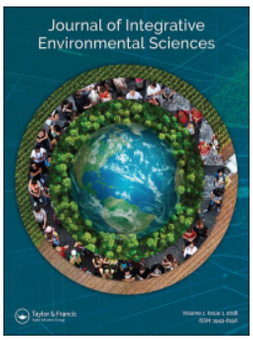

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SPECIAL ISSUE: RETHINKING THE URBAN NEXUS

The making of a sustainable food city in Barcelona: insights from the water, energy, and food urban nexus

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ABSTRACT

This paper examines the making of urban sustainable food provisioning through the case of Barcelona. Barcelona is seeking to develop a more sustainable food system. It aims to green its municipal food markets by reducing the distances from which the food is sourced from. This has been labelled by the city of Barcelona as "proximity food". We shed light on how, and to what extent, proximity food contributes to making the city more sustainable. To frame our analysis, we employ concepts from networks and flows as developed in sociology by Manuel Castells. We examine the provisioning processes that proximity food goes through before they enter retail markets. This includes an analysis of connections with urban energy and water flows. This so-called water, energy and food Urban Nexus, which we argue to be a key factor in the greening of urban food systems. This means that sustainability of food is not just determined by physical distances between its provisioning processes *per se* but by the specific ways in which food flows relate to connections (both physical and social) with energy and water.

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Urban nexus; governance; networks and flows; water-energy-food; food city

I. Introduction

The Sustainable Development Goals (SDG's) are pushing cities forward to develop sustainability agendas and action plans to address climate change and greenhouse gases emissions. Some of the core domains requiring action relate to water, energy, and food (United Nations 1992; UNDP 2015). Cities are critical places where stresses occur (e.g. traffic congestions, air pollution, land use change, etc.), but cities also represent the places for innovation and action to address unsustainable practices (Giezen 2016). There have been numerous efforts of cities around the world towards the greening of their policies, activities, and infrastructures, towards sustainability (Hopwood and Mellor 2007). Most of the European cities, in their commitment to become sustainable habitats, have focused on energy efficiency, followed by guaranteeing the resilience of cities, the internet of things, and the circularity of resources (Giezen 2016). In that context, cities commonly adopt labels to brand and promote their endeavours – e.g. green cities, ecological cities, smart cities, or resilient cities (see overviews in Serbanica and Constantin 2017; Khan and Zaman 2018).

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Food in the city is an aspect of sustainability that has often been overlooked in these endeavours, at least in Europe (Morgan 2009). But it is gradually taking off. European cities such as Barcelona, Ghent, Marseille, Milan, Thessaloniki, and Utrecht have started to give some attention to food in their policy and decision-making (see e.g. Milan Urban Food Policy Pact 2015). In approaching cities into sustainable habitats, food has been placed into the urban equation in different manners. For instance, food has been addressed in terms of public food procurement (e.g. local and organic food served at school canteens); urban farming initiatives; bridging the rural-urban divide (Sonnino 2009; see e.g. in Dubbeling 2013); but also in terms of an urban governance response which looks to include food as an asset of cities (Sonnino 2009; see e.g. Milan Urban Food Policy Pact 2015). In any such approach, gains towards sustainable food cities require a rearrangement of their food system as a configuration or network that organizes flows of urban food.

This paper will examine the case of Barcelona in its ambition to becoming a sustainable food city. Barcelona is one amongst the pioneering European cities that is working on its urban food policy and a sustainable food system. In particular, Barcelona, as an emerging sustainable food city, aims to gain on sustainability by strengthening, promoting, greening, and using its municipal food markets and the flows of "proximity food" commercialized through these markets (Ajuntament de Barcelona 2014). Proximity food means that the (fresh) food flows are easily accessible and organized with only a few intermediaries (see Spaargaren et al. 2012). It is a concept that is actively used in Barcelona's policy and practice on sustainable food (Ajuntament de Barcelona 2014). Food markets are a key puzzle in the food system of Barcelona as these are connected through short circuits of commercialization with local food producers in the proximity of Barcelona City. These short circuits employ two or fewer intermediaries in connecting food production with its commercialization through markets. What this equation assumes is to reduce food miles, and the related energy consumption and CO_2 emissions, along with food provisioning processes. In parallel, this equation also implies reconnecting and reconfiguring actors and flows, more locally, in the food system of Barcelona.

We shed light on how, and to what extent, food markets and flows contribute to making the city more sustainable. In doing so, we examine the main actors, their organization, and the policies and practices involved in the governing of urban food flows. To better understand Barcelona's development towards a more sustainable food city, we look into the provisioning processes for proximity food flows e.g. the distribution, wholesaling, and local production of this kind of (fresh) food. In our analysis, we consider how the city addresses the urban nexus of water, energy and food (WEF). How key actors for WEF flows interact, or fail to interact, and how they use urban nexus thinking and planning to improve sustainability in the city.

This paper is structured as follows. Section II presents a background of the positioning of food in cities and the approaches cities have taken to address food and its connections with water and energy. Section III addresses the methods used in this research. Section IV provides the case of proximity food flows retailed through municipal food markets in Barcelona and the role of these markets in building a more sustainable food system in the city. First it introduces the background of food markets and flows in Barcelona. Then it positions the aims of Barcelona towards reconnecting and reconfiguring the proximity of food. As a further step, it analyzes food proximity distribution through markets and their relationship with other upstream processes within the proximity food network. Then, it

discusses the main findings and reflects on the added value of using a broader WEF urban nexus perspective when addressing the puzzle of sustainability. Section V concludes on how the concept of proximity is a crucial element in the (re)coding by switchers and programmers of the urban food network and flows; employing this concept benefits further food sustainability in Barcelona.

II. Background: a WEF urban nexus perspective in cities

Cities, in their quest to become more sustainable habitats for their citizens, have gone through a transition from being places of economic growth towards places that represent an integrated and overall sustainable urban environment (Hodson and Marvin 2017). Sustainable cities research and practice have opened debates about what sustainability in an urban context means, and about the best possible strategies to develop towards a sustainable city (Williams 2010). Cities take different approaches to become more sustainable urban environments. In the last decades, adopting branding profiles by cities has become a popular practice (e.g. Smart City, Sustainable City or Food City). Those profiles anchor visionaries and values that cities seek to attain (e.g. the smartness or circularity of a city) (Khan and Zaman 2018). Cities use branding profiles as a way to push forward particular working agendas, urban planning principles, and policy and decision-making processes (Khan and Zaman 2018). For instance, extensive literature reviews examining different city profiling labels identified over a dozen of different city labels (see Hodson and Marvin 2017; Khan and Zaman 2018)[1]. Those mainly reflect different values, visionaries, and priorities portraying pathways towards sustainability. "Smart Cities", "Sustainable Cities", and "Low-Carbon Cities" are examples of the most recurrent labels adopted by cities (Hodson and Marvin 2017).

Food is a question that is often overlooked in the sustainability profiling, labelling, framing, and policy and decision-making of cities. When food interventions happen, they primarily focus on either ensuring food security, nutrition, poverty alleviation, or as a tool to reinforce community engagement (Haysom 2015; FAO 2018). Studying sustainable food provisioning in the city requires understanding and analysis of food from a more systemic perspective which also considers the different provisioning processes involved in the organization of access to more sustainable food (Dubbeling 2013). Learning about the key actors, networks, and flows is important since the strengthening of urban food systems so far has been constrained by weak governance structures, low capacity of human resources, and conflicting policies and practices between actors and jurisdictions (FAO 2018).

Effective and sustainable governance of urban food also requires attention to how it relates with energy and water in order to ensure a more integrated and informed food provisioning in cities (Covarrubias 2018). These urban-level cross-sectoral interactions have been defined by previous research as the Water, Energy and Food (WEF) urban nexus (Covarrubias 2018). The WEF urban nexus perspective is defined as a cross-sectorial policy-making approach which aims to overcome trade-offs between different flows and to stimulate synergies across and between networks that are important for sustainable urban development (Dubbeling 2013; Vogt et al. 2014).

Water and energy resource flows are domains that have already received special attention in nexus literature (Kenway, P. Lant, et al. 2011; Kenway, P.A. Lant, et al. 2011; Nair et al. 2014; Endo et al. 2015). Nexus literature has already put some efforts forward on

quantifying WEF resource flows and the implications of providing one resource in relation to the others at the regional, national and global levels (see e.g. Bazilian et al. 2011; Howells et al. 2013; Nair et al. 2014; Endo et al. 2015; Daher and Mohtar 2015; Chen and Chen 2016; Smajgl et al. 2016; Tevar et al. 2016). Nevertheless, the *urban level* of the nexus has received less attention in the literature when compared to the regional and national levels (for recent calls see Artioli et al. 2017; Covarrubias 2018; Covarrubias et al. 2019), just as food in the city has received less attention as compared to water and energy domains (Morgan 2009; Sonnino 2009). Understanding the WEF urban nexus of flows in the city, therefore, deserves further exploration.

Barcelona is one of the European pioneers emerging as a sustainable food city. The promotion of urban food markets and their proximity food flows are important elements of the sustainability strategy of the city. To make this proximity food strategy work, the city authorities engage with different societal actors from the food system in the context of a more horizontal process of policy and decision-making. Horizontal relations and frequent interaction between actors and organizations operating in the different networks that constitute the WEF urban nexus are considered key in the shaping of Barcelona as a sustainable food city.

To better understand this making of a more sustainable urban food system, we employ the concepts of networks and flows as developed in sociology by the Spanish sociologist Manuel Castells (2009). His theory on networks and flows is used to analyse and understand the policies, actors, processes, and relations at work. From this perspective, we examine in what manner the governance of *food in the city* is emerging as a more horizontal way of policy and decision-making (Milan Urban Food Policy Pact 2015; FAO 2018). Networks, as in this case the urban food network, are social organization structures that emerge around visionaries, values, and goals shared by two or more actors (Castells 2009) – for instance, markets, wholesalers, or producers. Social actors in the food network, for example, envision a more sustainable city by means of greening its food markets and flows. Networks, as organizational structures, configure and process flows (Castells 2009, 2010). For instance, the different actors through the food provisioning processes shape the way proximity food flows are provided in Barcelona. The different nodes within the network (food markets, producers, retailers, regulators, etcetera) organize the flows of urban food in particular ways. Flows are the continuous streams of materials, natural resources, information, or any other form that moves along between two or more nodes in the network (Covarrubias 2018). To deserve the title or brand of "proximity food" the network and its flows have to follow a particular programme or code, referring to the values and goals promoted by the network (see Section IV for details). To establish a continuous stream of proximity food moving from places of local production to places of access, the network has to be programmed in order to function in a particular way. The proximity food system includes certain values, strategies, products while not considering others (Castells 2009). Both the values and goals of the network refer to the ambition of Barcelona to become a sustainable food citywhich enhances its markets and flows for proximity food. The key actors in this process of building (new) networks are referred to by Castells as "programmers" and "switchers". They are the experts that stand out for their capacities and skills in (re)connecting and (re)configuring networks. They bring together the flows, actors, and programmes that envisage the sustainable urban food system of the future.

III. Methods

Working from a WEF urban nexus perspective means investigating the work of urban programmers and connectors who seek to integrate formerly separate networks into one, more encompassing and sustainable urban network. In that quest, questions of how, and to what extent, proximity food and its markets address issues of sustainability in Barcelona – on site and beyond – receive further attention in the following sections.[2]

In this context, we trace and follow proximity food flows in Barcelona City, and the way those interrelate with water and energy. For conducting this research, we borrow inspiration and insights from mobilities methodologies. Mobilities methodologies are useful tools to capture the complex dynamic movement of objects and actors as they happen in social life (Sheller 2011). Mobilities, similar to flows, is a commonly used terminology to refer as to 'something that moves or is capable of movement´ (Urry 2007, p. 7). Mobilities insights add value to the theory of networks and flows by understanding beyond movement of flows – or flowing – between two points towards actually understanding what 'the content of the line between them [the two points]' is about (Cresswell 2006, p. 2). As such, mobilities methodologies offer us the possibility to actually trace and follow the proximity food flows and network under study in detail, enabling a thorough understanding of the phenomenon of food markets and their proximity food flows in Barcelona. In particular, by understanding the dynamics of mobility of flows in creating movement or lack of movement (Sheller and Urry 2006), these methodologies help to provide answers to *why* and *how* flows and actors actually move, connect, and get configured with particular codes. In the making of such connections and pattering, these settings of connections form networks (Urry 2012, p. 24), which in turn shape systems of governance (Boas et al. 2018).

In more detail, in this case, we trace the different places and processes proximity food flows go through in order to assess their contribution to the making of the sustainable food city of Barcelona. We start our analysis at the Municipal Food Markets of Barcelona by shedding light on the main actors and practices governing food flows. We analyse beyond markets (as access points of consumption) by analysing their relationship with other actors and processes within the proximity food network such as distribution, wholesaling, and production in the proximity (see Figure 1). As a second step, we shed light on what the actors, networks, and flows are in these processes; and how these networks interact or fail to interact, from the perspective of the WEF urban nexus (see Figure 2).

1. Mobile observations

We employed simple and unstructured observations as a tool to trace the proximity food flows (traceable object in movement) through different networks and processes of provisioning, and to identify the WEF networks. In more detail, we visited the places that the proximity food flows go through (see Boas 2019 for such a methodology). We examined seven food markets, the main food-wholesaling centre "Mercabarna", and an important production area with the name of Agricultural Park of the Low Llobregat located in the peri-urban area of the City of Barcelona. This included interviews and guided walks together with local directors and other practitioners of the food markets and other relevant locations in the provisioning networks. This was supported by observations of daily activities and the tracing of how food was sourced and distributed. We traced as well panels and meetings of

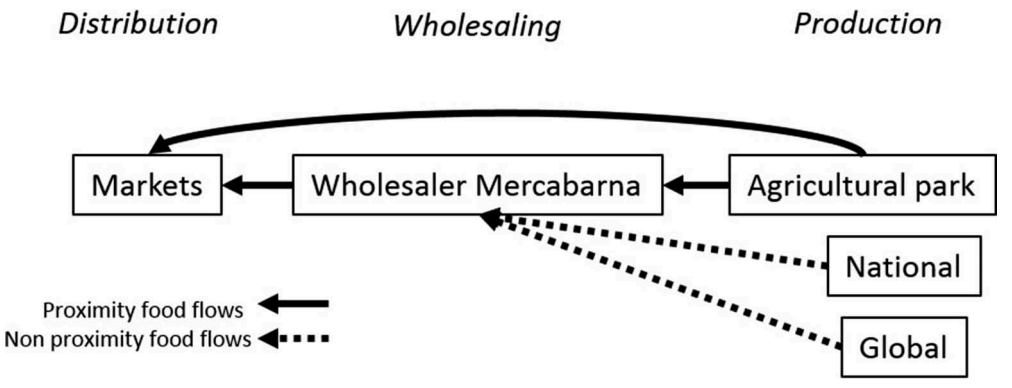

Figure 1. Proximity food flows and processes in Barcelona.

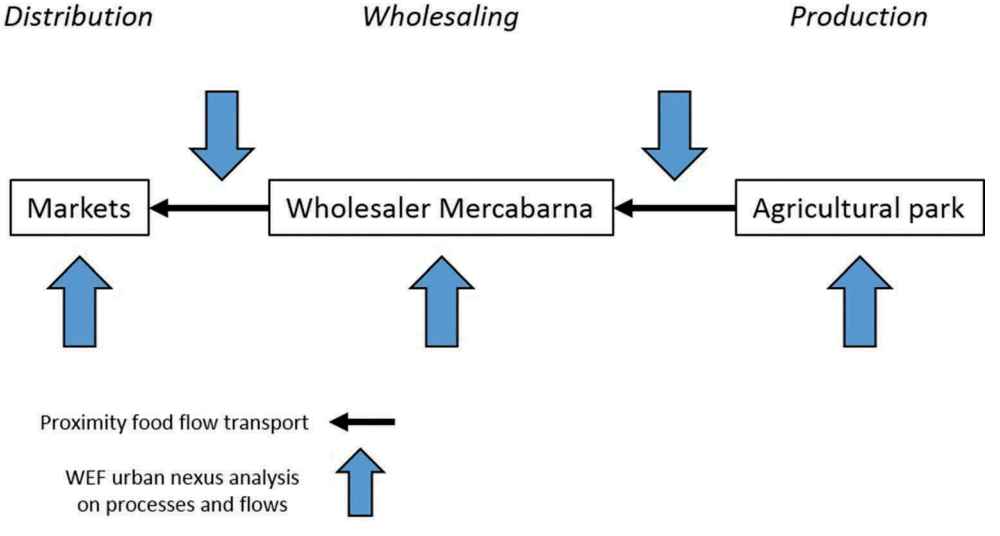

Figure 2. WEF urban nexus analysis.

the Food Council network in which actors from public, private and community sectors gather to discuss issues such as strategies to improve sustainable urban food through its provisioning processes. We also visited the main water treatment facilities around the city which have a connection with the urban food provisioning of Barcelona. Following these connections and networks around proximity food provided insights to better understand the actors around the positioning of Barcelona as an emergent sustainable food city.

2. Interviews

To gather data for this research we conducted one round of Semi-Structured Experts' Interviews (n = 27). After identifying WEF networks around the city and identified the social actors contributing to making Barcelona a sustainable food city, we contacted knowledgeable and accessible participants to conduct our interviews. As a second step,

we snowballed the contacts in order to explore WEF networks and to explore further respondents until we established a data saturation point. The aim of the interviews was to gather insights about the points of integration and connection between the actors involved in contributing to Barcelona with sustainable food, including from the actors involved in the governing of water and energy in Barcelona[3]. Table 1 shows the list of interviewed organizations, including the societal sector they belong to, the provisioning sectors they work on or address, and the number of respondents interviewed from each organization.

IV. The making of a sustainable food city in Barcelona

1. Background: food markets and flows in Barcelona

The City of Barcelona is located between the rivers Llobregat (South and Southwest limits) and Besós (Northeast). The Collserola Sierra delineates the Northwest of the city while the Mediterranean Sea shapes the South and Southeast borders of Barcelona (see Figure 3). Historically, the city of Barcelona has been fed with food produced, both, within its city borders and from the immediate fertile lands along the low Llobregat River. This river has been key as a freshwater input for food production in the region of Barcelona.

Since the Roman Age, commerce and exchange of goods have characteristically identified the city of Barcelona (Ajuntament de Barcelona 2017). The first market established in Barcelona "dates back to the 10th century" (Ajuntament de Barcelona 2017). From the Middle Age, the city of Barcelona has exerted authority over food provisioning. Food security, food safety, and taxation were the major values and objectives for taking over the control of food provisioning in cities such as in Barcelona. In part, those concerns

Table 1. List of interviews.

Interview reference	Organization	Societal Sector	Sectors	N respondents
1	Agricultural Park of the Low Llobregat	Private	Food	2
2	Farmers Union	Community	Food	1
3	Farmers	Community	Food	5
4	Deputation of Barcelona	Public	WEF	1
5	Deputation of Barcelona	Public	WEF	1
6	Municipality of Barcelona	Public	WEF	1
7	Barcelona Strategic Plan	Public	Food	2
8	Socio Economical Development of the Metropolitan Area of Barcelona	Public	WEF	1
9	Food Wholesaling Centre	Public/ Private	Food	3
10	Institute of Municipal Markets of Barcelona (IMMB)	Public	Food	1
11	Municipal Food Markets La Llibertad La Concepció Les Corts Sant Martí Fort Pienc Galvany Sant Gervasio	Markets	Food	7
12	Water Company	Public	Water	1
13	Water Company-Waste Water Treatment Plant	Public	Water	1
27			Total	respondents

Figure 3. Map of Barcelona city (from Google maps 2019).

led to the physical development of municipal markets in which food could be provisioned in a safe and secure way (Ajuntament de Barcelona 2017) (Interview 10, see Table 1).

Later in the '70s and '80s, advances in food technologies related to production, storage, and transport, contributed to reducing the number of small-size food retailers in the city (Ajuntament de Barcelona 2013). Such advances also gave room in Barcelona to the breakthrough and boom of supermarkets (being Carrefour the first supermarket established in the region in 1973) (Ajuntament de Barcelona 2013). During the '90s in Western Europe, already only a small number of large retailing companies – some of them operating globally – accounted for the vast majority of groceries sales (Spaargaren et al. 2012). These events, among others, have stamped a landmark in the ongoing dynamics of modern food provisioning in cities like in Barcelona (Interviews 10, 11).

The turn from a localized and controlled food provisioning system back in the Roman Age into a liberalized and global food system has brought a reconfiguration of the food provisioning dynamics. Nowadays, different societal actors interplay into the scene of shaping food systems. In Barcelona, these actors interact with each other through social

dynamics that reflect more as networked configurations in which the state is just one of the players – among private and community sectors – shaping its food system.

The turn, then, from sourcing the city, in the past, with food from the proximity towards sourcing the city with food coming from all over the world has come along with logistical, distributional, commercial, organizational, environmental, and water and energy trade-offs and synergies. One of those trade-offs relates to the growing distances that food needs to travel, mainly by fossil-fuels modes of transport, in order to reach consumers in cities. Another one relates to the actual manner of food retailing and access in the city. However, the emergent sustainable food system of Barcelona aims to position back proximity food in the city; it aims to do so by synergistically reconfiguring and reconnecting food-related actors, nodes, and networks and flows.

2. Towards reconnecting and reconfiguring the proximity of food

Nowadays, Barcelona aims to strengthen its position as a sustainable food city. In such commitment, the city envisions to invigorate the use of its food markets as a way to reduce its food miles and as a way to transition back to source its food intake from the "Proximity". Food from proximity is characterized as the food in which 'the physical and social distance between the primary producer and the ultimate consumer is reduced compared with conventional contemporary systems that may involve many social and economic actors and cover large distances' (Spaargaren et al. 2012, p. 136).

The physical distance that the current Proximity Accreditation Decree[4] aims for is one that does not exceed a radius of 150 kilometres (km) between places of production and access for consumers. Nevertheless, Barcelona targets to source its proximity food from places located at even shorter distances around the outskirts of the city. Between food proximity production and its retail, Barcelona aims to reduce social distances by employing two or fewer intermediaries. Proximity assumes a source of food that has used less energy during its transportation between its places of production and its access. In making the city more sustainable, proximity is targeted as a key element to pursue. Proximity Food in Barcelona finds its commercialization route through the series of municipal food markets. These represent an accessible option for city inhabitants to food. Proximity food and its distribution through food markets might make a contribution to greening the overall food system in the city and thereby contributing to making the city overall more sustainable. In the next lines we explain how, and to what extent, this contribution occurs.

In its commitment to go through an organizational, commercial, and infrastructural modernization of its food provisioning system, Barcelona puts a high emphasis on its food markets – as channels to food access – and on the proximity food those distribute (Interviews 6 and 10). These efforts come along with an organizational restructuration of the food actors and flows of the food-provisioning network in Barcelona. Such restructuration has given space to the emergence of the Food Council of Barcelona, in which different societal actors (re)organize and (re)configure *food in the city*. The Metropolitan Area of Barcelona, the city of Barcelona, food markets, the wholesaler Mercabana, the Municipal Institute of Markets of Barcelona, and the Agricultural Park El Baix de Llobregat are the main actors constituting the council, giving shape to the sustainable food system of Barcelona. Such modernizations include, as well, upgrading and updating food markets

into a highly competitive actor within the food system (both local and global) in which more actors (e.g. supermarkets, international chains, and e-commerce) interact and compete one to each other (Interview 7) (Ajuntament de Barcelona 2017).

In short, these modernizations imply to re-connect and to re-configure food networks and flows in Barcelona for providing a more sustainable food system. The city and its food council shape the re-setting of the origin of the input of food flows, the intermediary actors related to such flows, and the channels of distribution providing food access to consumers in Barcelona.

3. Food proximity flows provisioning and its WEF urban nexus interactions

3.1. Markets and their on-site water, energy and food dynamics

Municipal Food Markets have been appointed as key places, and actors, for connecting the access to proximity food flows with local production. The 39 markets play a key role in feeding Barcelona City. These are the most visited places where consumers buy 45.2% of their meat and fish, and 27.9% of their fruits and vegetables[5] (Ajuntament de Barcelona 2014). When zooming in into Proximity Food, the Institute of Municipal Markets of Barcelona (IMMB) estimates that 70% of meat[6], 22–28% of fresh fish and seafood, and between 22–28% of fruits and vegetables that municipal markets commercialize come from proximity (Interview 10). 8.3% of sellers in markets source food directly from the producer or they have their own food sources of production (Ajuntament de Barcelona 2014).

Markets are key food retailers that relate to water, energy, and food (WEF) dimensions in their daily operations. These dimensions relate to on-site dynamics and to processes in the food network. For example, next to the organizational and commercial modernizations that markets have gone through, their facilities have gone through an infrastructural modernization process. This modernization includes the upgrading of installations and saving appliances for water and energy use – among others. These modernizations are in part triggered by 2 reasons. (1) Water and energy intake by municipal markets came at the cost of their merchants, and (2) an increasing environmental awareness that merchants have acquired towards a conscious use of these resources (Interview 11). In terms of water installations, these have gained the most upgrades in the majority of markets. Those gains mainly relate to repairing water leakages (directors of the markets stated this was a big and general problem) and to the actual paying of the water bills by merchants in the markets[7] (Interview 11).

Up to date, out of the 39 food markets, 5 have had their last remodelling (building upgrading) after 2010, 20 markets had it between the 2000 and 2010, 12 markets before 2000, and the remaining 2 markets do not record any related data (Departament d'Estadísitca de la ciutat de Barcelona 2018). Infrastructural modernizations of markets represent a step forward on the making of a sustainable food city from a nexus point of view. However, this is not the case in every market. Some markets have not been physically upgraded for a considerable period of time. For instance, there are markets that were built in the '20s and '30s and had their latest upgrade in the '90s. This translates into outdated energy and water installations and appliances (Interview 11).

There are markets that have gained more progress with regard to energy and water savings and efficiency. Some of them already include appliances such as automatic lighting, LED lighting, solar photovoltaic (PV) panels, solar water heaters, common

freezing chambers with low energy consumption, and water saving taps. One of the most important factors with regard to energy consumption and savings relates to whether each market building has natural ventilation or not. Some of them have natural ventilation (with part of the upper walls open) whilst others are completely closed and rely on artificial ventilation systems. This factor represents an issue when it comes to air-conditioning the markets during summertime. For the ones that do not have natural ventilation, keeping an indoor temperature of 25 degrees in summertime represents a very energy intensive practice (Interview 11). Adoption of renewable energy technologies such as solar water heaters and solar PV panels, in particular, is not the case at every municipal market in Barcelona. In many cases, these technologies compete with heritage protection schemes, which safeguard the artistic and historical value of the "Catalan Modernisme" architectonical style portrayed on the facades and roofs of market's buildings (see e.g. Mercat de Galvany in Figure 4) (Interview 11).

Distances between WEF in the provisioning of proximity food through markets reflect different physical and social dimensions. Water and energy intake at markets reflect mostly inputs-and-outputs dynamics of consumption. In the cases of markets with renewable energy technologies or saving appliances installed, physical distances from food to water and energy are reduced. The lack of interactions between WEF actors on sustainable food retailing practices reflects a social distance between these resource domains. The urban nexus of food and energy relates to further distances between markets and their related upstream processes of food provisioning, as we further elaborate on below.

Figure 4. Mercat galvany (self-taken picture 2018).

3.2. Markets, wholesaling and their WEF dynamics

The network of 39 markets, distributed all over the city and across its 10 districts (see Figures 5 and 6), needs to be sourced by food coming from either Mercabarna or from direct sales from farmers (to markets and by farmers at markets) (Ajuntament de Barcelona 2014). Mercabarna is the largest wholesaling market in Barcelona.

The functioning of markets depends on both the available offer of food products and the way these products are sourced. The origin of food sourcing relates to an energy and food urban nexus. The physical distance of 10 km between Mercabarna and the city centre brings

Figure 5. Distribution of food municipal markets through the Barcelona's districts (from Ajuntament de Barcelona 2014).

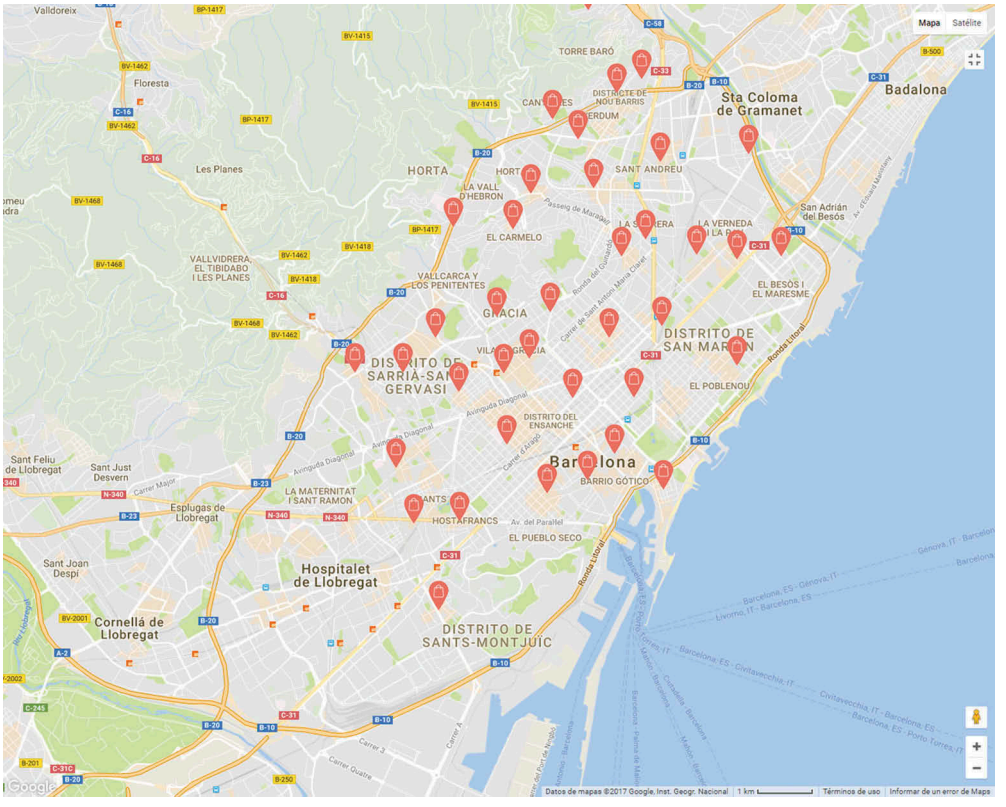

Figure 6. Map of food municipal markets throughout the city of Barcelona (from Google maps 2018).

an energy-related advantage in terms of the length that food needs to travel in its last mile, referring to the physical distance that food transport takes in the last stretch of its supply chain (Morganti and Gonzalez-Feliu 2015). Mercabarna is a key intermediary between producers (proximity, national, and global), distributors, and markets. It is organized in different wholesaler markets that commercialize different food types. Particularly, within the fruits and vegetables wholesaling market, the "Silo G" stands out for being dedicated to commercializing food from proximity. Mercabarna trades yearly an approximate to 225,000 tons of fruits and vegetables of proximity[8]. This represents around 19% of the total vegetable and food traded in Mercabarna (Interview 9).

Proximity Food suggests that shorter radius between food wholesaling and retailing might be more energy and environmentally friendly. Nevertheless, food flowing *in* and *out from* Mercabarna accounts for approximately 14,000 vehicles a day visiting its facilities. Most of these vehicles are powered by fossil fuels (Interview 9). Every sales-point owner from each market in Barcelona is responsible for its own food sourcing and logistics (Interview 11). These are 1667 independent sales-point owners from the 39 markets (Interview 10). It is a common practice that almost everyday merchants from markets go to Mercabarna to get food sources. They often do it with their own means of transport (Interviews 9, 10, 11). This results in a myriad of vehicles (mainly Light-Duty Vehicles or cars powered by diesel) commuting to Mercabarna almost every day, instead of just a few larger vehicles distributing food to each market. The main reason they do so is that 'if

sellers skip going to Mercabarna they miss the opportunity to negotiate or bargain the prices and to benefit from discounts or last-minute offers' (personal communication). Indeed, the choice for commercializing proximity food represents a step forward in shortening food miles. However, if this would result in a myriad of additional vehicles frequently commuting to Mercabarna, the benefits of proximity food will be reduced.

When zooming into the site's operations of Mercabarna, these do not reflect a standardized account of its energy and water consumption nor a close collaboration with such sectors (Interview 9, 12). The energy system of Mercabarna depends[9] on the inflow of electricity from the public energy grid (Interview 9). Water sourcing comes from two flows: the water network (exogenous flow) and a water well (endogenous flow). Water extracted from the well is high in its salinity content and it mainly serves for rinsing Mercabarna's infrastructures (e.g. roads, buildings, fish markets, etc.). Water from the public network is used in the markets for the wholesaling operations (e.g. rinsing and washing food). Wastewater from the slaughterhouse and fish & seafood markets goes to an on-site wastewater treatment plant (because of the content of organic solids). After this wastewater flow is treated on-site, it goes out of Mercabarna into a public wastewater treatment plant. The rest of the wastewater generated goes directly to the public wastewater network system (Interview 9).

The extent Barcelona addresses the puzzle of food sustainability lacks active connections, both physical and social, with water and energy networks. Instead, most of the physical connections, through wholesaling process and between retailing and wholesaling, relate to inputs-and-outputs relations in which water and energy flows engage with food as mere inputs of production. On top of that, there is a lack of social connections between the WEF networks. There have been, for instance, no formal or informal meetings or discussions held between the relevant actors from WEF networks to discuss on the policy and decision-making of these food processes and their implications in terms of water and energy.

3.3. Wholesaling and local production and their WEF dynamics

In connecting markets of Barcelona with proximity food flows, via Mercabarna, there is a key source of local food production: the Agricultural Park of the Low Llobregat (In Catalan: *El Parc Agrari del Baix Llobregat)*. It is located in the alluvial plains of the delta area of the lower basin of the Llobregat River (Diputació Barcelona). Its main objective is to safeguard and promote the agricultural activity within this Agricultural Park. This is the most proximate agricultural park and food producer for the city of Barcelona (Interview 1) and it is located 11.5 km from the city centre and 5.5 km from Mercabarna. This Park commercializes, approximately, 20–30% of its total production through direct sales via municipal food market, farmers markets, or shops (or it is sent to other cities), and the remaining 70–80% is commercialized through the wholesaler Mercabarna, as an intermediary (Interview 1).

Such proximity represents an energy-related advantage with regard to the distance food needs to travel from production to wholesaling (and then to retailing at markets). The way to arrange food transport from farms to Mercabarna depends on each food producer (Interviews 2, 3; personal communication with farmers). It is a common practice that farmers employ trucks or tractors (fuelled with diesel) to pick up or tow their food production. In terms of renewable energy power usage for food transport, farmers

experience difficulties to transport their products by these means (e.g. e-bikes or e-vehicles) due to the lack of biking infrastructure, the heavy loads of freights, and the lack of suitable e-vehicles offer (in terms of power and price) (Interviews 2, 3).

With regard to water and food interrelations in the agricultural park, its water intake provides an example of circularity of wastewater flows. A wastewater treatment plant, located in the proximity, partly sources the agricultural lands with treated water, which is high in nutrients for agricultural applications (Interviews 12, 13). The water network and seasonal rains provide the rest of the water needs of the park. Whilst for the energy intake of the agricultural park, this mostly relates to fuelling agricultural machinery by diesel or to powering refrigerating chambers for food storage with electricity (Interviews 1, 2).

Whether or not food produced in the Agricultural Park ends up flowing through Barcelona food markets, does not just depend on infrastructural circumstances. It is shaped by social dynamics. There is a lack of interactions between energy and food actors in Barcelona, preventing the urban nexus from taking shape in an effective manner. For instance, there is no evidence supporting formal or informal meetings held by actors from the energy and food sectors to discuss or to address possible synergies or trade-offs. In addition, dynamics around global markets and economies of scale play a role in connecting proximity food with food wholesaling process and retailing through food markets (Interviews 2, 11). Provisioning proximity food via Mercabarna competes with similar food products coming from different origins (national or global), and often offered at more competitive prices (Interviews 2, 11). This has resulted in part of food produced in the proximity of Barcelona being commercialized through other channels of distribution (e.g. another city, self-consumption or composting) (Interview 2). This puts pressure on further efforts by farmers in the proximity for increasing food production shares without having a guaranteed commercialization channel for it (Interviews 2, 3). Although the framing of this study does not aim to consider the global dimensions of food supply, it is important to notice how in particular economies of scale, and global and liberalized markets exert consequences on the wholesaling and retailing of food from both, the proximity and abroad.

4. Moving into a more sustainable food city

In short, the way the sustainable food network is coded often excludes dimensions of water and energy from the framing of what a sustainable food city is about. What this coding misses is an urban nexus perspective when envisioning food in the city through its provisioning processes and flows. To move forward in an urban nexus fashion, Barcelona could further anchor values on food as an asset of the city (Interview 7); and as an asset intertwined with water and energy dimensions. This implies a need to address urban systems as systems of food production, wholesaling, distribution, and consumption; and not exclusively as systems of resources consumption (Interviews 4, 5). Although water and energy are resource systems that already have a stake on the urban agenda, food *per se* is still an emerging dimension in the city politics and policy (Interview 7). Further efforts to address food policy in the city, from a more urban nexus-oriented point of view, still challenge the often-separated WEF networks in articulating cross-sectorial actors, values, and goals into one common direction (Interview 2, 5, 6, 8, 10, 12, 13).

V. Conclusion

It is often taken for granted that proximity food is a more sustainable alternative in the greening of food systems (Spaargaren et al. 2012). However, proximity flows and the circuits of provisioning in which those go through show different dimensions to observe and reflect on, as we have discussed in this paper. Establishing such an urban nexus does not just refer to more proximate – physical – connections along the food processes. Shortening physical distances between food processes does not *per se* mean more proximity. Proximity also refers to distances between WEF (nexus) networks, flows, and resources, and the distances between social actors in the practice and policy and decision-making of such resources governance. In this research approaching social distances – such as organizational practices and level of interactions between relevant actors – play a crucial role not only in understanding the proximity of food but also on understanding it nexus with water and energy.

This case study has shown the emergence and attempts of a Food Council to accommodate the different food puzzles into a proximity food system. Switchers and programmers from the food system, through the Food Council, configure steps forward towards an urban food policy framing and practice for Barcelona. In doing so, it aims to push the city endeavours to become a sustainable habitat. However, there are weak points that deserve further interventions and attention. The extent the city addresses the puzzle of food sustainability needs to consider beyond a proximity view *per se*. It lacks active connections, both physical and social, with water and energy networks. Instead, most of the physical connections, through food processes and flows, relate to inputs-and-outputs relations in which water and energy flows engage with food as mere inputs of production. On top of that, there is a lack of social connections between the WEF networks. There have been no formal or informal meetings or discussions held between the relevant actors from WEF networks at the Food Council nor are there shared practices around food provisioning processes. Proximity is developed as a concept by the Food Council to improve and gain on food sustainability in Barcelona and it has been employed as a crucial element in the (re)coding by switchers and programmers of the urban food network and flows. However, such *code* and *coding* still deserve further development on closing physical and social distances, not only within the food network (through its processes) but between the WEF (nexus) dimensions *through* every process of food provisioning in Barcelona.

It might be that other European cities than just Barcelona do not yet actively engage with WEF domains in their food policy and decision-making. Yet, effective and sustainable governance of urban food provisioning in these cities, as in this case Barcelona, would profit from integrating more cross-sectorial thinking and practices among practitioners, and policy and decision-makers from WEF domains (Artioli et al. 2017; Covarrubias et al. 2019). An effective level for action and innovation to address (un)sustainable practices of WEF connections would for instance be through a coordinating body similar to the Food Council as in the case of Barcelona. Specifically, by considering the council's members and their capabilities *to connect with* and *to configure* the relevant actors, policies, networks, and flows to further address the WEF urban as part of the coding of what a sustainable food city is about.

Notes

1. Other examples of labels include: garden city, creative city, livable city, zero carbon city, regenerative city, compact city, eco-city, resilient city, zero waste city, sharing city, etc.
2. We do this without claiming to conduct an ethnographic study.
3. In searching for respondents, it was not possible to establish contact with energy companies and operators. When contact was established with possible respondents for interviews, energy companies and operators argued they do not have time or permission to establish communication with third parties.
4. Decree of accreditation of sale of proximity approved by the Department of Agriculture, Livestock, Fisheries, Food and the Natural Environment.
5. Food markets are the second most visited place by costumers for buying Vegetables and Fruits.
6. Municipal Markets explain that they source their meat from different places than Mercabarna.
7. Directors of markets explained that the lack public enforcement for collecting the payment of water bills led to unconscious water consumption by the markets.
8. This data is based on a radius of 150 km and includes the Agricultural Park El Baix Llobregat.
9. The slaughterhouses have an inflow of natural gas for their operations.

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