Socio-economic Characterisation of Agriculture Models

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Abstract Analyses of transition towards a more sustainable agriculture often identify two different pathways that can be linked to either strong or weak sustainability. In this interdisciplinary work, we aim at overcoming this narrow choice between these two alternatives, by offering a socio-agronomic characterisation of multiple agriculture models that currently coexist in Western economies. We use an agronomic typology of farming systems based on the role of exogenous inputs and endogenous ecosystem services in agricultural production, and on the degree of embeddedness of farming systems within local/global food systems. This typology identifies six agriculture models that we analyse in socio-economic terms. We then clarify the structuring principles that organise these models, and the social values underpinning their justification. This analysis enables us to discuss the efficiency conditions of political instruments.

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Introduction

The Western societal model, largely grounded in the industrialisation process, has transformed the nature of agricultural activities and their role in society. Industrial agriculture is based on intensifying the use of synthetic inputs (pesticides, nitrogen fertilisers, antibiotics, etc.), mining inputs (oil, potassium, phosphates), and irrigation water. Its mass development has created significant external environmental damage (Rockström et al. 2009; Gomiero et al. 2011). Society's awareness of these impacts along with environmental regulations are driving farmers to change their relationship to nature (Horlings and Marsden 2011; Duru et al. 2015a, b). The scientific literature often identifies two agricultural evolution pathways to improve agricultural sustainability. In this sense, starting at the end of the 1990s, Hill (1998) contrasted "shallow sustainability" with "deep sustainability"; more recently, Wilson (2008) speaks of "weak versus strong multifunctionality"; Horlings and Marsden (2011) of "weak versus strong ecological modernisation of agriculture"; and Levidow et al. (2012) of "life sciences versus an agroecology vision". These conceptual dichotomies schematically oppose two different relationships to nature: one based on technological progress placed in the service of industrialising agricultural production; the other based on the protection or restoration of natural capital in order to develop associated ecosystem services.

Without denying the importance of such approaches, our research aims to more closely analyse the diversity of agricultural transformation models (hereinafter "agriculture models"). The dualisms presented above relate to oppositions that are often developed from the viewpoint of a single discipline, leading to incomplete descriptions focused on technicity and science, without exploring the social values orienting these choices. These analyses are often limited to: (i) inventorying the negative effects of the dominant model; (ii) presenting a more virtuous alternative model; and (iii) identifying the barriers and levers to transition from one to the other. In our opinion, the usefulness of frameworks that distinguish different agriculture models in more detail resides in the emphasis placed on the coexistence and co-evolution of these models, potentially demonstrating how they intertwine with one another. Yet the few publications that distinguish more than two agriculture models and include a socio-economic dimension in their analysis (ex. Gliessman 2007) tend to grant moral status only to "deep sustainability" forms (see also Wilson 2008).[1] We espouse the contrary belief that it is beneficial to develop a better understanding of the social value systems on which dominant practices rely in order to consider how to transform them. While all of this research appears to agree on certain features of the two main agriculture models, it does not question the social foundations that legitimise the choices, individual strategies, or practices in each of them. This research is consequently incapable of accounting for the variety of

[1] For example, while Sulemana and James Jr. (2014) show that environmental ethics qualify "conservationist" farmers rather than productivist farmers, this does not mean that the practices of the latter are devoid of ethical foundations.

agriculture models in our Western economies, of understanding their founding principles, and therefore of contemplating both the variety of pathways to transition toward greater agricultural sustainability, and the mechanisms of coexistence of these models.

To describe the different Western agriculture models, it is important to qualify the different moral values and social principles that legitimise and underpin coherent sets of practices, agricultural technologies, and embeddedness within food systems. While these principles are general and tacit, they nonetheless remain effective. This multidisciplinary work, which combines agronomic and socio-economic approaches, thus emphasises the technical and social rationales underlying current and emerging farming systems. It enables a reconceptualisation of the coexistence of agriculture models which, along with the multitude of institutional devices supporting them – including political devices –, are involved in the agricultural transition faced with sustainability issues.

The originality of this research lies in the fact that it combines multiple analysis frameworks to construct a detailed characterisation of the various agriculture models developing in contemporary Western economies. To this end, we first briefly present the analysis framework created by Therond et al. (2017), which defines diverse agriculture models based on: (i) the way that farming systems combine exogenous inputs (synthetic and biological) and ecosystem services provided to farmers[2]; and (ii) their level of embeddedness in globalised food systems versus territorial dynamics (circular economy, local food system, integrated-landscape management). This typology was created from an agronomic viewpoint (*sensu lato*) based on an extensive literature review. We then characterise these different agriculture models based on their main social features, drawing on the "Economies of Worth" framework (Boltanski and Thevenot 1991) which allows us to objectify the correspondence of organisation rules and social norms with the practices described in the agronomic typology. The result of this interfacing of analysis frameworks allows us to put to the test the socio-economic consistency of the agronomic description of seven agriculture models currently present in our Western societies, including six agriculture models constituting responses to the sustainability issues of industrial agriculture. By emphasising the variety of agriculture models constituting alternatives to the industrial model that emerged in the wake of World War II, this typological analysis is intended to go beyond existing frameworks that are often reduced to a dichotomy. This research thus provides categories allowing us to analyse the influence of human-technology-nature relations on modes of social organisation, on the practices and uses of nature, as well as on the institutional and political forms framing them.

Section "Economies of worth and sustainable agriculture" presents the Economies of Worth socio-economic analysis framework and its usefulness in examining human-nature relations. Section "Agriculture models at the intersection between

[2] Here, the notion of "ecosystem service"is focused on the services provided to agricultural ecosystem managers (or farmers) corresponding to ecological processes regulating the nutrient cycle, water, soil structure, and biological regulations (including pollination).

farming systems, food systems, and local dynamics" presents the agronomic typology of agriculture models. The latter are then analysed in Section "Socio-economic characterisation of agriculture models", based on the economies of worth model. Section "The usefulness of characterising sustainable agriculture models for designing public policies" discusses political support mechanisms.

Economies of Worth and Sustainable Agriculture

The economies of worth socio-economic model (Boltanski and Thevenot 1991) is a framework to analyse the formation and dynamics of collective actions. We will start by presenting its concepts and will then show how this socio-economic approach can put different typologies of agriculture models into perspective.

From Justification Principles to Organisation Principles

The Economies of Worth model emphasises the fundamental role of social values in establishing and structuring collective actions. These values serve as a basis for the justifications put forward to defend the well-founded nature of an individual choice. The justifications are collectively examined and tested, in particular during conflicts, and may eventually be accepted as legitimate. Boltanski and Thevenot (1991) use the term "higher common principles" to denote this set of collectively-accepted social values. These principles establish spaces of commensurability between individuals and objects (individuals and objects are "qualified" according to this principle) and of ranking (some individuals and objects qualified according to this principle "are acknowledged as being worth" more than others).

Boltanski and Thévenot identify six higher common principles drawn from Western political philosophy that theoretically constitute "cities", in other words, social orders (cf. columns of Table 1):

- wealth as the basis of a market city,
- efficiency as the basis of an industrial city,
- equity as the basis of a civic city,
- honesty as the basis of a domestic city,
- grace as the basis of an inspired city,
- fame as the basis of an opinion-based city.

Additional research has also sought to demonstrate the existence of other cities, particularly an ecological city based on the principle of good intentions directed at the environment or on the symmetry between humans and nonhumans (Latour 1998 – cf. last column of Table 1). Other authors argue that the theoretical requirements of the model preclude this possibility, primarily because an ecological city would imply that the biotic and abiotic elements of ecosystems can "exercise" their

Table 1 Overview of the common worlds (or cities) identified in the Economies of Worth model according to Thévenot et al. (2000)

	Common worlds (Boltanski and Thevenot 1991), according to different common principles						Additional common world (various authors)
	Merchant (wealth)	Industrial (efficiency)	Civic (equity)	Domestic (honesty)	Inspired (grace)	Opinion (fame)	Green/Ecological (good intentions)
Evaluation method (magnitude)	Price, cost	Technical efficiency	Collective well-being	Esteem, reputation	Grace, singularity, creativity	Renown, fame	Symmetry, environmental good intentions
Test	Competition	Competence, reliability, planning	Equality and solidarity	Reliability	Passion, enthusiasm	Popularity, audience, acknowledgement	Sustainability, resilience
Form of proof of admissibility	Monetary	Measurable, statistic	Formal, official	Oral, personal guarantee, exemplary nature	Expression, emotional engagement	Semiotic	Ecological ecosystem
Qualified objects	Market goods or services	Technical infrastructure, method, plan	Rules, fundamental rights	Local heritage, legacy	Body or emotionally charged object	Sign, media	Virgin, wild, natural habitat
Qualified beings	Customer, consumer, vendors, merchant	Engineer, professional, expert	Citizens, unions	Authority figure	Creative being	Celebrity	Environmentalist, ecosystem actors
Time of formation	Short-term, flexibility	Long-term, planned future	Perpetual	Customary	Eschatological, revolutionary or visionary moment	Vogue, trend	Future generations
Space of formation	Globalisation	Cartesian space	Detachment	Local, anchoring in proximity	Presence	Communication networks	Planetary ecosystem
Qualified nature (Godard 1990)	Market nature, consent to pay	Exploited, productive nature	Freely accessible nature	Domesticated nature	Exceptional natural sight, aesthetic value	Nature capable of mobilising opinion	Virgin nature, value of existence

"choice" (or their operation) in the city (Lafaye and Thévenot 1993). This impossibility leads to ecological justifications that are legitimised either by qualifying nature within existing cities (for example, as a source of spirituality or a productive resource – Godard 1990 – cf. last row of Table 1), or by combining principles from different cities (Lafaye and Thévenot 1993; Thévenot et al. 2000).

Actors refer to these principles to organise collective action, evaluate and justify the validity of their actions, criticise those of others, and/or build institutional or material devices that frame practices and collective actions. Theoretical "cities" are therefore declined in the "world" (in the sociological sense of the word), that is, in assemblies of objects (whether tangible and/or intangible) and in people.

Approaches to Sustainable Agriculture Put to the Test of Economies of Worth

Creating a typology consists of grouping individuals and/or objects together on the basis of criteria that qualify individuals and objects according to the same register. In this sense, the economies of worth model can contribute both to the creation of the typology (the establishment of equivalence within categories) and to the social relevance of these groupings.

The majority of the research that has studied the variety of sustainable agriculture models or analysed the diversity of transition pathways towards more sustainable agriculture presents certain typology problems. For example, the work of Gomiero et al. (2011), which presents a number of different "philosophical approaches to agriculture", or of Féret and Douguet (2001), who analyse various agricultural governance frameworks that they call "agricultural families", groups together types of agriculture (agroecology, organic agriculture, permaculture, intensification, etc. for the former; organic agriculture, peasant agriculture, rational agriculture, etc. for the latter) under conventional designations with varying levels of institutionalisation. These inventories are not the result of typological approaches, given that the criteria distinguishing these "philosophies", these "families", or these "reference frameworks" are not always explicit. On the contrary, our typology-based approach demonstrates that some of these "philosophies", by relating to very different agricultural practices, are qualified in different sustainable agriculture models (this is the case in particular for organic agriculture[3] or conservation agriculture).

Another line of research stems from the observation of agricultural practices and establishes distinctions based on better-defined criteria (Hill 1998; Gliessman 2007). Without overlooking the role of socio-economic context in these practices,

[3] In reality, organic agriculture relates to various practices (cf. Allaire and Bellon, 2014) described in various sustainable agriculture models (Therond et al. 2017) and justified by very different principles. Therefore, we believe it would be contradictory to acknowledge the diversity of organic agriculture while treating it as a single model (for example, cf. Benoit et al., 2017), whether to evaluate overall performance or to outline practices.

this research grants decisive importance to individuals' decision-making capabilities (see also certain ground-breaking research on agricultural multifunctionality, in particular Van der Ploeg 1996). It thus tends to consider that different agriculture models are independent of one another (alternative models are treated like contextual elements for another model). By contrast, the Economies of Worth model invites us to consider the fundamental role played by other agriculture models in the internal structure of a given model. This research also tends to attribute ethical or moral virtues to those models that most radically break with the conventional one. The Economies of Worth model teaches that even the most self-interested reasons are underpinned by powerful value (ethics) systems. In this sense, it is consistent with another body of research that more specifically addresses the problem of the transition to more sustainable agriculture (Horlings and Marsden 2011; Levidow et al. 2012). While this research emphasises the aspects structuring contexts (in particular food systems or territorial dynamics, as well as the practical aspects of farming systems, it tends to liken one to the other, considering that production practices (such as agroecological practices) go hand-in-hand with certain territorial dynamics (in this example, short circuits). However, according to the Economies of Worth model, these activities can stem from very different principles, which is what our typology aims to demonstrate.

Lastly, another set of research addresses the multifunctionality of agriculture (Laurent et al. 2003; Wilson 2008; Renting et al. 2009; van der Ploeg et al. 2009). For example, the typological approach developed by Laurent et al. (1998) highlights 11 types of agricultural activity model based on the domains in which the activity in question is embedded, the professional standard systems to which it refers, and the negotiation bodies mobilised to resolve difficulties related to the agricultural activity. This typology allows us to discuss three principal social functions of agricultural activities (providing professional income, insertion within a regime of social transfers, and own consumption and bartering). These functions nevertheless point to the principles of fairness that delimit and socially justify them. Apart from the implications for the agricultural sector, shining light on these principles allows us to assess the societal reach of agricultural activities. We believe that this focus is fundamental when it comes to considering agricultural sustainability stakes. Research on multifunctionality has therefore included the environmental function of agriculture. Some researchers establish "styles of agriculture" based on criteria comparable to those that we use (for example, Van der Ploeg 1996), but neglect the effects of supervision (or of authority) driven by productive structures, social structures, and more generally agro-food activity governance structures. Other multifunctionality research shows, on the contrary, that different types of agricultural activities (traditional agricultural logic, capitalist agriculture, agriculture as a structured profession, etc.) correspond to specific organisational structures with specific goals (agricultural income, increasing equity, subsistence and trade, etc.), the social relations of which are mediated by different forms of legitimate institutions (Laurent et al. 1998; van der Ploeg et al. 2009). However, nothing is said about the source of these institutions' legitimacy or of the principles and values underpinning the organisational forms described. The Economies of Worth model allows us to describe these social systems in detail.

Agriculture Models at the Intersection Between Farming Systems, Food Systems, and Local Dynamics

By considering the classic classifications of types of agricultural transformation (i.e. sustainability or strong versus weak multifunctionality), Therond et al. (2017) developed an analysis framework and a more detailed typology of sustainable agriculture models. These models correspond to types of farming systems that vary in their dependence on exogenous inputs or ecosystem services (y-axis of Fig. 1). They present a varying level of embeddedness in global food systems compared to the territorial dynamics that determine their biotechnical functioning (x-axis of Fig. 1). Each criterion relates to fundamental agricultural sustainability concerns (van der Ploeg 1996; Fraser et al. 2016). In this section, we elucidate these two main dimensions that differentiate sustainable agriculture models.

Sustainable Farming Systems: Exogenous Inputs and Ecosystem Services

In post-WWII Western economies the industrial development process required an increase in agricultural production. This was achieved primarily by selecting more productive plant species and animal breeds. Farmers also developed farming systems based on the use of exogenous inputs allowing them to control abiotic (water and nutrients) and biotic (the negative effects of pests) factors that could limit or reduce agricultural production (van Ittersum and Rabbinge 1997). The large-scale use of these inputs with a low relative cost enabled farmers to simplify cropping plans and rotations, and therefore led to the specialisation of systems and the standardisation of practices and products. Farmers became accustomed to adopting assurance practices consisting in intensifying the use of these inputs to limit production risks (e.g. pests). To combat the environmental damages caused by the development of these specialised farming systems, farmers can implement three agronomic strategies (Duru et al. 2015a, cf. also Hill 1998).

The first strategy consists in optimising the efficiency of input use considering the space and time needs of plants and animals, thus limiting fertiliser and pesticide use (efficiency optimisation strategy of the ESR model[4]). This strategy requires the best possible evaluation in time and space of the ecosystem services provided by the soil-plant(−animal) system in order to minimise the additional exogenous inputs necessary to reach production goals (Fig. 1, bottom of the y-axis). The development of this type of farming system is based on technological innovations, particularly so-called precision agriculture technologies, and on the use of plant and animal varieties less sensitive to limiting biotic and abiotic factors. Agricultural practices remain standardised and are therefore not well rooted in local knowledge.

[4] Efficiency, Substitution, Redesign (Hill, 1998).

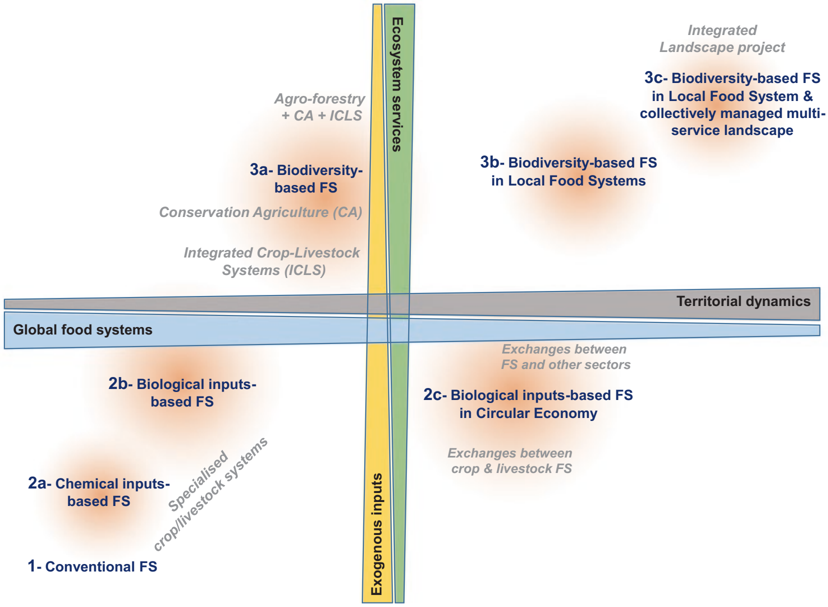

Fig. 1 Typology of agriculture models
Adapted from Therond et al. 2017. The agriculture models numbered 2 and 3 correspond to alternatives to the historical industrial agriculture model often described as "conventional", and which can also be configured differently depending on the context (numbered 1). FS means "farming system". A change from 1 and 2 to 3 indicates a profound change in biotechnical functioning in farming systems (y-axis) shifting from the use of exogenous anthropogenic inputs (1 and 2) to systems based on ecosystem services (3). The letters a, b, and c mainly refer to the relations between farming systems and global food systems or territorial dynamics (x-axis). Certain forms are already well developed; others correspond to niches or represent potential agriculture models in a given region or country. Most often, different forms coexist within a given territory, with one (or several) of them prevailing. Emblematic examples are indicated in italics; conservation agriculture – CA – is used here according to the definition of the FAO. (cf. footnote 5)

The second strategy involves farmers who are more reluctant to use synthetic pesticides and more sensitive to maintaining the health of people and ecosystems. Using a substitution strategy, they seek to develop a farming system that is based as much as possible on the use of organic fertilisers and biocontrol technologies (biopesticides, plant and soil health stimulators, addition of industrially-developed organisms to improve soil quality and biological regulations). However, even though farmers aim to reproduce the ecological operation of diversified agro-ecosystems, their farming systems often remain based on a low level of planned diversity. It is nevertheless possible that these practices (e.g. the use of biostimulants) may promote the development of ecosystem services.

The third strategy is based on managing the planned (domestic) and associated (natural) diversity of ecosystems in order to develop ecosystem services for agriculture (Zhang et al. 2007; Duru et al. 2015b). By redesigning farming systems, it consists in replacing a significant portion of exogenous inputs (whether chemical or biological) with "natural" regulation services that improve soil fertility (soil structure and nutrient cycle), water storage and restoration, pollination, and pest regulation (Fig. 1, top of the y-axis). Developing ecosystem services beneficial to the farmer requires the diversification of the species farmed/grown over time and in space (e.g. cover crops, extended crop rotations), and promotion of the diversity of semi-natural habitats on the level of the land parcel (the boundaries of fields, fallow land, hedges, and forests) (Bianchi et al. 2006), while limiting mechanical disturbances (Duru et al. 2015b). The properties thus targeted by farmers are based on the ability of ecosystems to: (i) store nutrients, energy, and water when these resources are available and to return them to the plants when necessary; (ii) regulate the dispersal and activity of biological pests; and (iii) provide an appropriate habitat for species that deliver regulation services. At field level, this requires the promotion of soil biological activity, such as through no-till practices and the insertion of cover crops during inter-crops. For animals, this may consist in using alternative livestock farming practices (e.g. low density) to ensure the health and vitality of young and adult animals throughout their life (de Goede et al. 2013). The particularity of this type of farming system is that even though its ecological principles are generic, management practices are fundamentally dependent on production/action situations (Duru et al. 2015a; Giller et al. 2015).

Sustainable Agriculture Models at the Crossroad Between Farming Systems, Food Systems, and Territorial Dynamics

Food systems consist in all of the institutions, modes of organisation, technologies, and practices that determine the modes of production, transformation, packaging, and distribution of food products. On top of influencing the nature of the products consumed and the way they are produced and traded, they also determine the conditions for accessing foods and their nutritional quality (Capone et al. 2014). Food systems have rapidly globalised over the past decades, resulting in homogenisation of initially different national food systems (Khoury et al. 2014). Farming systems overlap with these global food systems to varying degrees. They can also overlap with territorial dynamics, such as the development of circular economies, local food systems, or collective landscape management approaches (Fig. 1, x-axis).

Simplified farming systems based on the use of exogenous inputs are greatly intertwined with globalised food systems and, as such, constitute the most prevalent agriculture model in Western Europe (Levidow et al. 2012; Marsden 2013). Within these globalised food systems, power is intensely concentrated in the hands of a few companies (Marsden 2013). The economic resiliency of farming systems faced with the variability of prices and the impacts of biophysical hazards are assured by contractual or insurance devices. These assurance tools can lead farmers to maintain or develop simplified cropping systems or even monocultures that would otherwise be too risky without them (Müller and Kreuer 2016). There exist farming systems based on the use of biological inputs which, like in the previous case, are closely connected to globalised food systems for the purchase of these inputs and the sale of agricultural raw materials. Therefore, it is necessary to distinguish different ways of implementing organic agriculture given that replacing chemical inputs with biological inputs does not always result in a fundamental shift in the mode of production.[5]

In parallel, farming systems can be embedded within localised socio-economic contexts, such as circular economies (the organisation of which requires the management of input-output flows between activities, locally or regionally), alternative food systems (localised systems or those laying claim to social or environmental features), or even integrated regional development projects. In the latter case, the development of agriculture can be combined with integrated landscape management to promote the development of ecosystem services (Wu 2013; Mastrangelo et al. 2014). Most of these farming systems, which are usually diversified, are designed to address environmental or human health issues (products of biological agriculture, foods rich in omega-3s...) and satisfying consumers' demand for quality products, sometimes produced locally (Murdoch et al. 2000).

Certain farming systems may use local markets to access inputs meanwhile selling their products on global markets (or vice versa). For example, conservation agriculture,[6] agroforestry, integrated crop-livestock systems, or self-sufficient livestock systems can permit the development of ecosystem services and therefore, for certain of these, a reduction in the use of exogenous inputs while continuing to sell production via globalised food systems when no other solutions are available or when prices are appealing. Even in this case, certain raw materials can be sold off in globalised supply chains. Likewise, farming systems based on the use of biological inputs can simultaneously be connected to globalised food systems and a local circular economy. Therefore, global and local markets potentially appear to be complementary.

By cross-referencing the three biotechnical strategies of more sustainable agricultural production and the strategies for insertion in global food systems and territorial dynamics, Therond et al. (2017) obtain six sustainable agriculture models (cf. Fig. 1). The notation (2a, b, c and 3a, b, c) indicates a break between the first three forms, which are based on efficiency or substitution strate gies, and the last three forms, which require in-depth redesigning of farming systems. In the following section, we detail the socio-economic features of these forms by showing how each one is distinguished from the others.

[5] In particular, this type of biological agriculture does not encompass practices based on the development of ecosystem services as an essential mechanism in managing crops.

[6] Various agricultural practices can be described as conservation agriculture. Here, it corresponds to an agriculture based on three key principles: no-till, permanent soil cover, and diversified and long rotations (http://www.fao.org/ag/ca/1a.html). Debates exist surrounding the environmental performance of these practices, in particular because they may include an increase in herbicide use. In any event, to complement or replace the use of these phytosanitary products, these practices require farmers to manage ecosystem services as best they can.

Socio-economic Characterisation of Agriculture Models

Drawing on this typology, in this section we characterise the different agriculture models identified by Therond et al. (2017) in socio-economic terms according to the Economies of Worth grammar. Model by model, we detail the main socio-agronomic features of each one. These features have been selected because they correspond to the main examples of the different sustainable agriculture models. Table 2 presents a more complete overview of these features.

The Conventional Productivist Model Based on an Industrial/ Market Compromise

The industrial agriculture model of Western economies, which we qualify as "conventional" (1) pertains, in the sense of the Economies of Worth model, to a system of practices that are market-based and structured to maximise productivity (in the sense of the industrial principle). These two principles are based on standardising infrastructure, production technologies (machinery, petrochemical inputs, etc.), and end products enabling mass production and distribution. Striving for efficiency and profitability come together in economies of scale and agglomeration, which concentrate production to reduce unit costs. Agricultural practices are essentially oriented at the artificialisation of the environment in order to control or even eliminate the biophysical factors of production variability. For example, the use of chemical pesticides for crop-pest control, or of antibiotics to ensure animal health, are practices minimising the effects of these factors.

This model leads humans to instrumentalise nature by reducing the farming system to a technical economic system: production strategies are rationalised over relatively short time frames (crop season, short crop rotation); the global standardisation of seeds, breeds, production technologies, and products eliminates the local particularities of ecosystems (products are commodities; inputs and technologies are generic), and so on.

The Technology-Intensive Model Based on an Industrial Efficiency/Market Profitability Compromise (2a)

This model is essentially structured around the use of new digital technologies, precision agriculture, and improved varieties or breeds economising the use of industrial inputs, which are massively used in the conventional productivist model (1). In technology-intensive agriculture, the shift in practices in farming systems is driven by the idea that technological mastery can meet environmental requirements, reduce production costs, and thus improve farmers' incomes. Beyond

Table 2 Socio-agronomic characterisation of contemporary agriculture models in Western countries

Farming systems (Section "The conventional productivist model based on an industrial/market compromise")	Historical-conventional system	Farming systems based on chemical inputs connected to global food systems	Farming systems based on biological inputs connected to global food systems	Farming systems based on biological inputs connected to local food systems	Farming systems based on biodiversity connected to global food systems	Farming systems based on biodiversity connected to local food systems	Farming systems based on biodiversity connected to local food systems and multiservices landscape
Agriculture models	**Productivist model (1)**	**Technology-intensive model (2a)**	**Techno-domestic model (2b)**	**Circular model (2c)**	**Diversified-globalised model (3a)**	**Diversified local model (3b)**	**Diversified integrated-landscape model (3c)**
Common worlds involved	**Industrial (productivity) and market (income)**	**Industrial (efficiency) and market (profitability)**	**Domestic (proximity) and industrial (biotech efficiency)**	**Industrial (system efficiency)**	**Opinion and industrial (efficiency)**	**Opinion, domestic, market…**	**Green, domestic, civic…**
Higher common principles	Independence, food security, product diversity	**Same as in 1** + Efficiency and Well-being at work	Ethics of nature and human heath	Overall efficiency at the cluster scale	Ability to put nature to work and "one health" (farm level)	**Same as in 3a** + Value creation (farmer and region level)	Systemic thought, natural and landscape resources, "one health" (ecosystem level)
Modes of evaluation (test)	Productivity of labour and surface area, farm size, balance sheet, production and exports	Production costs, structure of investments, technological intensity	Social and environmental costs, sanitary conditions, environmental indicators	Waste-production balance at the cluster level, recycling rate	Sustainable use of nature, opinion of peers, income	**Same as in 3a** + Embeddedness in the local food system, added value for the region, income	Systemic (multilevel, multicriteria, multiactor)

(continued)

Table 2 (continued)

Qualified objects	Exogenous inputs, machinery, standards	**Same as in 1** + Connected and high-tech devices	**Same as in 2a** + Biological inputs	**Same as in 2b** + Biogas production, waste recycling equipment, co-products	Natural capital and ecosystem services, petrochemical and biological inputs	**Same as in 3a** + Products sold locally	**Same as in 3a** + Quality of the landscape and state of natural resources
Qualified human beings	Productive farmer, mass consumer	High-tech farmer/ entrepreneur, mass consumer	Socially responsible farmer, family, neighbourhood	**Same as in 2b** Cluster member	Agroecologist farmer, agricultural ecosystem	**Same as in 3a** Farmer connected to local consumer, other actors in the local food system, cluster member	**Same as in 3b** Local actors and ecosystems, network member
Time of formation	Short economic term	**Same as in 1**	Short- to medium-term biological cycles	**Same as in 2b** + Cluster cycles	Short-, medium- and long-term biological cycles	**Same as in 3a** + Institutional cycles	Short−/medium−/ long-term biological, social, and institutional cycles
Key spatial levels	Linked upstream and downstream of the global industry	**Same as in 1** + Infra-parcel	**Same as in 1** + Socio-environmental neighbourhood	Local industrial clusters	Peer communities, ecological environment of the farm	**Same as in 3a** + Local market	**Same as in 3b** + Local system, social networks
Mode of regulation	Contracts, intellectual property rights, incentives and financial support, production standards	**Same as in 1**	**Same as in 1**	**Same as 1** + Local industrial partnerships	Peer associations, adaptive field management	**Same as in 3a** + Local markets	**Same as in 3b** + Local system, adaptive management of landscapes
Mode of organisation/ coordination	Global markets and food systems	**Same as in 1** + Technologies shape relationship to nature, new markets	**Same as in 2a**	Circular economy	Peer communities, global food system	**Same as in 3a** + Peer communities, local markets	**Same as in 3b** + Polycentric organisation, adaptive governance

environmental regulations, the significant economic constraints of markets, both upstream (increases in input prices) and downstream from farming systems (increases in price volatility) are encouraging farmers of the conventional model (1) to increasingly change to this technology-intensive model (2a). As a result, they often wish to increase the size of their farm to benefit from economies of scale and increase their ability to invest in Technologies. The quest for efficiency and profitability justifies using these technologies while embedding them within a compromise between the industrial and business worlds. Therefore, like in the conventional model, human-nature relations remain mediated by technology, although by increasingly sophisticated technologies that require farmers to change their way of creating and using the environmental information produced (performance maps, representation of ecological areas, etc.).

The Techno-domestic Model Based on a Local Ethics / Biotechnological Efficiency Compromise (2b)

The techno-domestic agriculture model (2b) is characterised by the use of technologies derived from the living world (e.g. microbiological treatments based on *Bacillus thuringiensis*, addition of nitrogen by spreading free nitrogen-fixing bacteria over carbonaceous residues). The reason for the adoption of these living technologies is awareness of the health and environmental effects of chemical inputs. These practices are a response to the belief[7] that they are able both to improve the productive capacity of soils and plants (e.g. bio-stimulants of soil activity and plant health) and to limit the environmental and health impacts of agriculture (less eco-toxicity among inputs of biological origin). They aim to improve the operation of the agro-ecosystem without large-scale changes (diversification) in crop or livestock farming systems and without taking on board more global environmental concerns. They also aim to reduce the impact of agricultural practices on human health and the ecosystem. The use of technologies of biological origin (e.g. biocontrol) can make it necessary to take ecological time frames into account (e.g. the population dynamics of the organisms introduced). As a result, these practices induce a relationship to nature that is not strictly instrumental. The search for efficient production remains important in the techno-domestic agriculture model, but farmers' concerns for their own health, that of their family and neighbours, and for the local ecosystem make farmers (as well as the consumers qualified in this model) receptive to environmental ethics, guided by a principle of localness and embedded within a compromise between the domestic and industrial worlds.

[7] Here, the term belief is related to a lack of proof for this sustainable agriculture model, in which actors do not have the means to objectify the achievement of the common good (the effectiveness of their practices). In these situations, the shared belief of doing what is right (adopting environmental ethics) can be enough to sustain this order, but the absence of proof makes it fragile.

The Circular Model Based on a Compromise Between Efficiency and Industrial Ecology (2c)

Developing the circular economy at local or regional level gives farming systems opportunities to replace chemical inputs by organic materials derived from agricultural activities and other sectors of activity (e.g. organic fertilisers rather than chemical ones), or outlets for their production (biomass for energy production). Agriculture based on the circular economy is developing in some forms of crop-livestock farming combinations on the territorial level (Moraine et al. 2016). This sustainable agriculture model follows the principles of industrial ecology. It is thus essentially based on new ways of organising farmers and other agricultural actors into productive clusters. Geographic proximity plays an important role in developing the exchange of materials and energy at local/regional level. It can also contribute to redefining urban/rural relations. These forms of organisation are possible only if the actors involved in circular economies adopt a concept of production efficiency on the local/regional scale. In this sense, the practices qualified in this form relate to a relationship to nature that is peculiar to the industrial world: natural resources, waste and scraps are seen as resources to be used efficiently in an industrial economy of the environment (both in the use of resources as well as environmental impacts).

The Diversified-Globalised Model: A Compromise Between Opinion/Bioproduction Efficiency (3a)

Diversified-globalised agriculture refers to large crop or livestock farming systems that are diversified, and in particular farming systems based on conservation agriculture based on three pillars (no-till, cover crops, and long rotations) or agroforestry. These typical examples of this sustainable agriculture model are characterised by the adoption of production principles based on the "work" of nature (biodiversity at the origin of ecosystem services), without, however, prohibiting the use of synthetic or biological inputs. These practices make it impossible to use the underlying information on which farmers base their choices in type 2 agriculture models, in particular the technical benchmarks for standardised production associated with specialised and artificialised farming systems. To better understand the uncertainty of nature and the effects of biodiversity management practices, farmers organise into peer groups. These groups allow them to communicate and share experiences around nature and the effects of agricultural practices, thus activating social networks as a production resource. These forms of organisation, the main goal of which is to share knowledge and learn situated practices, also have the effect of re-drawing the boundaries of agronomic "standard practices". This entails redefining what constitutes good cropping practices, what a field is in a good state is like, what acceptable production levels are, or even the criteria for judging efficiency, and so on

(Cristofari et al. 2017). This way of organising knowledge circulation contributes to "valuing" others' viewpoints while simultaneously enabling the construction of a shared representation of collective values. These peer groups thus establish a test based on opinions, which makes the set of production practices stable and coherent. These practices are supported by the effects of reputation, with a principle of legitimacy resulting from a compromise between the industrial world and the opinion world. Two key characteristics set apart this agriculture model from the three previous models: (i) it institutes new social models for organising and validating practices, and (ii) it leads stakeholders to perceive nature as a place of life and as the main factor in production.

The Diversified Local Model Based on Opinion/Domestic/ Market Elements (3b)

As with the diversified-globalised model (3a), the environmental sustainability of this model's agricultural production is based on the development of ecosystem services. However, while the production of the former is essentially sold on global markets, the second distributes agricultural products locally. This enables farmers to sell the products of diversified crops that are more difficult to sell in global food systems (unappealing prices), and to participate in the local economy and development. Two organisational forms exist, supported by two different value sets. The first consists of communities of farmers within which agronomic practices are put to the test (in the sense of the economies of worth model) and socially validated. The other concerns the sale of products within local food systems. It exposes farmers (and their production practices) to consumers' judgements when evaluating the environmental, organoleptic, and sanitary quality of products (even if a portion of outlets are provided by global food systems). This market test is combined with that of the world of opinion (peer groups). By bringing consumers and producers closer together, this form of organisation answers the needs of the former to reconnect with nature. This requires them to be capable of recognising the specific qualities of the products of this system. In France, for example, *Associations pour le Maintien de l'Agriculture Paysanne*, (AMAP, associations for the maintenance of peasant agriculture) are the most visible alternative food systems today, but other distribution forms also exist (direct producer stores, farmers' markets, and different forms of "short-circuits", such as selling along the road, outdoor markets, local producers supplying retail stores, etc.; cf. Deverre and Lamine 2010). This production world thus broadens the relationship between society and nature, drawing from elements of the worlds of opinion and industry as well as the market, in a relatively loose compromise.

Diversified Integrated-Landscape Agriculture Based on Green/ Domestic/Civic Elements (3c)

For the time being, the existence of diversified farming systems embedded in integrated-landscape approaches is mainly theoretical in Western Europe, even though it is possible to spot its building blocks in reality. It is characterised by local stakeholders (farmers, consumers, local supply chain actors, citizens, etc.) sharing systemic thought and evaluating the effects of their actions at the territorial level. Beyond the adoption of production practices based on the work of nature (biodiversity at the origin of ecosystem services), this form of sustainable agriculture requires agricultural activities to be embedded within integrated approaches of landscape conceptualised as a social-ecological system. In certain respects, in France, the Biovallée project, based on the preservation and valorisation of natural resources in the service of the population's drinking water, food, habitat, health, energy, and leisure needs, is a relevant example of this form (even though some of its aspects borrow much from other forms – cf. Lamine 2012). In the agriculture model, the agricultural practices that contribute to territorial development, such as organising the spatial distribution of cropping systems and semi-natural habitats to develop ecosystem service at the landscape level, are considered legitimate. This is an extreme form of embedding agriculture in the socio-economic context, insofar as its development requires a participatory "landscape design" approach (cf. Nassauer and Opdam 2008) and the collective governance of land use and semi-natural habitats. Consequently, this form of agriculture borrows legitimising elements from the domestic world (a locally-based regime), the civic world (fair treatment of stakeholders within the territorial system), and the ecological world (nature is treated as an organised whole of living beings, whose intrinsic value is recognised). The preferred social organisation in this agriculture model is the network. It establishes the fair treatment of all the members, specific to the civic world and potentially extended to landscape's biotic elements, and has the particularity of not establishing a hierarchy of individuals within a social order. In this sense, but also because it is based on ecological justifications (in the sense of the ecological city), this model lies outside of the axiomatic system of the Economies of Worth model.[8] It more clearly appears to break with other sustainable agriculture models.

[8] The Economies of Worth model is based on an axiomatic system that postulates: (i) the common humanity of beings belonging to cities (which excludes from the outset, for example, considering the possibility of dialogue with beneficial organisms), and (ii) a principle of the ranking of individuals, which defines, for varying durations of time, states of worth (with "worth beings" constituting the individuals who are legitimate to take responsibility for the common good according to certain principles), which the "network" form, in this context, does not do.

The Usefulness of Characterising Sustainable Agriculture Models for Designing Public Policies

Research on the multifunctionality of agriculture (Wilson 2008; van der Ploeg et al. 2009) emphasises the multiple functions of agriculture not only as an economic and social activity, but also in view of its environmental impacts (Laurent et al. 2003). Drawing from this research, characterising the different sustainable agriculture models presented above illustrates how multifunctionality mechanisms can operate on different levels, and what the role of the interconnection between various locally-embedded stakeholders, as well as of consumers and citizens, is (cf. Renting et al. 2009).

By closely describing the specific consistency of the sustainable agriculture models that coexist, our framework provides paths to an improved consideration of the adjustment of policies to the models that they address. For example, the ecological conditionality of Common Agricultural Policy subsidies can shift the practices of conventional farmers towards technology-intensive and techno-domestic sustainable agriculture models (2a and 2b), because this public policy device is compatible with the principle underpinning them. Concretely, farmers primarily motivated by increasing their income are sensitive to monetary signals, including incentives, subsidies, or compensation. On the other hand, these devices do not trigger a transition toward diversified (3a), diversified local (3b), or diversified integrated-landscape (3c) models, because practices that take place in these diversified agriculture models are justified by a will to restore natural capital or to maintain local/regional economic activities. The stakeholders of these diversified models may be more sensitive to political devices seeking to socially animate the local/regional territory or to develop more sustainable agriculture. The effectiveness and efficiency of these public policies thus depend on their adjustment to the sustainable agriculture model that they address, which implies taking into consideration the value system underlying them.

Moreover, considering that the agriculture models are embedded in one (or multiple) specific world(s) and disqualified in others, by supporting certain agriculture models and not others, public policies reveal the extent of their contribution to the reproduction of relations of domination. For example, in France, the maintenance of the intellectual property devices underpinning the technology-intensive model (2a) prohibits seed exchange practices, which constitute an institutional and organisational device (despite operating via informal rules) that addresses the technical problems encountered in models based on adapting crops to local production situations. Likewise, international trade agreements promote the access of national products to global food systems and encourage models that are essentially dependent on outlets on these types of markets, but which discourage the production of products that do not meet their standards. Lastly, environmental services' payment devices, which compensate farmers for maintaining practices that respect the environment, can change the reference frameworks for judging farmers not motivated primarily by financial compensation, and can requalify technological practices (such as in models 2a and 2b) as producers of environmental services (Froger et al. 2016). Our socio-economic analysis of the agronomic typology thus allows us to show the extent to which a public policy, even when adjusted to the sustainable agriculture model that it addresses, can have harmful effects on other types of practices. In this sense, our analysis draws attention to the variety of lock-in mechanisms – not only those that are technical or cognitive, but also those that are normative and political – driving the stability of technology-intensive (2a) and techno-domestic (2b) sustainable agriculture models. While this stability draws from the ability of public policies to legitimise the practices of these agriculture models, it also resides in the ability to exclude the criticism directed at them, for example, originating from agriculture models with production based on ecosystem services (3a, b, and c).

Ultimately, the success of public policies depends on the agriculture models whose principles are consistent with those they convey, or on their way of arranging the complementarity (potentially on different levels) between various agriculture models. They are therefore potentially unsupportive of, or even antagonistic to, the development of other models, either because they appear to be illegitimate with respect to the principles and values underpinning these policies, or because they produce perverse effects (prohibition or discouragement of practices alternative to the target model), or because they disqualify the criticism that the most radical sustainable agriculture models level at the most conventional ones.

Conclusion

Our analysis presents the socio-agronomic features of seven agriculture models that currently coexist in Western economies. We have insisted on oppositions between the historical "conventional" model underpinned by industrial and market organisation principles, and six alternative models that provide answers to environmental and social sustainability issues. We have explained how these agriculture models are based on different ways of implementing practices and technologies to organise and regulate agricultural production. We have qualified the ways of doing and acting, with varying levels of incompatibility between models, based on the value system that socially justifies them in terms of sustainability. This research shines light on the complexity of agricultural territories that are composed of different models that coexist and co-evolve to differing degrees and at different levels, and on the multiplicity of transitions to more sustainable agriculture.

This analysis allows us to clarify the conditions under which public policy instruments are effective. First, the mechanisms for implementing policies must be consistent with the agriculture models that they address; in other words, they have to take into account the reasons why the stakeholders of these models act as they do. It is therefore necessary to properly design these policies based on the features of agriculture models and the multiple possible configurations of coexistence and interweaving of these models.

Faced with this complexity, an extension of this research would consist in two complementary directions. The first avenue would specify the socio-economic reality of this typological characterisation by providing quantified data (in terms of agricultural surface area, labour time, agricultural employment, added value, product volume, etc.). The objectives would be to evaluate the representativeness of each of these agriculture models and to better characterise configurations of coexistence and hybridisation between these models in a few developed countries. The second line of research would evaluate, in these countries, the sustainability of these configurations through multi-criteria assessments. These analyses would provide useful information to public decision-makers by allowing them to better adjust the instruments and targets of their policies. For the moment, we believe that adopting a precautionary principle appears to be necessary in order not to hinder the most marginal models' development, especially considering the likely porosity between different agriculture models. While the technical or organisational innovations that develop in minority models can be passed on to the most prevalent agriculture models and thus improve their sustainability, the systemic nature of these transition necessitates, beyond technical changes, profound moral and philosophical shifts in the way that we conceive of our relationship to nature and our food. The different agriculture models present distinct particularities in this respect.

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