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► **To cite this version:**

Alban Thomas, Claire Lamine, Benjamin Allès, Yuna Chiffolleau, Antoine Doré, et al.. The key roles of economic and social organization, producer and consumer behaviour towards a HAFEN (Health-Agriculture-Environment-Food Nexus). 2020. hal-02791694

**HAL Id: hal-02791694**

**<https://hal.inrae.fr/hal-02791694>**

Preprint submitted on 5 Jun 2020

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January 2020

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The key roles of economic and social organization, producer and consumer behaviour towards a HAFEN (Health-Agriculture-Environment-Food Nexus)<sup>1</sup>

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## Abstract

We discuss in this paper the role of the economic and social organization in agriculture and the food industry, in relation with the Health-Agriculture-Environment-Food Nexus (HAFEN) concept. The aim is to better understand the potential impact of the implementation of this concept in food consumption and production systems. We discuss the need for a detailed analysis of the economic and social processes underlying food consumption practices, as well as innovation drivers towards more sustainable agrifood systems. The paper suggests a research agenda dedicated to the modes of social and economic organization of key stakeholders in the implementation of Nexus-based systems, facilitating the convergence between health, food and environmental objectives. Based on a literature survey, three main topics are discussed: a) processes and drivers of change of food consumption practices; b) coordination and multi-agent governance modes to better account for health issues in agrifood systems; c) the analysis of paradigms that put forward health as an entry point to reshape existing agricultural and food systems, and associated modes of knowledge production. For each of these topics, we provide examples of researches based on past or on-going scientific projects on selected French case studies, and suggest some research priorities for the future.

**Keywords:** Nexus ; food system ; social and economic organization ; behavior

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<sup>1</sup> This paper originates from a working group of the collective foresight study on health and food nexus at INRA (French institute for agricultural research) in 2018 and early 2019. We thank Stephan Marette for helpful comments.

## Introduction

Scientific evidence on the multiple impacts of current farming and food systems, as well as the rise of alternative ways of producing and consuming food, point to the need to better connect the different objectives associated with health, food, agriculture and the environment (Hammond and Dubé, 2012 ; Marsden and Sonnino, 2012 ; Duru et al., 2017a, Gordon et al., 2017). Such a need is also debated in local and international institutions (Burlingame and Dernini, 2012; UN 2015), in line with a growing literature calling for a more integrated approach of food systems, instead of partial and fragmented views proposed by various scientific disciplines (Lamine et al. 2019). In this regard, a first integrated conceptual framework is the “One Health” concept which aims to link environment, agriculture (including animal breeding) and human health (Frazzoli and Mantovani, 2019). The concept of One Health was created in the early 2000s and originates from the “One Medicine” concept that “advocates a combination of human medicine and veterinary medicine in response to zoonoses” (Destoumieux-Garzón et al., 2018). This concept carries a significant novelty: “the incorporation of the eco-system health, including that of wild fauna. The One Health concept therefore constitutes a global strategy highlighting the need for an approach that is holistic and transdisciplinary and incorporates multisector expertise in dealing with the health of mankind, animals, and ecosystems” (Destoumieux-Garzón et al., 2018). A second type of integrated conceptual framework is the “Nexus” concept that has originally been suggested to examine water-food-energy interactions (Cairns and Krzywoszynska 2016) and food systems (Ipes-Food, 2015), but which has been extended to Health-Agriculture-Environment-Food Nexus (hereafter, HAFEN). The Nexus concept specifically acknowledges the fact that components of food systems are mutually reinforcing, deeply interconnected and subject to systemic dynamics (Ipes-Food, 2017).

Other integrated approaches exist with the aim of taking account the necessary reconnection of health, agriculture, food and the environment. Without being exhaustive, we can mention socio-ecological approaches (Gordon et al. 2017; Vallejo-Rojas et al. 2016), socio-metabolic approaches (Fischer-Kowalski et al. 2011) and socio-technical systems approaches (Dedeurwaerdere and Hannachi , 2019). However, as underlined by recent IPES Food reports (2015, 2017, see also Ericksen et al., 2010), the role of governance, coordination, power, knowledge transmission and controversies over visions of necessary transitions (of food systems towards sustainability) are generally underplayed in the literature. A possible explanation is that social sciences are seldom requested to contribute, by decision makers and stakeholders, to the debates on these issues.

In this paper, we propose to bridge this gap by providing an analysis of the literature in economics, management and sociology, which addresses the role of social and economic organization as well as the producers’ and consumers’ behaviour in food systems and their role in food system transitions. More specifically, we address the question of the potential development of new food systems based on the characteristics of a “Nexus” (entangling health, agriculture, food and the environment, i.e., HAFEN). A bibliographical analysis (mainly focused on the last five years) enabled us to identify major topics in the literature on health and food systems from the point of view of social sciences. This includes mechanisms underlying changes in:

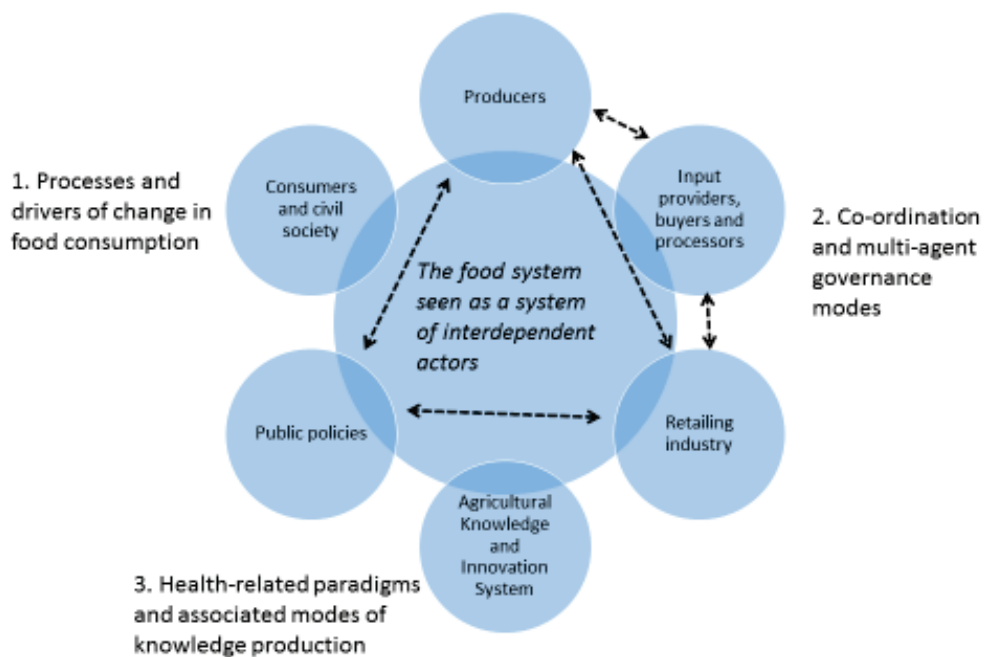
- food consumption behaviour;
- governance and coordination among agents in food systems;
- analysis of the HAFEN paradigms and knowledge production processes;

Our analysis reveals that on the first two topics, a vast research is available in social sciences but little connected to health issues. The last topic appears to be less explored but is indeed essential to better

understand in what way the keyword health may change the research practices and the visions of sustainability (see Diagram 1). A collective work carried out by the co-authors of this article through an iterative process allowed us to prioritize a series of six research priorities as well as to highlight the need to tackle an issue that has also been overcome in the scientific literature, that of welfare and health (including human health at work).

The paper is structured as follows. The first section will summarize research advances on processes and drivers of change in food consumption. The second section will address the novel research issues on the co-ordination and the multi-agent governance modes in food systems. The third section will outline the Health-related paradigms needed to reshape agricultural and food systems, and associated modes of knowledge production. In every section, beyond a state of the art, research priorities are suggested with the aim to better include health issues in food system research. Finally, the conclusion will address some methodological priorities linked to the aforementioned research issues. These priorities are originating from the research topics above, which are discussed in the paper with reference to the scientific literature on food systems.

**Diagram 1. How the HAFEN topics are positioned in the food system**



## 1. Processes and drivers of change in food consumption

In economics, there exists a vast literature that sets the standards of the identification of drivers behind consumer demand for food. Beyond key variables such as prices and household income, economic models of food consumption have tried to measure the relative role of the characteristics of food items on consumer demand (see the literature review by Irz et al., 2015). It is necessary to quantify, in particular, the impact of differences in product quality (mostly in nutrition terms, but also regarding sanitary conditions, although this dimension is less visible from the consumer side), on demand and on the price of these products. A wide range of theoretical research has been devoted to the understanding of differentiation processes in food products and the transmission of information to consumers (Bonroy and Constantatos 2015). On the empirical side, the literature has quantified the links between quality characteristics and the price of quantity demanded, for various agrofood chains (see for instance Hassan and Monier-Dilhan 2006 on labels). The above research implicitly includes in product characteristics the differentiation strategy by agrofood firms (Bazoche et al., 2005), of which organic food is a special case (Bazoche et al., 2013). The relationships between supply and demand can be understood in the other direction, i.e., the impact of demand representation on supply decisions of producers and on the strategies of agrofood firms, a recent stream of research in structural econometrics (see Section 2 and Bonnet and Bouamra-Mechemache, 2016).

Experimental economics (whether in the lab or on the field) is a way of analysing the impact of labelling and product information in general on consumption decisions (Marette et al. 2012 ; Barlagne et al., 2015 ; Julia et al., 2016) concerning for example health and environmental risks associated with a food product. From stated preference methods, one can obtain a fairly good precision on the willingness to pay (WTP) for product characteristics associated with health, the environment, food security, etc. (Bontemps et al., 2013; Bougherara and Combris, 2009; Lusk and Shogren 2007). More recent research addresses the evaluation of the WTP for different dimensions of sustainable food systems: ethical and responsible consumption, reduction of sanitary risk (Andersson et al., 2015) and the role of psychological determinants in purchasing decisions, etc.

In social psychology, sociology and anthropology, the analysis of consumer representations and practices represents a relatively well-structured research field. In psychology, there is a general consensus as to the fact that the causal link between agents' representation and practices is a complex one, in particular because of cognitive dissonance phenomena (see the reviews by Martin and Gaspard, 2016 and Swee-Jin Ong et al., 2017). In sociology and anthropology, representations are considered to be built from current practice and in social networks, and "alternative" knowledge and skills about food are shaping themselves therein. References include Beardsworth and Keil (1991) on vegetarianism, Lamine (2003, 2008) on organic food and "vegetarization" trends, and more recently Mouret (2016) on "vegetarized" behaviour involving reduced consumption of animal products, from "flexitarianism" to "vegetalism" and "veganism".

In the sociology of food, recent research has shifted from a focus on representations to a focus on practices, emphasizing how these practices refer to skills, norms or time (Plessz and Etile, 2018; Plessz and Gojard, 2015). In the particular stream of practice theory, scholars have assessed the role of routines, materiality, norms and time constraints in shaping food practices (Warde and Southerton, 2012; Warde and Yates, 2017). Some of these studies stress the persistent effect of social differentiation, whether related to fruits and vegetables consumption (Plessz and Gojard, 2013), obesity or anorexia

(Régnier and Masullo 2009), an effect also illustrated by research in nutrition (Darmon, 2003). While most research in socio-anthropology has dealt with consumers already “out of bounds” from markets and food (organic food, vegetarianism, etc.), recent work in sociology of food has highlighted the conditions for the adoption of sustainable or healthy food practices, and effects of social differentiation (Paddock, 2017). It has also stressed the importance of understanding inertia in food practices (Wahlen, 2011) and social determinants in social differentiation of food practices, such as the role of inter-individual networks and social trajectories (Plessz and al., 2016) and of collective dimensions (Wahlen and Dubuisson-Quellier, 2018).

Despite the notoriety of nutritional recommendations (see, e.g., ANSES, 2017), recent research in sociology on the reception of health and food standards (Plessz et al, 2014) suggests that the working class would be less likely to adhere to official nutritional or environmental guidelines, because of the distance to current practices and a lower confidence level regarding expert sources (Marty et al., 2015). Research in public economics applied to food consumption (Leroy et al, 2016 ; Irz et al, 2016) has evaluated the impact of nutritional or environmental recommendations in several European countries (European project EraNet SusDiet). The impact of nutritional recommendations is shown to be very heterogeneous and difficult to compare from one country to another. Communication policies seem to have a favourable benefit-cost ratio, with significant spillover effects when a recommendation campaign is targeting a particular goal (promotion of fresh products in the diet, salt contents, environmental impact, etc.). Indeed, there is a need for further research to address knowledge gaps about how specific social groups within the population choose to adhere or not to nutritional or environmental guidelines.

Other sociological studies address the construction of norms and have shown the diversity of private and public stakeholders (industrialists, associations, health professionals, etc.) involved in such construction (Depecker et al. 2013). The way organizations representing the interests of food industries, such as salt (Déplaud, 2014, 2015) or alcohol (Fortané, 2016) producers, are acting strategically to influence the design of public policies or to develop lobbying strategies through charities and philanthropic actions, is also explored in recent studies (Depecker et al., 2018). New incentive-based mechanisms such as Nudges also give way to an expanding literature (see Croson and Treich, 2014 ; Kusters and Van der Heijden, 2015; Kuhfuss et al., 2016; Schubert, 2017). They are designed to modify agents’ behaviour at a least cost, through a mere presentation of different situations without modifying the choice set and without economic incentives (Thaler and Sunstein, 2008 ; La Fabrique Ecologique, 2015). Recent research in sociology has however shown the limits of such approaches as well as the socially-contrasted effects of a policy targeting only behaviour (Dubuisson-Quellier, 2016; Whalen and Dubuisson-Quellier, 2018).

Another stream in the literature investigates the impact of “alternative” food systems such as local food networks on consumption habits as well as on the perception of food quality and its links with health and the environment. Research addresses the way such food networks may represent a place for public debate and collective learning on the combination of challenges associated with food (Dubuisson-Quellier et al. 2011). However, such forums sometimes tend to impose the vision of some stakeholders or population categories over others (Lamine, 2011). More recent work (see below) analyses the role of local food networks in the construction of sustainable consumption by ‘ordinary’ consumers, particularly through learning processes within inter-individual relations (Chiffolleau et al., 2017).

Data from the NutriNet-Santé cohort (see below) are currently being used in on-going research, with the objective to better understand food supply profiles through local food networks and their connections to health (through, e.g., consumer motivation for purchase). Examples in France include the project on the rebalancing of plant and animal proteins (see, e.g., Colombet et al., 2019), coordinated by INRA, and the BioNutrinet study. The latter started to explore the sanitary and environmental impacts of various

types of food profiles, which are characterized by the proportion of food consumption of both organic products and plant products (Seconda et al., 2018).

The researches mentioned above share a common feature, namely the issue of social accessibility to quality food, which involves two different approaches: one in terms of “food justice” (Gottlieb, 2009) and a second in terms of food democracy (Chiffolleau et al., 2018 ; Paturel and Carimentrand, 2018). The impact of novel social experiments, regarding in particular processes of change in stakeholder visions and learning, is beginning to be analysed through action-research approaches, aimed at fostering changes in food practices and at evaluating them with the relevant stakeholders (through, e.g., food solidarity networks, see Paturel and Ramel, 2017 ; Chiffolleau and Paturel, 2016 ; Darrot and Noel, 2018).

## **Learning about sustainable food consumption from the NutriNet-Santé cohort study**

Numerous on-going studies in epidemiology, bringing together social science and/or epidemiology and public health research teams, are exploring the links between socio-demographic and food profiles and health but also environmental impacts of food consumption practices that are considered more sustainable (organic products, lower contribution of animal products to the diet). The French NutriNet-Santé prospective cohort study that recruited more than 160,000 voluntary participants since 2009 has become a valuable source of information to study the relationship between nutrition and health outcomes, but also other determinants of food behaviour (Hercberg et al., 2010; Finkelstein et al., 2019). This cohort allows researchers to better describe dietary patterns such as vegetarianism, veganism or strict vegetarianism, “flexitarianism”, a concept related to the reduction of animal products consumption, in comparison with omnivore behaviours. Previous and ongoing studies also aim to identify determinants and motives for the consumption (Méjean et al., 2016) or the eviction (Allès et al. 2017b) of animal products (socio-demographical, economic, geographic, psychological determinants, and so on). Although the prevalence of vegetarianism is still very low in France, this cohort also provides an opportunity to apprehend a good variety of these diets, from partial animal product exclusions such as pescovegetarianism or vegetarianism with consumption of milk and eggs, to full animal products exclusion such as veganism or strict vegetarianism. Other research works have evaluated the sustainability-related motives of consumers in the general population (Allès et al., 2017a ; Allès et al. 2017b ; Baudry et al. 2017, Péneau et al. 2017 ; Sautron et al. 2015). The complex links between nutrition and health, which is a major component of sustainability according to FAO (2010), are also addressed by epidemiological approaches on the general population through the Nutrinet-Santé cohort, but also on specific populations such as patients with chronic pathologies (Fassier et al., 2017; Fassier et al., 2018; Adriouch 2017). An exhaustive discussion is provided in Seconda et al. (2018).

## **Research priority 1. Evaluating the willingness to pay for sustainable food**

Based on our literature review, the first research priority we suggest is to identify in an accurate manner the distribution of the willingness-to-pay (WTP, the maximum value - amount of their income - potential buyers are ready to forego to buy a unit of a good) for a sustainable food system. This is an essential step to the analysis of demand on existing markets (revealed preferences) or potential markets (stated preferences). The determinants of demand progressively include more and more drivers in relation with the pillars of the Health Nexus (in particular, sustainability and food security). With the exception of well-



identified sectors such as organic agriculture, labeling of sustainability dimensions on food products remains an important challenge for a satisfactory valuation of environmental benefits provided by producers. Experimental economics methods are making rapid progress towards a more accurate evaluation of WTPs for these different dimensions, also controlling for differences in socio-demographic factors (segmentation of the population). The number of scientific references in terms of products and their characteristics remains however too limited, so that an analysis of the total economic value associated with food products from “sustainable” food systems would be premature. Nevertheless, methods of transfer or a finer segmentation of controlled experiments should help in confirming the “external validity” of several empirical results from experimental economics. A scientific priority is thus to improve the explanatory power of WTP models, by including factors behind social classification, consumer location and the role of major life events (retirement, etc.)

Three routes can be suggested: a) work on larger population cohorts with more detailed information on nutrition and individual health, from which a WTP analysis could be performed repeatedly (as with the cohort NutriNet); b) combine consumer valuation of food through WTP with approaches in psychology, social psychology and neuroscience; c) test for features contributing to WTPs that would be associated with diet sustainability in the context of experimental online supermarkets.

## **Research priority 2. Understanding diet inertia**

A second research priority is a better understanding of diet inertia and the challenges of access of quality food for all. Recent research approaches allow one to explore the question of inertia in food consumption practices (their lack of change in most parts of the population), and by exploring new drivers of consumption in relation with social inequalities.

Bringing together several disciplinary fields is necessary to address this research priority. First, sociology of practices is addressing the question of household material environment (e.g., household equipment and appliances), food supply (logistics, market organization), social time patterns, household way of life, home cooking and storage skills, social norms and last, public policies (Shove et al., 2012). Second, foodscape and network approaches in geography and sociology aim at accounting for the integration of food practices of “ordinary consumers” in their geographical (for example, food deserts) and social (personal relations) environment (Morgan, 2010). Future approaches could typically involve, first epidemiologists and geographers together on the question of spatial distribution of food supply and its impact on consumer behaviour and second, nutritionists and sociologists on the role of social networks in overcoming inertia. This would also account for face-to-face relationships as well as the ones introduced by new (digital) communication technologies. An emerging field of research proposes to cross these two approaches by addressing the changes, or inertia, in relation with the expanding implementation of local food policies (such as those implemented by cities involved in the Milan pact at the international scale or cities and small regions involved in the “Territorial Food Projects” in France) which both modify foodscapes and social networks. Economic approaches also explore the connections between consumer decisions, their location and the characteristics of the local food supply (Caillavet et al., 2016 ; Gagné et al., 2013). Last, research based on the theory of settlements in social psychology (Lahlou, 2008) aims at understanding the role of physical space of economic agents. Participatory research platforms and cohorts should facilitate the implementation of the above approaches to deal with inertia in consumption practices and with new drivers of change in diets for “conventional” consumers (as opposed to the existing analysis of alternative food practices of individuals already engaged in sustainable consumption).

Finally, research is rapidly developing on food justice and democracy, with heterogeneous views on the challenge of access to quality food for all. An assumption to explore further, which has been the subject of early research (Le Velly and Paturel, 2013), is that specific mechanisms are necessary, combining social experiments targeting poor and/or diversified households and adequate public policies.

## 2. Co-ordination and multi-agent governance modes to better account for health issues in food systems

In economics, a first stream of literature considers agents' strategies in the agriculture and food industries, in order to analyze the role of market structure on consumer welfare and producer profit. Such structure originates from industrial strategies of major agrofood companies and is often represented in terms of market concentration. Structural econometric modelling is useful in jointly representing food demand and supply through agents' interactions, while industrial economics is helpful in evaluating producer margins within an industry. Coordination modes are mostly analysed from the angle of contract-based relationships (producers, suppliers, retailers) as well as the impact of merger strategies in agrofood industries on consumer welfare. If health is not always at the heart of merger strategies, it may however be the source of a renewal of contract-based relationships. The latter may, for example, provide a better sharing of commercial risk in case of contamination, or of sanitary control costs (Farès and Rouvière, 2010).

Relationships between producers and retailers are accounted for by structural supply-demand econometric models that are estimated on individual consumer data (Bonnet and Bouamra-Mechemache 2016). Moreover, these models have the capacity to distinguish between processors' and retailers' margins, thereby improving the understanding of vertical relationships within the agrofood industry. Complementary to the above researches, management scientists explore organizational determinants of agents' behaviour in agrofood industries. They show for instance the way margins of action are conditioned by their production structures and routines (Nakhla, 2017). The coexistence of genetically modified and conventional food shows the importance of such organizational determinants (Hannachi and Coléno, 2012 ; Coléno and Hannachi, 2015). Another question concerns nutritional labelling, with the example of the Nutriscore logo, which has been validated on October 31, 2017 by French authorities (Ministry of Agriculture and Food). The fact that some actors in the agrofood industry have accepted such a label while others oppose it, raises the question of coordination difficulties but also of the balance of power in this industry. Several papers in industrial economics are specifically looking at the impact of the implementation of production contracts or regulatory instruments (possibly associated with health and nutritional dimensions), on gains and losses for different categories of agents all along the agrofood chain (Cholez et al. 2017, 2018). It is also possible to evaluate entry and exit risks for producers at various stages of agrofood chains. Such risks are conditioned either by private strategies for developing food products with good health or nutritional quality, or by public policies for compulsory standards or labels (see, for example, Bontemps et al., 2013 ; Gagné and Larue, 2016).

Recent research in sociology and management science has addressed the growing role of private certification and standards (Fouilleux 2010; Hannachi and Coléno, 2012; Fouilleux and Loconto 2017; Sautier et al., 2017 ; Labarthe et al., 2018), as well as "participatory guarantee systems" (Loconto and Hakanata, 2017 ; Chiffolleau et al., 2016 ; Chiffolleau and Loconto, 2018). This points to the rise of co-regulation, i.e., the combination of public and private standards and beyond, market-based governance forms (Bernard de Raymond and Bonnaud, 2014 ; Loconto 2014, 2015), in particular about the reduction

of pesticide or pharmaceutical inputs (Bonnaud et al. 2012 ; Fortané 2016), food security (Bernard de Raymond, 2015) or nutritional risks (Déplaud, 2013). Bonnaud and Copalle (2009, 2013) show that, in the case of veterinary inspectors' duties in terms of food hygiene, public agents also contribute to the implementation of normalization chains.

A number of studies are dealing with the coordination of public actors and industries in terms of sanitary risk management, particularly in the case of animal breeding. Many sociological studies have explored, since the 1990s and particularly since the triggering effect of major "sanitary crises" such as the mad cow disease, the question of risk management or regulation and of traceability in the food industry (Chateauraynaud and Torny, 1999 ; Barbier, 2006 ; Bonnaud and Joly, 2012 ; Granjou, 2004 ; Granjou et Valceschini, 2005), as well as regulations regarding pesticide and additive use (Jas and Boudia, 2013). Research in animal health economics has explored risk regulation and management strategies associated with recent epizootic events (Cordier et al., 2013; Tago et al., 2016, in the case of the Foot-and-Mouth disease). These papers integrate the behaviour of cattle farmers in relation with the implementation of public policies that evolve according to the dissemination of the epizootic event. The economic analysis therein allows for an assessment of losses to cattle breeders but also welfare losses to consumers, at a fairly detailed geographical scale. Interdisciplinary research has also addressed the integration of the health dimension in the agrofood industry (Magrini et al., 2017), as well as associated technological, organizational and social innovations that pave the way for new challenges for participatory research (Desclaux et al., 2018).

The concept of responsibility and its sharing among stakeholders, associated with the development of a new "complex of requirements" (sanitary, ecological and ethical) among actors in production, retail and consumption stages, constitutes from this point of view an innovative research area (Ferreira et al., 2015). This requires taking into account, in particular, the role of "prosumers" in the transition of production sectors, beyond their participation in the construction of alternative food systems (Arcidiacono et al., 2018). Research in social sciences has also dealt with the role of public policies on the reconnection between health, agriculture, food and the environment – or their disconnection at the scale of the global food system (Lang and Barling 2013). However, their contribution on this topic has mostly been to point out to the necessity of developing more territorial (regional) approaches around a "new place-based food policy agenda" (Marsden and Sonnino, 2012).

Recent interdisciplinary research has analysed the impact of regional or local policies aimed at sustaining small farmholders, securing access to food for households and conserving biodiversity, pointing to the role of innovative public policies and adapted coordination modes (Chappell et al., 2016). In France, mechanisms fostering the "agro-ecological transition" have been analysed at the regional scale, based in particular on "sustainable transitions" or social innovation approaches. They have shown the way such mechanisms result from the commitment of agents in various stages of local food systems (producers, consumers, agricultural extension services, local decision makers and stakeholders, etc.). This implies a renewed definition of their interactions and interdependencies (Lamine et al. 2015; Chiffolleau and Loconto, 2018), but research having health as an entry keyword remains limited (see Hannachi et al., 2019a). Another field of literature shows the increasing role of urban actors in the consideration of health and the challenge of reconnecting health, agriculture, food and the environment, thereby contributing to the design of sustainable urban food systems (Brand et al., 2017), even though sanitary risks associated with urban agriculture cannot be overlooked (Aubry et al., 2015).

## **The role of local food networks in the design of more sustainable food consumption**

In the last two decades, different research projects in various countries have addressed the role of local food networks, either recently-emerged one such as collaborative associations for a “peasant agriculture” (community-supported agriculture schemes) or more conventional ones such as open-air markets, in the construction of more sustainable food consumption (Dunning et al., 2015; Ilbery and Maye, 2005; Sundkvist et al., 2005). In France, projects conducted at INRA (French Institute for Agricultural Research), over the past twelve years or so (such as ANR C3D, PSDR Coxinel and Casdar CODIA), have shown that social relationships, shaping themselves within local food networks, are also promoting learning processes around sustainable agriculture and risk sharing between producers and consumers (Lamine, 2005, Dubuisson-Quellier et al., 2011). This contributes to the modification of food practices, including “ordinary” consumers in the case of open-air markets, by triggering, more largely, several types of social mechanisms (learning, social control and self-esteem, see Chiffolleau et al., 2017), while generally favoring the appropriation of new norms and the reshaping of the relationship to food products. More fundamentally, these researches show, through qualitative and quantitative methods, the role of social networks in the change in food practices, besides or beyond social categories, the major steps in change trajectories, and the new types of prescriptions and prescriptors, as well as of technical advice that potentially appear as new drivers for action (e.g. implementation of new open-air markets or participatory labelling; Chiffolleau et al., 2016).

## **Concentration in the agrofood industry, actors’ strategies and consumer welfare**

Industrial economics provides useful tools for assessing the impact of concentration in the agrofood industry on consumer welfare (see for instance Turolla, 2016 ; Allain, Chambolle and Turolla, 2016 ; Allain et al, 2017; Chambolle, 2017). Turolla (2016) evaluated the market power of retailers in an urban area in the South of France, and showed that the significant economic markups of hypermarkets essentially result from an insufficient number of local competitors, and not from anticompetitive pricing strategies. Another article (Allain, Chambolle and Turolla, 2016) explored the impact on consumers of merger operations according to two retailers’ strategies: a spatial strategy of price discrimination and a uniform price strategy among local markets. Results show that, when a retailer adopts a nationwide pricing policy, the anticompetitive effect of merger on consumer surplus is propagating on markets that are not directly concerned with the merger. Such results lead one to reconsider the definition of “relevant markets” used in the context of merger control in the agrofood industry. A third example is an ex post evaluation of a merger operation in the French retail industry (Allain et al, 2017), which shows that merging parties have strongly increased their prices after the merger, but not in a homogeneous way over the country. In return, their competitors have already raised their selling prices, even more so when they face a large number of local retail stores from merging parties. The contribution of these three papers to guidelines for public decision makers is to confirm that the effects of some policies in France (e.g., the 1996 Galland Act), as well as correction measures brought by subsequent reforms (Economic Modernisation Acts), may be unexpected and undesirable for consumer welfare. They may

also have a negative impact on the economic situation of farmers, with a significant risk of exit for small farmers.

### **Research priority 3. Relevance of the regional/local scale for reconnecting health, agricultural, food and environmental challenges**

A first hypothesis worth exploring is that the regional or local scale is relevant for exploring the complex of health-related issues involving agriculture, food and the environment, because such level of analysis is consistent with the diversity of agents involved, and with the interaction of social, health-related and ecological processes (Lamine et al. 2019). The assumption can be put to the test from a comparative analysis of a variety of contrasted, rural and urban case studies. The way qualitative approaches address past or on-going transitions may be combined (or not) with modelling approaches is also a priority issue, that should be tackled within an interdisciplinary perspective (Lamine et al. 2019; Hannachi and Martinet, 2019, Hannachi et al., 2019a). A second hypothesis of interest is as follows: the reconnection between health, agriculture, food and the environment is possible only through a successful collective agreement on these interactions among such challenges. This may be based on a participatory construction of various approaches to learn and discuss about the different challenges regarding food (Chiffolleau et al., 2016), or on instruments of collective thinking that combine, at the regional scale, the objectives of individual health, collective welfare and sustainable development. The aspects above are rarely part of actual evaluation processes, which are more concerned about certain types of industry or agrofood chains (local or global, see Brunori et al., 2016) than the whole diet, and rather focused on food availability than food practices.

### **Research priority 4. Relationships between knowledge production, technological innovations, the transformation of organizations and agent behaviour**

Several technological innovations in the agrofood industry, such as substitutes to animal products or new information technologies (development of personalized food, digitalised food practices, smart fork and fridge, 3D printers, minimal processing etc.), already have an effect on the behaviour of actors in agrofood chains (Jönsson, 2016). It is necessary to analyse these effects as well as those from knowledge production modes (nutrition, epigenetics metagenomics, etc., but also participatory sciences), on the (re)qualification of food products (Den Hartog, 2012) and on consumption practices (Mol, 2013). More generally, one must understand the way agricultural and agrofood markets recompose themselves (or fail to) in relation with the rise of government modes for food patterns (Bergeron et al., 2016 ; Greenhalgh, 2016). In relation with the priority on the analysis of consumer WTP discussed above, agrofood firms' strategies in terms of product labelling and marketing should also be studied. Recent experiments with informational or nutritional labels, as well as numerical applications providing complementary information to consumers about health impact, need to be analysed as information and coordination devices that aim at influencing consumer behaviour, but also other agents' behaviour in agrofood chains (Frohlich, 2017), while influencing interactions between actors (see Julia et al. 2017a on Nutriscore). The long-run impact of such devices and innovations remains to be assessed.

### 3. Health-related paradigms to reshape agricultural and food systems, and associated modes of knowledge production

Reconnecting health, agricultural, food and environmental objectives is no easy task and in fact, most conceptual approaches combine challenges two by two : agricultural and environmental questions (with a diversity of paradigms and “ecologically-consistent” agricultural models dealing with animal and plant health) ; agricultural and food issues with the development of food-system approaches; food and health questions with thriving nutritional models; and finally, environmental and health issues with, e.g., the notion of global health (Lamine et al., 2019). There exist several paradigms and conceptual approaches that aim at reconnecting all these challenges: sustainable diets, nutrition/health sensitive agriculture, agro-ecology, one health, food security, food sovereignty, etc. All are not new, however: for example, the notion of sustainable diet, although often presented as a recent concept, has been introduced as early as the 1980s (Gussow and Clancy, 1986). It has been neglected since, because of the new focus on international discussions regarding food security with a quantitative vision (Jarosz, 2011), and it was only recently legitimized again, by FAO in particular (Burlingame and Dernini, 2012). The notion of “nutrition sensitive agriculture”, which has developed over the past years, does not deal with ecological dimensions as a priority (Balz, et al. 2015). The concept of global food security is also the subject of numerous controversies and of a debate over its definition, which involves a variety of stakeholders (States, agrofood industries, and non-governmental organizations that have put forward the notion of food sovereignty and/or food sustainability) (Wittman, 2011).

It is through such discussions over the framework of analysis that several objectives have been re-connected and their hierarchy modified, such as health, international trade flows and the sustainability of food systems (Bernard de Raymond, 2015). Over the recent period, it is around agro-ecology that one probably finds the most important connection among the above challenges, at least through discussions over the theoretical dimensions of such a reconnection (Francis et al. 2003; Gliessman 2007). However, the conceptual frameworks enabling such a connection need to be more explicit. This is required in order to move away from a situation where the convergence of ecology-consistent agricultural practices, better state of the environment and better nutritional and sanitary status of the population is taken as granted (Lamine et al. 2019).

A last field of research in sociology of science and technology addresses the connections between knowledge production, technological innovations, organizational transformations and agents’ behaviour. Applied to food studies, this field is not well developed when it comes to topics such as the impact of the generalization of nutritional qualification on world markets for processed and packaged food products (Clapp and Scrinis, 2017), or the way nutrition science modifies the cultural relations to one’s body in a context of diet monitoring and support (Mol, 2013).

#### **Bringing the challenge of health into food system analysis**

Original research is now available on the transformation of food systems to jointly accommodate environmental and health challenges, over all stages of the food chain value. Examples include recent analyses of the effects of diversification (Meynard et al., 2013) and protein (Duru et al., 2017a) crops. In the case of gluten allergy, an original approach, based on participatory science, aims at promoting and assessing the potential of local cereal systems (traditional varieties, sustainable farming, etc.). It succeeded in involving several actors of the agrofood industry and gluten-sensitive consumers (Desclaux

et al., 2018) in a collective assessment of the health effects of cereal varieties, cropping practices, processing, packaging and consumption modes, while analysing the associated economic and organizational models.

Several recent interdisciplinary projects, funded by the INRA division of plant health and the environment, have addressed the requirements for a collective and integrated management of plant health. For example, the Fondu project (Durable territorial strategies for the use of Fungicides) showed that the management of fungicide input on wheat and vineyards was characterized by a combination of the Tragedy of Commons (Hardin, 1968) and a “Tragedy of Anti-commons” (Heller and Eisenberg, 1998), a novel contribution to the literature on common goods (Hannachi et al., 2019b). Results from the “Eternal Rice” project showed that a particularly rich biodiversity in varieties of cultivated rice is securing sustainability of terrace paddy fields in YuanYang district, China. Sustainability also relies on social norms that consider seeds a common good (Hannachi and Dedeurwaerdere, 2018), and whose maintenance is guaranteed when all stakeholders implement “mixed-form markets” (Marwell and McInerney, 2005) by collectively targeting economic targets and non-monetary, socio-ecological welfare objectives (Dedeurwaerdere and Hannachi, 2019).

## **Extension of Nexus to welfare and health at work**

Compared with consumers, farmers and agrofood industry workers are less well accounted for in analyses of the HAFEN. Yet, in agriculture and the agrofood industry, health at work is more and more a structuring factor of the organization in the work place (good practices in pesticide handling, stronger requirements of worker protection due to the increasing share of paid workers in agriculture, etc.) A recent study funded by the French agency for Health (ANSES) points to the lack of data regarding exposure to pesticide of agricultural workers, and stresses the “invisibilisation” of this issue, which is slowing down the development of research on this area (Laurent et al., 2016). The health issue regarding agricultural workers may also be connected to the types of occupation, as a growing proportion of farm workers do not benefit from social and health benefit schemes, and they are poorly informed about risks when handling pesticide products. Health at work also covers psychic or mental health of farmers (psycho-social risks, suicide, etc., see Porcher, 2003 ; Deffontaines, 2017). An enlarged vision of the One Health concept would benefit from better accounting for psychic, mental and psycho-social aspects of health. Health is also becoming an important dimension of the transformation of occupational groups (see for example the question of occupational diseases associated with pesticide in Jas, 2010 ; Nicourt and Giraud, 2013 ; Jouzel and Dedieu, 2013), which also triggers the development of new interactions, interactions and solidarities among producers, citizens engaged in law suits against agroindustry corporations, and consumers (Harrison, 2011).

## **Research priority 5. Evaluating sustainable food practices and their connection to health**

Regarding the health impact, cohort surveys such as NutriNet-Santé are already able to connect consumption decisions and individual practices (such as for example, vegetarianism, involving a lower contribution of animal products to the diet) to the nutritional balance (Allès et al. 2017a) and the sanitary state of the population (Kane-Diallo et al. 2018). A first scientific, contemporaneous challenge is,

however, to develop global approaches for food quality, which would for example integrate the share of processed food in the diet (issue of “ultra-processed foods”, Fiolet et al. 2018; Julia et al. 2017b; Schnabel et al., 2019). A second challenge for research is to explore further the impact on health and the environment of food practices associated with organic food consumption (Baudry et al., 2016) and vegetarian diets, as well as the role of food environments (food deserts, concentration of retail stores, etc.) on the same nutritional and environmental dimensions. A last challenge is the capacity to develop research on the health effects of other dimensions of lifestyle (physical activity including leisure, work and commuting modes, tobacco and alcohol, etc.). This can be considered in practice by using, e.g., indicators of life style favouring good health (Healthy Lifestyle Index, HLI), which have been developed in epidemiology (Adjibade M. et al, 2018) but have not yet been connected to sustainable diets. Few research works are available in this area in the international literature, as they require the combination of several areas of expertise (epidemiology, nutrition, economics, sociology, etc.).

## **Research priority 6. The analysis of paradigms aimed at connecting health, agriculture, food and the environment**

A variety of paradigms that claim the main challenges of health, agriculture, food and the environment can be reconnected, through concepts and approaches such as sustainable diets, nutrition/health sensitive agriculture, agro-ecology, One Health, food security, food sovereignty, etc. The way such concepts emerge, how they are discussed in public forums and possibly implemented by some stakeholders, are questions that research should address. A necessary analysis of “connection paradigms” would explore the dynamics of these conceptual approaches and the influence they have on scientific (epistemic) communities. To muster scientific disciplines and skills (food science, plant and animal science, social sciences, etc.) is necessary to conduct this analysis of the “reconnection paradigms” (see Lamine et al., 2019). More specifically, the analysis of conceptual frameworks, public discussions and debate and the use of the notion of “global health” appears at that stage as a priority research topic (Duru et al., 2017b). For example, does this notion account for farmers’ and agrofood workers’ health status? How is the notion made operational by various stakeholders? It is also necessary to analyse the way the narratives of public decision makers, or citizens and private decision makers, make use of the paradigms, combining them with possibly other references (e.g., social innovation, see Chiffolleau and Loconto, 2018). Such priority incarnates both a specific challenge in sociology and a challenge for an interdisciplinary and institutional reflection on the above paradigms.

## **Conclusion: Methodological priorities**

Beyond the six research priorities that we have identified, which are based on our focused review of the literature and of recent research projects, we have also established a series of methodological priorities. These methodological perspectives are sometimes linked to the aforementioned research priorities and sometimes generated by the rise of new opportunities provided by new data sources (new data types or renewed access modes to existing or potential data sources). These priorities illustrate the diversity of methods that one needs to combine to address the health nexus, beyond a genuine cross-cutting, interdisciplinary research strategy.



A first methodological priority is linked to the increasing size of data bases on food purchases, diets and habits, which allows for a more accurate description of consumer choices with empirical demand models. This is particularly interesting in the case of consumer data with infrequent purchases (i.e., for a highly disaggregated description level of food items, see Bonnet and Simioni, 2001), but more detailed consumption systems can be considered if a wider range of demand determinants is available. The challenge is then to enrich existing databases with an even more detailed description of food items, e.g., the environmental impact of agricultural production and processing stages, pesticide residue and additives in food products, that may rely on participatory approaches. The same can be said of consumer practices and habits regarding cooking, food storage, food waste and recycling, which are typically not available in the same type of datasets than food product description or consumer purchases. Regarding social and economic aspects of access to food and social inequalities, an additional methodological priority concerns new and appropriate procedures for data collection, such as surveys and social experiments in urban and rural areas. In addition to the priority above concerned with more and richer datasets, it is the need for innovative ways of collecting individual data on food and diets that is also at stake. The involvement of local stakeholders is essential in this regard, especially if experiments are considered on “real” consumers or on actors in food systems (such as collective catering) to explore the benefits of “equity-oriented” alternative local food systems. Similarly, another priority is to collect experimental data on food labelling at a larger scale than what is currently performed, to calibrate demand models of consumer demand for food items produced from agro-ecological practices, etc.

Secondly, on modelling issues, accessing new data as suggested above is a first step from which more realistic demand models can be estimated or calibrated. Moreover, qualitative and quantitative approaches on past or on-going transitions in food systems can be combined with foresight studies on the same systems. An example of « hybrid » combination of qualitative and quantitative approaches is provided by a statistical and mathematical (graph and set theories, etc.) analysis of text databases (from, e.g., social media and networks, of bibliographical databases, see Loconto et al., 2019; Réchauchère et al., 2018), to explore reconnection paradigms concerning health, agriculture, food and the environment. Another example is the combination of expert qualitative assessments and quantitative methods to evaluate the environmental impacts of diets, accounting for the diversity of agricultural practices, processing technologies, etc. Product or industry typologies based on quantitative (for example, Life Cycle analysis) and qualitative methods (ordinal rankings, etc.) can then be constructed and extended towards new directions, more adapted to capture the relation with health (e.g. change of functional unit in LCA, from kilogram to healthy traits). An associated challenge is then to upscale such environmental evaluations, to produce, e.g., water and carbon footprints consistent with global or nationwide data on agricultural and food trade, that would also need a better understanding and modelling of local organisations (to take in account, e.g., pooling of logistic resources). A last example is the combination of multi-agent modelling with both qualitative knowledge about the new sources and contents of social influences regarding food and quantitative social networks analysis, in line with new collaborations around agent-based models (Casilli et al., 2014).

Third, for a better understanding of processes underlying the interactions between food and health within the Nexus, it would be important to combine epidemiological and experimental methods, in order to identify causality relationships at the individual level. This is especially important in settings where randomized controlled experiments on individuals are not possible (for ethical, logistic or legal reasons), while health-food connections are at the core of the analysis. A combination of methods may be useful:

for example involving individuals belonging to an observational cohort study, experiments using collective catering, virtual supermarkets, etc.

Fourth, regarding the organization and interactions of actors in agrofood chains, an observation network should be considered as a “living lab” of various stakeholders who operate at all stages (farming, agricultural extension, processing, retailing, consumers) of an agrofood industry. To be consistent with the concept of the Nexus, the latter would involve health-food issues and economic actors willing to engage in designing innovative food systems and products.

The methodological priorities above originate from the research topics proposed in the present paper, with reference to the scientific literature on food systems. These research issues and methodological priorities are primarily directed towards researchers and experts of food systems. Our suggested research issues and conclusion in terms of methodological priorities would greatly benefit from a feedback from public decision makers, regarding their relevance in the light of existing public policies. Organizing communication to and feedback from public decision makers would therefore be an interesting further step, regarding for example the connection with public policies associated with the development of sustainable and healthy food systems.

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