https://www.routledge.com/Ecology-Capitalism-and-the-New-Agricultural-Economy-The-Second-Great/Allaire-Daviron/p/book/9780815381617

Ecology, Capitalism and the New Agricultural Economy: The Second Great Transformation, edited by Gilles Allaire and Benoit Daviron. London: Routledge, 2019, pp.181-203 (Chapter 9)
ISBN Hardback**:** 9780815381617, e-book 9781351210041

Transitions towards a European Bioeconomy: Life Sciences versus agroecology trajectories

Les Levidow, Martino Nieddu, Franck-Dominque Vivien and Nicolas Béfort

Abstract: The Knowledge-Based Bio-Economy (KBBE) has gained prominence as an agricultural R&D agenda. The KBBE attracts rival visions, each favouring a different diagnosis of unsustainable agriculture and its remedies in agro-food innovation. Each vision links a technoscientific paradigm with a quality paradigm: the dominant Life Sciences vision combines converging technologies with decomposability, especially for industrial uses of non-edible biomass, while a marginal vision combines agroecology with integral product integrity for quality food. From these divergent visions, rival stakeholder networks contend for influence over EU research policies and priorities. Although a Life Sciences vision remains dominant, agroecological approaches have gained a presence, thus overcoming their general exclusion from agricultural research agendas. In their own way, each rival paradigm emphasises the need for collective systems to gather information for linking producers with users, as a rationale for funding distinctive research priorities.

Introduction

Since at least 2005, inter-governmental organisations have promoted a 'bioeconomy' as crucial for societal progress. They imply that a bioeconomy already exists, linking natural processes with new biotechnologies, which thereby warrant extra support to achieve further advances. A bioeconomy denotes 'the aggregate set of economic operations in a society that use the latent value incumbent in biological products and processes to capture new growth and welfare benefits for citizens and nations' (OECD, 2006: 1).

Priorities for a bioeconomy vary across countries (Levidow, 2015a). Although the US policy framework mentions diverse future products (White House, 2012), its R&D funds have prioritised efforts to turn lignocellulosic biomass into liquid fuel, known as second-generation biofuels. With a broader scope, the European Commission relaunched the Life Sciences as essential tools for a Knowledge-Based Bio-Economy (DG Research, 2005). Its KBBE vision combines environmental sustainability with economic advantage through more flexible, eco-efficient uses of biomass.

The EU's KBBE itself has been framed in various ways. In the dominant agenda, natural resources offer renewable biomass amenable to conversion into industrial products via a diversified biorefinery, thus horizontally integrating value chains (Becoteps, 2010). Environmental sustainability becomes dependent upon markets to stimulate technological innovation. In an alternative agenda, diverse knowledges inform agroecological methods as the basis for a truly knowledge-based bioeconomy (e.g. Niggli et al., 2008).

In this chapter, we analyse the following questions: What forces drive diverse agendas for a European bioeconomy? What are their inter-relationships, e.g. symbiotic, competitive or even antagonistic? How does each one link food and non-food products? How does it link food, energy and other sectors?

To explore those questions, the chapter examines debates around a transition towards a bioeconomy. As above, this concept has at least two trajectories: the dominant one drawing on Life Sciences and a marginal one drawing on agroecology. This chapter explores how the different bioeconomy trajectories relate to knowledge production and product quality as dual aspects which together can shape different futures. The first section introduces the theoretical concept of 'food regime', its potential 'greening' and its precursors in early concepts of a bioeconomy. The second section introduces the European Commission's bioeconomy agenda encompassing divergent trajectories, further analysed in subsequent sections – Life Sciences (third section) and agroecology (fourth section). In conclusion, the fifth section summarises prospects for a change in the dominant regime through forms of bioeconomy.

1 Regime transitions: What innovation trajectories?

Across the history of agricultural change, a food regime in general has been defined as a 'rule-governed structure of production and consumption of food on a world scale' (Friedman, 1993: 30–31). This global perspective identifies a hegemonic role played by an historical series of three global regimes (McMichael, 2009), despite significant national variations within each regime (Wilkinson and Goodman, this volume). Starting from the post-1990s regime, this section discusses current variants and alternatives, innovation paradigms potentially realising such alternatives and early bioeconomy conceptions as precursors of today's trajectories.

Greening the neoliberal agro-industrial regime?

Corresponding to wider neoliberal policy frameworks, since the 1990s, the dominant food regime has promoted 'liberalization of trade and empowerment of transnational corporations' (Friedmann, 1993: 55). The current regime replaced the post-War regime of national markets, which was increasingly in tension with export surpluses and differentiation of food markets. In the 1980s and 1990s, the debate on a successor regime arose from rule changes, especially in the Uruguay Round of the General Agreement on Tariffs and Trade (GATT). 'The implicit rules evolved through practical experiences and negotiations among states, ministries, corporations, farm lobbies, consumer lobbies and others, in response to immediate problems of production, distribution and trade' (Friedmann, 1993: 31). Through pressures for liberalisation of agricultural policies and markets, the GATT framework was superseded by the World Trade Organization in 1994.

In the North the agro-industrial regime has subsidised intensive production methods for surpluses that can be globally exported and undermine less-intensive methods elsewhere. This pressure has pushed farms everywhere to adopt intensive methods, expelling rural populations to cities, especially shantytowns of the Global South (Friedmann, 1993,2016).

This neoliberal regime has served to globalise the agro-industrial methods that had already become prevalent in the US, Europe and parts of Brazil by the 1990s. Such methods had already involved technological change, e.g. substitution of animal energy by fossil energy, substitution of animal waste by chemical fertilisers, in turn facilitating national specialisations such as links between soya and animal feed for intensive livestock. Agribusiness developed transnational circuits among such national specialisations within such value chains.

What drivers and prospects for the neoliberal agro-industrial regime to undergo change? The potential comes from tensions within the regime, as prophetically described just prior to the WTO:

> These prefigure alternative rules and relations. One is the project of corporate freedom contained in the new GATT rules. The other is less formed: a potential project or projects emerging from the politics of environment, diet, livelihood, and democratic control over economic life. (Friedmann, 1993: 51)

In this perspective, a regime's trajectory is an endogenous result of collective action. Such a transition 'can be defined as a period of unresolved experimentation and contestation', and that such periods 'are full of multiple possibilities' (Friedmann, 2009: 335–336). The new dominant regime poses threats that have provoked ecological, social, ethical, culinary and cultural contestations from diverse movements such as SlowFood, La Via Campesina, indigenous peoples, etc.

Some analyses have focused on strategies for 'greening' agro-food systems and supply chains as the potential basis of a new agro-food regime, with diverse potential trajectories. For example, 'green' industrial farms could replace agrochemical inputs with permissible bio-inputs for 'organic' certification, as happened in California (Guthman, 2004). By contrast, social movements promote new forms of production and consumption, linked through demands for food sovereignty, thus reducing market transactions and undermining capital accumulation. In some early visions of biofuels, non-food uses of biomass could support strategies for local energy autonomy and ecological re-industrialisation. As the dominant pattern, however, biomass energy extends global value chains of Malaysian palm oil and Brazilian sugar cane for biorefineries in Europe or North America (Nieddu et al., 2014).

The above corporate strategies can potentially overcome social or environmental tensions through an agro-food green capitalism, theorised as a 'corporate-environmental food regime' (Friedmann, 2005). Through capital-intensive processes, food ingredients are decomposed and then recombined for food or non-food products, drawing on knowledge of such recombinations. Second, markets are differentiated, e.g. between high-quality fresh products and chemically recombined ingredients. (Friedmann, 2005: 258).

This incipient regime shifts agro-industrial production methods in ways that reduce harmful environmental effects and accommodate consumer demand for 'green' products. A regime shift depends on higher quality standards, some of which were associated with alternatives to the dominant regime, e.g. organic food and functional foods. To be commercially successful, the change must devise new norms for product identity and quality. Some businesses maintain such a capacity from their power over global supply chains, as a basis to impose environmental and quality standards that can gain consumer support.

Through market differentiation, there have been efforts to market 'food from somewhere', by contrast with the dominant regime of 'food from nowhere', i.e. capital-intensive agro-industrial production (Campbell, 2009). As a different strategy, organic farming has become conventionalised in many places. Within food regime theory, some perspectives have emphasised prospects for the dominant regime to incorporate such alternatives, which thereby play symbiotic roles, for example as competitive options in the food marketplace.

But such a symbiotic perspective downplays tensions of many kinds. Despite its alternative products, the dominant food regime encounters socio-political resistance from agendas for agro-food localisation and its different quality basis. Non-commercial solidarity aims, alongside multifunctionality, have symbolised the *altermondial* agenda. The latter spatially reorganises rural production; this enhances ecological sustainability by protecting 'endangered food, biodiversity and local traditional knowledge' (Fonte, 2013). Such tensions between ideal-type trajectories lie within an incipient corporate-environmental food regime.

Innovation paradigms of knowledge and quality

Given the many strategies for diversifying food systems, how do they complement or contest the neoliberal agro-industrial regime? These dynamics can be explored through concepts of product quality and their knowledge-bases. Drawing on the generic concept of technoscientific paradigms (Dosi, 1982; Malerba, 2002), theoretical typologies distinguish between innovation paradigms of food systems, as follows (see Table 9.1).

As an overview, bioeconomy agendas can be theorised as two ideal-types of innovation. Along with strong techno-economic promises, one type characterises and develops compositional identities of semi-finished or intermediate products at various stages of value chains, e.g. through traceability or life-cycle analysis of bio-based chemical products from decomposable biomass. The other type constructs an integral identity of a product – including a territorial identity and labels, producer-consumer proximity, engagement with ecological processes, etc. Each pathway constitutes food through different forms of quality.

More specifically, Life Sciences emerged from 'new biotech' companies, in turn dependent on specific complementarities between institutionalised forms of science, IPRs and finance (Coriat et al., 2003). Life Sciences aim to modify plants to enhance productivity in adverse conditions, e.g. caused by pests, pathogens, drought, saline environments and unfertile soils, or to design plants for new objectives such as altered nutritional content or carbon chains for non-food uses (Vanloqueren and Baret, 2009: 972). These aims are often linked with a decomposability paradigm, identifying single traits or functional attributes (based on genetic characteristics) which can be extracted, decomposed and recomposed. Emphasising computable data, technoscientific knowledge seeks to characterise such components, for selectively recombining them into novel products (Allaire and Wolf, 2004). Through its various names, such as green or blue biotech, innovation agendas seek to link food and non-food uses within the same paradigm.

In a paradigm of decomposability, innovation identifies simple traits to convert biomass into intermediate products, such as bottled ethylene from biosourced bioplastic, by contrast with fossil-based biomass, which differs only in the age of the carbon utilised. Highlighting calculable facts, technoscientific knowledge characterises these semi-products (e.g. through life-cycle analysis), to be recombined selectively in global value chains. Although each entreprise may develop commercially confidential information, the construction of quality here depends on comprehensive standardised information about compositional characteristics and norms (e.g. 'bio-based content' in Europe or ASTM D6866 in the US). Decomposability must be supported by collective access to up-to-date databases (cf. Debref, 2014).

Diverse greening efforts have other trajectories. Some actors seek to establish novel products from local resources for non-food uses, sometimes by rediscovering the potential of neglected plants in a period of agriculture standardisation. 'Bioeconomy in Champagne-Ardenne', a regional project linking research and food industries, seeks to revive peasant agroecological knowledge of traditional plants such as high-protein vegetables. Other projects develop a 'doubly green chemistry' for utilising the complex structures provided by nature, rather than cracking agricultural feedstock as in an oil refinery (Nieddu et al., 2014).

The former strategy attempts to produce the same outputs, e.g. fuels and intermediate chemicals, which otherwise would come from fractionating oil. This strategy comes from extending collective production heritages, either traditional or modern, such as fractionation techniques for decomposing feedstock. For example, the 19th century Fischer-Tropsch thermochemical process degraded coal into small molecules for biogas production; this heritage was later extended through thermochemical pathways for biodiesel or biochemical pathways for ethanol. More generally, collective production heritages are cognitive tools that create a basis for learning between producers and users.

Although today's innovations are portrayed as radically novel (e.g. catalysis, biotechnology), they necessarily rely on those earlier production heritages (Nieddu et al., 2014; Nieddu and Vivien, 2016). Building on these, innovators seek to make transition pathways economically and environmentally viable. For example, they seek a localised territorial production and/or a redesign minimising environmental burdens at the end of each product's life. As the overall context of research agendas, there has been a lock-in of genetic engineering and related 'new biotechs', alongside a lock-out of agroecology (Vanloqueren and Baret, 2009).

By contrast with the former, agroecology aims to redesign agricultural systems to minimise dependence on agrochemicals and energy inputs. Farms develop agroecosystems, whereby greater biodiversity performs various ecological services within and beyond food production. Such services include recycling nutrients, regulating microclimate and local hydrological processes, suppressing undesirable organisms and detoxifying noxious chemicals (Altieri, 1999; Nicholls et al., 2016).

Ecological interactions among biological components enable agricultural systems to boost their own soil fertility, productivity and crop protection (Vanloqueren and Baret, 2009: 972). In practice this is linked with an integral product identity paradigm, seeking to valorise distinctive comprehensive qualities that can be socially validated for/by consumers in various forms, e.g. organic certification, territorial characteristics, specialty labels or farmers' markets (Allaire and Wolf, 2004).

The agroecology agenda is more than an ensemble of techniques. It has three different aspects: agroecology of production systems in the strict sense, applying Odum's principles of systematic ecology; agroecology of alternative food systems; and agroecology as knowledge of relationships between agri-production and society (Van Dam et al., 2012: 27). This corresponds with another tripartite definition, namely, agroecology as a scientific discipline, an agricultural practice and a social movement. Linking those three forms is essential for transforming the dominant food system (Wezel et al., 2009: 28).

As a different ideal type, a paradigm of integral product identity seeks to produce social innovations that help to achieve a systemic coherence, through standards fulfilling claims for a moral economy (Busch, 2000). For example, if taken separately, organic certification or food localisation do not fulfil this paradigm. Actors want organic and agroecological agriculture to facilitate the construction of food sovereignty and locally sustainable trajectories, with products accessible to low-income social strata (Goodman and Goodman, 2009; McEntree, 2010). Such aims need a reflexive localism in the process of boundary-making and object design, where the process can be more important than the consequent standards or conventions (Fonte, 2013).

In such a reflexive perspective, the 'bio' is a site of new alliances between producers, distributors and social movements (see Chapter 10). The latter can hold products accountable for marketing claims, e.g. about 'preserving the family farm' or providing public goods. Identity-based differentiation depends upon collective resources for accommodating diverse private demands and public norms (Allaire and Wolf, 2004: 449, 454).

In that sense these socio-technical innovations constitute an integral product identity; this seeks to valorise distinctive comprehensive qualities which can be socially validated for/by consumers in various forms, e.g. organic certification, territorial characteristics, specialty labels or farmers' markets. Comprehensive-identity supply chains can valorise agroecological methods: 'Agroecologists favour alternative food systems operating at a regional scale or based on closer farmer-consumer relationships, or product networks that mobilise localized resources and have strong identities' (Vanloqueren and Baret, 2009: 981).

Likewise the above tensions arise for non-food products: through life-cycle analysis or principles of green chemistry, efforts towards a territorial production seek conditions acceptable for ecosystem protection at the end of each product's life, but separate criteria fail to bring a systematic coherence. Tensions also arise around rival forms of knowledge from collective production heritages (Nieddu and Vivien, 2016, as above).

Section 2 will use those typologies to analyse the two bioeconomy agendas – Life Sciences and agroecology. Both have precursors in earlier concepts of a bioeconomy, as explained next.

Before the EC's bioeconomy, two other conceptions

From the history of 'bioeconomy' agendas, the earliest conception has contributed to ecological economics (Vivien, 1998) and somewhat to agroecology. Georgescu-Roegen became known for his work on peasant economy, contrasted with unsustainable energy in industrial agriculture (Vivien, 1999): ‘the survival of humanity poses a totally different problem than any other species because it is not only biological nor only economic; it is bio-economic’ (Georgescu-Roegen, 1975: 130; also 1971). Rene Passet’s book, *L’économique et le vivant*, presents a renown schema of three spheres whereby the economic sphere lies in a sub-system of the social sphere, itself a sub-system of the biosphere; biological cycles become integrated at the heart of economic reason (Passet, 1979: 11, 2011).

The second conception is the biotech revolution. From the discovery of the DNA triple helix in 1953, further research elucidated the regulation of protein synthesis in 1961, enzymes’ capacity to dissect the DNA molecule in a predictible pathway in 1962, and isolation of the gene in 1969. This discovery was quickly understood – by Monsanto since 1972 – as not only a paradigmatic revolution in biology but also a great Schumpeterian rupture in pharmacy, medecine, agrosciences and chemistry. European Commission strategists warned that Europe was missing the global opportunity:

> The Industrial Revolution took place in Europe, but the promises of Biotechnology and of its spin-offs were gradually moving away from our European horizons to the USA and some emerging economies. European leaders realised that Europe was facing a maybe unique chance to support its science base and to develop the potential represented. (Aguilar et al., 2013: 10)

In the name of fulfilling the promise, public policy has been mobilised for research programmes and ‘technology-driven initiatives’ to overcome disciplinary frontiers and path dependencies.

Such support measures have made the techno-economic agenda more visible, thus provoking controversies. It illustrates a wider ‘economics of technoscientific promises’, which facilitate investment, mobilisation, circulation, and accumulation of resources (Joly, 2010). Such promises instrumentalise the Life Sciences in the service of explicitly seeking to industrialise biology (NRC, 2015). A key aim has been intellectual property rights (Birch et al., 2010), by commoditising knowledge through new markets for technology (Arora et al., 2001; Birch, 2017). Technological promises led policymakers to promote an institutional change granting property rights to ‘biotechnological innovations’, (EC, 1998), thus broadening the scope of discoveries or techniques that could be privatised. Such broader claims for intellectual property have led to controversy over its ethical and economic aspects: Should Life be patented? Who owns genes?

In those ways, the Life Sciences agenda promotes a linear model of innovation, whereby new products apply basic research for commercial uses. This agenda links technoscientific advance, their mass-media promotion and an economics of promises, including intellectual property rights. The latter is inscribed in various legitimation devices, e.g. validation by venture capital, alliances with incumbent firms or public support through technoscientific research programmes.

2 Bioeconomy: divergent agendas

The term ‘bioeconomy’ encompasses at least two different conceptions. The Life Sciences conception has gained a prominent role in the bioeconomy agenda of the European Commission since 2005; this exemplifies efforts towards a corporate-environmental food regime (Friedmann, 2005). Critical responses led to an agroecological conception of bioeconomy. After a brief survey below, each conception is elaborated in subsequent sections.

Life Sciences globally flexibilising agro-industries

Extending ‘the new biotechs’, the dominant trajectory of a bioeconomy reconceptualises agro-industrial production as decomposable and recomposable biomass. As an early symbol of a future bioeconomy, edible biomass was converted to biofuels; controversy provided a stimulus for greater ambition. The Life Sciences agenda redesigns and converts food, feed and non-food biomass into diverse industrial products, towards horizontally integrating various industrial sectors, while substituting for fossil fuels in the name of sustainably replacing fossil fuels. (OECD, 2006, 2017). It promotes flexibility of biomass feedstocks – their sources, types, conversion processes and end products – especially through novel biorefineries. R&D seeks more efficient techniques for converting biomass to cellulosic bioethanol and other industrial products, while also expanding opportunities for proprietary knowledge (Murphy et al., 2007).

According to a later report by the World Economic Forum, biorefinery strategies anticipate a competitive advantage for companies becoming 'backward-integrated' into multiple feedstocks and flexibly converting them into multiple products:

> The newly established value chain will have room for non-traditional partnerships: grain processors integrating forward, chemical companies integrating backwards, and technology companies with access to key technologies, such as enzymes and microbial cell factories joining them. (WEF, 2010: 20)

More flexible uses will give the Global South greater business opportunities to supply raw materials:

> a new international division of labour in agriculture is likely to emerge between countries with large tracts of arable land—and thus a likely exporter of biomass or densified derivatives—versus countries with smaller amounts of arable land. (ibid.: 21)

Complementing this globally flexible division of labour, a Life Sciences trajectory envisages a future 'value web', developing more flexible value chains through more interdependent, interchangeable products and uses, thus promoting horizontal integration of industrial sectors (Becoteps, 2010). Various examples provide flex-crops and flex-commodities, whereby raw material suppliers can be thrown into more intense competition for supplying upper parts of value chains (Borras et al., 2016). Such integration shifts power relations towards global markets and land uses serving such markets.

Tensions of the European bioeconomy agenda

Towards a European bioeconomy, the prevalent agenda claims to promote a 'holistic approach' – meaning especially Life Sciences, including genomics within converging technologies such as infotech and nanotech. This trajectory promises to enhance environmental sustainability, global economic competitiveness and thus European prosperity, according to the European Commission's narrative of technoscientific promise. This would flexibly accommodate rising global demand for food, feed and fuel, thus promising to alleviate constraints on natural resources (DG Research, 2005).

Yet tensions among bioeconomy perspectives have arisen during conferences, bringing together all stakeholders to formulate a technological roadmap. For alternative agendas, holistic means articulating between agroecological practices and industrial eco-design. In contrast, for Life Sciences, holistic means flexibly integrating material flows across industrial sectors.

Prevalent trajectories depend on a knowledge base of decomposability, conversion and recomposition through biochemical pathways: other trajectories develop thermochemical techniques (see Section 3). Both neglect food production. A different 'bioeconomy' trajectory seeks to preserve and improve extensive agriculture by linking different agro-innovation pathways; this links agroecology with an integral product identity for environmental sustainability and food quality (Levidow et al., 2013; see fourth section).

Those divergent trajectories have been accommodated within a multi-stakholder compromise, the Knowledge-Based Bio-Economy (KBBE). This framework has extended the Lisbon agenda, which sought greater R&D investment in a knowledge-based economy to make Europe 'the globally most competitive knowledge-based economy by 2010' (European Council, 2000). The European Commission defines the KBBE as 'the sustainable, eco-efficient transformation of renewable biological resources into health, food, energy and other industrial products' (DG Research/FAFB, 2006: 3). Food and non-food trajectories have been kept within the same agenda. On the one hand, EC policy documents emphasise food in order to portray 'the bioeconomy' as already enormous; on the other hand, R&D funds have gone mainly to Life Sciences, especially for non-food products (Schmid et al., 2012).

The next two sections examine the Life Sciences and agroecology agendas in more detail.

3 Life Sciences-based bioeconomy

In the Life Sciences trajectory of bioeconomy, agriculture becomes 'oil wells of the 21st century' (BiomatNet, 2006). This metaphor of biomass as 'biocrude', as feedstock for a biorefinery, naturalises the decomposability paradigm. 'The seed oils of plants are structurally similar to long chain hydrocarbons derived from crude oil' (EPOBIO, 2007: 10). This trajectory seeks to mimick an oil refinery cracking oil, as a basis for a like-for-like substitution of petrol products by building blocks from biomass (Nova-Institut, 2017). This follows the US roadmap of the Top Ten (Bozell and Petersen, 2010): 'New developments are ongoing for transforming the biomass into a liquid "biocrude", which can be further refined, used for energy production or sent to a gasifier', according to an antecedent of the European Biofuels Technology Platform (Biofrac, 2006: 21).

Life Sciences emphasise promises that have been impeded by non-food 'biomass recalcitrance', to be overcome through biotech innovations, e.g. novel crops or microbial enzymes for easier biomass conversion. Some define bioeconomy as converting biomass into building blocks that can substitute like-for-like the products from oil for non-food uses such as energy, chemistry and biofuels (McCormick and Kautt, 2013). Other trajectories seek to substitute the functions brought by these products, rather than strictly identical renewable carbon substituting for chemical structures and fossil carbon (Colonna et al., 2015).

Alongside that decomposition-recomposition paradigm, the European context has alternative trajectories of a bioeconomy. Some favour extensive cultivation methods to provide biomass feedstock for 'biorefineries without biofuels' or alternative value chains (Gallezot, 2010). For example, Italy's Novamont company seeks feedstock for biorefineries producing chemicals, thus substituting for oil; novel plants are locally grown on poor soils, thus complying with principles of a circular economy (Nieddu et al., 2013; Bastioli, 2008,).

In this Life Sciences agenda, knowledge production and economic activity function differently than in the 'biotech revolution'. Central to this is a Great Transition towards renewable resources for energy, chemicals and materials through a biorefinery, a transitional technological object. Although the biotech revolution has great narrative power, it does not unify this agenda because its actors seek to keep open their options, including alternatives to thermochemical or biochemical conversion trajectories.

Diversified biorefinery for horizontally integrating industries

To address many limitations of the early products, especially conventional biofuels, bioeconomy visions have promoted the concept of biorefinery producing second-generation biofuels (Banse et al., 2011; CEC, 2012; Huang et al., 2012). This would convert non-food components of plants, or non-food plants or from waste. Looking beyond biofuels, the European Biofuels Technology Platform develops strategies to optimise valuable products from novel inputs. It requests funds to 'develop new trees and other plant species chosen as energy and/or fiber sources, including plantations connected to biorefineries' (EBTP, 2008: SRA-23).

More ambitiously, the 'integrated diversified biorefinery' has been envisaged to diversify inputs and outputs, especially through novel enzymes and processing methods, generating diverse by-products including biofuels:

> the integrated diversified biorefinery—an integrated cluster of industries, using a variety of different technologies to produce chemicals, materials, biofuels and power from biomass raw

> materials agriculture—will be a key element in the future. And although the current renewable feedstocks are typically wood, starch and sugar, in future more complex by-products such as straw and even agricultural residues and households waste could be converted into a wide range of end products, including biofuels (EuropaBio, 2007: 6)

This seeks horizontal integration of agriculture with the oil, chemical and transport industries, thus optimising the market value of resources and intellectual property. Inputs and outputs can be flexibly adjusted according to temporary market advantage, thus throwing suppliers into greater competition with each other and intensifying agri-production systems.

According to a lobby group for biofuel innovation, a successful diversified biorefinery depends on government subsidies for research and development and demonstration (R&D&D) plants. According to the European Biofuels Technology Platform, the necessary investment is too costly and commercially risky for the private sector, which therefore requests much more public funds to cover the risks. Testing commercial viability requires an expensive scale-up: 'With an estimated budget of €8 billion over ten years, 15–20 demonstration and/or reference plants could be funded' (EBTP, 2010: 26).

This vision justified allocating €4.7 billion to the bioeconomy in Horizon 2020, the EU's research framework for 2014–20, as well as potential diversion of other funds. 'Various funding sources, including private investments, EU rural development or cohesion funds could be utilised to foster the development of sustainable supply chains and facilities' (CEC, 2012: 7). Towards future 'advanced integrated biorefineries' that could compete with fossil counterparts, the EU's Framework Programme 7 funded numerous projects totalling €50m and involving 68 European partners between 2010 and 2014. All these depend on an economics of technological promises: 'Biorefineries converting feedstock into chemicals and materials will become the backbone of the future production of sustainable products' (Horizon 2020 call BBI.2017.F1, 2017).

To mobilise such investment, the model of innovative start-up depends on promises to become the 'Google' of the bioeconomy, in turn justifying broader intellectual property rights as a prerequisite. Yet any such ambition has institutional constraints. Given the large fixed-capital commitments and the complexity of knowledge to be integrated (Dubois, 2011, 2012), biorefinery development starts from agro-industrial sites (e.g. Pomacle-Bazancourt) or paper mills in Scandinavian countries.

These depend on shared knowledge through open innovation platforms. These industrial complexes imply a complementary relation between food and non-food; in particular, as a co-product of biofuels, animal feed contributes to the economic viability of biorefineries. Yet such co-products have attracted criticism for disguising waste which potentially harms animal health, as well as for potentially supplementing the animal feed supply (cited in Levidow, 2015a).

Novel food recomposition trajectories

A decomposability innovation paradigm likewise informed the food industry's early research priorities and their incorporation into Framework Programme 7. The European food industry federation (CIAA) has led an ETP Food for Life. Its research agenda has sought to link food innovation with future markets: 'consumer demands will drive the R&D and innovation needs' (FfL, 2005: 13; also FfL, 2007: 6). To avoid difficulties in marketing, it is 'essential to build effective systems of product tracing and identification that consumers can have trust in' (FfL, 2007: 6).

To overcome consumer resistance to novel food products, the food industry has combined technoscientific innovation with appeals to 'natural' foods: 'Most of the novel food processing technologies carry the promise to deliver safe food without sacrificing naturalness and nutritional benefits' (FfL, 2005: 25). Yet 'naturalness' claims became difficult to justify, so the concept is almost absent in subsequent documents.

Later such a claim was revived as ‘less refined, more natural food ingredients to be used in minimal or gentle processing’. As it turns out, this meant ‘food ingredients by tailored fractionation of the raw material into classes, which are not pure isolates, but which consist of mixtures of structures and components with very good functionalities’ (FfL, 2016: 57). This trajectory must be somehow reconciled with consumer understanding of naturalness in order to gain commercial success.

Public health claims about novel products have been likewise a task for technoscientific innovation: ‘These products, together with recommended changes in dietary regimes and lifestyles, will have a positive impact on public health and overall quality of life’ (FfL, 2008: 3). However, further research was needed to support such health claims: ‘Therefore knowledge built up in the priority areas is aimed at reformulating a wide range of foods and designing new foods, and making them eligible for health claims’ (ibid.: 18). The industry also advocates life-cycle analysis of food production, e.g. to demonstrate eco-efficiency benefits in using natural resources, as a basis for informed choices by consumers (ibid.: 40).

To clarify public health benefits of novel foods, the agenda seeks to extend existing databases. These already had linked ‘the composition and biological effects of nutrients and non-nutrients with putative health benefits’ (FfL, 2008: 51). By combining several information sources, a key aim has been ‘harmonised national databases on food composition and consumption patterns, including ethnic and traditional foods’ (ibid.: 32).

Indeed, the food industry faces demands for locally familiar and speciality foods, based on an integral product identity. In response, the industry has sought to incorporate food traditions into technoscientific innovation: ‘The integration of the rich traditions of European cuisine with the innovation-driven market place represents a great and constant challenge’, which can be addressed through ‘innovation in and industrialisation of regional gastronomy’ (FfL, 2005: 9, 22), especially by ‘using modern media and new digital technologies’ (FfL, 2017: 8). Thus its research agenda attempts to appropriate consumer desires by translating the product-identity paradigm into the decomposability paradigm (Levidow et al., 2013).

At the same time, the innovation agenda ruptures any food tradition. Through recomposition techniques, it optimises functional foods ‘towards achieving the right metabolic effect’ (FFL, 2017: 37). It also seeks to synthesise food components ‘from non-food materials or the use of non-traditional resources such as insects or microalgae’. These sources provide means to overcome resource limits and thus make claims for environmental sustainability (FFL, 2017: 10).

In all these ways, technoscientific innovation remains central. Indeed, it is a solution searching for a problem: ‘Many of the weaknesses identified could be solved technologically’ (FfL, 2008: 7). Pervasive tensions arise around claims for health or environmental benefits vis a vis unprocessed foods, which can retain an integral product identity.

4 Agroecology-based bioeconomy

Partly in response to the dominant agenda, organic agro-food organisations formed a stakeholder network to advocate organics and agro-ecosystems research for a ‘knowledge-based bioeconomy’ (Ifoam-Europe, 2006). They built broad stakeholder support including relevant commercial actors across the agro-food value chain as well as environmental NGOs.

Eventually they published a *Vision for an Organic Food and Farming Research Agenda to 2025* (Niggli et al., 2008), with the aim to set up Technology Platform Organics.

This was followed by a *Strategic Research Agenda*, which linked the term ‘innovation’ with public goods, efficiency, farmers’ knowledge, learning and competitive advantage. It elaborated ‘eco-functional intensification’:

> The weakness of organic agriculture so far remains its insufficient productivity and the stability of yields. This could be solved by means of appropriate ‘eco-functional intensification’, i.e.

> more efficient use of natural resources, improved nutrient recycling techniques and agroecological methods for enhancing diversity and the health of soils, crops and livestock. (Niggli et al., 2008: 34; cf. Schmid et al., 2009: 59)

Horizontal integration between agriculture and energy production, partly from waste materials, provides means to shorten organic cycles as well as to substitute for external inputs:

> Diversified land use can open up new possibilities for combining food production with biomass production and on-farm production of renewable energy from livestock manure, small biotopes, perennial crops and semi-natural non-cultivated areas. Semi-natural grasslands may be conserved and integrated in stockless farm operations by harvesting biomass for agro/bioenergy and recapturing nutrients from residual effluent for use as supplementary organic fertiliser on cultivated land. (Schmid et al., 2009: 26)

This strategy develops new knowledge for a reflexive localism (cited above) around multi-stakeholder alliances broader than organic producers: 'Stakeholders along the whole food chain are able to participate in this development and civil society must be closely involved in technology development and innovation' (Schmid et al., 2009: 16). The research strategy emphasises cooperation among all stakeholders in producing knowledge: 'The joint production of knowledge model transgresses the boundary between knowledge generators and users, so that *all* partners involved may be undertaking research' (Padel et el., 2010: 58).

Indirect support came from changes in research policy. As a new opportunity for agroecological agendas, the EU's Food, Agriculture, Fisheries and Biotechnology (FAFB) research programme hosted expert foresight studies exploring wider knowledges for agricultural innovation. The exercises were commissioned by the EU's Standing Committee on Agricultural Research (SCAR), with support from some national agencies promoting farmers' knowledge. According to the first expert report, farmers often develop modest innovations but these are readily dismissed or ignored (SCAR FEG, 2007: 8). As a more fundamental diagnosis, research agendas have become more distant from producers' knowledge, instead favouring specialist laboratory knowledge for agricultural inputs and processing methods (SCAR FEG, 2007: 11).

As a way forward, the expert group advocated agroecological approaches, *in situ* genetic diversity, farmers' knowledge, etc. It also advocated new kinds of Agricultural Knowledge Systems (AKS) beyond the formal research system: 'The AKSs that have been developed outside the mainstream, to support organic, fair trade, and agroecological systems, are identified … as meriting greatly increased public and private investment' (SCAR FEG, 2008: 42). Agroecological approaches should be given priority:

> Approaches that promise building blocks towards low-input high-output systems, integrate historical knowledge and agroecological principles that use nature's capacity and models nature's system flows, should receive the highest priority for funding. (SCAR FEG, 2011: 8; also EU SCAR, 2012: 92)

The report linked agroecology with a sufficiency perspective, counterposed to the dominant productivist one.

In response to such expert reports and TP Organics' proposals, FP7 eventually gave greater prominence to agroecological themes, which reached a total budget of €20 million by 2010 and increased thereafter. Drawing on proposals from TP Organics, there were calls for the following production methods, generally as substitutes for external inputs: ecological services based on eco-functional intensification, enhancing soil management and recycling organic waste via mixed farming, replacing chemical or copper pesticides with bio-control agents, enhancing on-farm production of renewable energy, etc.

Some research topics have sought to facilitate public reference systems necessary for embedding agroecological methods within wider institutions, for example through community-supported agriculture, agricultural extension services, food retailers and territorial labels. Knowledge for/about closer producer-consumer relations was the focus of a new topic, 'Short chain delivery of food for urban-peri-urban areas', whereby food localisation brings producers closer to consumers (c*ircuits courts*). The topic emphasises 'sustainable solutions for water management and nutrient recycling' as a task for institutional interactions, for example in 'the relation between peri-urban pressures and the participation of farmers and other stakeholders in rural development measures' (DG Research/FAFB, 2011: 31).

Despite those successes in influencing the KBBE programme, the Commission's senior officials still exclusively promoted the Life Sciences vision of a bioeconomy. This dominated documents for a public consultation that was meant to inform future research priorities for a European bioeconomy, especially in the successor to FP7 (DG Research, 2010). As a shift in strategy, TP Organics now highlighted divergent accounts of a European bioeconomy.

In responding to the public consultation, it criticised the Commission for favouring 'specific new technologies (such as genetic modification) and capital-intensive "innovation" at the expense of agriculture' (TP Organics, 2011: 7). It counterposed agroecological methods and agro-food relocalisation for a different bioeconomy: government should value agricultural knowledge that has been already developed over many decades, especially in co-producing agriculture with public goods (ibid.: 10). Likewise it ambitiously advocated 'a network of agroecological innovation centres in farming communities across Europe' for transdisciplinary and participatory approaches (TP Organics, 2011), potentially transforming relations between researchers and farming.

In all these ways, the strategy sought an explicit place for an agroecological vision in EU policy documents and long-term resources for stakeholder-knowledge networks. Supporters have intervened in EU agendas by promoting agroecological perspectives and expertise, especially through the European Innovation Partnership for Agricultural Productivity and Sustainability (EIP-Agri). This comes under the EC's Rural Development Regulation, which includes the aim of 'working towards agroecological production systems and working in harmony with the essential natural resources on which farming and forestry depend'.

As its overall method, 'EIP-AGRI pursues the "interactive innovation model" which focuses on forming partnerships: using bottom-up approaches and linking farmers, advisers, researchers, businesses, and other actors in Operational Groups that engage in practical projects' (EIP-AGRI, 2013). Operational Groups facilitate farmers' joint knowledge production with experts, including agroecological methods (Levidow, 2015b; TP Organics, 2017). Although initially marginal, this agenda has sought to transform European agriculture through agroecological practices.

5 Conclusion: divergent trajectories of a European bioeconomy

The liberalised agro-industrial system, globally dominant since the 1990s, has been destabilised by multiples crises and resistances, in turn creating new opportunities for transitions. This article has identified two European trajectories of a bioeconomy: one industrialising life through Life Sciences and the other promoting agroecological methods. The latter trajectory treats the economic system as a sub-system of a finite living world, whereby biological cycles are integrated at the heart of economic reason (Passet, 2011). That relation is inverted by the Life Sciences trajectory, which treats biological materials as a sub-system of a globally integrated market competition for commodity exports and intellectual property. These trajectories coexist within the EC's institutional compromise around the KBBE.

By comparing the two trajectories, it is possible to identify tensions within and across them. Those divergent trajectories have been explored here through the following questions. What forces drive different agendas for a European bioeconomy? Given these different agendas, what are their inter-relationships – symbiotic, competitive or even antagonistic? How does each one link food and non-food products? How does it link food, energy and other sectors?

‘*Life Sciences*’

This trajectory exemplifies wider moves towards a corporate-environmental regime, as a variant of the dominant food regime. The latter links capital accumulation with ‘green’ innovations, some of which had been previously associated with alternatives, such as renewable resources (Friedmann, 2005). For the past decade, a KBBE has been jointly promoted by EU policymakers, capital-intensive industry and its public sector research base. A decomposability paradigm informs R&D for ‘quality’ novel foods, especially functional foods, as well as for simulating traditional specialty foods; this illustrates edible commodities from recombined ingredients (Friedmann, 2005: 258).

More importantly, the Life Sciences are extended far beyond food by linking economic and environmental sustainability through non-food biomass. The dominant bioeconomy trajectory aims less at decarbonising society and more at substituting renewable biomass for fossil carbon. The Life Sciences agenda seeks larger genomic databases to inform novel processes and non-food products, for example by cracking biomass into co-products or intermediate products, to provide greater global flexibility for input-output chains. Hence agriculture is promised to generate the black gold or El Dorado of the 21st century, especially through intellectual property.

Global competitive pressures of the neoliberal food regime are being extended for globally integrating several industrial sectors (agriculture, chemistry, energy). As new business opportunities increase resource burdens, especially through land use and biomass processing, the decomposition trajectory may not enhance environmental protection, nor livelihoods. Such benefits may potentially come from other trajectories relying on compositional knowledge, such as doubly green chemistry.

‘*Agroecology*’The agroecology trajectory seeks to go beyond the dominant food regime through multi-stakeholder networks and alternative research agendas. It links eco-functional intensification, agroecology and an integral product identity for remunerating producers through short food supply chains (also known as *circuits courts*). These innovations depend on a different knowledge base than the Life Sciences agenda.

In sum, invoking a European bioeconomy, rival stakeholder networks contend for influence over research priorities, innovation trajectories and wider policy agendas. Each promotes its own innovation niches and protections through institutional support measures, alongside its own narrative of economic and environmental promises. Each elaborates divergent meanings of the same terms (see Table 9.1). For example, ‘building blocks’ can mean either simulating oil-based materials through new compositional techniques (Nova-Institut, 2017) or else simulating nature’s flows through agroecological methods (SCAR FEG, 2011). Such tensions warrant further analysis (Levidow et al., 2014; Levidow, 2015b), as a basis to identify multiple possibilities, their contestations and potential outcomes for food regimes (Friedmann, 2009: 335–336).

As shown here for bioeconomy agendas, it is necessary to study the complex relationships between Life Sciences and agroecology trajectories, including different relationships between food and non-food production within different paradigms. A sharper conceptualisation is necessary to analyse divergent enactments of agricultural innovation. Each involves distinct technoscientific trajectories, knowledge-bases, economic activities and their interlinkages. Such analysis can identify contestations and incorporations vis a vis the dominant regime, within and/or beyond a corporate-environmental food regime.

Table 9.1: **Divergent agendas of a European bioeconomy**
Each agenda combines paradigms from the upper part of the table.

	Dominant agenda	**Marginal agenda**
Agri-innovation paradigm		
Technoscientific (Vanloqueren and Baret, 2009)	Genetic engineering and Life Sciences: modifying plants and animals for greater productivity or for new objectives, e.g. nutritional content.	Agroecological engineering: designing agricultural systems that minimise need for external inputs, instead relying on ecological interactions.
Quality (Allaire and Wolf, 2004)	Decomposability (via converging technologies) for re-composing qualities into novel combinations for extra market value.	Integral product identity via holistic methods and quality characteristics recognisable by consumers, as a basis for their support.
Knowledge (Allaire and Wolf, 2004)	Computable data for novel inputs and/or outputs that can gain market advantage, especially by matching compositional qualities with consumer preferences.	Knowledge systems for validating comprehensive product identities, e.g. organic, agroecological production methods, territorial characteristics, specialty products.
R&D agendas	**Life Sciences**	**Agroecology**
Problem-diagnosis: agro-economic threats to be overcome	Inefficient production methods disadvantaging European agro-industry, which falls behind in global market competition for technoscientific advance.	Agro-industrial monoculture systems – making farmers dependent on external inputs, undermining their knowledge, distancing consumers from agri-production knowledge, etc.
Solution in sustainable agriculture	More efficient plant-cell factories as biomass sources for diverse industrial products, thus substituting for fossil fuels and expanding available resources.	Agroecological methods for maintaining and linking on-farm resources (plant genetic diversity and bio-control agents), thus minimising usage of external resources.
Intensification of renewable resources	More efficient biomass conversion from lab knowledge and more decomposable qualities.	Eco-functional intensification via farmers' knowledge of agroecological methods.
Agri-energy linkages	Redesigning plants and processing methods for more efficiently converting biomass into energy and other industrial products.	Converting agricultural waste into bioenergy in on-farm small-scale units, thus substituting for external inputs.
Knowledge-Based Bio-Economy (KBBE)	Sustainable production and conversion of biomass (or renewable raw materials) for various food, health, fibre, energy and other industrial products.	Agroecological processes, in mixed and integrated farming, for optimising use of energy and nutrients, so that producers gain from the value that they add.
Scientific knowledge	Standard databases of lab knowledge (from converging technologies, esp. genomics) to integrate agriculture with other industries.	Scientific research to explain why some agroecological practices are effective, as a basis to intensify and apply them more widely.
Product quality	Verifiable compositional changes for better nutritional content, agronomic characteristics and/or extractable substances.	Sustainable cultivation methods and/or territorial identity recognised by consumers via food distribution systems.

Source: adapted from Levidow et al. (2013)

References

Allaire G., Wolf S., 2004. Cognitive Representations and Institutional Hybridity in Agrofood Innovation. *Science, Technology & Human Values*, 29(4), 431–458.

Altieri M.A., 1999. The Ecological Role of Biodiversity in Agroecosystems. *Agriculture, Ecosystems and Environment*, 74(1), 19–31.

Arora A., Fosfuri A., Gambardella A., 2001. Markets for Technology and Their Implications for Corporate Strategy. *Industrial and Corporate Change*, 10(2), 419–451. doi: 10.1093/icc/10.2.419.

Banse M., Van Meijl H., Tabeau A., Woltjer G., Hellmann F., Verburg P.H., 2011. Impact of EU Biofuel Policies on World Agricultural Production and Land Use. *Biomass and Bioenergy*, 35(6), 2385–2390.

Bastioli C., 2008. Renewable Raw Materials and the Transition from a Product-based Economy to a System-based Economy. In: *Conferral of her Honorary Degree in Industrial Chemistry by University of Genoa*, 4 July, Genoa, Italy.

Becoteps 2010. *Bioeconomy 2030: Towards a European Bioeconomy that Delivers Sustainable Growth by Addressing the Grand Societal Challenges*. Brusssels, Bio-Economy Technology Platforms (Becoteps). www.epsoweb.org/file/560.

Biofrac 2006. *Biofuels in the European Union – A Vision for 2030 and Beyond*. Brussels, Commission of the European Communities.

BioMat Net, 2006. 1st International Biorefinery Workshop [website defunct].

Birch K., 2017. *Innovation, Regional Development and the Life Sciences: Beyond Clusters*. London. Routledge, Taylor & Francis Group.

Birch K., Levidow, L., Papaioannou, T., 2010. 'Sustainable Capital'? The Neoliberalization of Nature and Knowledge in the European 'Knowledge-Based Bio-economy'. *Sustainability*, 2(9), 2898–2918. www.mdpi.com/2071-1050/2/9/2898/pdf. doi: 10.3390/su2092898.

Borras Jr., S.M., Franco J.C., Isakson R., Levidow L., Vervest P., 2016. The Rise of Flex Crops and Commodities: Implications for Research. *Journal of Peasant Studies*, 43(1), 93–115. doi: 10.1080/03066150.2015.1036417.

Bozell J.J., Petersen G.R., 2010. Technology Development for the Production of Biobased Products from Biorefinery Carbohydrates—The US Department of Energy's "Top 10" Revisited. *Green Chemistry*, 12(4), 539–554.

Busch L., 2000. The Moral Economy of Grades and Standards. *Journal of Rural Studies*, 16, 273–283.

Campbell, H. (2009). Breaking new ground in food regime theory: corporate environmentalism, ecological feedbacks and the 'food from somewhere'regime? *Agriculture and Human Values*, *26*(4), 309-319.

CEC, 2012. *Innovating for Sustainable Growth: A Bioeconomy for Europe* {SWD(2012) 11 final} Brussels, Commission of the European Communities.

Colonna P., Tayeb J., Valceschini E., 2015. Nouveaux usages des biomasses. In *Le Déméter 2015*. Paris, Club Demeter. pp. 275–305.

Coriat B., Orsi, F., Weinstein, O., 2003. Does Biotech Reflect a New Science-Based Innovation Regime? *Industry and Innovation*, 10(3), 231–253.

Debref R., 2014. *Le processus d'innovation environnementale face à ses contradictions: le cas du secteur des revêtements de sol résilients*. thèse de doctorat en sciences économiques. Reims, Université de Reims-Champagne-Ardenne.

DG Research, 2005. *New Perspectives on the Knowledge-Based Bio-Economy: Conference Report*. Brussels, DG-Research, Commission of the European Communities.

DG Research/FAFB., 2006. *FP7 Theme 2: Food, Agriculture, Fisheries and Biotechnology*. 2007 Work Programme. Brussels, Commission of the European Communities.

DG Research, 2010. European Strategy and Action plan towards a sustainable bio-based economy by 2020. Brussels, DG-Research, Commission of the European Communities.

Dosi G., 1982. Technological Paradigms and Technological Trajectories: As Suggested Interpretation of the Determinants and Directions of Technical Change. *Research Policy*, 11(3), 147–162.

Dubois J.-L., 2011. Requirements for the Development of a Bioeconomy for Chemicals. *Current Opinion in Environmental Sustainability*, *3*(1–2), 11–14. doi: 10.1016/j.cosust.2011.02.001.

Dubois J.-L., 2012. Refinery of the Future: Feedstock, processes, products. In Aresta, M., Dibenedetto, A. and Dumeignil, F. (Eds.), *Biorefinery: From Biomass to Chemicals and Fuels*. Berlin: De Gruyer, pp. 20–47.

EBTP, 2008. *European Biofuels Technology Platform: Strategic Research Agenda & Strategy Deployment Document*. Newbury CPL Scientific Publishing. www.biofuelstp.eu/srasdd/080111_sra_sdd_web_res.pdf.

EBTP, 2010. *Strategic Research Agenda 2010 Update: Innovation Driving Sustainable Biofuels*. Newbury CPL Scientific Publishing. www.biofuelstp.eu/sra.html.

EC, 1998. Directive 98/44/EC of the European Parliament and of the Council on Protection of Biotechnological Inventions. *Official Journal of the European Union*, 30(July), L 213 13.

EIP-Agri, 2013. *Strategic Implementation Plan: European Innovation Partnership, Agricultural Productivity and Sustainability*. Brussels, EIP-Agri, http://ec.europa.eu/agriculture/eip/pdf/strategic-implementation-plan_en.pdf.

EU SCAR, 2012. *Agricultural Knowledge and Innovation Systems in Transition: a Reflection Paper*. Brussels: Standing Committee on Agricultural Research (SCAR) of the European Union, https://scar-europe.org/images/AKIS/Documents/AKIS_reflection_paper.pdf

EuropaBio, 2007. *Biofuels in Europe: EuropaBio Position and Specific Recommendations*. Brussels, European Association for Bioindustries.

European Council, 2000. *Presidency Conclusions, 23–24 Mars*. Lisbonne, Lisbon European Council.

FfL, 2005. *European Technology Platform Food for Life: Vision for 2020 and Beyond*. Brussels, CIAA.

FfL, 2007. *European Technology Platform Food for Life: Strategic Research Agenda*. Brussels, CIAA.

FfL, 2008. *European Technology Platform Food for Life: Implementation Action Plan*. Brussels, CIAA.

FfL, 2016. *Food for Tomorrow's Consumer: Strategic Research and Innovation Agenda*. Brussels, European Technology Platform Food for Life (FFL). Brussels: CIAA.

FfL, 2017. *European Technology Platform Food for Life: Implementation Action Plan*. Brussels, CIAA.

Fonte M., 2013. Reflexive Localism: Toward a Theoretical Foundation of an Integrative Food Politics. *International Journal of the Sociology of Agriculture and Food*, 10(3), 397–402.

Friedmann, H., 1993. The Political Economy of Food: A Global Crisis. *New Left Review*, 1(197), 29–57.

Friedmann H., 2005. From Colonialism to Green Capitalism: Social Movements and Emergence of Food Regimes. *Research in Rural Sociology and Development*, 11, 227–264.

Friedmann H., 2009. Discussion: Moving Food Regimes Forward: Reflections on Symposium. *Agricultural and Human Values*, 26, 335–334.

Friedmann H., Daviron B., Allaire G., 2016. Political Economists have been Blinded by the Apparent Marginalization of Land and Food. *Revue De La Régulation*, [En ligne] 20, |2e semestre/Autumn 2016, mis en ligne le 20 décembre 2016. https://regulation.revues.org/12145.

Gallezot P., 2010. Alternative Value Chains for Biomass Conversion to Chemicals. *Topics in Catalysis*, 53(15), 1209–1213.

Georgescu-Roegen, N., 1971. *The Entropy Law and the Economic Process*. Cambridge, (Mass.), Harvard University Press.

Georgescu-Roegen N., 1975. Energy and Economic Myths. *Southern Economic Journal*, 41(3), 347–381.

Goodman D., Goodman M.K., 2009. Food Networks, Alternative. In Kitchin, R. and Thrift, N. (Eds.), *International Encyclopedia of Human Geography*. Amsterdam, Elsevier Science, pp. 208–220.

Guthman J., 2004. *Agrarian Dreams: The Paradox of Organic Farming in California*. Berkeley, University of California Press.

Huang J., Yang J., Msangi S., Rozelle S., Weersink A., 2012. Biofuels and the Poor: Global Impact Pathways of Biofuels on Agricultural Markets. *Food Policy*, 37(4), 439–451.

Ifoam-Europe, 2006. *Principles of Organic Agriculture*. Bonn, Ifoam.

Joly P.-B., 2010. On the Economics of Techno-Scientific Promises. In Akrich, M., Barthe, Y. and Muniesa F. (Eds.), *Débordements. Mélanges Offerts À Michel Callon*. Paris, Presses des Mines, pp. 203–221.

Levidow L., 2015a. Eco-Efficient Biorefineries: Techno-Fix for Resource Constraints? *Économie Rurale*, [En ligne] 349–350, 31–55. |septembre–novembre 2015 http://economierurale.revues.org/4729 https://economierurale.revues.org/4718 mis en ligne le 15 décembre 2017.

Levidow L., 2015b. European Transitions towards a Corporate-Environmental Food Regime: Agroecological Incorporation or Contestation? *Journal of Rural Studies*, 40, 76–89, doi: 10.1016/j.jrurstud.2015.06.001.

Levidow L., Birch K., Papaioannou T., 2013. Divergent Paradigms of European Agro-Food Innovation: The Knowledge-Based Bio-Economy (KBBE) as an R&D Agenda. *Science, Technology and Human Values*, 38(1), 94–125. doi: 10.1177/0162243912438143.

Levidow L., Pimbert M., Vanloqueren G., 2014. Agroecological Research: Conforming – Or Transforming the Dominant Agro-food Regime? *Agroecology and Sustainable Food Systems*, 38(10), 1127–1155.

Malerba F., 2002. Sectoral Systems of Innovation and Production. *Research Policy*, 31, 247–264.

McCormick, K. and Kautt, N., 2013. The Bioeconomy in Europe: An Overview, *Sustainability* 5(6), 2589-2608, https://doi.org/10.3390/su5062589

McEntee J., 2010. Contemporary and Traditional Localism: A Conceptualisation of Rural Local Food. *Local Environment*, 15(9–10), 785–803.

McMichael P., 2009. A Food Regime Genealogy. *The Journal of Peasant Study*, 36(1), 139–169.

Murphy A.M., Van Moorsel D., Ching M., 2007. *Agricutural Biotechnology to 2030: Steady Progress on Agricultural Biotechnology*. Paris, OECD.

National Research Council 2015. *Industrialization of Biology: A Roadmap to Accelerate the Advanced Manufacturing of Chemicals*. Washington, DC, National Academy of Sciences. www.nap.edu/read/19001.

Nicholls C., Altieri M., Vazquez L., 2016. Agroecology: Principles for the Conversion and Redesign of Farming Systems. *Journal of Ecosystem Ecography*, S5, 010, doi: 10.4172/2157-7625.S5-010.

Nieddu M., Garnier E., Bliard C.. 2014. Patrimoines Productifs Collectifs Versus Exploration Exploitation: Le cas de la bioraffinerie. *Revue économique,* 67(6), 957–987.

Nieddu M., Van Niel J., Youssef A., 2013. Novamont: Un modèle de bioraffinerie sans biocarburants. *Biofutur*, 32(344), 52–59.

Nieddu M., Vivien F.-D., 2016. La bioéconomie: entre enjeux économiques et projets de société. *Biofutur*, 35(378), 60–61.

Niggli U., Anamarija S., Schmid O., Halberg N., Schlüter M., 2008. *Vision for an Organic Food and Farming Research Agenda 2025 – Organic Knowledge for the Future*. Brussels, Ifoam Regional Group European Union.

Nova-Institut, 2017. *Biobased Building Blocks and Polymers: Global Capacities and Trends 2016–2021*. Hurth, Germany, Nova-Institute GmbH. www.bio-based.eu/reports.

OECD, 2006. *The Bioeconomy to 2030: Designing a Policy Agenda Scoping Paper*. Paris, OECD, 2017. *Towards Bio-Production of Materials: Replacing the Oil Barrel*. (No. DSTI/STP/BNCT(2016)17/FINAL) Paris, OECD. www.innovationpolicyplatform.org/system/files/DSTI-STP-BNCT%282016%2917-FINAL.en__0.pdf.

Padel S., Niggli U., Pearce B., Schlüter M., Schimd O., Cuoco E., Willer E., Huber M., Halberg N., Micheloni C., 2010. *TP Organics, Implementation Action Plan for Organic Food and Farming Research*. Brussels, Ifoam-EU Group.

Passet R., 1979. *L'économique et le vivant*. Paris, Economica.

Passet R., 2011. L'avenir est à la bio-économie, *Libération*, 23 mai, www.liberation.fr/economie/2011/05/23/l-avenir-est-a-la-bio-economie_737500.

Research/FAFB, D.G., 2011. *FP7 Theme 2: Food, Agriculture, Fisheries and Biotechnology*. 2012 Work Programme. Brussels, Commission of the European Communities.

SCAR FEG, 2007. *Foresight Expert Group, FFRAF Report: Foresight Food, Rural and Agri-Futures.* Standing Committee on Agricultural Research. Brussels, Consultative Expert Group.

SCAR FEG, 2008. 2nd Foresight Exercise: New challenges for Agricultural Research: Climate change, food security, rural development, agricultural knowledge systems. Brussels: Standing Committee on Agricultural Research (SCAR), Foresight Expert Group (FEG).

SCAR FEG, 2011. *Sustainable Food Consumption and Production in a Resource-Constrained World*. Brussels: Standing Committee on Agricultural Research, Foresight Expert Group.

Schmid O., Padel S., Halberg N., Huber M., Darnhofer I., Micheloni C., Koopmans C., Bügel S., Stopes C., Willer H., Schlüter M., Cuoco E., 2009. *Strategic Research Agenda for Organic Food and Farming*. Brussels, Ifoam-EU Group.

Schmid O., Padel S., Levidow L., 2012. The Bio-Economy Concept and Knowledge Base in a Public Goods and Farmer Perspective. *Bio-Based and Applied Economics (BAE)* 1(1), 47–63. http://orgprints.org/20942/, http://www.fupress.net/index.php/bae/article/view/10770.

TP Organics, 2011. TP Organics Response to the Consultation on the "Green Paper on a Common Strategic Framework for Future EU Research and Innovation Funding". Brussels, Technology Platform Organics.

TP Organics, 2017. *Innovating for Organics: Organics in EIP-AGRI Operational Groups*. Brussels, Technology Platform Organics. http://tporganics.eu/wp-content/uploads/2017/09/TPO_brochure_EIP_AGRI.pdf.

Van Dam, D., Streith, M., Nizet, J., Stassart, P., 2012. *Agroécologie: entre pratiques et sciences sociales*. Dijon:, Educagri éditions.

Vanloqueren G., Baret P.V., 2009. How Agricultural Research Systems Shape a Technological Regime that Develops Genetic Engineering but Locks out Agro-ecological Innovations. *Research Policy*, 38(6), 971–983.

Vivien F.-D., 1998. Bioeconomic Conceptions and the Concept of Sustainable Development. In Faucheux, S., O'Connor, M. and Van Der Straaten, J. (Eds.), *Sustainable Development: Concepts, Rationalities, Strategies*. Alphen-sur-le-Rhin, Kluwer Academic Publishers, pp. 57–68.

Vivien F.-D., 1999. From Agrarianism to Entropy: Georgescu-Roegen's Bioeconomics from a Malthusian Viewpoint. In Mayumi, K. and Gowdy, J.M. (Eds.), *Bioeconomics and Sustainability: Essays in Honour of Nicholas Georgescu-Roegen*. Cheltenham, Edward Elgar, pp. 155–172.

Wezel A., Bellon S., Doré T., Francis C., Vallod D., David C., 2009. Agroecology as a Science, a Movement and a Practice. *Agronomy for Sustainable Development*, 29(4), 503–515.

White House, 2012. *National Bioeconomy Blueprint*. Washington, DC, The White House.

World Economic Forum, 2010. *The Future of Industrial Biorefineries*. Geneva, World Economic Forum.