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REVIEW ARTICLE

Policies for agroecology in France: implementation and impact in practice, research and education

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HIGHLIGHTS

- **France is the first country having a law for agroecology and related policies.**
- **Success in more implementation of agroecological practices, and more conversion to organic agriculture.**
- **Failure on the reduction of pesticide use.**
- **Quicker and stronger implementation of education and training, and increased agroecology related research.**

KEYWORDS **agricultural policy, policy tools, agroecological practice, organic agriculture, sustainable agriculture, training and higher education**

Abstract

The challenge of feeding the growing world population while reducing the adverse environmental effects of agriculture will only be met by combining fundamental changes in agricultural and food systems. France is considered to be one of the first countries to develop policies in agroecology and translate them into concrete programmes and laws. This paper analyses the historical development of different agroecology-related programmes and policies and their implementation. It discusses whether they have made an impact and considers the obstacles and resisting forces that have become apparent. The work reported here is mainly based on literature review using scientific papers and grey literature and web source analysis as well using informal discussion with experts. The policy for agroecology started in 2010 with wide ranging debates about challenges for agriculture in France in preserving natural resources and developing an economically viable and socially acceptable agricultural system. In 2012, the French Ministry of Agriculture and Food launched the "Agroecological Project for France" supporting education, research and incentives for farmers to move forward with agroecology. Within this general project different sectoral programmes were set up and launched, addressing farming practices and innovation led by individuals or farmer groups. These also looked at incentivising research in national research programmes. New agricultural curricula for high schools and higher education institutions were also included in the scope of the project. The policy initiated in 2010 resulted in acceleration and stronger implementation of education and training, and in increased research focussing on certain topics. It also stimulated a certain 'transition' in the agricultural sector with a wider acceptance of agroecological approaches. It brought forward pioneers which stimulated innovation based on agroecological principles. The policy measures aimed directly at farmers have facilitated more implementation of agroecological practices, stronger recognition of the importance of biodiversity for agriculture, and increased conversion to organic agriculture regardless of the farming system. However, the French policies have failed to reduce the use of pesticides in conventional agriculture. The policy development at national level was supplemented by French initiatives at European and international level to introduce more agroecology components and principles in future policies.

1 Introduction

Feeding the currently predicted global population of 9×10^9 people in 2050 is a growing challenge in the context of climate change, land degradation, biodiversity loss, access to food, food waste, food scarcity and insecurity. These challenges come conversely with over-consumption and unbalanced diets that raise the incidences of chronic diseases affecting human health. There are strongly contrasting and highly diverse views on how to overcome these challenges and which avenues to take for the best management of future

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agriculture and food systems. Different scenarios explored the range of possibilities of feeding the projected 2050 world population by varying agricultural intensification, livestock feed composition and changes to human diet. These demonstrate that a large range of options exist without expanding the global agricultural area (Paillard et al., 2010; Couturier et al., 2017). In this respect, agroecology offers potential solutions to design sustainable agricultural and food systems and credible options to address food and environmental challenges through adoption of farming and food systems that are environmentally sound, social just, and economic viable (Muller et al., 2017; Poux and Aubert, 2018).

The term 'agroecology' was first used at the end of the 1920s (Wezel and Soldat, 2009). Since then, its meaning, definition, interpretation and approach have changed enormously up to the present. Agroecology as a scientific discipline developed slowly in the 1930s to 1960s. From the 1970s onwards, interpretations of agroecology expanded and diversified. Agroecology as a movement gradually emerged in the 1970s in addition to being a scientific discipline, and consecutively also being seen as a set of practices beginning in the 1980s (Wezel et al., 2009). Agroecology's historical evolution covers a transition from addressing the plot and field scales (1930s to 1960s) to the farm and agroecosystem scales (1970s to 2000s) (Wezel and Soldat, 2009). It has now been extended to encompass the wider dimensions of the food system (Francis et al., 2003; Gliessman, 2007).

The foundation of the agroecological movements in the 1960s and 70s were laid within the environmental movements which opposed the negative impacts of industrialised agriculture that came with the Green Revolution. In particular, the negative consequences of agricultural chemical use were highlighted. This pointed at the adverse impacts of pesticides or other toxic substances on fauna and flora and other natural resources. While more environmentally-sound approaches were advocated by environmentalists, the movement did not relate directly to the term 'agroecology' before the 1990s. Agroecology became more associated with specific agricultural and social movements in the 1990s, especially in Latin America, where the term was used to express a new way of considering agriculture and its relationships with society promoting family farming systems and food sovereignty.

Since the 1980s, a third usage of the term 'agroecology' has emerged beyond that of a science and movement. This describes a set of agricultural practices aiming at maximising the use of ecological processes in the functioning of agroecosystems. Local farmers, supported by an agroecological approach, sought to improve and adopt farming practices that do not rely anymore, or to a decreased extent, on the widespread use of chemical inputs (fertilisers, pesticides) that are used in intensive systems (see Altieri 1989, 1995; Gliessman, 2007). Conserving natural resources is the basis. This involves implementing best soil fertility management practices and favouring and enhancing agrobiodiversity on fields and farms. These practices included intercropping, cover crops, diversified rotations, no or reduced tillage, biological control, mixed crop-livestock systems and integration of semi-natural landscape elements supporting functional biodiversity (Arrignon, 1987; Altieri, 1989, 1995; Gliessman, 2007, IAASTD, 2009; Wezel et al., 2014a, 2014b).

In recent years, agroecology is increasingly seen as being able to contribute to transforming the whole agri-food systems by applying ecological principles in many dimensions such as in fertility management, plant and animal production, land use, non-food uses, and human diets. Applying the principles of agroecology to agri-food systems must be understood in relation to address simultaneously issues relating to health, food security, the protection of natural resources and biodiversity, and climate mitigation (Francis et al., 2003; Gliessman, 2007; Fritz and Schiefer, 2008; Wezel and David, 2012; Wezel et al., 2015; HLPE, 2019). At the same time, and indivisible from respecting ecological principles, it is the imperative to consider social and cultural aspects in developing equitable food systems within which all people can exercise choice over what they eat and how and where it is produced. This means that all people have sovereignty in meeting their food and nutrition requirements. Today, agroecology combines science, practice and a social movement. These complement each other, although they may not all remain in step with one another and efforts will be required to ensure effective collaboration between these components. Moreover, different policies are emerging in recent years that aim at supporting the development of agroecology in its different forms. They are mostly not yet specifically called agroecology policies but use other terms. The current negotiations on the new Common Agricultural Policy (CAP) in Europe for the period 2021 to 2027 with the 'Farm to Fork' strategy and the New Green Deal reflect debates related to agroecology even it is considered by some incompatible with tackling other crucial challenges: producing enough for Europe and the world while developing bioeconomy sectors in Europe (EC, 2018). For instance, the agroecology ten year scenario addresses this apparent dilemma by examining how much feed/food/fuel and other materials the agricultural sector could and should produce to tackle, with equal priority, challenges associated with climate change, health, the protection of biodiversity and natural resources, and the provision of a sustainable and healthy diet to Europeans without affecting global food security (Poux and Aubert, 2018).

In this paper we start with a short overview about agroecology from a European perspective before providing a description of the French case, describing instruments and policies and their implementation to support agroecology. We finally discuss the success of these policies and obstacles or hindering forces that have become apparent. The work is mainly based on review of scientific journal papers and of the grey literature. The section on policy instruments also draws on information from web sources, and on informal discussions with French and European experts. The judgement about success or failure is the judgement of the authors.

2 European context

At the European scale, there has been so far no clear EU strategy for agroecology and sustainable agriculture even if some recent discussions draw on the notion of agroecology (e.g the

Farm to Fork strategy). Consequently, national programmes, policies or action plans for agroecology are rare in Europe (currently only France, Denmark and Italy mention agroecology in their policies) and these differ widely. With the new CAP, the European Commission established a policy of 'Greening' in 2014 which requires limited agroecological practices for all direct payments. These practices encompass establishment of ecological focus areas on five percent of the agricultural land (e.g. hedgerows and other diverse habitats, but also cover crops), crop diversification on farms, and restriction on converting permanent grassland into cropland (EC, 2013; Niggli, 2015). The CAP for 2014 to 2020 included valuable elements, in addition to already existing agri-environment measures, but with limited funding and implementation so far. However, the debates on the new CAP 2021 to 2027 in Europe increasingly include discussions related to agroecology. So far, France is the only country among the EU member states to have set up an explicit "Agroecological Project for France" strategy in December 2012 (Ministère de l'Agriculture, de l'Agroalimentaire et de la Forêt, 2016a).

More recently, in May 2020, the EU Commission launched two strategies which include different elements of agroecology. The 'Farm to Fork' strategy sets ambitious objectives for example to reduce chemical pesticides by 50 %, reduce fertiliser use by at least 20 %, and achieve 25 % of total farmland and organic farming, all by 2030 (EC, 2020a). The new EU Biodiversity Strategy includes also these points and adds others such as increasing biodiversity-rich landscape elements on agricultural land, and halting and reversing the decline of pollinators (EC, 2020b).

3 Agroecology in France

3.1 Agroecology policy

In 2012, the government of France defined agroecology as the general principle of agricultural practice, supported by different laws applied to agriculture, food and forestry ('Loi d'avenir', launched on October 2014). However, the implementation of policies for agroecology in France started more than a decade ago, but without calling them agroecological at that time. The different programmes and elements include the Grenelle Environment Forum, a debate and consultation process, the Ecophyto programme, the French response to the EU Framework Directive on the sustainable use of chemical plant protection products, the Ambition Bio programme for strong development of organic agriculture, and more recently a law to promote balanced commercial relationships in the agricultural and food sector and healthy, sustainable food.

3.1.1 Grenelle Environment Forum

In 2007, the French government lead by a coalition of the conservative and liberal parties (under President Nicolas Sarkozy) launched a national debate called Grenelle de l'Environnement (Grenelle Environment Forum) bringing together the government, state and representatives of civil society to draw up a road map for the environment and sustainable development (*Figure 1*). The notion of 'agroecology' was first mentioned during a Forum meeting in October 2007 when the impact of climate change and loss of biodiversity in agriculture was discussed. Before that, the debate on agriculture in France remained dominated by macro- and micro-institutions that put food availability and agricultural production at the heart of the problem and solutions. Environmental issues were not given priority by governments for a long time. The Grenelle Environment Forum consultation process in 2007 was followed by further discussion and proposals until the new French president and government elections in 2012. The consultation process involved a large group consisting of farmers, trade unions, representatives of agri-food companies, non-governmental organisations, local authorities and public service representatives to work out policy measures. A further objective of the Forum was to establish an action plan of concrete and quantifiable measures that would be met with the broadest possible agreement among participants. Topics selected were climate change, biodiversity, environment and health, sustainable production and consumption, environmental democracy, and environmental growth and economic instruments (ESEC, 2012). The role of agriculture in relation to these topics was an important part of the debate. Some of the major achievements of the Forum include stakeholders' consensus in almost all the fields of environmental protection, and agreement that the government should adopt and implement stronger laws that reflect the final decisions adopted by the Grenelle Forum. Corporate Social and Environmental Responsibility was emphasised. The Forum also provided a platform for exchange and discussion for key actors of the civil society. One outcome was that new bilateral relations, e.g. between NGOs and unions or NGOs and local governments, have been created and developed.

3.1.2 Ecophyto – national action plan to reduce pesticide use

The Ecophyto 2018 programme was set up in 2008, just after the start of the Grenelle Forum, to reduce the use of pesticide by 50 % by 2018. The aim was train farmers and to inform them about alternatives to chemical inputs. A reference indicator was defined through active discussions between experts, representatives of agrochemical companies, civil society, and official state agencies. This indicator calculates the number and quantity of active ingredients in products, and assesses the usage intensity of plant protection active substance. Its purpose is to monitor pesticide use and progress in reduction. Since the start of the Ecophyto programme in 2008 several actions have been carried out with i) a pilot farm network that brings together 3000 farms working with alternative methods to reduced or avoided pesticide use, ii) an experimental farm network of 41 sites including 170 experimental sites testing and then demonstrating agroecological practices that do not use pesticides, iii) a strong network of higher education institutions and colleges (128 colleges of agricultural science and 3 universities of agriculture and food science decided to convert their experimental facilities to implement and test agroecology practices) with specific programmes on agroecological practices, and iv) continuous education programmes and training for current or future practitioners.

3.1.3 Action programmes for organic agriculture

The first Organic Action Plan was launched by the former Minister of Agriculture, Michel Barnier in 2007. The five-year programme aimed to increase organic production in France to cover the national demand. It also aimed to promote research and education programmes. This reflected the fact that France ranked 13 in Europe in terms of organic food production in 2006 with 50 % of consumption met by imports. Organic production covered less than 2 % of Utilised Agricultural Land (UAL) and accounted for 2 % of French farms in 2007. Organic production doubled by 2013 with 4 % of UAL and 5.3 % of French farmers practising organic agriculture. This first action programme can be considered as a success by doubling production area and number of organic farms. But consumer demand continued to increase due to a massive increase in the number of regular and occasional consumers of organic products in the supermarket (from 24 % to 40 %). Consequently, supermarkets built their expansion of organic products on imports to compensate the lack of national production. In response to this, a new organic action plan called "Ambition Bio 2017" was set up in 2012. It introduced direct payments for organic farmers and higher payments during the conversion, financial support for supply chain actors, more funds for research and dissemination, better training and education of farmers and supply chain actors, and more communication on public services to achieve a 20 % share for organic products in public catering. By 2017, the organic production had increased to 6.5 % of UAL and 8.2 % of farms. However, the ongoing increasing demand of organic food in France and Europe led policy makers to set up a further programme to support transition towards more organic production to cover increasing national and international demands. The Organic Ambition 2022 plan was launched in 2018 with the ambition to reach 15 % of UAL under organic by 2022 and a share of 20 % organic products in public catering. The massive increase of consumer demand during the last fifteen years led to the setting up of regular programmes to support organic production and consumption.

3.1.4 The 'Agroecological Project for France' supported by the new 'Law for the Future of Agriculture, Food and the Forest'

In 2012 the French Ministry of Agriculture launched the 'Agroecological Project for France' strategy (Ministère de l'Agriculture, de l'Agroalimentaire et de la Forêt, 2016a). This strategy was the start of an explicit policy in favour of agroecology. In 2014, France was the first country in the world to set up a law for agroecology, with the ambition of applying agroecology to 200,000 farms by 2025. This law, 'Loi d'Avenir' (Law for the Future of Agriculture, Food and the Forest), which was adopted in October 2014, includes agroecology as a solution to current problems in the agricultural sector. The law states that 'public policies aim to promote and sustain agroecological production systems, including organic production, which combine economic and social performance, particularly through a high level of social, environmental and health protection. More specifically, the notions of 'agroecological model' and 'agroecological measures' are mentioned in the law in Article L1, Section II of the 'Code Rural et de la Pêche Maritime' (Rural and Marine Fishery Codex), that defines the objectives of policy support for agriculture,

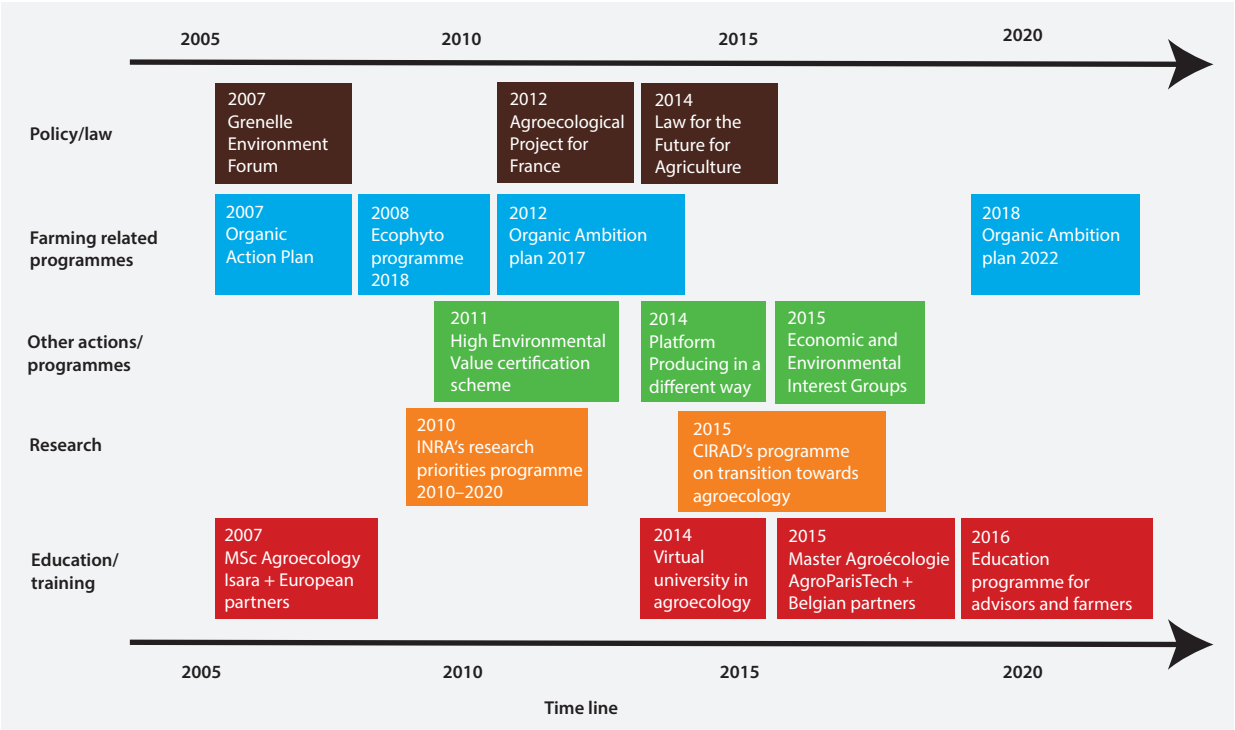

FIGURE 1
Time line of policies and programmes for agroecology in France

food and marine fisheries (Légifrance, 2017). This integration of agroecology into law is remarkable as "agroecology represents a revolution when considered in relation to the dominant agricultural production model. It claims to produce based on the functionality of ecosystems, and not by using inputs to fight environmental constraints" (Hermon, 2015).

One concrete first action in 2014 was the employment of over 200 new researchers and tutors by the French state to teach agroecology across the country as a core part of the national agricultural educational programme (Crosskey, 2014). In addition, the agroecology policy and law were implemented to address growing concern about France's ageing farmers. Forecasts showed that about 40 % of France's agricultural workforce would retire within five years or were already past retirement age. This created a pressing need to train a new generation of farmers who can take over farms and create more jobs in the sector. Soil protection is therefore a high-priority issue for France, especially in terms of the preservation of farmland and the implementation of policies and measures for carbon enrichment and sequestration in soils. In this context, France specifically advocates the '4 per 1,000 initiative: Soils for Food Security and Climate'.

In addition to the national project for agroecology launched by the French minister of agriculture in 2012, an international plan focused on the FAO was added in 2014 (Loconto and Fouilleux, 2019).

3.1.5 Programmes and platforms supporting the 'Agroecology Project for France'

Agroecology platforms

Different programmes and platforms supported the 'Agroecology Project for France'. One platform was 'Agricultures: Producing in a different way' which has been launched in 2012 to promote the policy to make France a nation of environmental excellence (Bellon and Ollivier, 2018). This platform existed for a few years but has been placed now under the general website of the French Ministry of Agriculture and Nutrition providing related information (Ministère d'Agriculture et de l'Alimentation, 2019b).

Economic and Environmental Interest Groups

The promotion and establishment of Economic and Environmental Interest Groups (in French GIEE), of which 527 have been created since 2015 with 492 still active in 2019 (Ministère de l'Agriculture et de l'Alimentation, 2019c) are tangible outcomes of the new law for 'Future of Agriculture, Food and the Forest' (Section 3.4). These farmer groups including about 8000 farms and 9500 individual farmers were developed to support agroecological initiatives. Farmer groups can apply for the programme and also get some financial support from regional governments. The programme is quite similar to the previous presented Ecophyto policy favouring the implementation of more agroecological practices and supporting the transition of individual farms, education and extension facilities (e.g. experimental sites) to test agroecology. The major topics of the GIEE are i) reduction of pesticide use and use of synthetic fertilisers, ii) feed autonomy of livestock farms, and iii) conservation agriculture practices.

'High Environmental Value' certification scheme

The French Ministry of Agriculture launched a policy in 2011 with a new system of 'High Environmental Value' (HVE) certification for agricultural operations to promote their engagement in practices that are especially beneficial for the environment. This encourages farmers to enhance biodiversity conservation, decrease the negative environmental impacts of pesticide use, and improve management of fertiliser inputs and water resources. Farmers need to reason their practices based on agroecological principles at the whole farm level taking into account also the natural area on the farm (Ministère de l'Agriculture, de l'Agroalimentaire et de la Forêt, 2016c). It is intended to be complementary to the organic certification and to be seen also as potentially bringing a premium for farmers when marketing these products. In April 2019, the first supermarket chain in France declared the intention to enlarge their products with a HVE certification to favour for the development of agroecology (AgroMedia, 2019). By March 2019, 8 % of family farms dedicated to crop production were involved in the HVE certification scheme. Therefore, the Ministry of Agriculture and Food has recognised 74 territorial food supply action plans in 47 regions. These territorial action plans aim to promote optimum use of local resources – leading to a detailed management of nutrient flows at the territorial level – with the willingness to support dietary change. In particular, diets should contain less animal product (but better quality), less sugar, higher fibre intake and increase consumption of in-season fruit and vegetables.

3.2 Research on agroecology

Research in France on agroecology has developed gradually since 2000, in most cases coming from researchers in agronomy who questioned their discipline amidst increasing criticism about environmental and health problems related to agriculture. They saw the need to legitimise the application of ecology to agriculture (Bellon and Ollivier 2018). Since 2010, INRA, renamed INRAE in 2020 (National Research Institute for Agriculture, Food and Environment), has developed a priority programme on agroecology. This has impacted drastically on their strategy (Guillou et al., 2010). For instance, some joint research units, grouping 80 to 150 researchers from various disciplines, are fully dedicated to agroecology (Wezel et al. 2018). These include for example:

- Joint research unit 'Agroecology', consisting of researchers from INRAE Dijon, CNRS Dijon, AgroSup Dijon, and the University of Burgundy, Dijon.
- Joint research unit 'Agroecologies, Innovations and Ruralities', a cooperation of INRAE, ENSAT and INP at Toulouse.
- Joint research unit 'Health and Agroecology of Vineyards' combining researchers from INRAE Bordeaux, Bordeaux Sciences Agro, Institute of Vine & Wine Science, Bordeaux.
- Joint research unit 'Biodiversity, Agroecology and Landscape Management', a cooperation of researchers from Agrocampus Ouest and ESA, Angers, and INRAE, Rennes.

Some of the INRAE research units gradually introduced the name 'agroecology' between 2006 and 2009 (Bellon and Ollivier, 2018). Other institutions followed later.

One example is CIRAD (Agricultural Research for Development), a French applied research institution specialised in the tropics and subtropics, that launched a specific programme on transition towards agroecology in 2015 (Côte et al., 2019). They created a research unit 'Agroecology and Sustainable Intensification of Annual Crops' to develop ecological intensification of cropping systems. Also, Isara, an institute for higher education and research in Lyon, launched a research unit called 'Agroecology and Environment' in 2014 that deals with different research topics in agroecology, and interacts with the social science unit in agroecology and the food systems research. A similar institute for higher education, ESA Angers, has a research unit 'Leguminosae, Plant Ecophysiology, Agroecology'.

A strong reinforcement of agroecology in the French national research agenda started with INRAE's strategic research orientation plan 2010-2020 (INRA, 2010). Agroecology was acknowledged as a new science by INRAE. It was also framed in terms of a joint environmental and economic performance in response to the governmental framing (Guillou et al., 2013; Bellon and Ollivier, 2018). For INRAE and CIRAD, "agroecology is often seen as a cross between ecology and agriculture, aimed at designing and managing sustainable agro-ecosystems. It also draws on economics and social sciences to develop reliable systems and roll them out through appropriate public policy and support mechanisms. Agro-ecology therefore offers a new paradigm for creating sustainable food systems" (INRA and CIRAD, 2016).

3.3 Education and training in agroecology

In order to train the future generation of agroecologists, universities and other intuitions of higher education created education programmes in agroecology in Europe. Several of the master programmes (MSc – Master of Science) are international and organised by a consortium of universities from different countries, among them French institutions (see more details in Wezel et al., 2018). Some of these programmes are run as double degrees with two or more universities involved, the first one was created in 2007 (Isara, France – NMBU, Norway). Moving from one university to another allows the student to have a diversified academic and practical (e.g. case studies) experience of agroecology. Moreover, the programmes gather a diversity of nationalities and backgrounds, especially for those taught in English. Another programme with the AgroParisTech and Belgian universities was launched about 8 years later. There are also several French national BSc-level programmes that recently revised their curricula to introduce agroecology concepts with 17 programmes of two years and 8 programmes of three years (Ministère de l'Agriculture, de l'Agroalimentaire et de la Forêt, 2014; Ajates Gonzales et al., 2018). In particular, the so-called BTS programmes (more practice-oriented BSc programmes) should include agroecology in their curricula (this was carried out, but without changing the titles of the programmes). Besides the MSc and BSc programmes, there is also a virtual university in agroecology which started in 2014 (UVAE, 2019).

The challenge today is largely about promoting agroecology. Twelve key actions have been set up by the French Ministry of Agriculture to support transition towards agroecology (Ministère de l'Agriculture, de l'Agroalimentaire et de la Forêt, 2016b) by 2025 for a majority of French farmers. Education programmes for advisers and farmers were set up in 2016 to disseminate experience from the first pioneers (see section Economic and Environmental Interest Group). Moreover, there is a fund (VIVEA) for training farmers in France. It includes also more specialised training in agroecology in recent years. These are often several-day, highly practical, instructor-led training events. An increasing amount of training in agroecology is now offered by various institutions, associations and NGOs.

4 Discussion

In France, agroecology started to become more visible in 2008, mainly due to social movements like Colibris founded in 2006 by Pierre Rahbi and colleagues. These support agrobiodiversity-rich, and fair family-run agriculture (Norder et al., 2016). Curiously, agroecology was also been advocated a bit later by some conventional agri-food business organisations (Bellon and Ollivier, 2011, cited in Norder et al., 2016) to develop a new model between conventional and organic agriculture. Despite this, the concept of agroecology was practically non-existent before 2012 among conventional agriculture organisations and was also criticised by the dominant French agricultural union (FNSEA) working closely with the agricultural chambers (Norder et al., 2016). In contrast, the Confederation Paysanne, the traditionally left-wing agricultural union, has been a staunch supporter of agroecology movements in and outside France such as Via Campesina and has strongly supported small and medium-sized family farms engaged in organic conversion.

One explanation for this is that agroecology was not really a feature of the French agricultural policy debate before 2012. Instead, the terms and concepts of "ecoagriculture" and "ecologically intensive agriculture" predominated (Bellon and Ollivier, 2018). Agroecology gained more legitimacy internationally in preceding years with for example the International Assessment of Agricultural Knowledge, Science and Technology for Development report (IAASTD, 2009) and the right to food report of De Schutter (2010). A further push forward for the visibility of the term agroecology from 2010 onwards in France can be attributed to the launch of INRAE's strategic research orientation plan 2010 to 2020 (INRA 2010), highlighting agroecology in future research.

4.1 Impact of policies

The policies and programmes for agroecology developed in France vary greatly in their impacts. The first and stronger impacts can be seen with research and education. New research programmes (both with state funding and funding from foundations) were established with a specific focus on agroecology or on topics that are indirectly related to

agroecology. New programmes in agroecology were launched in higher education, although some existed already before policies started, and some high school programmes included agroecology concepts.

For practical application in farming, the Economic and Environmental Interest Group programme has promoted farmers' initiatives to develop and implement agroecological practices such as biological control, cover crops, no till, and organic practices. These interest groups developed rapidly after agroecology became integrated into French law showing that such regulation can be an important catalyst for its development supporting pioneers' implementation of agroecology. Overall, the policies of the 'Agroecology Project for France' remained modest because of limited funding (Bellon and Ollivier, 2018).

Varied impact with the Ecophyto programme

The impact of the Ecophyto programme to reduce pesticide use shows quite divergent results. Some advances have been made and positive outcomes can be seen, e.g. the establishment of demonstration cases with pilot farms based on reduced or no use of pesticides and creation of Ecophyto farm networks. This included a network of thousands of farms that test and apply methods that reduce the use of chemical plant protection products, improved national surveillance of pests and plant diseases, and funded research on technologies and techniques that reduce pesticide use. Nearly 500 million Euros has been spent on implementing the Ecophyto programme so far. From 2010 to 2018, the 3000 pilot farms have reduced their pesticide use by 18 % (Ministère de l'Agriculture et de l'Alimentation, 2019a).

Overall, the Ecophyto 2018 policy has critically failed as indicated by an 14 % increase in pesticide use for the whole agricultural sector (Lamichhane et al., 2019). This contrasts with a 38 % decline in use in non-agricultural areas (e.g. public gardens, roads). By 2016 pesticide consumption in France increased by 17 % compared to 2011 (Eurostats, 2018) and the highest ever consumption of pesticides was recorded in 2018 (Eurostats, 2019). The failure of this policy brings to light the dependency of French agriculture on pesticides especially on perennial crops such as grape vines, fruit crops, vegetables and industrial crops. However, in the last two years, the dramatic droughts in France have potentially alerted farmers of the need to limit inputs like pesticides where production is constrained.

Agroecology is well recognised

In January 2017, 83 % of farmers interviewed stated that they had heard about agroecology, against 79 % in 2016 and only 50 % in 2015 (Gramond 2015, 2016). Additionally, 73 % of farmers have already engaged in at least three agroecological practices. This was 83 % for young farmers. This indicates that agroecology supports the joint realisation of environmental and economic outcomes that was a leading paradigm for the French agroecology policy, and is now an underlying trend in French agriculture. Nowadays, the major French agricultural union is slowly increasing its support of agroecology but seeing it as a set of practices. This is for example in contrast to the national farmers union in Canada that considers agroecology as a holistic approach to food production that uses social, cultural, economic and environmental knowledge to promote food sovereignty, social justice, economic sustainability, and healthy agricultural ecosystems (National Farmers Union, 2015). The French FNSEA agricultural union also clearly announced that they will support an agroecological transition only if the European Commission and France reconsider the economic dimension of agriculture, with ongoing debates in France and about the new EU CAP.

Development of organic farming

There was some growth in the area of agricultural land under organic farming rising from under 2 % in 2006 to 7.5 % in 2018. The number of organic farms rose from 3 % to 9.5 % in the same period (Agence Bio, 2019). Organic agriculture support programmes may have played a role, but markets were the main driver as more consumers as well as the French and international markets demanded more organic products. Moreover, the growing number of farmers converting to organic agriculture resulted in a larger and more diverse offer of organic products of French origin on the national market.

The conflict between conventional and organic production, historically supported by the differing positions of the two major farmers' unions (e.g. the conservative FNSEA farmers' union supported the conventional agricultural model, whereas the Confederation Paysanne supported the organic movement), did not help the development of organic production. Nevertheless, with fears over GM crops, health scandals and crises in agriculture, more consumers are changing their dietary habits, supporting the booming of the organic market since the beginning of the 21th century, in and outside France.

Ambiguity within agroecology and between agroecology and organic agriculture

With the launch of the agroecology policy, it became evident that many stakeholders have difficulty seeing how agroecology is different from organic agriculture (Migliorini and Wezel, 2018). For some it is more or less the same, other see large differences. Many 'conventional' farmers see organic agriculture as a clearly different way of farming, involving another way of thinking and conviction. Therefore, there is a risk that some farmers reject agroecology because the agroecology policy includes the promotion of organic agriculture in France. Moreover, most farmers and other stakeholders have difficulty understanding what agroecology is. This is related to different interpretations and definitions, which are in addition differently present in different countries of the world (Wezel et al., 2009; Méndez et al., 2013; Agroecology Europe, 2017; Gliessman, 2018). So, there might be confusion or even rejection when policies are not explicit enough about what they mean by agroecology. The policies in France relate more to certain elements of agroecology, such as agroecological practices and farming systems that jointly improve environmental and economic performance at the production level. For the most part, they do not address elements of the food system, or even transformation of the current food system,

which is seen as an essential part of agroecology today (Francis et al., 2003; Gliessman, 2007; Wezel et al., 2015; Ajates Gonzales et al., 2018; Poux and Aubert, 2018; HLPE, 2019). Only recently, the law for Agriculture and Food in 2018 (Ministère de l'Agriculture et de l'Alimentation, 2019d) addressed wider aspects of food systems which is an important component of the larger definition of agroecology (Wezel et al., 2009; Wezel and Soldat, 2009). However, the law does not make a clear link to agroecology and does not even state the term (Legifrance, 2018). It includes sub-points such as i) a target of 50 % of local products or origin- and quality-labelled products (including organic) in the public-sector institutional catering by 2022, or ii) intensification of efforts to control food waste (Ministère de l'Agriculture et de l'Alimentation, 2019d), both which relate to the food systems dimension of agroecology. But other sub-points such as i) a ban on neonicotinoids and other products with identical modes of action in order to protect biodiversity and bees, or ii) a separation of sales activity from advisory services for plant protection products, are much more specific and more advanced compared to the former agroecology law.

Although the discourse of the French Ministry of Agriculture presents agroecology as a new paradigm, the framing of agroecology is intended more to be in tune with public action processes and to gain support for agricultural development policies amongst a large diversity of agri-food stakeholders. This is even associated with more intensive and competitive agricultural models (Ajates Gonzales et al., 2018). The assumption is that to continue to be supported by society, agriculture policy has to clearly demonstrate that it is meeting society's contemporary needs. Social expectations regarding healthy diets, the protection of natural resources and biodiversity are becoming increasingly apparent in France and at the European level. The French government clearly promotes "family-based and sustainable farming to bring about the ecological transition, improvements in agricultural practice to meet the expectations of the public and fair remuneration for the actors involved, all this with the application of the same rules to countries exporting to the European Union" (Ministère de l'Agriculture et de l'Alimentation, 2018). Faced with production and market globalisation, France needs to overcome a number of major challenges regarding the social and economic viability of the agricultural sector. Strong lobbying by French agricultural unions and major companies tend to limit the transition towards a wide ranging agroecological model.

One major difficulty is that so far only organic agriculture is clearly labelled and certified in a way which is visible to consumers. The development of 'high environmental value' (HVE) certification label in France could be a tentative opportunity for future agroecology labelling. This supports the labelling of farms, among them a share of 50 % of independent vine growers. It is less visible so far on other products. These different certifications and the growing number of other public and private certification schemes have led to confusing messages for consumers. For example, there is a more recent development of new guidelines for 'regenerative agriculture' supported by large national and international companies (e.g. Danone, Nestlé) or 'living agriculture' ('agriculture du vivant') supported by a group of French food industry players. Moreover, the search for market recognition with a brand or label integrating the principles of agroecology was led by the INAO (Institut National de l'Origine et de la Qualité) in 2016. But apart from the organic sector, the proposal was contested at this time by most affected organisations (Bellon and Ollivier, 2018). Generally, the private companies' 'living agriculture' and 'regenerative agriculture' labelling/certification schemes and the public certification of HVE certification scheme can be regarded as agroecology schemes designed to support business opportunities. The policy and private trend towards new agroecology certification schemes could create even more confusion with the strong growth of organic certification (Migliorini and Wezel, 2018).

4.2 The role of visionary politicians and charismatic leaders

The "Agroecological Project for France" launched in 2014 was strongly promoted by Stéphane Le Foll, Minister of Agriculture and former member of the European parliament and one of the founders of the European think tank Groupe Saint Germain (Guilloux and Denoux, 2014). Edgard Pisani, minister of agriculture from 1961 to 1966, created this think tank. Pisani was a visionary politician and one of the founders of a European policy for agriculture. This charismatic leader focused first on the recognition of family farms and diversity. This was followed by consideration of a better connection between agriculture and citizens' awareness regarding environmental protection and food quality.

The political changeover in 2017 with the new President Emmanuel Macron and the new party has not (yet) induced profound changes despite the departure of the charismatic Stéphane Le Foll from the Ministry of Agriculture. The policies for agroecology continue but are not as visible with new programmes or regulations as they once were. For example, the discussion about a ban of glyphosate has not yet reached a decision. Moreover, many policy debates focus since 2019 more on the new European CAP policy (Ministère de l'Agriculture et de l'Alimentation, 2018). The development of agroecology in France is now surprisingly supported by the large French farming union (FNSEA) although they strongly criticised the organic movement in the past.

4.3 Lobbying at international level

France was first in launching a national policy for agroecology. This was quickly followed by policy initiatives at an international level. France played an important role in supporting and promoting agroecology at the FAO and with other initiatives such as the carbon sequestration initiative '4 per 1000' recognised in the world as a prominent and leading initiative to promote agroecology. This initiative, launched in Paris at the COP 21 of the Climate Change Convention, aims to increase the soil organic matter content and carbon sequestration through the implementation of agricultural practices adapted to local environmental, social and economic conditions. This involves in particular agroecology, agroforestry, and conservation agriculture.

Furthermore, France was among the initiators of the first agroecology symposium of the FAO in 2014 and provided significant funding (Loconto and Fouilleux, 2019). Moreover, France is member of the Friends of Agroecology group that promotes the development of policy for agroecology (Bellon and Ollivier, 2018). The group was created in 2015, and currently includes 17 countries (Brazil, China, Estonia, France, Ivory Coast, Hungary, Iran, Italy, Ireland, Japan, Madagascar, Mexico, Senegal, Slovenia, Switzerland, The Netherlands, Venezuela). It is an informal and open group, composed of permanent members wishing to support the FAO's work on agroecology, to exchange their national experiences with each other, and to develop scientific partnerships.

Finally, France has also supported new job positions related to agroecology at FAO. Moreover, France is also represented in the Committee on World for Food Security (CFS), an international and intergovernmental platform for stakeholders to work together to ensure food security and nutrition in the world. The Committee reports to the UN General Assembly and to the FAO, and is technically supported and based with the secretariat at the FAO. In the CFS, France chaired until recently the steering committee giving guidance to the HLPE (High Level of Experts) carrying out an expert assessment of "Agroecological approaches and other innovations for sustainable agriculture and food systems that enhance food security and nutrition" ending in early summer 2019 (CFS, 2018; HLPE, 2019).

Overall, it can be stated that France played an important role in the international political arena to support expanding discussion and debates for alternatives to the present agricultural models as well as for upscaling of agroecology at the international level.

5 Conclusions

The policy for agroecology started with debates about environmental and natural resource management in France. This translated into a national programme, involving different sectoral programmes, and finally also a law for agroecology in 2014. Sectoral programmes were set up and launched with respect to farming practices and innovation by individual or farmer groups, research incentives for national research programmes were provided, and new agricultural curricula for high schools and higher education institutions were developed. However, the success of the different programmes and policies varies significantly in terms of their impact so far:

1. There has been a quicker and stronger implementation of education and training, and increased research focussing on certain topics.
2. The policy also started a 'movement' in the agricultural sector and brought forward pioneers which stimulated innovation in agroecology such as with the Environmental and Economic Interest Groups.
3. The agroecology policy has facilitated more implementation of agroecological practices, stronger recognition of the importance of biodiversity for agriculture, and more conversion to organic agriculture, but failed to reduce the use of pesticides.
4. French policy on agroecology has clearly demonstrated that it is meeting society's contemporary needs.
5. And finally, the policy development at national level was complemented by lobbying at international level, supporting national implementation.

Overall, some of the sectoral programmes also delivered progress towards sustainable conventional agriculture. The overall agroecology programme also raised awareness about how to farm for the future. It drew attention to the importance of biodiversity and diversification in agriculture, and increased interest in the process quality and re-localisation of food products. Changes and adaptations in education provided a foundation. However, the overall impact might be regarded as limited. But such fundamental change needs more time as is evident from the history of the Green Revolution. Moreover, if the EU agricultural policy with the Farm to Fork strategy and the New Green Deal does not include more elements of agroecology, impact and changes might remain very restricted also in France as the national policies regarding agriculture are framed by EU policy. To scale agroecology up and to further integrate it within the main farming and food systems, much stronger political support and a regulatory framework, both at national and European levels is required. France and its policy for agroecology can be seen as a precursor, at least for now. France will need to pull its weight in the EU and make sure that Farm and Fork and New Green Deal are fully allied with its agroecology policy, otherwise the 10 years of mixed success, but success still, will have been partly in vain.

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REFERENCES

Agence Bio (2019) Les chiffres clefs [online]. Retrieved from <https://www.agencebio.org/wp-content/uploads/2019/06/DP-AGENCE_BIO-4JUIN2019.pdf> [at 30 Nov2020]

Agroecology Europe (2017) Our understanding of agroecology [online]. Retrieved from <http://www.agroecology-europe.org/our-approach/our-understanding-of-agroecology> [at 30 Nov 2020]

AgroMedia (2019) Leclerc fait le choix de la certification HVE pour ses fruits et légumes [online]. Retrieved from <https://www.agro-media.fr/actualite/leclerc-fait-le-choix-de-la-certification-hve-pour-ses-fruits-et-legumes-33117.html> [at 30 Nov 2020]

Ajates Gonzales R, Thomas J, Chang M, (2018) Translating agroecology into policy: the case of France and the United Kingdom. Sustainability 10(8): 2930, doi:10.3390/su10082930

Altieri MA (1989) Agroecology: A new research and development paradigm for world agriculture. Agr Ecosyst Environ 27(1–4):37-46, doi:10.1016/0167-8809(89)90070-4

Altieri MA (1995) Agroecology: the science of sustainable agriculture. 2nd edition. Boulder, CO: Westview Press, 433 p

Arrignon J (1987) Agro-écologie des zones arides et sub-humides. Paris: Editions G-P Masonneuve & Larose et ACCT, 283 p

Bellon S, Ollivier G (2018) Institutionalizing agroecology in France: Social circulation changes the meaning of an idea. Sustainability 10(5):1380, doi:10.3390/su10051380

CFS (2018) Agroecology & Innovations for FSN [online]. Retrieved from <http://www.fao.org/cfs/cfs-hlpe/news-archive/detail/en/c/1103100> [at 28 Feb 2019]

Couturier C, Charru M, Doublet S, Pointereau P (2017) The Afterres 2050 scenario [online]. Association Solagro. Retrieved from <https://afterres2050.solagro.org/2020/02/929/> [at 01 Dec 2020]

Côte FX, Poirier-Magona E, Perret S, Roudier P, Rapidel B, Thirion MC (eds) (2019) La transition agro-écologique des agricultures du Sud. Versailles: Edition Quae, 368 p

Crosskey P (2014) Conversion to agroecology: France's hopes for environmental salvation [online]. ARC2020, 28 p. Retrieved from <https://www.arc2020.eu/wp-content/uploads/2016/01/151228-pesticides-download-rev3-less-compressed.pdf> [at 01 Dec 2020]

De Schutter O (2010) Report submitted by the Special Rapporteur on the right of food, Oliver de Schutter. Human Rights Council, 16th session. Geneva: United Nations, 21 p, A/HRC/16/49. Retrieved from <https://www2.ohchr.org/english/issues/food/docs/a-hrc-16-49.pdf> [at 17 Sept 2020]

ESEC (2012) Bilan du Grenelle de l'environnement : pour un nouvel élan [online]. Retrieved from <https://www.lecese.fr/travaux-publies/bilan-du-grenelle-de-l-environnement-pour-un-nouvel-elan> [at 01 Dec 2020]

EC, European Commission [2013] CAP Reform – an explanation of the main elements [online]. MEMO/13/937, 9 p. Retrieved from <https://ec.europa.eu/commission/presscorner/detail/en/MEMO_13_937> [at 01 Dec 2020]

EC, European Commission (2018) A sustainable bioeconomy for Europe: strengthening the connection between economy, society and the environment [online]. 107 p. Retrieved from <https://ec.europa.eu/knowledge4policy/publication/sustainable-bioeconomy-europe-strengthening-connection-between-economy-society_en> [at 01 Dec 2020]

EC, European Commission (2020a) Farm to Fork strategy – for a fair, healthy and environmentally-friendly food system [online]. Retrieved from <https://ec.europa.eu/food/farm2fork_en> [at 01 Dec 2020]

EC, European Commission (2020b) EU Biodiversity strategy for 2030 [online]. Retrieved from <https://ec.europa.eu/info/strategy/priorities-2019-2024/european-green-deal/actions-being-taken-eu/eu-biodiversity-strategy-2030_en> [at 01 Dec 2020]

Eurostat (2018) Pesticide sales, percentage change 2016 compared with 2011 for 16 EU member states [online]. Retrieved from <https://ec.europa.eu/eurostat/statistics-explained/index.php?title=File:Pesticide_sales,_percentage_change_2016_compared_with_2011_for_16_EU_Member_States_.png&oldid=398428> [at 01 Dec 2020]

Eurostat [2019] Agri-environmental indicator – consumption of pesticides [online]. Retrieved from <https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Agri-environmental_indicator_-_consumption_of_pesticides> [at 01 Dec 2020]

Francis C, Lieblein G, Gliessman S, Breland TA, Creamer N, Harwood R, Salomonsson L, Helenius J, Rickerl D, Salvador R, et al. (2003) Agroecology: the ecology of food systems. J Sustain Agric 22(3):99–118, doi:10.1300/J064v22n03_10

Fritz M, Schiefer G (2008) Food chain management for sustainable food system development: a European research agenda. Agribusiness 24(4): 440–452, doi:10.1002/agr.20172

Gliessman SR (2007) Agroecology: the ecology of sustainable food systems. New York: CRC Press, 384 p

Gliessman SR (2018) Defining agroecology. Agroecol Sustain Food Syst 42(6):-599–600, doi:10.1080/21683565.2018.1432329

Gramond F (2015) Perception de l'agroécologie par les agriculteurs [online]. Retrieved from <https://www.bva-group.com/sondages/perception-de-lagro-ecologie-par-les-agriculteurs-francais/> [at 15 Dec 2020]

Gramond F (2016) Perception de l'agro-écologie par les agriculteurs français. Evolution depuis un an [online]. Retrieved from <https://agriculture.gouv.fr/sites/minagri/files/presentation_bva_agro-ecologie_15-16_v3_revbh.pdf> [at 15 May 2019]

Guillou M, Guyomard H, Huygue C, Peyraud JL (2013) Le projet agro-écologique: vers des agricultures doublement performantes pour concilier compétitivité et respect de l'environnement. Propositions pour le Ministre [online]. 163 p. Retrieved from <https://agriculture.gouv.fr/sites/minagri/files/documents//rapport_marion_guillou_cle05bdf5.pdf> [at 15 Dec 2020]

Guillou M, Riba G, Houllier F, Eddi M, Leverve X, Guyomard H, Soussana JF, Chemineau P (2010) INRA's scientific priorities for 2010–2020: targeted research [online]. 19 p. Retrieved from <https://hal.inrae.fr/hal-02819525/document> [at 01 Dec 2020]

Guilloux JM, Denoux P (2014) L'intelligence est dans le pré. Penser la ruralité du XXIème siècle. Paris: Edition François Bourin, 340 p

Hermon C (2015) L'agroécologie en droit: état et perspectives [online]. Revue juridique de l'environnement 40(3): 407–422. Retrieved from <https://www.cairn.info/revue-revue-juridique-de-l-environnement-2015-3-page-407.htm> [at 01 Dec 2020]

HLPE (2019) Agroecological and other innovative approaches for sustainable agriculture and food systems that enhance food security and nutrition. A report by the High Level Panel of Experts on Food Security and Nutrition of the Committee on World Food Security. Rome: HLPE c/o FAO, 163 p. Retrieved from <http://www.fao.org/3/ca5602en/ca5602en.pdf> [at 10 Sept 2020]

IAASTD (2009) Global report: International Assessment of Agricultural knowledge, science and technology for development. Washington: Island Press, 592 p, Agriculture at a crossroads. Retrieved from <https://www.weltagrarbericht.de/fileadmin/files/weltagrarbericht/IAASTDBerichte/GlobalReport.pdf> [at 10 Dec 2020]

INRA (2010) Document d'orientation INRA 2010–2020: une science pour l'impact. 56 p. Retrieved from <https://hal.inrae.fr/hal-02823708/document> [at 10 Dec 2020]

INRA, CIRAD (2016) Agro-ecology. Strategic research at INRA and CIRAD [online]. 8 p. Retrieved from <https://www.cirad.fr/en/news/all-news-items/articles/2016/institutionnel/agro-ecology-cirad-and-inra-showcase-their-joint-position> [at 10 Dec 2020]

Lamichhane JR, Messéan A, Ricci P (2019) Research and innovation priorities as defined by the Ecophyto plan to address current crop protection transformation challenges in France. Adv Agron 154:81–152, doi:10.1016/bs.agron.2018.11.003

Légifrance (2017) Code rural et de la pêche maritime. Livre Préliminaire: Objectifs de la politique en faveur de l'agriculture, de l'alimentation et de la pêche maritime [online]. Retrieved from <http://www.legifrance.gouv.fr/affichCode.do?cidTexte=LEGITEXT000006071367> [at 15 Dec 2017]

Légifrance (2018) LOI no 2018-938 du 30 octobre 2018 pour l'équilibre des relations commerciales dans le secteur agricole et alimentaire et une alimentation saine, durable et accessible à tous [online]. Retrieved from <https://www.legifrance.gouv.fr/affichLoiPreparation.do?idDocument=JORFDOLE000036562265&type=general&typeLoi=proj&legislature=15> [at 01 Dec 2020]

Loconto A, Fouilleux E (2019) Defining agroecology: Exploring the circulation of knowledge in FAO's global dialogue. IJSAF 25(2):116–137. Retrieved from <https://d0f777f0-44f0-4115-a90d-3efac4187b3c> [at 10 Dec 2020]

Méndez VE, Bacon CM, Cohen R (2013) Agroecology as a transdisciplinary, participatory, and action-oriented approach. Agroecol Sustain Food Syst 37(1):3–18, doi:10.1080/10440046.2012.736926

Migliorini P, Wezel A (2018) Converging and diverging principles and practices of organic agriculture regulations and agroecology. A review. Agron Sustain Dev 37:63, doi:10.1007/s13593-017-0472-4

Ministère de l'Agriculture, de l'Agroalimentaire et de la Forêt (2016a) Le projet agro-écologique en France [online]. Retrieved from <http://agriculture.gouv.fr/agriculture-et-foret/projet-agro-ecologique> [at 15 Jan 2019]

Ministère de l'Agriculture, de l'Agroalimentaire et de la Forêt (2016b) Le projet agro-écologique en 12 clés [online]. Retrieved from <https://agriculture.gouv.fr/le-projet-agro-ecologique-en-12-cles> [at 01 Dec 2020]

Ministère de l'Agriculture, de l'Agroalimentaire et de la Forêt (2016c) Bio et haute valeur environnementale : deux modes de valorisation complémentaires [online]. Retrieved from <https://agriculture.gouv.fr/bio-et-haute-valeur-environnementale-deux-modes-de-valorisation-complementaires> [at 01 Dec 2020]

Ministère de l'Agriculture et de l'Alimentation (2018) European and international strategy 2018–2022 [online]. Retrieved from <https://agriculture.gouv.fr/la-strategie-europe-et-international-2018-2022-du-ministere-de-lagriculture-et-de-lalimentation/en> [at 1 Dec 2020]

Ministère de l'Agriculture et de l'Alimentation (2019a) Les fermes Dephy: partout en France, des systèmes de production performants et économes en pesticides [online]. Retrieved from <https://agriculture.gouv.fr/les-fermes-dephy-partout-en-france-des-systemes-de-production-performants-et-economes-en-0> [at 1 May 2019]

Ministère de l'Agriculture et de l'Alimentation (2019b) Alim'agri [online]. Retrieved from <https://agriculture.gouv.fr/mots-cles/alimagri> [at 15 Febr 2019]

Ministère de l'Agriculture et de l'Alimentation (2019c) Les groupements d'intérêt économique et environnemental (GIEE) [online]. Retrieved from <http://agriculture.gouv.fr/les-groupements-dinteret-economique-et-environnemental-giee> [at 15 March 2020]

Ministère de l'Agriculture et de l'Alimentation (2019d) Infographics – Law to promote balanced commercial relationships in the agricultural and food sector and healthy, sustainable food [online]. Retrieved from <https://agriculture.gouv.fr/infographics-law-promote-balanced-commercial-relationships-agricultural-and-food-sector-and-healthy> [at 01 Dec 2020]

Muller A, Schader C, Scialabba NEH, Brüggemann J, Isensee A, Erb KH, Smith P, Klocke P, Leiber F, Stolze M, Niggli U (2017) Strategies for feeding the world more sustainably with organic agriculture. Nat Commun 8:1290, doi:10.1038/s41467-017-01410-w

National Farmers Union (2015) Agroecology in Canada: Food sovereignty in action [online]. Retrieved from <https://www.nfu.ca/wp-content/uploads/2018/05/Agroecology-booklet-eng-final.pdf> [at 15 May 2019]

Niggli U (2015) Incorporating agroecology into organic research – an ongoing challenge. Sustain Agric Res 4(3):149–157, doi:10.5539/sar.v4n3p149

Norder LA, Lamine C, Bellon S, Brandenburg A (2016) Agroecology: polysemy, pluralism and controversies. Ambient Soc 19(3):1–20, doi:10.1590/1809-4422ASOC129711V1932016

Paillard S, Treyer S, Dorin B (eds) (2010) Agrimonde: scénarios et défis pour nourrir le monde en 2050. Versailles: Editions Quae, 295 p

Poux X, Aubert PM (2018) An agroecological Europe in 2050: multifunctional agriculture for healthy eating. Findings from the ten years for agroecology (TYFA) modelling exercise [online]. 74 p. Retrieved from <https://www.iddri.org/en/publications-and-events/study/agroecological-europe-2050-multifunctional-agriculture-healthy-eating> [at 10 Dec 2020]

UVAE, Université Virtuelle d'Agroécologie (2019) Ressources pour la formation en ligne à l'agroécologie [online]. Retrieved from <https://www6.inra.fr/uvae/> [at 01 Dec 2020]

Wezel A, Bellon S, Doré T, Francis C, Vallod D, David C (2009) Agroecology as a science, a movement and a practice. A review. Agron Sustain Dev 29: 503–515, doi:10.1051/agro/2009004

Wezel A, Casagrande M, Celette F, Vian JF, Ferrer A, Peigné J (2014a) Agroecological practices for sustainable agriculture. A review. Agron Sustain Develop 34:1–20, doi:10.1007/s13593-013-0180-7

Wezel A, David C (2012) Agroecology and the food system. In: Lichtfouse E (ed) Agroecology and strategies for climate change. Dordrecht: Springer, 17–33, doi:10.1007/978-94-007-1905-7

Wezel A, David C (2019) French policy for agroecology – development, implementation, and lessons learned. In: Chiappero E (Rules of Utopia. Policies to drive us out of the crisis. Milano: Fondazione Giangiacomo Feltrinelli, 126–150, Quaderni/30

Wezel A, David C, Ferrer A, Letort A, Féret S, Peigné J, Vian JV, Celette F (2014b) Agroecological practices supporting provision of goods and services in agriculture: Examples from France and Europe. Lyon: ISARA 67 p

Wezel A, Fleury P, David C, Mundler P (2015) The food system approach in agroecology supported by natural and social sciences: topics, concepts, applications. In: Benkeblia N (ed) Agroecology, ecosystems, and sustainability. Boca Raton, FL: CRC Press, 181–199, doi:10.1201/b17775

Wezel A, Goette J, Lagneaux E, Passuello G, Reisman E, Rodier C, Turpin G (2018) Agroecology in Europe: Research, education, collective action networks, and alternative food systems. Sustainability 10(4):1214, doi:10.3390/su10041214

Wezel A, Soldat V (2009) A quantitative and qualitative historical analysis of the scientific discipline agroecology. Int J Agr Sustain 7(1):3–18, doi:10.3763/ijas.2009.0400

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