Assessing food balance of Mediterranean city-regions. A multi-level methodology to highlight interactions between land system and food systems

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Abstract: *In the current global context, characterized by urban growth and concerns about food security and safety, a "new food equation" emerges (Sonnino, 2014) examining the capacity of city-region food systems to feed the city and the possibilities of reconnecting production with consumption to increase food autonomy. Furthermore, the proximity of urban areas enhances the development of farming systems functionally linked to the city. Which land systems are being affected by these processes and which farming systems should be considered when enhancing local food systems? This challenge requests to think food systems in a multi-level approach. From a scientific point of view, there is still no clear method to link different levels of analysis while, at the same time and from an operational point of view, the linkage is needed to integrate the local vision from stakeholders into regional policies on food systems planning and vice versa. This is especially urgent in Mediterranean context, where food security is threatened by global change and urbanisation process.*

We present here an original methodology to investigate the interactions of land systems and food systems focusing on local food supply and enabling thus the assessment of the food balance of city-regions (proportion of local-grow food that is consumed in a given place). We will develop an abductive reasoning with mixed methods: founded on literature review and on results of empirical research, we have developed a qualitative framework to analyse the food system at local level (NUTS-3). Then, we have developed a quantitative model connecting the local, regional and global (Western Mediterranean Basin) levels in a feedback process. The connection between local and WMB levels will be mainly made by the identification of the food system stakeholders' capacity to develop proximity food systems enhancing local food supply. This methodology will be shortly tested in seven study-cases representative of the diversity of Mediterranean land systems.

Keywords: *territorial food system, food planning, land systems, mixed methods, multi-level, interdisciplinary, Mediterranean*

Introduction

Defining concepts: Food security, food systems, food balance

The question of food supply strongly arises in territorial politics to respond to the "**new food equation**" (Morgan et Sonnino, 2010) characterised by an intertwining between social, economic and natural dynamics:

- **food security**[1], erected to a question of national security, especially because of the erratic functioning of the foodstuff market (eg. wheat or rice prices have risen threefold since 2008 crisis).

- the **global change** (specially water resources scarcity) and its consequences on agricultural production, in terms of inter-annual variability of crop yields which could generate price rise.

- the climbing of conflicts linked to land (provoked specially from the acquisition of farmland by wealthy or emerging countries, in Africa or Asia).

- **fast urbanisation** on farmland and urban population growth, that has risen city-dwellers awareness and concerns about food supply for urban areas.

Since more than one half of world population lives in cities (United Nations Organisation (UNO), 2014), food security has also taken a strong urban dimension. Actually, initiatives for local and more sustainable food proliferate throughout the world motivated by the awareness that food is a key factor for health and for individual and collective well-being (Alkon et Agyeman, 2011). Inadequate dietary patterns can generate chronic diseases, going from hunger and malnutrition to noncommunicable diseases associated with overnutrition (obesity, diabetes, heart diseases, cardiovascular diseases (Nelson et al., 2016). Furthermore, dietary choices link human health and environmental sustainability. Thereby, food-diet composition is seeing as one of the determining factors of climate impact caused by farming systems. Actually, the current global dietary transition in which traditional diets are replaced by diets higher in refined sugars, refined fats, oils and meats, result in higher agricultural greenhouse gas emissions, land clearing and associated extinction of species (Tilman and Clark, 2014)[2]. While consumers' choices of foods and diets are determined by a complex set of personal values, social norms, habits, and aspirations (de Haen and Réquillart, 2014), research results shown that the drivers of global dietary transition are rising incomes and urbanization (Popkin et al., 2012).

Nowadays, more than 50% of people on earth are living in urban areas and, following FAO prospective, this share may reach 86% in developed countries in 2050 (FAO, 2011). Feeding the city is a main political concern (FAO, 2011). Furthermore, the management of food systems are a challenge to link urban and rural areas (FAO, 2017; Soulard et al., 2017). Food security, in quantitative terms, is an issue of availability but also of accessibility, because the delocalisation of production and consumption makes cities extremely dependant of external factors. In this way, assessing city-regions' food balance is a scientific and a

[1] Food security, as defined by the United Nations' Committee on World Food Security (CFS), is the condition in which all people, at all times, have physical, social and economic access to sufficient safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life. The four pillars of food security are availability, access, utilization and stability (CFS, 2009).

[2] Food production and diet, and specially meat-based diets with a high content of sugar and refining fats, contribute to more of 25% of greenhouse gas emissions in the world.

practical challenge to develop a sustainable food system[3]. **Food balance** is defined here as the proportion of local-grown food that is commercialised locally[4] and so oriented to local food supply. We make the assumption that local-grown food products that are commercialised locally would be incorporated in the food which is consumed locally.

According to Malassis (1994), a **food system** is the way in which people organize themselves in order to produce, distribute, and consume their food. Furthermore, following the High Level Panel of Experts on Food Security and Nutrition (HLPE, 2017), a **food system** gathers all the elements (environment, people, inputs, processes, infrastructures, institutions, etc.) and activities that relate to the production, processing, distribution, preparation and consumption of food, and the outputs of these activities, including socio-economic and environmental outcomes. The HLPE identifies three constituent elements of food systems: food supply chains[5], food environment[6] and consumer behaviour[7]. These are the key points for an analysis focus on nutrition. We will focus on **food supply chains**, because this constituent element of food systems enables to link effectively the different ways in which food is produced and consumed from a geographical point of view.

Besides, following the pioneer works of H. Friedmann (1987) and the Food Regimes[8] theory in the Anglo-Saxon scientific community and those of J-L. Rastoin and G. Ghersi (2010) in the francophone one, the notion of food system will be used to provide a basic understanding of the key concepts and challenges in **standard setting** in food policy[9] by highlighting the global challenges of food systems located in a specific geographic space (territory or region). Despite the **convening power of the food system concept** and the integrative approach it conveys (Bedore, 2014), from a scientific and practical perspective, the challenges persist whenever it comes to handle the complexity, the interdependencies and feedback loops or even precisely define the geographical limits of the food systems (Reardon and Timmer, 2012). Recent scientific literature identifies many case-studies but there is a lack of proposals of theory and empiric comprehensive frameworks enabling the production of pragmatic results mobilisable for food planning (Halberg, 2017).

Nevertheless, food policies are currently fragmented into separate domains and disconnected stakeholders (Moragues-Faus et al., 2017): nutrition and public health, social and economic access to food, environmental protection, nexus water-energy-food, agricultural economics and agri-food industry. Public policy segmentation reflects the

[3] A sustainable food system "delivers food security and nutrition for all in such a way that the economic, social and environmental bases to generate food security and nutrition for future generations are not compromised" (HLPE, 2017).

[4] One of the most confounding questions of local food systems is what constitutes locale. In this paper, the spatial extent of the « local » food system corresponds to NUTS-3 scale.

[5] "The food supply chain encompasses all activities that move food from production to consumption, including production, storage, distribution, processing, packaging, retailing and marketing. The decisions made by the many actors at any stage of this chain have implications for other stages. They influence the types of food available and accessible, as well as the way they are produced and consumed" (HLPE, 2017: 11).

[6] "The food environment refers to the physical, economic, political and socio-cultural context in which consumers engage with the food system to acquire, prepare and consume food" (HLPE, 2017: 11).

[7] "Consumer behaviour reflects the choices made by consumers, at household or individual levels, on what food to acquire, store, prepare and eat, and on the allocation of food within the household" (HLPE, 2017: 11).

[8] *Food Regimes* theory was developed from American political economy and analyses the strategic role of agriculture in the history of the world capitalist economy. It analysed specifically the agro-food systems from a critical point of view focused on power relationships, and identifying the stable periods of capital accumulation associated to particular configurations of geopolitical power and to particular relationships between production and consumption inside and

[9] For instance, in France, in the Territorial Food Projects (*Projets Alimentaires Territoriaux*) intended in the legislation for the future of agriculture, food and forest promulgated the 13th October 2014 (art. 39) looking for bringing closer local production and local consumption.

fragmentation of approaches of food from scholars in geography and land sciences. On one hand, research has focused in quantified approaches of farming production linking land use and food security (Le Mouël, 2016) or highlighting the adaptation required of water and land management to future global change (Malek and Verburg, 2017). On the other hand, cultural geography considers food as a cultural product that structures social organisation (Fumey, 2016). Furthermore, some scholar fellows have spatially analysed the relation between farming and food in value chains by the means of the notion of "territorial agri-food system" focused in shorts circuits and considering the role of actors (Kneafsey et al., 2013; Muchnik et al, 2008). Moreover, researchers are recently working on the spatiality of food systems, especially in North America on the notion of "food deserts" (Gatrell et al., 2011). Lastly, geographers have worked on the geographical inequities in health and on food justice (Hochedez et Le Gall, 2016). Nevertheless, a dynamic geography of food security and safety is lacking to these intellectual constructions.

The main goal of these communication is to propose a **multi-level modelling enabling to analyse the interactions between land systems and food systems**, focused on the capacity to develop proximity food systems enhancing local food supply. Our aim is to **highlight the articulations and interdependences between macro levels** (i.e. national strategies with respect to global change) **and micro levels** (i.e. household consumption choices). Furthermore, there is no question that all actors and stakeholders should know and understand the interconnections of their actions and their consequences (Bricas et al., 2011). Our purpose is to develop a framework (methods and tools) for a geography of food enabling to characterize and represent the spatio-temporal dynamics of metropolitan food systems, operational in a food spatial planning approach. We will address this question in the global context of territorial food systems following a systemic approach.

Assumptions for a multi-level and spatial approach of city-regions' food balance

In this research we explore which **agricultural land systems** should be considered to **enhancing city-regions food autonomy,** in other worlds, to increase the proportion of local food supply in the food balance. According to Verburg *et al.*, "land systems represent the terrestrial component of the Earth system and encompass all processes and activities related to the human use of land, including socioeconomic, technological and organizational investments and arrangements, as well as the benefits gained from land and the unintended social and ecological outcomes of societal activities (Verburg et al., 2013 : 433)." For our purpose, we will consider three indicators to characterise agricultural land systems: a) land intensity relating to inputs; b) farm and land management, referring to preservation public policies and farming activities; and c) land structure, concerning land-use fragmentation and landscape morphology.

Experts agree to think food systems as a network (HLPE, 2017), but the spatial organisation of foodstuff is usually approached as the city-consumer dominating by the means of market the dynamics of the countryside-producer (Lançon et al., 2014). Nevertheless, the location of crops is not necessarily determined by the distance to the nearest city (Sanz Sanz, 2017 et Sanz Sanz et al. 2018), but further by sectorial logics, social phenomena (eg. reproduction of former patterns of productive specialisation), by norms or public decisions (eg. subsidies), even by physiological elements (eg. attachment to a site) (Hinojosa et al., 2016). Furthermore, territorial food systems are strongly integrated in global markets (a French farmer supplies food to approximately 80 consumers, from whom 70 living in France; an employee of the agri-food sector supplies food to 125 people, from whom 100 living in France) (Rastoin and Ghersi, 2009). To conclude, two types of food systems coexist in the **territorial food systems**: the global agro-industrial model and **proximity food models** associated to short supply chains and oriented to local food supply (Lamine et al., 2012).

Thus, global and local dimensions are combined in territorial food systems in a complex way: farmland whose production is oriented to exportation are close to farmland whose production is sold locally; food and non-food productions compete; consumers buy both proximity and imported food goods; finally, farming systems strongly contributing to food security are not necessarily virtuous from an environmental impact and climate change point of view. In this context, the main goal of this communication is to analyse the articulation of the various food production scales in the food supply of a given territory, considering both local farming systems[10] and local food supply chains, enabling to assess cities food balance at the Mediterranean west basin[11].

The main assumptions are: 1) that the current land-system dynamics in Mediterranean area may enhance, in many cases, situations of land-use pattern diversity (inside agricultural areas with changes in agricultural practices, in peri-urban situations with the competition between agricultural and urban uses or in semi-natural areas used by extensive farming systems), and 2) this diversity is an indicator of places where there is an ability to develop proximity food systems (i.e. an homogenous area of monospecific agriculture isn't usually in favour of the new farming systems integration).

Concerning methods, we stand that spatial modelling is a good medium and tool to describe the determinants and components of territorial food systems and to link spatial-temporal dynamics in a multi-scale approach (du local –micro-geographical- to the scale of Mediterranean basin –macro-geographical-). Other recent works (SALSA, ongoing H2020 projet - Small Farms, Small Food Businesses and Sustainable Food Security; Malek and Verburg, 2017; TRANSMANGO, 2017 - Assessment of the impact of global drivers of change on Europe's food security; GLAMUR , 2017- Global and local food supply chain assessment: a multidimensional performance-based approach; FOODMETERS, 2016 - Food Planning and Innovation for Sustainable Metropolitan Regions; DUALINE, 2011 - Durabilité de l'alimentation face à de nouveaux enjeux -) show that the analysis between farming systems, and territorial food systems should rely on multi-scale and multi-dimension approach. The research presented in this paper relies on this basis to develop a methodology to analyse food systems based on spatial analysis.

We will present a new methodology that investigates the capabilities of land systems to promote proximity food systems and to assess city regions' food balance, connecting the local and the global levels in a feedback process. Firstly, we will present the materials and methods mobilised to construct the methodology. Secondly, we will develop the stages in the development of the methodology as well as the challenges we encountered. Finally, we will discuss the application of this methodology at the moment, the expected results and further research perspectives.

Materials and methods

Empirical research at Western part of the Mediterranean Basin

[10] A farming system is defined as a population of individual farm systems that have broadly similar resource bases, enterprise patterns, household livelihoods and constraints, and for which similar development strategies and interventions would be appropriate (Dixon et al., 2001).

[11] We place our work in the frame of DIVERCROP project (Arimnet2 2017/20, see https://divercropblog.wordpress.com/) which seeks to highlights interactions between current dynamics of agricultural practices, species diversity and local food systems at multiple spatial scales going from the whole Western part of the Mediterranean Basin (WMB) to different regions and to specific local study cases.

Most researches have dealt with the whole European scale, whereas this research is focussed in Western part of the Mediterranean Basin (WMB). Following Metzger et al. (2005), our work area covers the three Mediterranean Environmental zones in Europe, that is Mediterranean South, Mediterranean North and Mediterranean mountains restraints to WMB countries (figure 1). From an agricultural perspective, the Mediterranean basin has a long history in terms of production of food for the provisioning of rich civilizations. In parallel, it has also delivered many typical land uses and landscapes after sometimes strong reshaping of the environment (e.g. terraces and irrigation canals, hedgerows, agro-silvo-pastoral systems) (Pinto-Correia and Vos, 2004; Blondel, 2006). For these reasons, the current agricultural systems and the complementarities between crops are pretty complex and inherited from a long history of agricultural and cultural purely Mediterranean traditions (Zeder, 2008). In this context, several farming systems are known to provide food to the city-regions by the means of short supply chains (Berti and Mulligan, 2016). Nowadays, scientists look at these farming systems with a renewed interest, as recent studies have shown how it could potentially enhance the city food autonomy (Wiskerke, 2009).

At the same time, the Mediterranean basin is characterized by a scarcity condition for agriculture (poor and shallow soils, steep slopes and a dry summer), a limited availability of resources, mainly water, and a complementarity of different and complex agricultural systems (Caraveli, 2000). This region also presents some particularities in its social organization, such as the low level of entrepreneurship in some hilly/mountain marginal regions, mainly characterized by traditional extensive farming systems (Petanidou et al., 2008), a property structure based on family lands considered as a heritage more than as a production factor and a low level of taxes on land ownership (Otero et al., 2013).

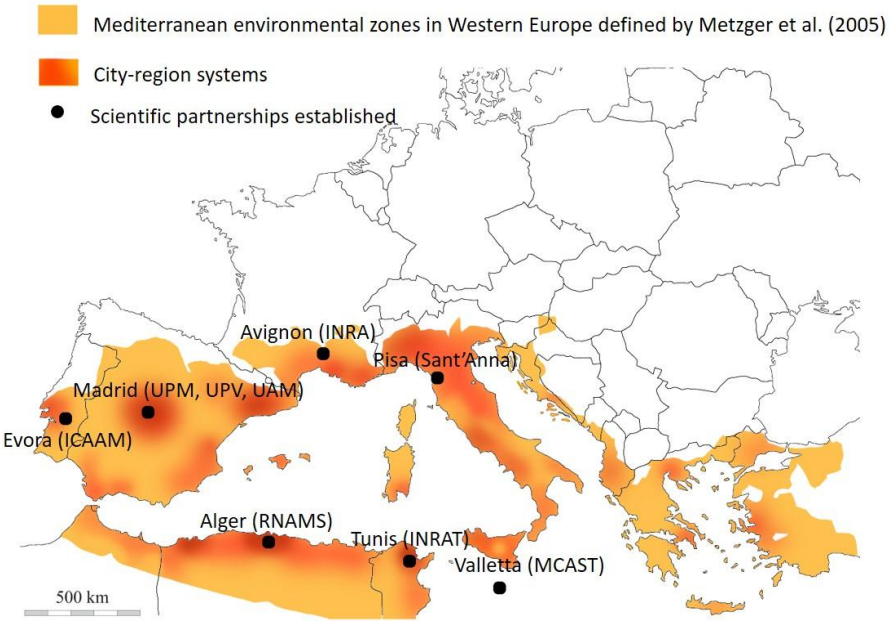


Figure 1. Study cases in the Mediterranean environmental zones in Western Europe

We will apply the methodology of food systems characterisation in 7 study cases on North and South of the WMB (figure 1): Avignon, Madrid, Pisa, Evora, Tunis, Alger, Valletta. We will develop an abductive reasoning: founded on literature review and on the results of empirical previous research concerning, on one hand, the recognition of farming systems oriented to local markets (Sanz Sanz, 2016), and in the other hand, the modelling and

mapping of the farming systems more suitable to develop proximity food systems[12], we have developed an framework to assess food balance. This communication presents this methodology that will be applied soon in study cases. The core of the analysis presented here is thus to define the limits of the territorial food systems involved in the specific local study cases, to describe their drivers and their constituent elements and patterns. We assume that the geographical extension of a food system cannot be a priori limited but that it is drawn depending on the analysed links (we will develop this point in the next section). This challenge requests to think the local production system and the food consumption patterns in a multi-scale approach (Watts et al., 2005).

Framework to analyse Mediterranean food systems at territorial level

Following the recommendations of the International Panel of Experts on Sustainable Food Systems (IPES-Food, 2015), we consider the **complexity of food systems as a network of interactions between actors and processes of the system**, including policies. In that way, we place the study of food systems at territorial level in the qualitative framework developed by Armendáriz et al. (2016) to analyse the **Food Supply and Distribution Systems** (FSDS) in city-region[13] systems. This framework enables a systemic and comprehensive understanding on FSDS focusing on the integration of urban and rural structures and considering the system biophysical boundaries and societal targets. This model has been developed by using the System Thinking and System Dynamics approaches in order to provide insight for territorial policy creation, about the characteristics and mechanisms of change of the FSDS. Thus, this framework enables the analysis of the interactions between the constituent elements of food supply chains, i.e. the activities of production, storage, distribution, processing, packaging, retailing, marketing and consumption. The model developed by Armendáriz et al. consists of a causal loop diagram and was designed to be applied in transition countries. We have **adapted it** to our purpose, and we have identified 16 feedback structures or variables (Figure 2): i) territory capacity; ii) food system organisation; iii) ecological footprint of FSDS; iv) food demand at local level; v) food system pressure on urban space; vi) urban lifestyle impact on consumers behaviour and on food regimes; vii) urbanisation impact of economy and on food demand; viii) effects of technology on FSDS efficiency; ix) urban planning and markets administration; x) management of food waste; xi) food system efficiency; xii) urban growth; xiii) economic growth impact on urban population; xiv) food planning : diversification of farming activities and productions as well as marketing circuits; xv) technology development and its effects on the food system efficiency; and xvi) effects of food demand on local economy and employment policy.

[12] Ongoing French project Aliville (Participative prospective for the relocalisation of urban agro-food system) conducted by Aurélie Cardona, Claude Napoléone and Esther Sanz Sanz, on Avignon area.

[13] City-region is a term in use since about 1950 by urbanists, economists and urban planners to mean a metropolitan area and hinterland experimenting several flows: people (i.e. daily commuting to work), goods (i.e. food), services (i.e. health), capital and assets (i.e. property rights), waste and pollution, environmental resources, knowledge, social norms… . A city-region is often no limited by a single administrative boundary (Davoudi, 2009)

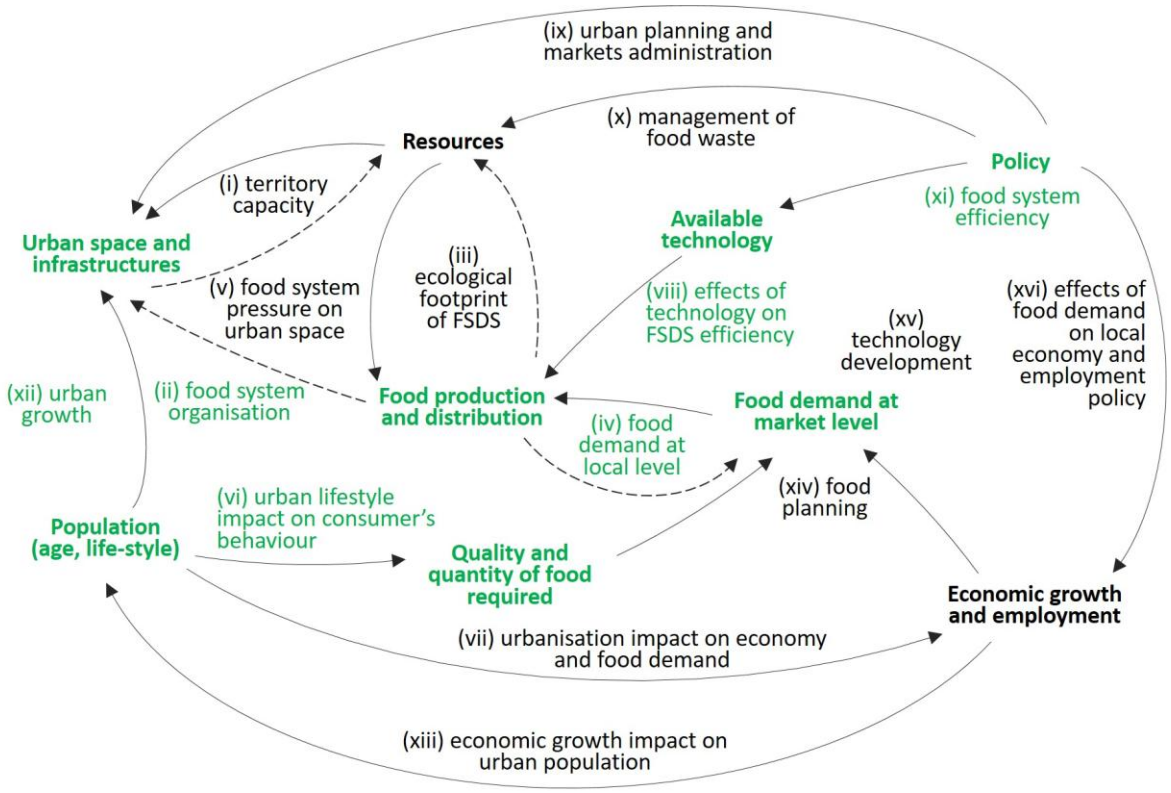


Figure 2. Qualitative framework to analyse food systems at local level, adapted from Armendáriz et al., 2016

In figure 2, a positive causal effect is shown by a black arrow (i.e., when one variable increases or decreases, the other variable changes in the same direction). A negative causal effect is shown by a dotted arrow. The elements participating in activities of production, storage, distribution, processing, packaging, retailing, marketing and consumption of food, are shown in bold font. The feedback structures (or "loops" of balancing or of reinforcing) are show in normal font. In green, items considered in the multi-level modelling to analyse territorial food systems proposed in this communication.

We will apply the qualitative framework adapted of Armendariz et al., (2016) to several study cases at NUTS-3 level. This qualitative model proposes a representation that allows to understand the global functioning of a food system in interaction with others (i.e. urbanisation, mobility, economy, technology…), in a city-region. It shows the imbrication and the reciprocal influences between these systems and the links between the drivers of the different elements. We will focus our analysis on the **local food supply**[14], that is locally-grown food that is consumed in a given place. So, for our purpose, we will restraint the analyse to green-coloured elements and structures of figure 2. Given that quantifying the whole local food supply at NUT3 level would be unfeasible, this task will be focused on 1 or 2 outstanding agricultural products for each case study by the means of focus groups. Furthermore, in order to better understand the interactions between land systems and food systems in city-regions, interviews would be conducted to key informants to collect information about the changes undergone throughout the past 10 years.

The utilisation of this model suppose the following assumptions: a) policy and regulations proposals about land use influence the quality and quantity of local food available and accessible for the population; b) food demand differs from real quantity of food produced in a territory; c) urbanisation processes are the main pressures exerted onto food systems, especially because of their effects on the evolution of land use; and d) a systemic approach

[14] Local food supply drivers are related to food environment: socio-political context, human, historic, cultural, normative and statutory) (Brand et al., 2017).

combined with modelling enables the characterisation of a territorial food system and analysing the organisation of food supply; the qualitative model will enable the formalisation of a simulation model and so to check its validity with empirical data.

Mixed methods and multi-level spatial modelling to analyse territorial food systems

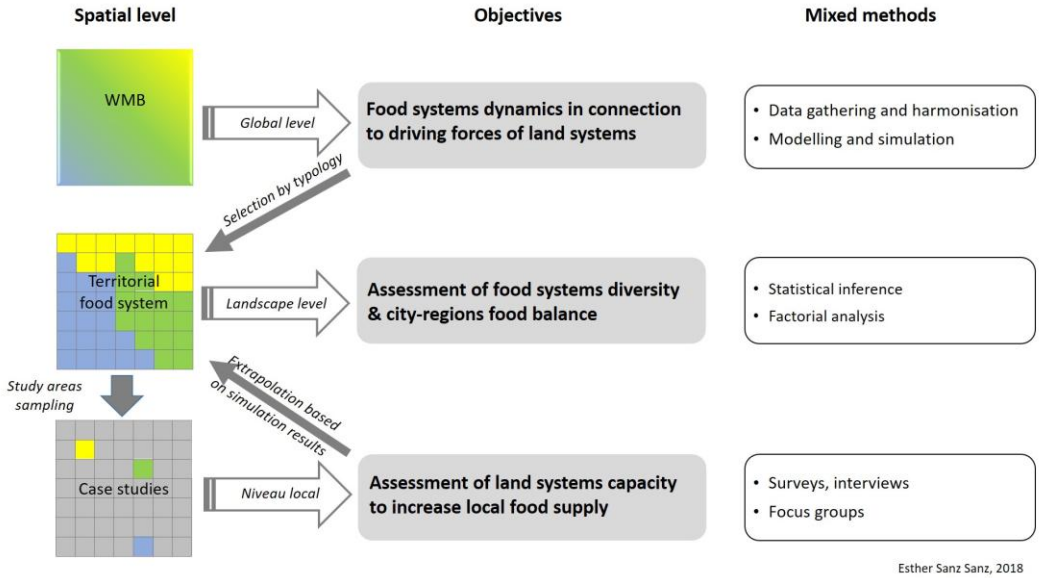
In order to address the complexity of food systems, it is necessary to combine a wide range of disciplines and tools: geography, land use change, agronomy, ecology, sociology, economy and political sciences. We have developed a methodology for spatial analysis with a multi-level approach, going from the local to the landscape level and then upscaling again the final results at the West Mediterranean Basin level, to inform food planning decisions. It implies integrating the food dimension into land and landscape planning and management, in connection with urbanisation dynamics. Graphic representations (loop diagrams, cartography, schemas) will be employed first to develop research on the analysis of system dynamics and definition of the links between their elements, and then to represent the final results. Furthermore, we seek to develop mixed methods combining qualitative and quantitative methods of analyse in order to understand the complexity of food issues in urban contexts. Our objective is to integrate into modelling the uncertainty and fluctuant dynamics related to local food supply focusing in local food production and consumption.

To understand complex systems, it seems essential to relate the trajectories of food systems at micro-regional level to the food systems configurations observed at macro-regional level (WMB scale) (Pumain et al., 2015). In this perspective, our work is based on a **three-level modelling with specified objectives** (figure 3):

1) to assess land systems capacity to promote local food supply (local level[15]) from the sampling of study-cases representing the diversity of WMB land systems.

2) to assess the food systems diversity from the point of view of local food supply (landscape level) and to assess thus city-region food balance.

3) to identify food systems dynamics in relation to driving forces of land systems at WMB scale, focusing on the impact of urbanisation on the evolution of farming systems (changes in production ways and diversification of farming activities) (global level);



[15] For modelling, this level will probably correspond to NUTS-3 level, equivalent in France to the *département* administrative level.

Figure 3. The multi-level modelling to analyse territorial food systems

The project is being developed in a multi-level approach by applying a new methodological framework: successive loops of up-scaling and down-scaling in which the interface between local and global is kept under focus. In that way, we go from the landscape level to local level by downscaling, then upscaling final results to landscape and WMB levels appropriate for a potential intervention of public action, and thus reinforcing the interface between research and practice. The connection between local and WMB levels will be mainly made by the identification and the understanding of the food system stakeholders' capacity to develop proximity food systems enhancing local food supply, and the way they react to global drivers of change.

From a scientific point of view, there is still no clear method to link different levels of analysis.

In that way, the first step of our work consists in an empirical research from study-cases at local level, in a back and forth qualitative and statistical characterisation. For this purpose, we will analyse the practices and capacity of the actors of territorial food systems to orientate local food production to local consumption. The food systems dynamics identified at micro-geographical level would contribute to the production of knowledge and also provide pragmatic results that could be mobilised in action, especially in food planning (eg. Territorial Food Projets). Furthermore, the analysis of study-cases enables to highlight interactions between food and farming systems involved in land systems at local level, and thus assessing the capacity of land systems to enhancing local food supply (land systems which produce food that is consumed locally).

These results will serve us to begin with the second step of our work, and thus to formulate hypothesis about the relationship between land systems and local food supply to question the data out at landscape level, and thus to asses food systems diversity. Our goal is to identify food systems dynamics concerning food balance (% of local food supply) in relation to the driving forces of land systems at the WMB level. Besides, the dynamics identified at macro-geographical level will enable modelling and simulation of the evolution of food systems. It would be likely that Mediterranean food system configurations present lot of resemblances, despite their different locations and position in the urbanisation progress which certainly explain some of their particularities (Debolini et al., 2018; Sanz Sanz et al, 2018).

An original methodology to assess cities' food balance from land systems analysis

Unlike geospatial land use data, data concerning the food systems are only available in connexion with administrative units. Most statistical data about food imported/exported and flows in food systems are only available at national level. At more detailed levels (i.e. regional), most of the available data are qualitative and are based on field surveys. It has to be noticed that there is currently no data on volumes of food exchanged (produced in one region and consumed in another), with the exception of a few studies on specific products of the national economy (i.e. Garçon, 2015).It is thus not evident how to infer from these sources food system dynamics at regional scale. In this context, we have developed a method that enables to estimate the participation of each land system in local food supply from the analysis of study cases. The ulterior objective is to detect if there are common patterns for different land systems, and when that happens, under which conditions results could be extrapolated to similar land systems across the WBM.

As it is explained in the next section, geospatial data about agricultural land, crops and practices, are available for the Mediterranean area in several spatial databases, in particular MapSPAM at a 10 km resolution level. Combining these geospatial data sources with statistical analyses, especially hierarchical clustering, a general typology of land systems

(LS) has been produced[16]. Each land system is a homogeneous area from a geographical and agronomic point of view, composed of a specific arrange of different food crops and non-food crops areas, and statistically defined by 10 km square cells informing notably about crop production. When applied to a case study, these data can be completed by the means of fieldwork and surveys with information concerning the proportion of local production (for each selected representative food-crop -FC- at cell level) which is oriented to local market (local food supply, figure 4). By aggregating and offsetting the estimated participation in local food supply of every cell composing land systems involving in the study case, we can estimate the participation in local food supply of every land system at landscape level. Finally, we can assess the food balance of a given city-region, that is, the proportion of local-grown products that are commercialised locally and so oriented to local food supply.

Furthermore, since each study case contains different land systems, which in turn, are mainly oriented to different crops, we will be able to generate a partial database that relates food crops and market orientation. This database will serve as a basis to recognise patterns and confirm if some farming systems associated to land systems are more likely to orientate their production to local markets, and thus to participate in proximity food systems. The results on potential correlation between land systems and territorial food systems will be upscale to the WMB level.

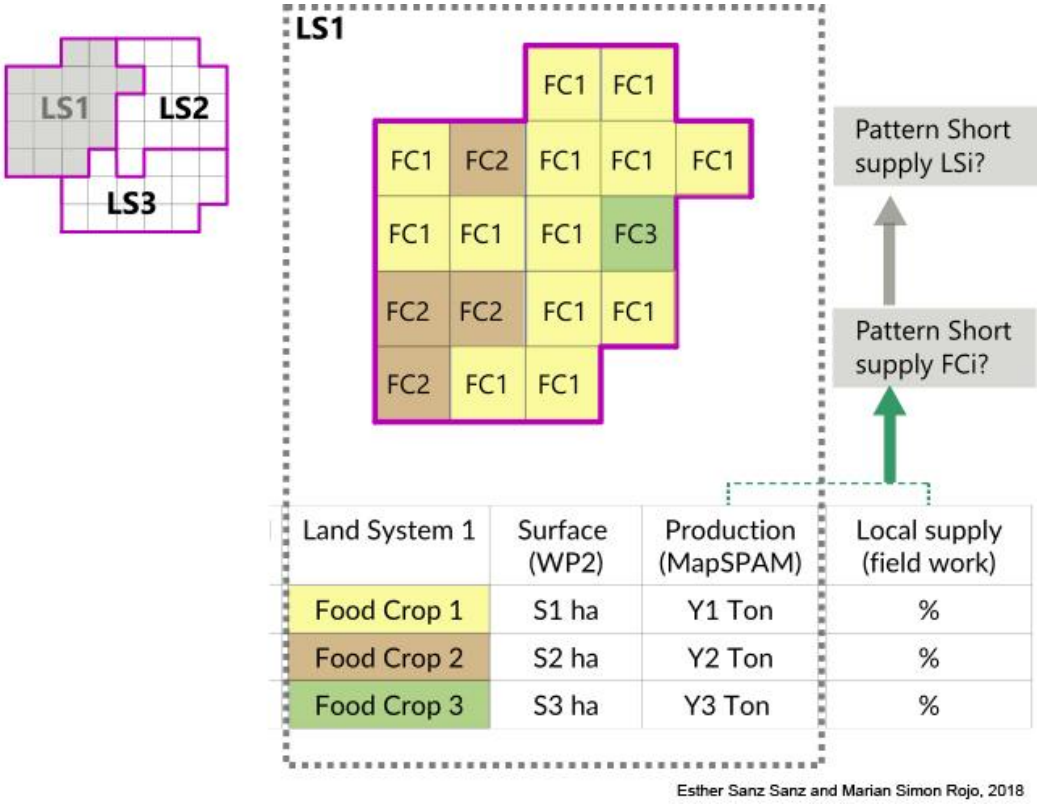


Figure 4. Estimation of the participation of land systems in local food supply

A main typology of land systems (LS) is defined for the whole WMB (eg. LS1, LS2, LS3…). Each land system is statistically composed by 10 km2 square cells with data about crops, from which: food (FC) or not-food and type, surface occupied by each crop in the cell and tonnage. When applied to a case study, and by the means of surveys and interviews, we can infer data concerning the proportion of local food production which is oriented to local food supply, for each food-crop. By aggregating and offsetting the estimated participation in local food supply of every cell composing land systems involving in the case study, we can infer and extrapolate the participation in local food

[16] Ongoing project Divercrop, WP2.

supply of every land system at landscape level. Finally, this methodology enables the assessment of food balance of a given city-region.

Building a Mediterranean harmonised database on food systems

The empirical identification of a food system is problematic due to the scarcity of data to map the relationships under which a territory is organized (both in transnational and in regional terms). In the case of the Mediterranean area, there is no such statistical data at the regional level (NUTS-3) that would enable us to estimate the relative weight of the production of local agriculture in local consumption. Most studies using quantified data are based on simulations[17] (van Wijk, 2014). As a result, although there is a wide body of literature on case studies, we have only limited knowledge about how the stakeholders are organized in space and time, to obtain and consume their food - using the Malassis definition of the food system (1994).

We seek to address this structural lack of information so as to build a database for the comparative analysis of food systems of the Mediterranean basin. Furthermore, one of the issues at the stake is how to build a harmonised database adapted to the concept of food system and enabling comparative studies. Accordingly, the concept of "city-region food system" will be applied and adapted to each region, taking into account the peculiarities relating to different land systems combination patterns. The foreseen scale is NUTS-3 level (. It will then be possible to compare at landscape level the dynamics of different types of food systems. It should be noted that the construction of a database is primarily a scientific and secondarily a technical issue. Access to data has become a critical social and political issue for which researchers have a role to play.

By combining existing databases at national and regional level, a homogeneous and comprehensive database for the western part of the Mediterranean basin will be developed. Thus, regarding the agricultural production at the scale of the Mediterranean basin, we rely on the spatial database **MapSPAM** (You et al., 2018, http://mapspam.info) which provides data about production of 42 crops (27 of which are food crops) and on the performance of farming systems. MapSPAM is based on censuses and other statistical data produced at the sub-national level, and it is a joint initiative between FAO (Food and Agriculture Organization of the United Nations), IFPRI (International Food Policy Research Institute) and SAGE (Center for Sustainability and the Global Environment, de l'Université de Wisconsin-Madison). It was launched in 2002 to address the need for harmonized data on land use and agricultural production for international comparisons. This database breaks down the space into a grid of cells (pixels) of 10 km resolution, and data is currently available for 2000 and 2005. This spatial resolution (10km) will be the basic spatial unit to coordinate the heterogeneous sources of data available and focus on the **9 types of food crops most consumed in human nutrition in the Mediterranean**, selected among those 27 crops reported by MapSPAM: wheat, rice, potatoes, beans, chickpeas, lentils, temperate fruits and vegetables. This information will be complemented by the statistical data from **AO-AGA** (Food and Agricultural Organisation's Animal Production and Health Division) about livestock densities, based on data that are matched to their corresponding administrative boundaries and then converted into density maps, with 1km cell resolution, which are in turn aggregated into 10 km square cells.

[17] For example, the calculation of urban food self-sufficiency produced by the French Utopies Think Tank (Laville et al., 2017), or the calculation of the "metropolitan economic balance assessment" and "local foot-print hectares" realized in the part of the European Foodmetres project: Food planning and innovation for sustainable metropolitan regions (Wascher et al., 2015).

After this, it is possibly to carry out a spatially explicit comparative analysis between heterogeneous territorial food systems that are developed in the Mediterranean basin, at landscape level (between NUTS1 and NUTS-2). In addition, these units will make it possible to analyse metrics inspired by landscape ecology (fragmentation, diversity, etc.) to characterize the structure of the food system and to understand the link between spatial structure and regulation, providing valuable information for decision-makers and land use planners (*cf.* Leitão and Ahern, 2002).

Finally, these data will be complemented with **FAO's a-spatialized Food Supply Databases** (**FAOSTAT**: Food supply and Food Balance Sheets, http://www.fao.org/faostat/en/#data), which are available for each country, between 1961 and 2013. These data show for each type of food product (i.e., each primary product and a number of processed products potentially available for human consumption), the source of supply and its use. The total amount of food produced in a country, added to the total quantity imported and adjusted for possible changes in the stock for the reference period, gives the food available in the period. Food crops in FAOSTAT database can be aggregated into the 9 types of food crops most consumed in the Mediterranean area, as well as the products of animal origin (meat, fish, crustaceans, honey, eggs, dairy products). The common field "type of food culture" will thus make it possible to link FAOSTAT and MapSPAM's databases. Regarding the use of foodstuffs, it discriminates against several uses: livestock feed, seeds, processing for food and non-food use, losses during storage and transport, and food supplies available for human consumption. It will be interesting to compare the proportion of food-crops oriented to local market estimated using the methodology founded on land systems, with the statistical data of FAOSTAT, at national scale, in order to validate the results.

Conclusion

In the current global context, characterized by urban growth and social concerns about food security and safety, more insights are needed into the connections between land systems and food systems for the management of landscapes across multiple geographical scales (local, regional, national). This is especially urgent in Mediterranean context, where food security is threatened by global change and urbanisation process. This presentation proposes a methodology to highlight interactions between Mediterranean land systems and food systems, at multiple spatial levels. It enables the assessment of the eventual connection between farming systems -associated to land systems- and territorial food systems. In other words, the methodology enables to highlight farming systems that could potentially enhance local food supply by orientating food-crops to local market. These results allow us to calculate the food balance for a city-region, at landscape level. Furthermore, we proposed a qualitative framework to analyse the food systems dynamics in relation to the driving forces (geographical, agronomical and socio-economic) of land systems, at WMB level.

We presented here the methods and materials which we are handling to design and develop such a multi-level methodology to analyse food systems. Combining quantitative and qualitative methods in an abductive reasoning, and associating three levels of analysis (local, landscape, global) by upscaling and downscaling processes, this methodology would represent a real finding in planning science and landscape agronomy. Furthermore, we seek to contribute to a new geography of food by proposing spatial methods of analysis usable by stakeholders and operational for food planning. We will shortly test our systemic approach in seven study cases, both in North and South Mediterranean basin: Avignon (France), Madrid (Spain), Pisa (Italy), Evora (Portugal), Alger (Algeria), Tunis (Tunisia) and Valletta (Malta). Then, the main goal of this research is to establish solid results replicable from data (fieldwork and statistical) made comparable by the means of a common framework of

analysis despite the heterogeneity of available statistical data. Moreover, we seek to construct a harmonised Mediterranean database on food systems.

To conclude, there is a need to estimate significance threshold of city-regions food autonomy in order to highlight regions with poor food autonomy where the question about the ecological intensification of farming systems would then strongly arises in a food security perspective. This issue would open up some interesting new research perspectives about the controversies exposed by Tilman et Clark (2014) on the links between food diets and environmental impact of farming. In that way, research on food systems planning enables the articulation of social, economic and ecological issues about city-regions food security.

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References

Alkon, A.H., Agyeman, J. (Eds.), 2011. Cultivating food justice: race, class, and sustainability, Food, health, and the environment. MIT Press, Cambridge, Mass.

Armendáriz, V., Armenia, S., Atzori, A., 2016. Systemic Analysis of Food Supply and Distribution Systems in City-Region Systems—An Examination of FAO's Policy Guidelines towards Sustainable Agri-Food Systems. Agriculture 6, 65. https://doi.org/10.3390/agriculture6040065

Bedore, M., 2014. The convening power of food as growth machine politics: A study of food policymaking and partnership formation in Baltimore. Urban Studies 51, 2979–2995. https://doi.org/10.1177/0042098013516685

Berti, G., Mulligan, C., 2016. Competitiveness of Small Farms and Innovative Food Supply Chains: The Role of Food Hubs in Creating Sustainable Regional and Local Food Systems. Sustainability 8, 616. https://doi.org/10.3390/su8070616

Brand, C., Bricas, N., Conaré, D., Daviron, B., Debru, J., Michel, L., Soulard, C.-T. (Eds.), 2017. Construire des politiques alimentaires urbaines. Concepts et démarches. Éditions Quae, Versailles (France).

Bricas, N., Esnouf, C., Russel, M. (Eds.), 2011. Pour une alimentation durable. Réflexion stratégique duALIne. Editions Quæ, Paris.

CFS, C. on W.F.S., 2009. Reform of the Committee on World Food Security. Final version (Thirty-fifth Session. Rome, 14, 15 and 17 October 2009. Agenda Item III. No. CFS:2009/2 Rev.2). Rome.

Davoudi, S., 2009. City-Region. International encyclopedia of human geography.

de Haen, H., Réquillart, V., 2014. Linkages between sustainable consumption and sustainable production: some suggestions for foresight work. Food Security 6, 87–100. https://doi.org/10.1007/s12571-013-0323-3

Dixon, J., Gibbon, D.P., Gulliver, A., Hall, M., 2001. Farming systems and poverty: improving farmers' livelihoods in a changing world. FAO, World Bank, Rome : Washington, D.C.

FAO (Food and Agriculture Organisation of the United Nations), 2011. Food, Agriculture and Cities. Challenges of food and nutrition security, agriculture and ecosystem management in an urbanizing world. Rome (Italie).

FAO (Food and Agriculture Organisation of the United Nations), 2017. The future of food and agriculture: Trends and challenges. Rome, 180p.

Friedmann, H., 1987. International regimes of food and agriculture since 1870, in: Shanin, T. (Ed.), Peasants and Peasant Societies. Oxford, pp. 258–76.

Fumey, G., 2016. L'alimentation demain: cultures et médiations. CNRS Editions, Paris.

Garçon, L., 2015. Réinventer les pommes et les pommes de terre : une géographie de la qualité à l'épreuve des produits ordinaires. Université Lumière Lyon 2.

Gatrell, J.D., Reid, N., Ross, P., 2011. Local food systems, deserts, and maps: The spatial dynamics and policy implications of food geography. Applied Geography 31, 1195–1196. https://doi.org/10.1016/j.apgeog.2011.01.013

Halberg, N., 2017. Food Systems is the new black, but will it really become consumer driven? Natures Sciences Sociétés. https://doi.org/10.1051/nss/2017019

Hinojosa, L., Lambin, E.F., Mzoughi, N., Napoléone, C., 2016. Place attachment as a factor of mountain farming permanence: A survey in the French Southern Alps. Ecological Economics 130, 308–315. https://doi.org/10.1016/j.ecolecon.2016.08.004

HLPE (High Level Panel of Experts on Food Security and Nutrition), 2017. Nutrition and food systems. A report by the High Level Panel of Experts on Food Security and Nutrition. Committee on World Food Security, 152p.

Hochedez, C., Le Gall, J., 2016. Justice alimentaire et agriculture. Justice Spatiale/Spatiale Justice [en ligne].

IPES-Food (International Panel of Experts on Sustainable Food Systems), 2015. The new science of sustainable food systems. Report 01, 22p.

Kneafsey, M., Eyden-Wood, T., Bos, E., Sutton, G., Santini, F., y Paloma, S.G., Venn, L., Schmutz, U., Balázs, B., and Trenchard, L. (2013). *Short Food Supply Chains and Local Food Systems in the EU: a state of play of their socio-economic characteristics.* Sevilla, (Spain): European Commission, Joint Research Centre, Institute for Prospective Technological Studies. Retrieved from: http://ftp.jrc.es/EURdoc/JRC80420.pdf

Lamine, C., Renting, H., Rossi, A., Wiskerke, J.S.C., Brunori, G., 2012. Agri-Food systems and territorial development: innovations, new dynamics and changing governance mechanisms, in: Darnhofer, I., Gibbon, D., Dedieu, B. (Eds.), Farming Systems Research into the 21st Century: The New Dynamic. Springer Netherlands, Dordrecht, pp. 229–256.

Lançon, F., Mora, O., Aubert, F., 2014. L'extension urbaine à travers le monde : enjeux pour les villes et les campagnes. Cahier Demeter 83–100.

Laville, E., Florentin, A., Chabanel, B., 2017. Autonomie alimentaire des villes. Etat des lieux et enjeux pour la filière agro-alimentaire française (Note de position No. 12). Utopies.

Leitão, A.B., Ahern, J., 2002. Applying landscape ecological concepts and metrics in sustainable landscape planning. Landscape and urban planning 59, 65–93.

Le Mouël, C., 2016. Agrimonde-Terra: Foresight land use and food security in 2050. INRA/CIRAD.

Malassis, L., 1994. Nourrir les Hommes. Flammarion Dominos, Paris.

Malek, Ž., Verburg, P.H., 2017. Adaptation of land management in the Mediterranean under scenarios of irrigation water use and availability. Mitigation and Adaptation Strategies for Global Change. https://doi.org/10.1007/s11027-017-9761-0

Metzger, M.J., Bunce, R.G.H., Jongman, R.H.G., Mücher, C.A., Watkins, J.W., 2005. A climatic stratification of the environment of Europe: A climatic stratification of the European environment. Global Ecology and Biogeography 14, 549–563. https://doi.org/10.1111/j.1466-822X.2005.00190.x

Moragues-Faus, A., Sonnino, R., Marsden, T., 2017. Exploring European food system vulnerabilities: Towards integrated food security governance. Environmental Science & Policy 75, 184–215. https://doi.org/10.1016/j.envsci.2017.05.015

Morgan, K., Sonnino, R., 2010. The urban foodscape: world cities and the new food equation. Cambridge Journal of Regions, Economy and Society 3, 209–224. https://doi.org/10.1093/cjres/rsq007

Nelson, M.E., Hamm, M.W., Hu, F.B., Abrams, S.A., Griffin, T.S., 2016. Alignment of Healthy Dietary Patterns and Environmental Sustainability: A Systematic Review. Advances in Nutrition: An International Review Journal 7, 1005–1025. https://doi.org/10.3945/an.116.012567

Popkin, B.M., Adair, L.S., Ng, S.W., 2012. Global nutrition transition and the pandemic of obesity in developing countries. Nutrition Reviews 70, 3–21. https://doi.org/10.1111/j.1753-4887.2011.00456.x

Pumain, D., Swerts, E., Cottineau, C., Vacchiani-Marcuzzo, C., Ignazzi, A., Delisle, F., Cura, C., Lizzi, L., Baffi, S., 2015. Multilevel comparison of large urban systems. Cybergeo : European Journal of Geography [En ligne], Systèmes, Modélisation, Géostatistiques. https://doi.org/DOI : 10.4000/cybergeo.26730

Rastoin, J.-L., Ghersi, G., 2010. Le système alimentaire mondial: concepts et méthodes, analyses et dynamiques, Synthèses INRA. Quae, Versailles.

Rastoin, J.-L., Ghersi, G., 2009. Le système alimentaire mondial. Concepts et méthodes, analyses et dynamiques, Synthèses. Editions Quae, Paris.

Reardon, T., Timmer, C.P., 2012. The Economics of the Food System Revolution. Annual Review of Resource Economics 4, 225–264. https://doi.org/10.1146/annurev.resource.050708.144147

Sanz Sanz, E., 2016. Planification urbaine et agriculture. Méthodologie systémique de caractérisation de l'agriculture périurbaine à partir d'une recherche empirique en France et en Espagne. International doctoral thesis. Ecole des Hautes Etudes en Sciences Sociales and Universidad Autónoma de Madrid, 454p. URL: http://www.theses.fr/2016EHES0115 (last accessed 31/08/2017).

Sanz Sanz, E., Napoléone, C., Hubert, B., 2017. Caractériser l'agriculture périurbaine pour mieux l'intégrer à la planification urbaine: propositions méthodologiques. L'Espace géographique 46, 174–190. https://doi.org/10.3917/eg.462.0174.

Sanz Sanz, E., Martinetti, D., Napoléone, C., 2018. Operational modelling of peri-urban farmland for public action in Mediterranean context. Land Use Policy 75, 757–771. https://doi.org/10.1016/j.landusepol.2018.04.003

Sonnino, R., Moragues Faus, A., Maggio, A., 2014. Sustainable food security: an emerging research and policy agenda. International journal of sociology of agriculture and food 21, 173–188.

Soulard, C.-T., Perrin, C., Valette, E. (Eds.), 2017. Toward Sustainable Relations Between Agriculture and the City, Urban Agriculture. Springer International Publishing, Cham. https://doi.org/10.1007/978-3-319-71037-2

Tilman, D., Clark, M., 2014. Global diets link environmental sustainability and human health. Nature 515, 518–522. https://doi.org/10.1038/nature13959

United Nations Organisation (UNO), 2014. World urbanization prospects: the 2014 revision. UNO. Department of Economic and Social Affairs. Population Division.

van Wijk, M.T., 2014. From global economic modelling to household level analyses of food security and sustainability: How big is the gap and can we bridge it? Food Policy 49, 378–388. https://doi.org/10.1016/j.foodpol.2014.10.003

Verburg, P.H., Erb, K.-H., Mertz, O., Espindola, G., 2013. Land System Science: between global challenges and local realities. Current Opinion in Environmental Sustainability 5, 433–437. https://doi.org/10.1016/j.cosust.2013.08.001

Wascher, D.M., Zasada, I., Jeurissen, L., Arciniegas, G., de Kroes, J., Sali, G., Corsi, S., Monaco, F., Schmutz, U., Glavan, M., Pohle, D., van Eupen, M., 2015. Indicators, tools and method for metropolitan footprint tools 57.

Watts, D., Ilbery, B.W., Maye, D., 2005. Making reconnections in agro-food geography: alternative systems of food provision. Progress in Human Geography 29, 22–40. doi:10.1191/0309132505ph526oa

Wiskerke, J.S.C., 2009. On Places Lost and Places Regained: Reflections on the Alternative Food Geography and Sustainable Regional Development. International Planning Studies 14, 369–387. https://doi.org/10.1080/13563471003642803

You, L., Wood-Sichra, U., Fritz, S., Guo, Z., See, L., Koo, J., 2018. Spatial Production Allocation Model (SPAM) 2005.