indicator used (gross margin or direct margin).

Some transition costs are difficult to estimate

Even if the transition is cost-effective in the medium term, it may not be implemented when transition costs are too high. These costs are unfortunately difficult to estimate, but they undoubtedly constitute a major obstacle to system change, especially since only AB benefits from transition assistance in the *strict sense*. This may explain the low deployment of certain agroecological reference systems.

CAP ASSISTANCE TOO DISCONNECTED FROM ENVIRONMENTAL REQUIREMENTS

CAP subsidies ensure the profitability of farms, whether agroecological or conventional. Certain specifications or agroecological reference frameworks such as the MAEC systems and the AB benefit from specific subsidies (see Box 2). Do the amounts only remunerate a loss of income (post-transition cost), as provided for in the framework for the payment of aid under the second pillar of the Common Agricultural Policy and the competition policy, or also an environmental service?

Aid disconnected from environmental services

We have given each reference system an environmental performance score that takes into account the intensification of environmental services. and reduction of the use of inputs. When these scores are compared with the amounts of aid granted, it is clear that the levels of compensation are not commensurate with the environmental requirements. Some farms belonging to the same reference system, with the same level of environmental requirements (AB), receive different amounts depending on the type of production, whether it is conversion aid or maintenance aid implemented historically. Similarly, farms benefiting from DFAIT have variable subsidies that are not proportional to the level of environmental requirements. Finally, for the same production (field crops) but with different references (AB, DFAIT), the total amounts of aid per hectare are higher for less environmentally demanding production.

Assistance that does not perfectly compensate for a loss of income

AB support, which have been implemented in a targeted manner since 2017[25], will they make it possible to compensate for the loss of income that some farms may suffer at the end of their transition to the new system.

In the few cases identified above as less profitable compared to the conventional – notably some beef farmers in Burgundy in 2016 – these subsidies to the AB have guaranteed a profit, despite yield losses and prices that are not much higher than the conventional.

However, support for AB is not proportionate to the economic costs or benefits we have observed. Even if they ensure the profitability of the most struggling farms, these farms do not receive the highest amounts of aid. In AB, for example, it is the winegrowing and market gardening farms that receive the most aid per hectare in total, even though they have the greatest economic benefits.

As far as arable crops are concerned, CAP subsidies also appear to be uncorrelated with environmental requirements. This can be verified by comparing the amounts of subsidies paid for MAEC and organic farming according to the agroecological requirement score; or the total surplus of subsidies received for these two examples by integrating all CAP subsidies (basic payment entitlements - BPS[26], AB or MAEC subsidies) (see graph 2 on the next page).

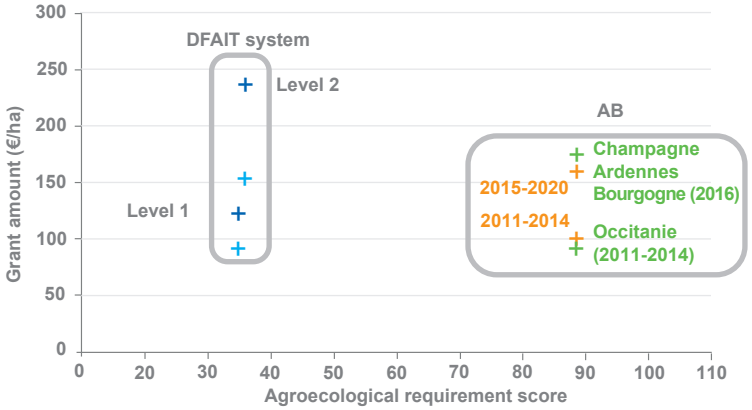
RECOMMENDATIONS

In 2017, Workshop 11 of the French "États généraux de l'alimentation" (EGAlim) entitled "Making a success of the ecological and solidarity transition of our agriculture by promoting sustainable food" concluded that France must become the European leader in agroecology, aiming to convert one third of farms to AB and one third to HVE by 2030[27]. In the light of our analysis, these two specifications clearly appear to be the two most demanding standards from an environmental point of view. To achieve this ambition, it is necessary to accelerate the dissemination of the most environmentally beneficial agroecological practices and modes of production and to mobilize the actors downstream (processors, cooperatives, distributors, retailers, consumers), as well as to ensure public support commensurate with the environmental services[28] provided. In the extension of the EGAlim, a certain number of agroecological support mechanisms have been implemented by the ministries in charge of agriculture and the ecological and solidarity transition (see Box 5).

In order to accelerate the agroecological transition of the "Ferme France" and to reduce the negative externalities of agriculture, a combination of action levers relating to the environment and demand appears necessary. Concerning

25. See https://agriculture.gouv.fr/sites/minagri/files/08_aides_a_la_conversion_et_au_maintien_de_lab.pdf
26. The PPSs depend on declared agricultural areas and historical references.
27. National Assembly (2018), États généraux de l'alimentation: restitution of the conclusions of the fourteen workshops; (http://www2.assemblee-nationale.fr/static/15/commissions/CAffEco/egalim-atelier11.pdf).
28. Payments for environmental services pay land users for the services they produce and charge the beneficiaries of these services. These beneficiaries can be society as a whole when global public goods are produced (carbon sequestration in soils or water filtration, for example).

Graph 2 – Amounts of aid granted in field crops according to the agroecological requirement score



+ Total aid surplus observed compared to conventional

+ Maximum amount + Minimum amount + Maintenance assistance

Reading: the theoretical amounts of aid fixed by the State appear in blue on the graph. In green are two examples observed in two different geographical areas and whose total aid surpluses are estimated over different periods. In arable crops, the surplus of total aid received by farms in AB in Champagne-Ardennes-Bourgogne in 2016 is at the lower limit of the amount granted to DFACE level 2, despite their difference in terms of environmental requirements. Over the period 2011 to 2014, the aid actually received by cereal farms in the Occitanie region is lower than the amount of aid for theoretical maintenance and the amount of aid received in DFAA field crops level 2. This benefit is equal to the lower limit of the amount of DFAIT field crops level 1.

Source: France Stratégie

offer, we propose either to really adjust public aid to potential shortfalls in earnings, or to remunerate the positive environmental externalities of agroecology with bonus-malus on the main levers for preserving biodiversity and climate (maintenance of permanent grasslands and agroecological structures, crop rotations). The taxation of negative externalities linked to the use of inputs – pesticides and fertilizers in particular – and the reuse of the proceeds of this tax to finance the transition of farms also contribute to this dynamic. A first step in this direction was taken in 2019 with the increase in the levy for water pollution, announced at the EGAlim, the proceeds of which will be used to convert to organic farming and to finance payments for environmental services (‘150 million) as part of the biodiversity plan announced in 2018. These proposals are in line with the common agricultural policy development paths proposed in 2019 by France Stratégie[29]. For some of them, they could be integrated into the eco-scheme of the future national strategic plan. In order to sustain demand and increase the willingness to pay for agroecological products, more consumer information on the environmental requirements of the various specifications appears necessary. In this perspective, four levers are to be favored:

Lever 1 – Internalize positive externalities for specifications with high requirement scores pre-sensing costs. This would involve integrating part of the cost of changing the system into the prices. To do this, it is possible to :

- Systematize the agroecological requirements in the official quality signs, recognized reference systems for which consumers are willing to pay more (Label Rouge, PDO, PGI, etc.), as proposed at the General States of Food;

- Strengthen coordination between actors in the sectors, such as exists in organic agriculture, notably through the “fonds avenir bio[30] ”, in order to develop long-term contracts that guarantee a stable income for the farmers involved in this transition. The commodity chain contracts implemented following the “États

Box 5 – Some recent financial mechanisms for the development of agroecology

Certain specific or general financing mechanisms can contribute to the development of agroecology, including those provided for in the Major Investment Plan launched at the end of 2018[31]. These include the National Initiative for French Agriculture (INAF), which mobilizes national funds and resources from the European Fund for Strategic Investments (EFSI) to guarantee the first losses of a loan portfolio. These guarantees can notably support the upgrading of production systems, the creation of added value and the transition of production systems to agroecology.

INAF is also complemented by various calls for projects, including “Agriculture and Food of Tomorrow”, which supports innovation projects (demonstration or development of a new product, process, service or business model) with a minimum total cost of 2 million euros. One of the four axes of this call for projects specifically targets the transformation of agricultural models towards agroecology.

In addition, since February 2020, 150 million euros have been mobilized by water agencies to pay for environmental services provided by farmers, particularly when they create a landscape structure for bio-diversity or change their agronomic practices to improve their environmental performance.

29. Fosse J. (2019), *Faire de la politique agricole commune un levier de la transition agroécologique*, report, France Stratégie, October
30. Quelin C. (2010), *Agriculture biologique* : La fin du retard français ? Les Études de l'ASP, ASP, Limoges.
31. https://agriculture.gouv.fr/quest-ce-que-le-volet-agricole-du-grand-plan-dinvestissement

Généraux de l'Alimentation" can provide a basis for coordination in this respect;

- Strengthen consumer recognition of HVE certification to allow consumers to be willing to pay a fair price to the farmer and to have HVE recognized at the European level in a logic of harmonization of practices;

- to strengthen support for the transition to agroecological systems (organic agriculture, HVE), to assess the impact of the tax credit for organic farms and to promote payments for environmental services in response to specific territorial issues.

Lever 2 – Supporting the economic returns for farms with high scores on environmental requirements, such as organic farming and HVE. This can be done by :

- to take into account the greater labour intensity of agroecology, which is the source of additional costs, in the parameterization of public aid schemes;

- as an extension of the call for projects "Agriculture and Food of Tomorrow", increase public investment in R&D

- to promote innovation and productivity gains, for example in plant protein chains, under-cover sowing and soil conservation techniques ;

- reinforced communication on these medium-term profitable references (by specifications, by production).

Lever 3 – Communicate better on standards with low requirement scores but with low or zero costs (case of certain Dephy farms with economic inputs). This implies :

- in the short term, to communicate the performances of low and very low-input farms that do not have transition costs;

- in the medium term, to generalize good practices and set up economic instruments leading to a reduction in the use of pesticides to reach the levels of Dephy farms (taxation of pesticides and use of the products of this tax to finance the agroecological transition).

Lever 4 – More specifically, study the costs of implementing agroecological reference systems by developing a longitudinal monitoring system for farms in transition.

CONCLUSION

The joint mobilization of these levers could contribute to the development of agroecology compatible with the improvement of the economic situation of farms. Nevertheless, as highlighted by many foresight exercises[32] , these changes in practices at farm level will have to be extended by the evolution of consumer food practices, in order to ensure the transition of our food system towards sustainability, in a global manner. The reduction of food waste and a rebalancing of the household consumption basket could help compensate for the generally higher price of food from organic or HVE agriculture compared to conventional agriculture[33]. Finally, the role of processing and distribution companies, as well as contract caterers, is determined in supporting production from farms with high environmental requirements.

Keywords: agroecology, organic agriculture, agroecological transition, common agricultural policy, synthesis inputs

32. Poux X. and Aubert P.-M. (2018), "Une Europe agroécologique en 2050: une agriculture multifonctionnelle pour une alimentation saine", *IDDRI Study*, n° 08-18, September.
33. https://www.famillesrurales.org/sites/multisite.famillesrurales.org._www/files/ckeditor/actualites/fichiers/DP%20Observatoire%20des%20Prix%20FL%20%202019_0.pdf and https://www.lyonne.fr/auxerre-89000/actualites/quelle-difference-de-prix-entre-des-courses-bio-ou-conventionnelles-nous-avons-fait-le-test-dans-l-yonne_13522159/

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