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# Urban food planning, city logistics and sustainability: the role of the wholesale produce market.

## The cases of Parma and Bologna food hubs.

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# Acronyms and abbreviations

| | |
|---|---|
| UM | Urban Metabolism |
| WPM | Wholesale Produce Market |
| Ho.Re.Ca. | Hotel, Restaurant, Café |
| UGT | Urban Goods Transport |
| UDC | Urban Distribution Center |
| UFD | Urban Food distribution |
| FH | Food Hub |
| LCV | Light commercial vehicle |
| HCV | Heavy commercial vehicle |
| GDP | Gross Domestic Product |
| RER | Regione Emilia- Romagna |

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# 1. Introduction

Com'è bella la città,
com'è grande la città,
com'è viva la città,
com'è allegra la città....!
Piena di strade e di negozi
e di vetrine piene di luce,
con tanta gente che lavora,
con tanta gente che produce.
Con le reclames sempre più grandi
coi magazzini, le scale mobili,
coi grattacieli sempre più alti,
e tante macchine, sempre di più.

*Com'è bella la città* (Gaber, 1969)

At global level, the population is increasingly concentrating in the cities. In Europe, around 75% of the population lives in urban areas and it is foreseen to increase up to 80 % by 2020 (EEA, 2010). At the same time, the quality of life in the cities is declining and urban pollution keeps increasing in terms of carbon dioxide and greenhouses gas emissions, waste, noise, and lack of greenery (Alexandre, 1996; EEA, 2010). Together with several social, economic and environmental causes, at urban level, the food supply system notably impacts on overcrowding, social inequity, and health problems related to food accessibility and pollution.

## 1.1 Sustainability of the urban food system

The existing food supply system has recently incurred in critical disruptions such as food prices surge of 2007-08 and climate change effects, and the consequences of the global food crisis strongly affected – and still affect – consumers in city environments, where food access and food security have been seriously threaten.

This lead to focus on remodeling the food production and distribution systems, towards more sustainable food system including social, economic and environmental issues, all along the food supply chain. In this scenario, cities appear as key actors leading the transition process (Morgan, 2010) addressing a variety of problems related to urban food provisioning and interconnected with health, transport, land use and local economic development.

The evolution of urban food strategies becomes object of growing interest and the multifunctional character of the agri-food system is now viewed and valued in more strategic terms because it is deeply related with burgeoning public health costs, exploiting natural resources and influencing local economic development, for example (Morgan & Sonnino, 2010). Food systems are inextricably linked to other community systems, including transport, land use, and waste management but these interconnections are still mistreated and organic data and information are missing.

Urban food planning is a field of research that is now rapidly growing. The main scope of food planners is to understand the role of cities as food policy actors and their real and potential impacts on the regional economy (see for example the Policy Guide on Community and Regional Food Planning, produced in 2007 by the American Planning (APA), and the Association the Association of European Schools of Planning (AESOP), which in 2009 decided to establish a new thematic group about Sustainable Food Planning). It deals with the development of integrated approaches to food policy and with the definition of analytical tools to assess opportunities and barriers of innovative food provisioning projects (Sonnino, 2010).

Cities inevitably require larger amount of food and a freight transport system to deliver it. The urbanization trend and mobility implies that people gather in a location which is remote from their sources of food (Oedgen,1992). In addition to the vital role in sustaining urban areas, urban freight transport is also recognized for its more unsustainable impacts, in particular for its impact in air quality. This entails an urgent need to promote new policies on urban freight transport and food distribution. Among the variety of issues addressed by urban food strategies, one of the most controversial issue relates to the need of developing an urban food transport system on a social, economical, and environmental sound basis. Although, the governmental interest as well as the research effort in the fields of food system sustainability and urban freight transport increased over the last years, there are only few experiments in practice which aims at making food transport in urban areas more sustainable.

In a growing number of cities as San Francisco, New York, London, policy makers are thus setting a variety of measures to better integrate food issues in the urban policy agenda, and, together with the community and supply chain actors, are implementing innovative projects dealing with provisioning and distributing food.

Most of these urban food strategies include significant connections with city logistics and freight transport issues, in order: (i) to reduce the air pollution; (ii) to contribute to the enhancement of food access and quality in urban environment; (iii) to improve the resources efficiency and cost effectiveness of the transportation of goods, taking into account the external costs.

In the current scenario, where limited public resources are available and the persisting economic crisis entails new significant investments, researchers and scholars are looking for innovative solutions to facilitate the urban food transport sustainability by renewing the role of the existing food supply chain actors. This is the case of the wholesale produce markets, which are already providing marketing and logistics services to suppliers, producers and urban retailers. The wholesale markets can identify additional logistics services and become *food hubs,* contributing to a more sustainable urban food system.

To this extent I have identified the case of the whole market of Parma (located in North-Centre of Italy, Emilia Romagna region) as one of the most innovative city logistics project for sustainable food distribution in Italy and I built a methodological scheme to evaluate its impact in the ecological sustainability at urban level. The evaluation measures have been also tested for a more complex urban area, focusing on Bologna whole market (Emilia Romagna region), that has been identified as potential successful replication case in Italy.

## 1.2 Research questions

The main research question of this study is:
*How the urban food transport system affects the ecological sustainability of modern cities?*

Four specific questions have been defined to frame the in-depth analysis:

1 *What are the food flows circulating in the city? How to estimate the demand of food requested by city dwellers and city users? How to estimate the supply of food offered by the different food retail systems existing in the city?*

The *urban food metabolism* is investigated through the inbound flows of food circulating in the city, according to a demand/supply perspective. This study attempts at identifying a methodology and applying to estimate the food flows intended both to "at home" and "out of home" consumption, including the hidden flows represented by the food waste generated at retailing and consumption level. I apply this methodology to assess the urban food metabolism of two case studies located in the cities of Parma and Bologna.

2 *What are the basic features of the urban food supply transport systems*?

The study focuses on the last part of freight delivery journey for two food supply chains: independent retailers and catering business as hotels, restaurants, cafés (Ho.Re.Ca.). To this extent it detects the *last mile,* in this case the "last food mile", and the basic features of the transport and delivery system, such as frequency, weight and type of vehicles.

3 *What is the environmental impact of the urban food transport?*

Among the various environmental impacts generated by the road transport, the research considers the air pollution. The pollutant emissions generated by the urban food transport of the selected supply chains is calculated for the baseline scenarios and for the enhanced transport efficiency scenarios in both cities. The gas emissions estimated are: carbon dioxide (CO), nitrogen oxide ($NO_x$), volatile organic compounds (VOC), and particulate matter (PM). The effects of these air pollutants are diverse and numerous, they generate serious consequences for the health of human beings, including pulmonary, cardiac, vascular, and neurological impairments.

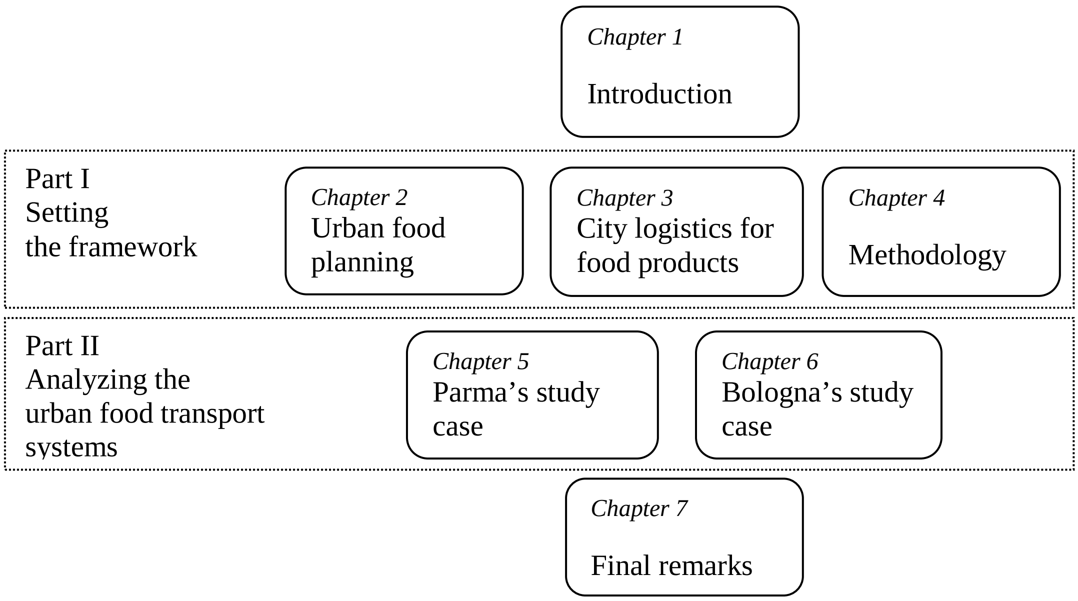
4 *What are the potential actions on improving the food transport efficiency? Which logistics solutions can be implemented by the wholesale produce market as actors of the food supply system?*

Among the various city logistics initiatives, I investigate the opportunity to the set an urban distribution center (UDC) which is a logistic platform located in a strategic node of the city, where the deliveries can be rationalized and then performed by eco-friendly commercial vehicles. In particular, I focus on the crucial role of the existing wholesale produce market in our cities, which can act as *food hubs* in the urban food supply system by providing renewed logistic services.

## 1.3 Outline of the thesis

This provides an outline of the thesis. This thesis contains two parts that together with this introduction chapter and the last concluding chapter complete the Ph.D. thesis (see Figure 1.1) entitled “Urban food planning, city logistics and sustainability: the role of the wholesale produce market. The cases of Parma and Bologna food hubs”.

Figure 1.1 Outline of the thesis



PART I Setting the framework

*Chapter 2. Urban food planning*

This chapter examines the literature on sustainability of urban food provisioning and distributing policies. I investigate the current food system in modern cities by using the concept of urban food metabolism. I identify the food flows which characterize our cities with particular emphasis on the retailing system organization.

*Chapter 3. City logistics for food products*

This chapter examines the factors that determine the urban distribution schemes for the independent retailers and Ho.Re.Ca. operators. I explore the main patterns of the urban food delivery system, according to the specific features of the two food supply chains examined. Special focus is on "last mile" logistics and urban distribution centers, relating to the role of the wholesale produce market in the urban food supply chain.

*Chapter 4. Methodology*

This chapter develops a framework for estimating the full amount of food circulating within the city. The purpose of the framework is to identify basic flows of food demand and supply. In the second part, I propose a structure to describe the urban food transport. Finally it is presented the methodology Copert 4, that has been applied to estimate the pollutant emissions by the food transport system.

PART II Analysing the urban food transport system

*Chapter 5. The Emilia-Romagna context and the city of Parma – Case study 1*

In this chapter, a brief introduction of the context of Emilia Romagna is provided. Next, I apply the defined methodology to detect the urban food metabolism, the urban food transport patterns, and its environmental impact on urban air quality. The Ecocity project on food distribution and transport is presented, focusing on the role of the wholesale produce market as logistics provider. Then I provide an estimate of the environmental impacts achieved by the project in terms of pollutant emissions reduction.

*Chapter 6. The city of Bologna- Case study 2*

This chapter examines the urban food metabolism, the food transport performance and the air pollution it generates at urban level. On the basis of the Ecocity model, I provide a preliminary assessment of the potential environmental benefits resulting by the implementation of a urban distribution center in the Bologna wholesale produce market area. Two optimization scenario are developed in order to estimate the air pollution decrease in case of adoption of city logistics measures.

*Chapter 7. Final remarks*

The final chapter provides with the key findings of the research that answer the research questions, by specifically highlighting opportunities and barriers to add the function of urban distribution center to the wholesale produce market. In line with the results achieved by the study, at last, there are presented the opportunities for policy makers' applications and research cues to be develop at academic level.

# PART I. Setting the framework

# 2. Urban food planning

Food supply is one of most fundamental aspects of the material basis for social life and, indeed, it is a constant routine function in all the urbanized societies, taken for granted most of the time by those not directly involved (Pothukuchi et al. 1998). However, critical disruptions in the urban food supply system recently occurred and raised the attention on the inefficiencies in the current corporate food regime, in terms of ecological criteria fulfillment. Under the food crisis effects, additional concerns about security and sustainability of the agri-food system arisen and generated a debate on remodeling the food production and distribution systems. Discussions are mainly related to the way we produce and distribute food as commodity and to the several vulnerabilities of the food supply system. The high dependence of the agri-food sector on fossil fuel, the need to adapt it to climate change, the food security and the land conflicts are some of the main issues on the debate floor, where the discussants are the community, policy makers and food supply chain actors. In this scenario, cities have acquired a new role in order to respond to the new ecological and political challenges.

## 2.1 Cities role in the agri-food system transition

The urban food provisioning is a growing concern due to a number of complex interrelated processes which are modifying the global agri-food system, with direct consequences on the everyday life of urban residents. Among the relevant phenomena leading to the present transition in the food system, there are the food price surge of 2007-08, the effects of climate change on food production and distribution chains, and the rapid urbanization in both developed and developing countries). The scenario build by the interconnections of these transitional phenomena is defined with the expression of *new food equation* (Morgan & Sonnino, 2010) and identifies the current complex trends that need a response by reconfiguring the global food provisioning frame.

Different interpretations about the evolution of capitalistic agri-food paradigm emerged during the last decades (Lang,1999; Goodman, 2010). In recent years, the debate has been fuelled by a growing public opinion awareness on health and environmental effects of the food supply, generating  pressure on national and international governing bodies to address food policy and to regulate the food sector. Today, the field of food provisioning is one of the most controversial and it is clear that global and national regulatory regime largely failed to achieve sustainability objectives (Sonnino, 2009). Now there is public consensus about the fact that traditional patterns of economic development are no more sustainable, leading to conflicts with the carrying capacity of the planet, in terms of population growth, pollution and consumption of resources.

The concern about the economic growth and the related depletion of non-renewable resources arisen during the 1970's, when researchers focused their attention on evaluating the impact of human consumption of resources. The common agree to decouple economic growth from environmental degradation has led the research of 'management rules'. Ehrlich, describing the U.S.A. scenario, identified the relevance of governing these issues at national or federal level and stated:

*"Not only don't we have a population policy. We don't have a consumption policy either. We are the most overpopulated country in the world. It's not the number of people. It's their consumption."*

Ehrlich (1971)

In this context, the new food equation set the bases to redefine *what* is intended for 'food sustainable system' and *who* is the most adequate driver to the transition. These topics are particularly hard because, first, *sustainability* is a complex and multi-dimensional concept, set up on economic, social and ecological values (Thompson et al., 2007). Secondly, various actors at different levels (i.e. business sector, institutional planners, consumers) are involved in the food chain, creating articulated nets and highly fragmented connections at both local and global scale. Simply put, the current global context presents theoretical limits, practical obstacles and political barriers that delay the definition of effective and shared solutions towards a more sustainable food system.

Far from finding an unique way to foster the sustainability of the global agri-food system, most of the authors agree on the importance of internalizing the costs that are externalized in the food supply chain, mainly represented by environmental and healthcare costs (Pothukuchi, 2009; Morgan et al., 2006; Pretty et al., 2001). This goal can be reached, for example, through taxes, incentives, and advantages promoted by governments. However, due to the fact that the current agro industrial system is almost entirely dependent on fossil fuel energy, and the externalities are generated in every stage from food production to transportation to food preparation and storage, identifying a common regulatory process to reduce the external costs at local and global level seems to be a visionary approach.

Furthermore the capitalistic agri-food system is dominated by the economic interests of large companies producing, processing, and retailing food on a national and global scale (Morgan et al., 2009), having limited interest on internalizing environmental costs on the food supply chain. Although, due the pressure on remodeling the system shown by consumers (certain consumers, particularly educated, middle class), business companies are adopting renewed approach to sustainability. This trend is particularly evident in urban areas, where the biggest concentrations of consumers, looking for healthy and accessible food, influence the market and the type of business[1]. It results that the urban communities, in a complementary action with governing bodies, can foster the transition to more sustainable food system with policy and measures. Thus, cities appear to be the natural arena where the redesign of the food system take place, through the definition of urban food plans which include interests and needs of consumers, retailers and producers in the regional area.

#### *2.1.1 Urban food governance*

In a growing number of cities in Europe and in North America, there are disquieting trends related to the rising rate of obesity, food insecurity and food access, that forced municipal governments to devise strategies guarantying public health and equity issues for the urban population. Moreover other factors, i.e. air quality and waste management, which are less directly connected with food, but strongly influencing urban life, have been object of special attention in urban policy agenda of the past decade. To address these problems, many city-governments identified an holistic approach to sustainability based on health, environment and equity concepts, and developed urban food plans which include policy measures on transport, land use and economic development, for example.

Urban food strategies have been defined in cities as San Francisco, New York, Toronto, London, Belo Horizonte[2]. Among various examples on urban food strategies, San Francisco deserves special attention for the broad network of stakeholders that worked together in defining the criteria of sustainable urban food plan. The community, the city-government and the food chain actors set up a *ad hoc* committee to coordinate urban and peri-urban forces involved in urban food provisioning. On 9 July 2009, Gavin Newsom, the Mayor of the City and County of San Francisco, issued an Executive Directive on Healthy and Sustainable Food for San Francisco, which elaborated a plan SF Foodshed Plan – revealing the guiding principles of the urban food plan approach. The plan contains 16 mandatory actions that are time limited and that foresee a concrete and multi-dimension implementation.

In Italy, local policies on food planning are still isolated cases, addressing single issues as direct-sale from small producers or public procurement of sustainable food. The only example of administrative body which officially recognized in the urban planning agenda the significance of food to health, well being and local economy is represented by the District of Pisa, that created a political space for these issues. In this food

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[1] It is the case of organic, local and direct-sale food products, that increased the market share in the last decade both in Europe and in the U.S.

[2] More documentation about the pioneer urban food plans is presented in *International Planning Studies* Volume 14, Issue 4, 2009 Routledge.

community path are involved the University of Pisa, the civil society, the producers, the retailers and other food system actors. The ultimate scope is the definition of the *Piano del cibo* for the district of Pisa.

The challenge for municipal governments is to become food chain innovators by facilitating access to food by consumers and creating conditions to ensure investments needed to increase sustainable food supply at city level under hygienic, healthy and environmentally sound conditions (UN-FAO, 2010).

### *2.1.2 Cities as food chain innovators*

Policy response on food security and ecological sustainability of cities is important and urgent, but the complexity of urban system requires integrated and balanced solutions at local, regional and national level. Indeed, the quality of life of city dwellers is strongly connected with the urban food system, in fact it has direct implications on the health of individuals, on local economy performance, local land use and transportation, preservation of agricultural land, solid waste problems and quality of local water air and soil (Pothukuchi et al.,1998). Thus, the contemporary urban food strategies are more than just reduce food insecurity and implement “feed the cities” policies: it deals with creating new economic opportunities for small farmers and retailers, fostering individual and communal health, enhancing environmental friendly programs at urban and peri-urban level (Morgan & Sonnino, 2010; Marsden, 2006). These initiatives focus on an ecological approach and set objectives based on the triple-bottom-line: environmental, economic, and social sustainable development, in order to guarantee higher standards of urban life.

An integrated and territorial mode of governance which detects emerging alternatives to the globalised food system is the *(peri-)urban foodscape* approach (Johnston et al., 2009), focusing on the new geography of food and including heterogeneous socio-economic and socio-spatial dynamics considered to be intrinsic to the community food systems. The (peri-) urban foodscape, as represented by Winskerke (2010) in figure 1, is shaped by three interrelated and mutually reinforcing societal axis: (i) sustainable supply chains (market/civil society axis); (ii) public food procurement (state/market axis); and (iii) urban food strategies (civil society/state axis). According to this approach, the relationships between food, health, environment, transport, etc. are investigated and new strategies can be devised by the public sector and civil society to address societal problems, and include sustainability aspects in the conventional food companies management.

Even before devising the urban food strategies and actions, policy makers need to determine who has the food planning functions within the municipal government, since this issue has not be addressed at local level until now. It is not an easy task to identify the existing or potential city institutions which could be the most appropriate to set the urban food strategies, due to interrelated actions between food system and other community services like housing, transportation, land use, and economic development. Some proposal, formulated by Pothukuchi and Kaufman (1998), identified the opportunity to create a *department of food* within the local government body, or to charge of food planning functions the city planning agency. Both solutions are still far to be systematically adopted by local governments, anyway more and more cities started food policy councils and now discuss urban food plans at institutional level.

Figure 2.1 The Peri-Urban Foodscape


Source: Wiskerke, 2010

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## 2.2 Assessing the urban food metabolism

The modern city has frequently been presented as an interconnected space of flows dependent on the external input of energy, materials and information. However the urban environments is affected by its surrounding environment *and* also affects that environment. In this perspective, the city is part of a broader ecological system and itself can be considered as en ecosystem, to be investigated by using an ecological lens (Pickett et al., 2001, Gliessman, S. 2001), which detects the effects of urbanization on human and environmental health, including social and economic understandings. Considering the city as an urban ecosystem, scholars developed urban sustainability assessment tools to evaluate material consumption and waste disposal of a given urban setting. These tools are i.e. material flow analysis, life cycle assessment, urban metabolism and the ecological footprint (EF).

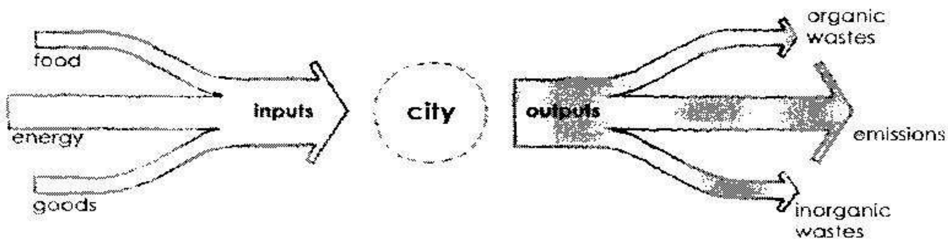
### *2.2.1 Urban metabolism*

Among the means of understanding of the sustainable development of cities, different models base on the concept of "urban metabolism", hereafter UM, (Wolman, 1965), which conceives the city as a living organism, assessing that:

> *The metabolic requirements of a city can be defined as the materials and commodities needed to sustain the city's inhabitants at home, at work, and at play…* (Wolman, 1965: 179)

Exploring the analogy of the metabolic processes of organisms, UM can be defined as the sum total of the technical and socio-economic processes that occur in cities, resulting in growth, production of energy, and elimination of waste (Kennedy et al., 2007). In this vision, cities are characterized by an inward flow, feeding the internal processes, and by an outward one, constituted by the sink of wastes and emissions into surrounding environment (see Figure 2.2). The urban system is described as a 'black-box', where the transformations take place. In practice the study of an UM requires quantification of the inputs, outputs and storage of energy water, nutrients, materials and wastes in terms of functional relations. It goes without saying that the metabolism of most 'modern' cities is essentially linear, and urbanities show still few concerns about the origin and the destination of resources flows.

Figure 2.2. The linear urban metabolism




Source: Roger, 1998

An UM model focuses on the key urban processes and their metabolic consequences, in terms of material flow analysis stock and flow, in relation to services demand of the inhabitants of an urban region. The definition of a urban ecosystem is reached through a systemic approach which includes all the variables contributing to recreate the complex urban structure, with interlinkages and implication for its food, energy, and goods use. The crucial factors constituting the urban form are: density, morphology, transportation technology, and climate (Kennedy, 2007). In addition, different areas in the city (i.e. peri-urban district, city centre district, industrial sites, etc.) are characterized by different kind of functions and services and they are influenced by different types of metabolism (Garcia, 2008). The resulting UM scenario provides a broad knowledge about consumption patterns, generation of waste and contaminants, and capacity of response of a city to external shock. This representation orients urban planners to more sustainable development actions.

### *2.2.2 Urban food metabolism*

Most of urban metabolism studies describes the resources flows referring to the whole and comprehensive model of city sustainability, however it is relevant to this study to understand the specific patterns of the urban food system. The relationship between food and urban space can be investigated by the concept of "urban food metabolism", according to the Bohle's adaption of UM concept to the urban food system (1994).

It could be seen that, whereas the whole UM system has been widely addressed, some topics such as food supply system, together with the consideration of functions and services provided by the urban food chain, have been mistreated in most of the previous studies. In fact, the models generically describe *all* the kinds if resources and imports go in, *all* the kinds of wastes and exports go out, but the inner workings are not systematically and specifically investigated. This trend can be explained by the fact the analysis of an urban food metabolism system implies to bring together a wide range on data referring to economic, political, and social dimensions, which are usually viewed apart. And, in some cases, the lack of data for urban level strongly limits the opportunity to complete these models. Moreover, there are additional problematic issues about quantifying and weighing the elements and the flows of the urban system in their interaction. Although, the greatest potential of studying the urban food metabolism is that urban food system can be described as a functional unit, encompassing different processes and broadening the knowledge of what is often described as a black box, the city (Wolman, 1965).

Within a flows analysis framework, Bohle asserts that the series of connectivities between the food supply chain and the city can be depicted as nodes of input-output systems, where the transformation process takes place. Thus, for the sake of simplicity, the urban food system can be disaggregated into four types of sub-systems: production, supply, distribution, as well as a consumption of food. Therefore a specific metabolic process for food is identified within the UM model and the central issue investigated deals with the "efficiency" of the urban food system, in providing quality of life, or, more specifically, food security to vulnerable urban groups (Bohle, 1994).

According to the World Bank (2004), the food system has to guarantee city dwellers with food availability, food access and food use. If translated into a food chain perspective, these elements can be identified with the phases of supply, distribution and consumption of food products. These sub-systems are deeply embedded in the whole food local and regional systems, and generate highly complex and fragmented processes. Their structure and functioning are influenced by: market prices, food production and trade organization, typologies of market channels, hierarchies of traders, commercial distribution system (i.e. traditional, modern, alternative formats), consumption patterns, income and employment variables (Bohle, 1994). Hence, the goal of the urban food metabolism study focuses on the identification of existing or available services, functions, and planning and structural aspects related to food, with the aim of defining, afterwards, variables to quantify them.

## 2.3 Detecting the urban food flow

The food flow analysis provides a snapshot of the flow of food products through the urban environment. As such, it allows the categorization and measurement of these flows in a variety of ways (by distribution channel, type of consumption, etc.), allowing the identification of main determinants of food requirement by city population. The total food requirement estimates the circulating quantity of food, including the hidden flows, i.e. food waste, and it can be combined with the application of sustainability indicators such as the Ecological Footprint to measure the environmental impact of these flows.

### *2.3.1 Consumers: driving force in the urban food system*

With intensive urbanization, the food systems move very large volumes of food through a variety of channels, entailing complex economic, social and cultural interconnections. In the urban environment, this food flow depends on the balance between food availability (production and distribution) and urban consumers' demand (consumption)[3]. Considering that the conventional agro-food chain is able to supply food in large quantities and to ensure year-round availability of most of the food products, we can say that the urban food market is mainly driven by the consumers needs and the urban food styles. The urban food demand is shaped by city consumers dietary patterns and their expenditure and consumption behavior, which varies for different consumer groups, according to their cultural backgrounds, socio-economic status and lifestyles.

In recent years, urban food demand not only increased worldwide, but changed with shifts in consumption patterns determined by a number of individual-related and external factors. Indeed, the urban environment entails important changes in lifestyles, economic activities, exposure to marketing and reference group influences (Delisle, 1990). As consequence, food purchase patterns changed and are still evolving: consumers shop less often and in increasingly larger food retailer stores, on-line shopping is becoming popular, certain consumers groups are looking for quality and healthy food through farmers markets and direct sale, and almost all individuals, no matter what their age or socio-economic status, consume food outside the home. For example in Italy, food consumption at home is slowly increasing or even stagnating, but eating out from home is increasing fast with the rapid development of catering sector (Peta, 2009), e-commerce gains market share and the farmers markets sales incremented of 8% in 2008 (Swg & Coldiretti, 2009).

In order to better understand the complex and articulated urban food supply chain and to investigate the kinds and the amounts of food consumed, two main determinants are identified:

- Food expenditure patterns

Household food purchase and individual consumption are influenced by food prices, family income, food habits and cultural taboos, nutrition knowledge and advertisement, tastes and preferences. A strong component of new consumer product demand is for out-of-home food preparation and consumption. Pressed by time and a limited interest in food preparation, household increasingly demand frozen and chilled foods and pre-cut, pre-prepared meat, fruit and vegetables. These trends are also reflected in the growing

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[3] We consider 'urban consumers' city residents and people who travel, live, use the city (see chapter 2. City users).

percentage of household expenditures spent on out-of-home. On the supply side, in fact, we observe a rising number of food services businesses and institutional cafeterias in urban locations.

- Dietary patterns

Diets are determined by a number of individual and environmental factors. Ecology, culture, income and other socio-economic status variables, are strong determinants, moreover individual attitudes and lifestyles are also central to food choices. Urban diets and their evolution are not uniform world-wide, but some trends appear to be universal, as they have been similarly observed in vastly different settings, as the increase of meat consumption and the preference for processed foods and snacks prepared outside the home (Delisle, 1990). Recently, the growing sensibility to the quality and the safety of food products, shown in particular by the global North middle class, influences new diet patterns including higher quantities and varieties of fresh and local products (Morgan et al., 2006).

### *2.3.2 Hidden Flows: food waste*

In the urban food system analysis, there are hidden flows which have not been systematically investigated until now. In our perspective, a hidden flow is the food losses that occurs when providing, distributing and consuming the food products in a given environment i.e. the city. If goods and resource hidden flows occur in almost all the commodities supply chains (see the Total Material Analysis)[4], in the case of food supply, this phenomenon is even more relevant, due to the perishable nature of food products.

Food waste is the difference between the food purchased from retail establishments or brought in from outside the community and the food actually ingested. Food waste is created when perishable food that has not been used soon enough is disposed, when inedible portions are removed during food preparation, and when food is left on the plate after a meal. Food wastes are disposed into MSW, given to a food bank or rescue program, composted, or added to the sewer system through a disposal device **(**Garvin, et al. 2000).

In recent times, food waste raised the attention of public opinion, and both academic and institutional sectors, and it became field of research in most of industrialized countries. Typically, scholars developed aggregated estimations related to the country food supply chain (WRAP, 2008; Segrè et al., 2010), depicting quantitative assessment of the type and consistency of food waste generated at every stage of the national supply system. However limitations inherent the food supply data hamper food loss estimates for the consumer, retail, and foodservice sectors at local and regional level.

[4] According to the Total Material Requirement analysis (Brigenzu, 2003), the hidden flows are those materials or waste that do not enter the financial economy. To the scope of our investigation, we translate this concept to foodstuffs which actually enter the supply chain, but whose traceability is not provided at retailer and consumer levels. Food losses in the retailing sector usually merge in “inventory shrinkage costs”, which are identified as loss due to breakage, damage, spoilage or theft, therefore no direct and effective monitoring of food waste is assured. At consumption stage, the typical consumer behavior is someway similar to the retailer management approach, not being aware of the real cost of the wasted food.

### *2.3.3 Measuring the ecological impact of the urban food flow*

To indicate environmental sustainability, there are various models and indicators which expresses the relationship between humans and the natural environment. The linkages between the consumption of resources, population growth and industrialization/technological development and how this relates to our impact on the global environment have been set out by Ehrlich et al. (1971). The model assesses that the impact of a human population on the environment can be thought as the product of the population's size, its affluence, and the environmental damage inflicted by the technologies used to supply each unit of consumption, and it can be simplified as:

$$\text{Impact} = \text{Population} \times \text{Consumption}$$

A methodology developed on the basis of this formula is the Ecological Footprint, which sets the material flows in the context of sustainability and provides a measure of the ecological pressure associated with these flows, by communicating this information in a way that is easily understood by decision makers and the general public. Developed in the early 1990s by William Rees and Mathis Wackernagel, ecological footprinting has risen to prominence as an indicator of environmental sustainability, and has been applied at global, european, national and regional levels. The components usually analyzed in the ecological footprint are: direct energy, materials and waste, food, personal transport, water.

The food components includes the total food flow within a given area, considering the impact generated by the whole food supply chain for food consumed in the home and eaten out by the residents. On a literature review, we observe that is the food one of the most relevant components in the cities ecological footprint, which usually accounts for 30% of city residents’ total impact.

Alternative estimation of urban food flow and its relative impact have been draft by Barlez (2007) and Billen et al. (2008) calculated long-term nitrogen flows associated with the food imports into the Paris city. They detected the decreasing “food-print”, or area required to support the nitrogen food metabolism of Paris, despite the increasing per capita nitrogen consumption.

## 2.4 The urban food provisioning

The consumption and production of marketed food are spatially separated. Production is generally in rural areas and consumption primarily in urban areas (Tracey, 1994). This dichotomy become a steady and peculiar element of our communities since the industrial revolution has taken off, and the consequent rapid urban expansion produced an equally rapid loss of agricultural land in peri-urban areas. In fact, thanks to the technological changes in farming, transportation and food preservation and processing, food came from more distant places and from farms that were intensively cultivated (Lerz and Jacobsons in Pothukuchi et al., 1998). Thus, the evolution of global food system lead to a process in which cities progressively disconnected from the natural resource-base of their surroundings and from the productive systems that were associated with it (Pothukuchi et al.,1998). Even if the food system become less and less visible, food itself was – and still is – abundant and easily accessible in many supermarkets, food outlets, restaurants and fast food places in cities of the global North. As results, city residents and urban policy-makers generally take the food system for grant, and the food issue is not perceived as problematic as housing, crime or transportation. Although this is no longer the case.

### *2.4.1 The urban food distribution system*

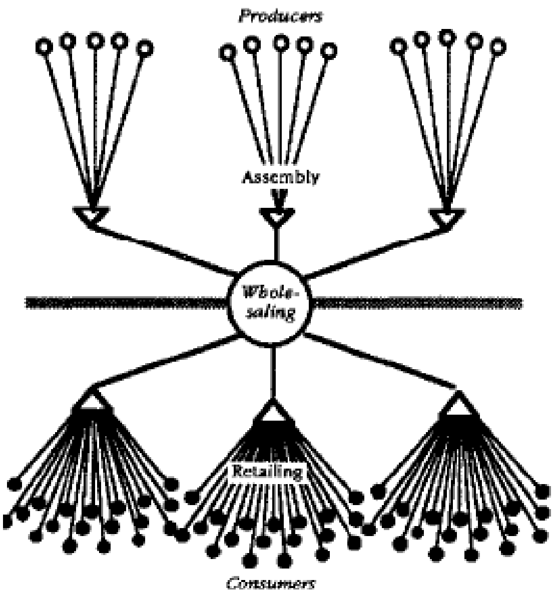
The urban food supply chain is a complex system of activities, functions and relations where the actors influence in a mutual way their decisions, and where the local and regional infrastructure, facilities and laws determine the supply chain performance. The actors involved in the urban food supply system are economic agents (e.g. producers, wholesalers, retailers); public institutions (e.g. city and local governments, public food marketing boards, Ministry of Agriculture, Ministry of Transport) and private associations (e.g. traders, transporters, shop owners and consumers (Aragrande et al., 2001). Economic, social, legal, societal and nutritional factors weight on the decision process of urban players, modifying market conditions and price definition processes.

The goal of the urban food supply system is to enable cities to meet their food requirements, according to the quality, quantity and hygienic conditions of the local context (Bohle, 1994; Aragrande, 2001). In our cities, constraints are represented by a variety of consumption models and food purchasing patterns typical of multicultural and multiethnic cities, moreover limitations are caused by obsolete infrastructure and facilities. According to Aragrande (2001), all these elements influence the capability of the food supply chain to respond to the city needs, which can be evaluated in terms of *efficiency*, referring to three main attributes:

- qualitative and quantitative: the capacity to supply a city with the quantity, variety and quality of food products required by the urban consumers;
- economic: the capacity to supply the required food products at the lowest possible cost
- temporal: the capacity to ensure stable food supplies over time.

To detect the food flows within the city and assess their efficiency, the whole system can be grouped in two subsystems: (i) the "food supply to cities" subsystem that includes all activities required to produce food and bring it to cities: production (including urban food production), imports as well as processing, storage, packaging, transport etc.; and (ii) the "urban food distribution" (UFD) subsystem that includes all formal and informal activities required to distribute food within an urban area: wholesale, intra-urban transport and retailing (formal-informal and traditional-modern retailing, restaurants, street food, etc.). Concerning the UFD, the food flows coincide with the market routes between wholesalers and retailers, caterers and food businesses at city level, as showed in the simplified diagram Fig. 2.3. The representation illustrates the role of the wholesale trading system enabling farmers and suppliers to sell in small quantities and purchasing by traders and wholesalers to be made in bulk. This representation is rather accurate for fruit and vegetables supply, nonetheless the marketing process for processed food is more complex and usually entails the participation of a wider range of players in the food chain (processors, importers, agents, distribution centers, etc.).

Figure 2.3 The urban food distribution process, simplified representation.




Source: Tracey,1994

The main players of the UFD system can be grouped into three categories, according to the functions they play (Aragrande, 2001):

- *Wholesalers.* Produce and food products wholesale markets are commercial and logistic nodes in the food supply chain. The operators generally are producers, assemblers, importers, wholesalers, processors and service providers (credit, storage, information and extension).
- *Urban transport actors.* A variety of actors realize the last part of transport and delivery service in the urban area, connecting wholesale (or distribution center or processors site) to retail sectors. They are carriers, shippers, third party logistics providers, suppliers, producers, customers, i.e. food services owners and retailers.
- *Retailers and food services.* There is a wide and complex range of food businesses in the urban environment, with different types of business, service, products. The receivers of food products and fruit and vegetables are traditional/modern distribution outlets, alternative markets and flea markets, restaurants, hotels, cafés, institutional and company cafeterias.

Despite this simplified representation, the food supply and distribution chains are very articulated, in fact there are some actors which play different role at different phases, i.e. the wholesaler who delivers the goods to the customer, or the shopkeeper who pick up the foodstuffs in his own.

### *2.4.2 Current trends in the urban food distribution system*

In the last decades, the food retail industry has reshaped itself at different levels, resulting in fewer corporate chains capturing a larger share of the retail market (Collin, 2003). In the urban area, this process of consolidation and growth entailed changes in the food distribution system with fewer, more concentrated shopping centres, supermarkets and hypermarkets, to the detriment of the grocery stores and public markets. In the past years, in our cities it was common to observe two main scenarios: in the inner city there were fewer and smaller grocery stores, with higher prices than in their suburban counterparts, where, conversely, there was abundance of conventional distribution outlets (supermarkets, hypermarkets), offering higher amounts and wider variety of foods at convenience prices (Dixon et al. 2007: 124-125, Luceri, 2009).

Nowadays, an innovative trend is appearing in the Italian corporate retailing system, and a growing number of retailer choose to open *superette*[5] in the inner urban areas (Aiello, 2009; Pederzoli, 2010). These small stores have an average sale area of 250 $m^2$, prices are typically higher than at a supermarket and only one or two choices are available. Even if supermarket has still a prevailing role in the retailing sector (average 50% of the market share in food Italian supply chain), superette model is increasingly popular. This business model aims to respond to the current conflicting requests expressed by different categories of urban consumers with limited opportunity to so shopping by car, i.e. elderly people, working single, low-income families. In fact, the shopping trends show an increasing interest for convenience food, but also more popularity of healthy and local food and a preference for ready to cook, ready to eat products (Morgan et al., 2006).

The challenge for conventional retailer is to design a business solution which responds both to price and quality demand requests, balancing economies of scale advantages with specialty selection costs[6]. Moreover there at least two additional sets of constraints which entail the superette development: i) environmental sustainable distribution services and stores, due to the current emphasis on these issues shown by the consumers (Aiello, 2009) and ii) physical and structural constraints occurring in the inner city areas, where traffic congestion, transport regulations and obsolete infrastructures hamper the logistics services (Quack, 2008).

A relevant example of this process is represented by the Emilia Romagna region's retail distribution system. The conventional retail sector shows a small but steady growth in the market share, with an increasing

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[5] The term "superette" intends a grocery store, primarily self-service, offering all five major supermarket departments, but smaller than a supermarket - having a selling area of about 250-300 $m^2$.

[6] Transformations in the retailer food supply chain become common in recent years, particularly in fresh produce supply chain, through the inclusion of innovative specialist suppliers at local level (Dreier et al., 2008; Hingley, 2008).

number of convenience stores in the main cities of the region (Fanfani et al., 2010). By contrast, the independent sector (small groceries, independent food stores, public markets) is suffering of a decreasing market share, covering only the 36% of the whole sale area, but representing the 91% of the total amount of food sale points (Osservatorio regionale del commercio, 2010). The negative trend performed by the traditional sector selling performance is engendered by a variety of factors as urban dwellers consumption and purchase patterns, lower prices offered by the large retailing corporations, and, not least, increasing economic costs of supplying and distributing small quantities of products in urban environments (mainly costs related to transport and logistics services)[7].

With special regard to the fruit and vegetables supply chain, we observe that decline in grocery stores and public markets in inner urban areas also paralleled the decline of wholesale produce markets (WPMs), due to their strong commercial relationships with the traditional and independent sector and their limited presence in the corporate retailing system. However, some new trends are shown at local level in Europe and in the North America, where WPMs redesign their role including renewing services as commercial and logistic actor in the urban food distribution system. In some cases, the restructuring process started by the conventional retail system foresees a shorter supply chain, mostly addressing fruit and vegetables and local products, and thus include the wholesale produce market with its primary function of “market place” (see King et al, 2010, Morley,2010).

In other contexts, the WPM takes part to urban food planning projects and additional services related to urban food distribution and transport are implemented i.e. San Francisco, London, Parma. Special emphasis is given to the relationship between WPM and catering sector, as hotels, restaurants and cafés (Ho.Re.Ca.). In this case, the WPM usually performs or facilitates logistics activities, acting as consolidation center and optimizing the delivery services to these receivers.

[7] Centralized distribution and economies of scale in food transport represent a significant profit margin in the conventional retailing sector (Hingley, 2008).

# 3. City logistics for food products

Considering that urbanization implies that people concentrate in areas (i.e. cities) which are apart from the source of food, consumer products, and waste disposal opportunities, urban community requires urban goods transport (UGT)[8] to sustain it (Quack, 2008). Moreover, UGT is a key factor which contributes to local economic vitality, urban life quality, accessibility and attractiveness of local community (Quack, 2008; OECD, 2003). The relevance of UGT is now more evident than ever because, due to the rapid urbanization and to the increasing movements of goods and people, cities in the world are facing difficult problems including traffic congestion, environmental issues, traffic accidents, and energy consumption relating to urban traffic.

As result, it is crucial to manage the urban distribution system and to conciliate economic efficiency with environmental and social sustainability. This task is particularly hard in case of food products logistics, since perishable goods category entails additional peculiar constraints, as short lead time, *ad hoc* transport vehicles and facilities, and articulated supply and distribution chains.

## 3.1 Last mile in urban areas

City logistics[9] incorporates the "last mile" or "final mile" of the freight delivery journey, identified as the small scale distribution of goods in urban environment. This part of the freight transport system is often the most expensive since economies of scale diminish from the point the vehicle has left the road network (Lewis, 2005). The "small order problem" consists in deliveries and collections often comprising a small number of parcels, and hence commercial vehicles operate below their maximum carrying capacity (Quack, 2008) and empty runs accounts for a significant part of total kilometers-vehicles.

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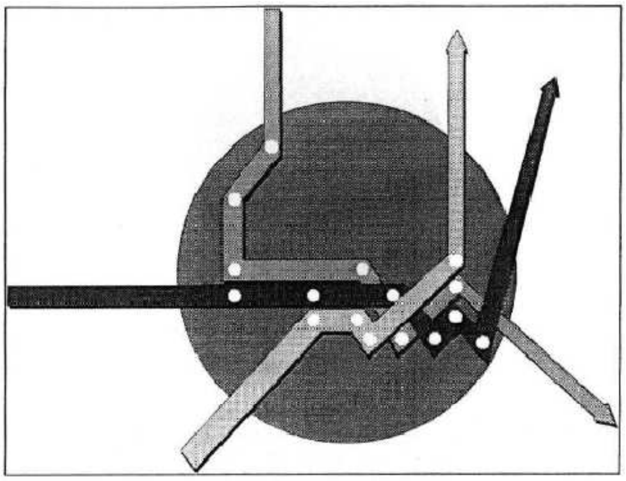
[8] The OECD defines the urban goods transport as *"The delivery of consumer goods (not only by retail, but also by other sectors such as manufacturing) in city and suburban areas, including the reverse flow of used goods in terms of clean waste."*(2003).

[9] Eisele et al. (2000) describe as CityLogistics: "...all co-ordinated measures comprising logistic collection and delivery activities of logistic service providers in urban areas that aim at the reduction or prevention of commercial traffic and its negative external effects."

This freight atomization results by the demand of urban distribution sector: the receivers usually are the large numbers of businesses, shops, commercial and services activities representing the economic structure of urbanities. Their goods provisioning process has become even more problematic due the recent changes of structure of transported goods (e.g. the increasing importance of flexibility in time and place) and changes in production and storage strategies (e.g. just-in-time deliveries: higher delivery frequencies, limited storage space). The resulting scenario is  a variety of vehicles circulating within the city without co-ordination. Figure 3.1 shows typical urban transport patterns that call for synergies: each vehicle serves major parts of the city (some even several cities) within the same route, delivering or collecting only small consignments at each stop.

Figure 3.1 Urban transport patterns calling for synergies

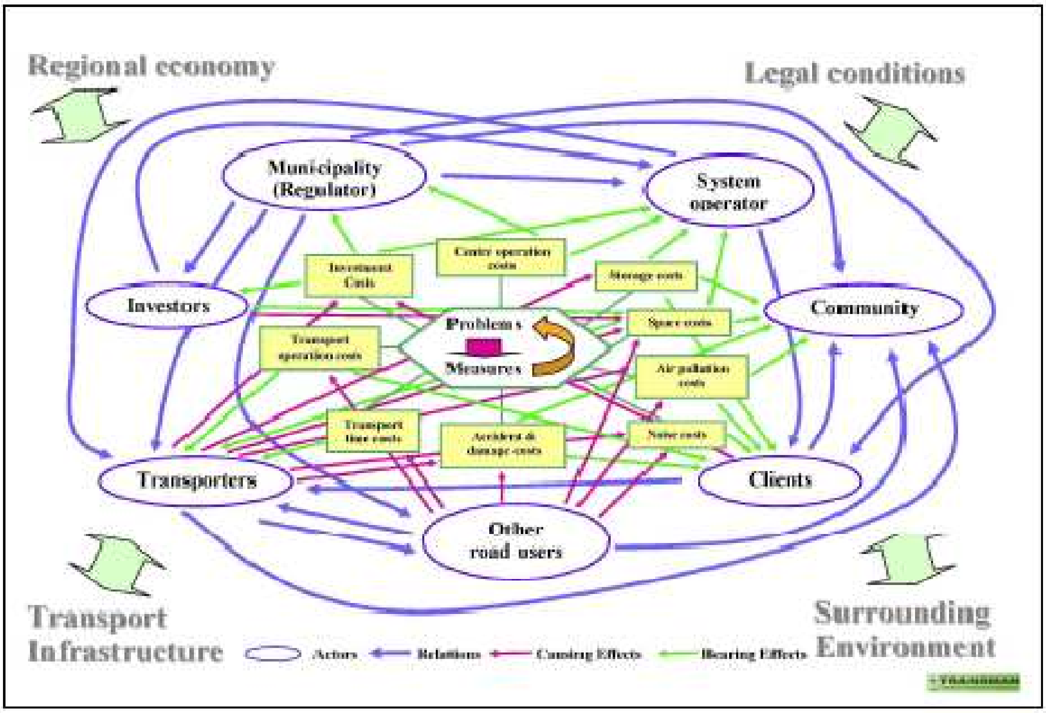


Source : COWI/NTU, 1996

Since urban congestion arises and leads to time and money losses, companies show interest in new solutions achieving more efficiency in the delivery process, especially by reduced vehicle miles travelled and less heavy vehicle traffic in sensitive areas (Hesse, 1995).

The business side is not the only one concerned by the urban freight transport problems. Politicians and local administrations (lead by the public opinion force) are aware of these critical issues, which have economic, environmental and social consequences in the urban life. City planners look for strategies which make freight transport more efficient, more sustainable and less expensive, through a combination of economic and ecological incentives (Spinedi, 2009). Several initiatives of city logistics are proposed and actually implemented in some cities including advanced information systems, cooperative freight transport systems, load factor controls, new freight transport systems, etc. One of these actions is the creation of urban distribution centers (UDCs) which are logistic platforms located at the edge of the city and which can reduce the current inefficiency by bringing together different parties engaged in "small orders" distribution to collaborate in joint-deliveries (McKinnon, 1998). Indeed, UDC success depends on the cooperation among the various actors of the city logistics system, which are the receivers (i.e. shop owners), carriers and transport operators, local authorities and residents. Moreover a certain frame for city logistics, given by the local and regional economy, the transport infrastructure, the surrounding environment and legal conditions, strongly entails the UDC's potential contribution to the city logistics optimization process. This complex network is shown in figure 3.2.

Figure 3.2 Main Actors Relations and Effects in urban freight transport




Source: BESTUFF, 2005

The opportunity to develop an UDC has to consider not only the need of various actors to collaboratively work together (public private partnerships are desirable), but also the physical structure of the urban environment in terms of accessibility by the regional and national transport system (by road, rail, canal, etc.), local infrastructures, and existing facilities and terminals. This aspect is crucial because within cities land is not an issue anymore. As common feature of cities in Europe, we observe that urban land for logistics activities is not more available and, thus, there are few chances that logistics operators locate their terminals in the vicinity (Dablanc, 2010). Most likely the origin of their trip will be at more than 50 miles from the inner city generating an increase in the vehicle miles travelled. However, a response to this urban land deficit for logistics activities arises by the identification and renovation of existing premises/terminals having a logistics potential as urban distribution platform, not expressed so far (see Vaghi, 2009). We consider the case of the wholesale produce market, especially for perishable goods but also for other supply chains, as one of the most relevant potential players in this scenario.

### *3.1.1 Transport and logistics for food products*

In the global marketplace, time and place represent fundamental variables, as explained by Henskett:

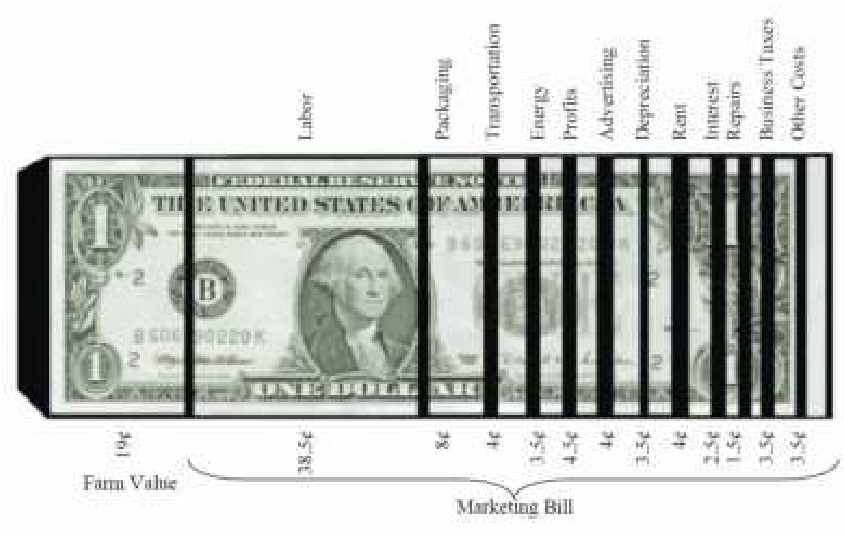
“*When is a* refrigerator *not a* refrigerator*?. . . When it is in Pittsburgh at the time it is desired in Houston.”*

James L. Heskett, Nicholas A. Glaskowsky, Robert M. Ivie, 1964

This statement is correct in general for the consumer goods distributed in the global commodity market, but it is even more evident in case of food products, which are perishable and require timely delivery and careful handling - including temperature control and cooling - to preserve the quality and to prevent spoilage. Thus food, especially fruit and vegetables, is different from other commodities and need *ad hoc* logistics channels able to guaranteeing product quality requirements in line with international regulations and market side expectations.

The relevance of perishable goods logistics has increased considerably over the years, concurrently with the agri-food market and trade globalization, and, as consequence, the food transportation and logistics costs accrued too (USDA, 2006). The whole food transportation chain transportation covers a relevant role within the full costs of supplying food products, which include labor, packaging, energy, profits, etc. According to the study of the USDA, transportation represent the third biggest part of the total food marketing bill, as depicted in the figure 3.3.

Figure 3.3 Components of the food dollars in 2006




Source: USDA-Economic Research Service, 2006

Due to the current economic crisis, there are strong commitments by the supply chain operators at reducing transport costs, together with higher margins for producers and reduced transport externalities. Although the process of planning, implementing and controlling efficient, effective flow and storage of perishable goods requests additional cooperation among all the food chain actors, because many subsystems of logistics are undergoing a process of “fragmentation” limiting the implementation of a comprehensive planning strategy.

In fact there is an increasing demand of *frequent deliveries*, within systems of just-in-time and 'quick replenishment', that creates continuous flows of goods to and from food companies. Moreover the narrowed *time-windows*, in which goods need to be delivered, pose new challenges to the planning and coordination of distribution. Technological developments, economic pressures, and the improvement of transport infrastructure have together shaped customers' expectations concerning quality of service, prompting companies to adopt more customer-oriented production strategies, and further reinforcing the trend towards a 'flow society' (Defra, 2005).

### *3.1.2 Renewing the role of wholesale market*

To enhance UFD efficiency and to improve the network of producers, suppliers and retailers, city-governments provide infrastructure, facilities and public utilities where marketing and logistics activities take place. This is the case of fruit and vegetables wholesale markets. Historically, they covered the role of *network shaping agent* in the urban food supply system, grouping local and regional producers, and assuring direct links with urban retailers. Here there is a brief description of wholesale market's scope edited by J. D. Tracey-White (1994) in the "Wholesale Market - Planning and design manual".

> *The fundamental objective of wholesale markets is to improve efficiency in the food distribution pipeline. By centralizing transactions at a single location, reducing the period for transactions, and separating wholesale and retail functions in the distribution system, wholesale markets promote greater transparency and better price formation through a clearer interplay of supply and demand. Storage and handling conditions are also enhanced, leading to significant reductions in post-harvest losses (by about 30 percent in European experience), especially in the case of perishable produce.[...]*
>
> *Wholesale markets were built adjacent to city centres, located at a focal point of the inter-city transport facilities and close to the main retailing areas. Population growth, changes in urban land-use patterns and the development of modern transport* systems *have all had an influence on the suitability of existing and proposed wholesale market sites.*

According to this description there are two crucial points which are still crucial almost ten years later: (i) the WPM's contribution to the *efficiency* in the urban food supply chain – mainly for fruit and vegetables – and (ii) its *strategic location* in the city environment. These points represent the key elements having direct effect both on the urban food planning strategies and on WPM's market performance.

The challenge deals with re-design WM's management by giving priority to the current requests about market efficiency for sustainable food and sustainable logistics at urban level. Concerning the market and management services, the main components are collaboration, network design and telematics, while concerning the sustainable logistics, the services had to facilitate greater capacity vehicles, out of hours delivery, optimization of delivery route, having a direct impacts as lower carbon footprint, better air quality and less congestion (Palmer, 2007).

Shifting from a traditional WPM to a renewed market WPM, new organizational concepts that are now discussed by researchers under the model known as regional and/or alternative *food hubs* (FH). FHs potentially represent an organizational model managing aggregated food supply for the urban context, providing adequate volumes and services, and including additional environmental and social dividends associated to the sustainable food systems. The working definition proposed by Morley and Morgan is:

*Food Hubs are partnership based arrangements that coordinate the distribution of a range of food products from producers of a uniform provenance to conventional or hybrid markets.*

Morgan & Morley, 2009

FH can be an existing supply chain infrastructure playing a new or renewed role as alternative intermediaries, FH can be wholesaler led, retailer led, public sector led, producer cooperative led, producer-entrepreneur led. The FH core components are:

- Aggregation/ Distribution – Wholesale
- Active coordination
- Permanent facilities

According to Palmer, successful wholesaling requires a good balance between small-scale and large-scale suppliers and a diverse mix of customers to provide the best marketing option for each grower's fruit. As the supply base continues to consolidate, alliances must be built with large national and regional supply organizations while at the same time, relationships must be maintained with small, high quality producers. Among the WPM customers, there is a growing number of retail chains. Servicing the supermarkets requires a high level of quality assurance, supply planning, transport, logistics and business management. By contrast, servicing the independent stores requires attention to detail and developing good personal relationships, and logistics service too.

There are crucial components such as marketing, organizational and technical elements which determine the performance of the wholesale market at both commercial and logistics levels. Going further in this double function perspective, the FH should be able to integrate logistic urban networks and to provide services to achieve a high degree of collection in the goods flows, in order to supply efficient transport from the market area to the city centre. By doing so, the FH can play the logistics role of *urban distribution center* for food products (it can be only fruit and vegetables, potentially, for other food and non- food products), having as principal advantage the alleviation of local environmental and traffic concerns in urban areas by increasing in the load factors of commercial vehicles dedicated to food deliveries.

## 3.2 Urban food distribution’s environmental impact

Reducing the transport inefficiencies is particularly urgent because transport – mainly road transport – is responsible for about a quarter of the EU's greenhouse gas emissions. The European Environmental Agency (EEA) estimate that 12.8% of overall emissions are generated by aviation, 13.5% by maritime transport, 0.7% by rail, 1.8% by inland navigation and 71.3% by road transport (2008).

Concerning pollution at urban level, road transportation is the largest source of local air pollutants such as carbon monoxide (CO), sulfur dioxide ($SO_2$), oxides of nitrogen (NOx), volatile organic compounds (VOCs), and particulate matter (PM). These emissions are generated by cars, light and heavy commercial vehicles, account for 40–80 % of air quality problems in cities and megacities both in developed and in developing countries (Ghose, 2004).

The European Commission (EC, 2006) predicts that the increase in the volume of freight activity will continue to drive $CO_2$ emissions upwards, despite the expected efficiency improvements in terms of tonne-kilometres per unit of GDP and energy use per tonne-km. According to the White paper on transport [10] the European transport sector has to reduce at least 60% of greenhouse gas emissions by 2050 compared to emission levels in 1990. In particular the urban transport has to achieve a big shift to cleaner cars and cleaner fuels, phasing out ‘conventionally fuelled’ vehicles in urban transport and promoting a $CO_2$-free movement of goods in major urban centres by 2030.

### *3.2.1 Light commercial vehicles: use and performance*

Most of UFD deliveries are operated by light commercial vehicles (LCVs) and their activity has increased substantially over time. This has come about as a result of the suitability and versatility of LCVs for a wide range of goods and servicing tasks, and due to the traffic restrictions in city centers on heavy commercial vehicles. Even if this type of vehicle provides many advantages in terms of logistics and organizational performance, it usually consume large quantities of fossil fuel, and also generates the release of higher quantities of pollutant emissions (PM, CO and NOx), compared to the petrol engine vehicles of the same category[11] (see table 2.1). This substantial contribution of commercial vehicles to air pollution is confirmed by international findings that suggest that older diesel vehicles, particularly vans, are responsible for a disproportionate amount of pollution[12].

[10] The European Commission adopted the “Roadmap to a Single European Transport Area – Towards a competitive and resource efficient transport system” in March 2011 - COM(2011) 144.
[11] In 1989, the International Agency for Research on Cancer classified diesel exhaust as a probable human carcinogen.
[12] International studies reveal that a small number of poorly maintained diesel and petrol vehicles contribute a disproportionate amount of pollution. For example in California, these vehicles are classed as ‘gross polluters’, and although they represent only 10% to 15% of all vehicles, they are estimated to be responsible for more than half of all vehicle emissions.

Table 3.1 LCVs Pollutant emissions – Petrol and Diesel engine.

| Type of LGV & Year | Carbon monoxide | Hydro-carbons | Oxides of nitrogen | Particulates | Carbon dioxide |
|---|---|---|---|---|---|
| *Petrol LGV* | | | | | |
| pre 1994 | 136 | 96 | 94 | 19 | 111 |
| 1994-1997 | 20 | 3 | 19 | 2 | 140 |
| 1998-2000 | 5 | 2 | 16 | 1 | 143 |
| 2001-2005 | 4 | 1 | 7 | 1 | 136 |
| 2006- | 3 | 1 | 5 | 1 | 128 |
| *Diesel LGV* | | | | | |
| pre 1994 | 10 | 19 | 81 | 187 | 143 |
| 1994-1997 | 5 | 9 | 63 | 51 | 143 |
| 1998-2001 | 5 | 9 | 60 | 53 | 143 |
| 2002-2005 | 3 | 7 | 45 | 37 | 131 |
| 2006- | 3 | 4 | 23 | 24 | 122 |

Note: Petrol LGVs pre 1994 were without three way catalysts. Petrol LGVs have had three way catalysts since 1994.
(Source: DfT, 2008)

As it is clearly shown by these data, the use of LCVs as main solution to distribute food products in city area need a shift to environmentally less-damaging modes of transport and technological improvements in the performance of road vehicles such as gains in fuel efficiency and catalytic converters.

### *3.2.2 Defining urban food transport policies*

Related to the food transport and logistics issues, a growing concern for the environmental and social effects generated by the urban haulage of goods has led local and national authorities, together with companies and transport operators, to promote actions for an improvement of the associate logistics. Maunsell (2007) proposes to focus on the four areas of intervention:

- the potential impact of consistent implementation of existing best practice on food transport logistics efficiency;
- opportunities for reducing the external impacts of food transportation by improving local supply and distribution networks;
- opportunities for improving transport efficiency through step changes in transport methods or infrastructure; and
- the potential impacts of changing regulations on logistics.

Concerning these topics, the European Commission highlights five main approaches to the adoption of environmental concerns in freight transport (European Commission, 2001):

1. reducing the impact of freight through cleaner, alternative fuels and improved truck design;
2. driver training and behavior;
3. improving vehicle utilization by increasing load factors, utilizing new information technology, improving routing and collaboration between companies;

4. switching to more environmentally-friendly modes; and
5. city logistics.

According to these objectives, it is urgent that policy makers at local, regional and national level identify policies and measures that compel companies to change their actions and thereby become more environmentally or socially efficient. These measures include traffic management schemes, land use zoning, infrastructure developments, licensing and regulation, terminals and distribution centres, road pricing and taxation.

## 3.3 The gap: how to evaluate the urban food transport environmental efficiency

At present measurement methodologies helping policymaker to depict urban food distribution functioning and performance are missing. There is an urgent need to identify these kind of tools, in order to capture processes of change and modernization occurring in the supply chain system and then identify integrated policies and interventions which the community planners must adopt in the short, medium and long terms order to meet urban food requirements adequately and preserve life quality in urban environment.

Most of the existing methodological tools focus on freight transport issues *or* on food supply chain sustainability issues. According to my preliminary investigation, only few indicators, for the example the "food miles", include *both* components in the research approach, and *none* — provides a comprehensive scheme to detect the transport of food in urban areas.

City logistics evaluation topics deal with the distribution rationalization policies and the associated goal of enhancing the quality of life in cities through reduced vehicular traffic and negative environmental impacts. Two questions are thus particularly relevant in this research: (i) where and how to perform the consolidation and coordination activities and (ii) what vehicles should perform the transportation activities (Crainic, 2007).

# 4. Methodology

To understand the key elements and the functioning of the food supply system in urban environment, we refer to the “urban food metabolism” concept (Bohle, 1994), describing the city as a complex organism with a the metabolic process, that transforms food flows in human biomass and waste. In our study, the model has been adapted to examine the urban relationships between food chain actors, citizens, and food flows, from a logistics point of view. Thus, we apply this model to examine three sub-systems, such as the urban food supply, the food distribution, and the urban food demand in two cities. In practice, the selected processes we investigate are: (i) the urban food provisioning, (ii) transport and (iii) consumption, and our methodology is intended to provide means to:

- estimate the daily food supply by the food businesses and food services;
- estimate the daily food demand by the city population and people temporary fluxes;
- evaluate the urban food transport performance, for independent retailers and Ho.Re.Ca. operators;
- evaluate the environmental impact of the urban food transport, related to the different logistics measures.

The identified approach enables at mapping the existing interactions and food flows, detecting the operating characteristics of urban food transport sector, and evaluating its environmental impact in the urban areas. Finally, this methodology aims at defining a basic tool that help policymakers in assessing the environmental sustainability of different logistics measures related to urban food transport. Following this approach, two case studies on urban food transport are examined: the cities of Parma and Bologna located in the Po Valley, in the Emilia-Romagna region, which is Northern Italy. Parma and Bologna are two medium-sized cities which can be identified as two *average* cities, as representative as possible of urban structure and organization in the contemporary Italian landscape, and eventually, in the European one.

This chapter is structured as follows. Section 1 outlines principal features of the urban food requirement, such as demand and supply of food products by the whole city. Section 2 describes the urban food distribution system finalized to “at home” and “out of home” consumption, and the key concept of the "last food mile" is introduced in section 3. The development of the methodology to study environmental impacts of freight transport is described in section 4. Section 5 and 6 describe the selection of case studies and the data collection procedures. Finally, general assumptions are stated in section 7.

## 4.1 Mapping the urban food metabolism

In our research, we set the boundaries of investigation to selected processes of the urban food systems, identified as demand, supply and transport of food within the city: we investigate how these flows are interlinked and who represents the driving forces. In particular, we focus our attention on the logistics sector involved in the food distribution system, analyzing the role of the main actors and their relevance in the food distribution chain. Among the players, we centre on city dwellers and city users, suppliers, retailers, market operators and logistics providers which take part to the food system and set the basis for the city food provisioning.

Cities are social and economic centers of communities and generate a complex interrelation of functional, environmental and social aspects. Daily, people coming from the peri-urban and regional areas travel to the city for a variety of reasons, including work, study, shopping, business and socializing. These transitory flows are defined as *city users* (Martinotti, 1993) and, together with permanent and temporary residents and tourists, they provide a complete picture of people taking part to the city life, by utilizing goods and services, and participating to the socio- economic city networks. The issues of feeding inhabitants and city users, by guaranteeing the food access, are highly depending on a mix of urban policies and local interactions, such as, commercial opportunities, regulatory conditions, as well as transport services and infrastructures. These elements contribute to shape the urban food system and set the frame in which food supply chain actors operate.

### *4.1.1 The urban food system*

In this section, we describe the methodology to estimate the total amount of food requested by and available to the population, drafting a sort of *Annona* for the selected cities. In ancient Rome, the *Annona* was the plan of all means of subsistence, especially grain stored in the public granaries, for provisioning the city (Chisholm, 1911). Thus, the *Annona* was a planning tool used by Roman governors to guarantee the supply and the distribution of corn requested by capital residents.

The urban food system is investigated from the demand/supply perspective, as showed in Figure 4.1.The demand of food considered in the study is the daily average amount of food consumed by residents and city users, and the amount of food waste generated by them[13].

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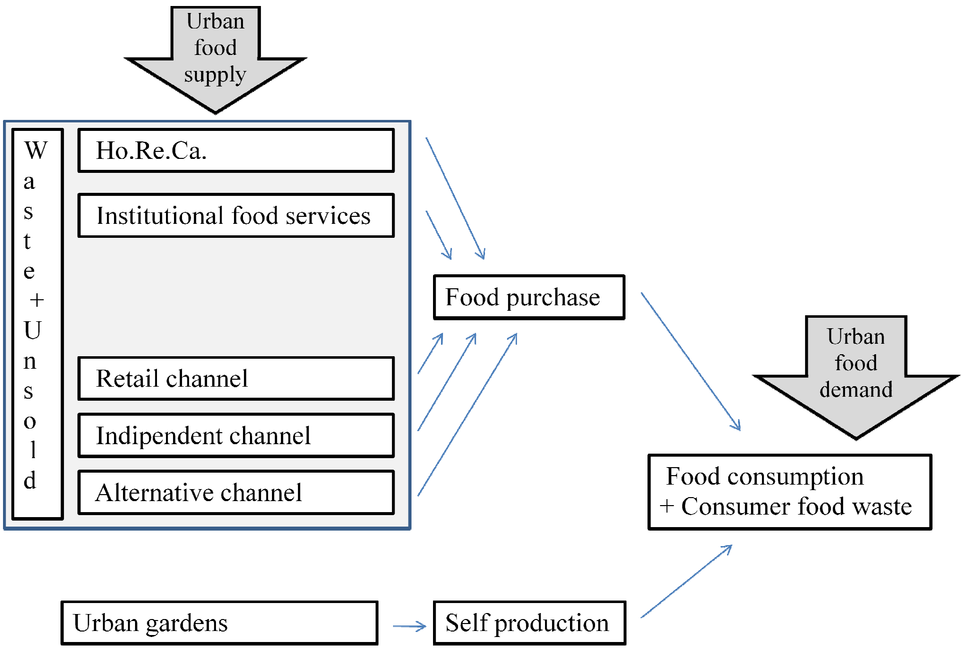
[13] In many countries studies have estimated the quantity of food wasted by households; it results be a consistent portion of the total purchased food, between 20% and 30%, that go to the disposal sites. The first report, *The food we waste*, has been drafted by WRAP in 2008.

In Italian urban areas, except for a very small amount of food grown with own urban vegetable gardens[14], most of the food is purchased through a variety of commercial channels, depending on the at home (supermarkets and groceries) or out of home (Ho.Re.Ca. and catering services) consumption. The full urban food supply includes the amount of products *sold* by the food suppliers, and the amount of *unsold* or *wasted* food (Segrè et al. 2011). The volume of food products managed by the urban food suppliers at the distribution stage provides the total amount of food which daily reaches and circulates in the city.

Figure 4.1 Urban food system




Source: my elaboration

### 4.1.2 *The urban food supply*

In this section, we describe the methodology to assess the urban food supply, which represents the total amount of food available for purchase in a urban environment, the term *food* includes all types of food and beverages ingested by humans and the wastes associated with discarded food. Food items are counted as part of flow as they would appear in a retail store, whether fresh or in processed form.

To describe the main features of the distribution supply system, a brief analysis of the urban marketing channels is drafted, identifying the highly complex and fragmented supply chain in modern cities. The urban food availability figures are based on the food demand and they include an estimation of the amount of food wasted or unsold by the food outlets[15].

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[14] In Italy, urban agriculture has recently gained new attention, but its role in the urban food provisioning is (still) minimum, due to the limited green spaces available within the city centers (Galli et al., 2010).

[15] A certain amount of food in the retailing and catering sectors is wasted or unsold. Studies and researches investigated the "food loss" occurring in different types of business models, at different stages of the distribution chain. In our

The distribution system can be grouped in three market models: (i) corporate retail, (ii) independent retail, (iii) alternative channels (see USDA, 2009), as shown in table 3.1. We consider corporate retail the mainstream points-of-sale as hypermarkets, supermarkets, discounts, and superettes; the independent retailing system includes grocery stores, corner shops and specialty stores, and in alternative channels are comprised flea market, on farm retail, farmers markets and community supported agriculture initiatives. To depict the whole urban food supply, we choose to include self-production by home gardens and public gardens within the city limits, due to the renewed interest by city dwellers in home grown produce. While detailed data are scarce on urban horticulture in developed and developing countries, FAO (2010) observes as common trend the growing quantity of fruit and vegetables production in the urban and peri-urban areas.

The available data on the Italian food market distribution show the dominant position of the corporate retailers, which reaches almost 78% of the market turnover, with positive trend in the past years. Consumers prefer shopping in the mainstream channels, with high competition among hypermarkets, supermarkets and discounts, although superettes are becoming more attractive for city consumers. Traditional small grocery stores and corner shops - identified as independent retail system - which historically constituted a vital part of city life in Italy, now reaches approximately 19% of the whole retailing market (Emilia Romagna Region, 2008). In fact, the independent sector is facing a growing loss of market share and a general decline in the number of stores. Alternative channels, such as different forms of direct market for specific products (organic, integrated, regional, artisanal, etc.), experienced an impressive growth in recent years. However they still handle a relatively small portion of the total product demand (around 2%).

Table 4.1 Urban food retailing system

| **Urban population food supply – at home consumption** | |
|---|---|
| Corporate retail | ◦ Hypermakets<br>◦ Supermarkets<br>◦ Superettes<br>◦ Discounts |
| Indipendent retail | ◦ Grocery stores<br>◦ Corner shops<br>◦ Health and Specialty stores |
| Alternative channels | ◦ Flea market<br>◦ On farm retail<br>◦ farmers markets<br>◦ PYO –Pick Your Own<br>◦ CSA-Community Supported Agriculture |
| Self production | ◦ Home gardens<br>◦ Public vegetable gardens |

Source: my elaboration on USDA, 2009

analysis, we elaborated estimates on Last Minute Market data collected through food recovery projects in a variety of food outlets and services in Italy.

This design sketches out the complexity of supply chains of the retailing system, for food products finalized to “at home” consumption. With regard to “out of home” consumption provided by food businesses, in table 3.2 we illustrate the three main distribution channels of the food service industry: (i) Ho.Re.Ca., (ii) institutional food services, as canteens in schools, colleges, hospitals, etc., (iii) and corporate cafeteria providing food in offices buildings.

Table 4.3 Urban food catering system

| **Urban population food sourcing – out of home consumption** | |
|---|---|
| Ho.Re.Ca. | ◦ Hotels<br>◦ Restaurants<br>◦ Cafés |
| Institutional food services | ◦ Schools<br>◦ Universities<br>◦ Hospitals<br>◦ Prisons<br>◦ Military bases |
| Corporate cafeterias | Canteens in factories and office buildings |

Source: own elaboration

In the food services scenario, it is possible to distinguish between the “organized” Ho.Re.Ca. channel and the “non-organized” channel (Ponce-Cueto et al., 2009). The first is the one established, for example, with some hotel chains (NH Hotels, etc.) and restaurant chains (Burger King, McDonalds, etc.). The second type, the “non-organized” channel, is the one that supplies small bars and restaurants, some hotels, etc.

### *4.1.3 The urban food demand*

In this section, we describe the methodology to estimate the daily food demand figures by the city. The food demand is calculated on the *per capita* food requirement multiplying by the total flows of people which daily live the city and use goods and services. Then, the amount of food finalized to at home and out of home consumption is estimated for the two case studies, on the basis of two assumptions:

1. there are no daily or seasonal changes in Parma and Bologna’s population flows.
2. the cities of Parma and Bologna are identical to the Italy and on for the following items:
    - mass of food consumed and purchased on a per capita basis
    - food wastes generated on a per capita basis (before composting and food rescue programs)
    - consumption pattern (out of home/ at home consumption habits).

- Individual food requested

The human daily food purchase is estimated on the basis of consumed and discarded food studies describing Italian food consumption and waste habits[16].

[16] Consistent data on the amount of food and drink waste generated by the Italian consumers are missing. The available figures are estimates on the value of the wasted food (ADOC), thus we elaborated these figure. There is a large

- Urban population flow

To estimate how many consumers are circulating in the city in a working day, we analyze the people flows constituted by: permanent and temporary residents, nights sleeping tourists, and city users (employees, business-persons, one day tourists etc.).

The consumer patterns are very different among the whole urban population, thus the main trends are investigated, distinguishing on population groups and consumption habits. In order to calculate the total amount of food request at urban level, we choose to divide urban population in two main groups - if they overnight or not in the city. The first group consists of permanent and temporary residents, nights sleeping tourists, and we assume they purchase and consume the entire amount of food they need within the city. The second group includes the city users (commuters, professional consultants, one day tourists etc.), and we assume they consume in the city only the half of the total amount of daily food requirement. For example, commuters most likely will consume lunch and, eventually, breakfast in the city, and dinner at home.

Consumers purchase preferences centre on two main market systems, according to the type of consumption: at home and out of home. In the first case, the consumer buys food in chain retail, independent retail or in alternative channels, in the second case the suppliers are hotels, restaurants, and cafés, institutional food services and corporate cafeterias.

## 4.2 The urban food distribution: logistics features

Food outlets and stores have to receive their goods in time and in the right amounts. According to economic and physical criteria, as the type of business, type of products, store location, etc., different distribution schemes are implemented. Here, we report a brief description about the logistics operations with reference to the type of food business, distinguishing between distribution finalized to "at home" and "out of home" consumption.

### *4.2.1 Logistics systems for distribution finalized to "at home" consumption*

Retailing is closely linked to the distribution sector which includes wholesale and warehouse supply chains which support retailing through the storage and delivery of goods to stores. Different retail outlets, from national chains of supermarkets through to local corners shops, utilize a range of distribution systems according to types of products, market integration and supply chain network.

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contribution from fresh produce – fresh fruit, vegetables and salad - and other highly perishable products (bakery, dairy, eggs, meat). Our estimates for the Italian system are similar to the figures presented by the Wrap study for the UK food system, which estimates on 22% the households food waste.

- Corporate retail distribution system

Corporate retailers developed centralized supply chain management systems to efficiently manage stocks, to monitor the flow of goods and to coordinate inbound and internal logistics[17]. Thanks to the information technology support and to the coordination with channel partners, as suppliers, intermediaries, third-party service providers, the logistics management of perishable products procurement in the retailing system reached high consolidation rates and, thus, cost-effective performance. In particular, the existing delivery scheme between distribution centers (and supplier warehouses) and supermarkets provides timely order fulfillment and economies of scale savings, rates.

Although there are not only full truckload restocking supermarkets. In almost all the mainstream points-of-sale, there are increasing amount and varieties of food products sourced by local producers and suppliers, addressing the current consumers preferences. These products are usually bakery, diary, and selected varieties of fruit and vegetables. The day-to-day liaison with these suppliers are managed at local level, by supermarket managers, and the logistics activities utilize the direct store delivery scheme. The result is likely to be a consistent number[18] of separate small deliveries, suffering the typical inefficiencies of *last mile* logistics operations (empty runs, non-optimized routes, etc.).

Finally, after an explorative analysis of the mainstream distribution mechanisms, we observed that the distribution strategy adopted by the corporate retailing system is essentially cost-effective and mostly optimized through centralization measures. However there are opportunities to improve the logistics services for those goods sourced locally, which represent a growing percentage of market share in the urban food supply chain.

- Independent retail

Independent retailers have usually limited stock management and logistics activities, and their distribution system reflects the atomized and fragmented supply chain scenario peculiar of small and medium enterprises of food sector. The resulting transport and logistics operations present inefficiencies (i.e. empty runs, old and high fuel consumption vehicles, non-optimized routes, etc.) which strongly entail the business performance and constitute higher management costs and, thus, reduce their economic margins. Many corner shops and grocery stores are attempting to reduce logistics costs by shifting to self provisioning deliveries and consolidation operations, but the high competition and the lack of coordination initiatives limit successful results.

[17] The centralized *hub and spoke* distribution network enables efficient retail operations thanks to highly consolidated deliveries at distribution centres into full vehicle loads.

[18] It depends on specific provisioning system adopted by each retail chain, however - according to our original data collection- in a medium-size supermarket there can be 15-18 small deliveries per day, managed through light commercial vehicles by local and regional suppliers.

- Alternative channels

Products from local and regional farm are marketed through local food supply, articulated in a variety of trade circuits, i.e. farmers markets and box schemes. Local food market usually requires that both producers and consumers travel in order to distribute and purchase local goods. Different studies have been carried out to depict the fragmented and complex scenario of alternative retail distribution (Winter, 2009; Hingley 2009); however structural differences occur in the specific types of alternative channels, and generalizations are not reliable.

### *4.2.2 Distribution and logistics systems finalized to "out of home" consumption*

Out-of-home consumption is fast growing as segment in urban food supply system, and *ad hoc* logistics services are required by food services operators.

- Ho.Re.Ca.

In modern cities, Ho.Re.Ca. is a fragmented and geographically dispersed channel, demanding for elevated logistics requirements, such as small and frequent deliveries of perishable products in congested urban areas. Moreover, from the food supply side too there is high atomization, due to the presence of small local distributors and manufacturers. For these reasons, the physical distribution of products presents similar features to the independent retailing distribution scheme, and in some cases, the logistics channels are actually the same.

- Institutional food services and corporate cafeterias

There are some characteristics of foodservice that make it unique compared to distribution and logistics of other food supply chains, in particular: prepared meal is highly perishable, requiring to be handled properly and fast during the delivery activities; demand for food occurs at peak times (around breakfast, lunch, and dinner). Most of the foodservices adopted a centralized system, which consists in a by central food production facility where the food is prepared and from there transported to external locations (satellites or receiving kitchens). The centralized system is common in Emilia Romagna region, where centralized foodservice systems are implemented in schools, hospitals, prisons and other institutional bodies.

### *4.2.3 Selecting the distribution systems to investigate*

In this study, we focus on the urban distribution systems of adopted by two sectors: (i) independent retailers, and (ii) Ho.Re.Ca. industry, through the analysis of the case studies for the cities of Parma and Bologna, Italy. We choose to investigate these sectors for a variety of reasons. First of all, independent retail and Ho.Re.Ca presents structural and organizational similarities and the actors in both sectors are interconnected at different levels, therefore parallel analysis facilitate a broader comprehension of food supply and distribution systems.

The corporate retail system is not included even if there are certain logistics processes which are relevant in the urban food distribution system. Thus, the redesign of the distribution network for this commercial channel should be further investigated.

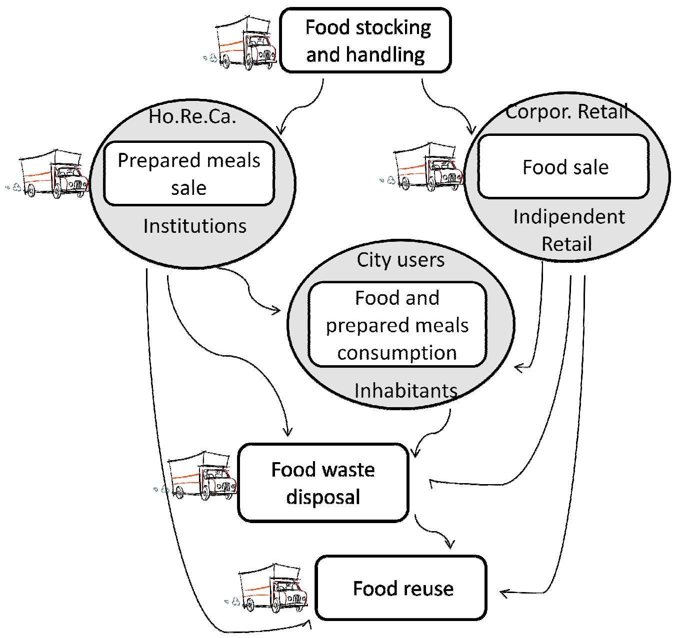
Due to the scarcity of data and the relative limited share of alternative channels in the whole urban availability, in this study we do not investigated the distribution and logistics systems of alternative food supply channels.

In the institutional food services and corporate cafeteria systems, transportation and logistics are crucial issued, in fact delivery schedules must be coordinated in order to guarantee the prepared meals in the right place at the right moment. For this reason, the distribution and logistics activities in centralized foodservice systems are mostly optimized and efficient. Therefore this sector will not be included in this study.

## 4.3 "The last food mile"

At different phases of the urban distribution system, logistics and transport implement and control the forward flows of food products and related information between the point of origin and the point of destination. The figure 4.2 shows the main processes of the urban food chain and the related transport functions operated by commercial vehicles: from local warehouses, wholesalers and suppliers facilities foodstuffs are transported to urban food retailing and catering operators (corporate and independent retailers, Ho.Re.Ca., institutional food services and business canteens), so-called "last mile" logistics. Then, additional transport operations are needed from food outlets to the landfill and to the food reuse site.

Figure 4.2 The urban food flow – Focus on transport activities

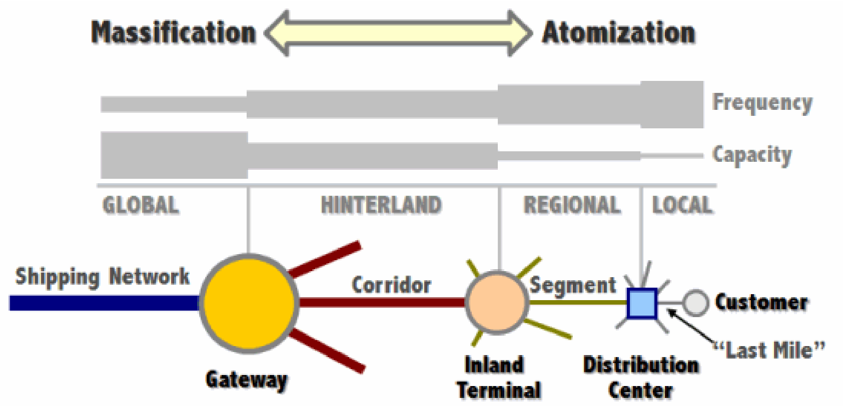



Source: own representation

*4.3.1 Defining the last part of the food supply chain*

In this study, we focus on the "last mile" logistics, notably for retailing, often consists of LCV deliveries taking place over short distances, reconciling many customers and a variety of shipments. The "last mile" is one of the most important yet problematic parts of the supply chain. First of all, the small scale distribution of goods in urban environment is the least efficient part of the supply chain due to the high atomization of receivers and to their increasing requirements by greater constraints in terms of service, as time schedule and number of deliveries (Lenz, 2004). Secondly, basically the high degree of "empty running" implies extra (high) costs. The figure 4.3 represents how the commodity chain is interconnected at different levels: global, hinterland, regional, and local, through diverse logistics nodes.

Figure 4.3 The "Last Mile" in freight distribution




Source: Rodrigue, 2009

Within a *food miles* analysis (Pirog et al. 2001; Coley et al., 2007), we investigate only the final part of the food supply chain delivery and we identify the environmental impact caused by urban food transport, in terms of air pollutants. For this purpose, we define the concept of "last food mile", being an expression combines the *last mile* and *food miles* concepts, and we use it in the study to facilitate the comprehension of our research. Conceptually, merging city logistics and food sustainable system concepts leads to centre on the sustainability of urban food transport, and to detect the multi-level interconnections existing between these two research fields.

The working definition of what we have termed "last food miles" is as follows:

*"Last food mile" refers to the physical distribution of food occurring in the last part of food supply chain. It refers to the final delivery of perishable goods to urban food outlets.*

The "last food mile" includes logistics criteria related to the efficient and effective distribution schemes, related to the economic, environmental and social sustainability of urban communities. It usually consists in small deliveries managed by transport operators and suppliers, wholesalers and distributors, and also, as self-provisioning operation, by shop owners and food retailers.

### *4.3.2 Variables to describe the urban food transport performance*

The urban food distribution scheme is different according to the type of supply chain it relates with. In the case of independent retail and Ho.Re.Ca., it concerns a wide variety of retailing activities, often of small scale (single store), where logistics operation are often informal activities. In general, food outlets need high frequency deliveries, usually on daily bases, provided by diverse suppliers. It is usually observed a predominant use of own-account delivery vehicles (with trucks, vans) or self-transport operations by shop and restaurant owners, resulting in high use of light commercial vehicles within urban environments.

As LCVs perform a greater proportion of their vehicle trips and vehicle kilometers in urban areas than HGVs, they make a greater contribution to urban congestion than HGVs. Operations involving de-consolidation from a few HGVs to many LCVs at urban distribution centres because of traffic restriction on HGVs may result in worsening urban congestion.

Table 4.3. City logistics variables set

| Types of variables | Variables | Details |
|---|---|---|
| Logistics variables | Frequency | delivery frequency |
| | Load unit | shape in which the goods are usually grouped and loaded on vehicles (pallet, roll, box, etc.) |
| | Delivery features | N. of deliveries /trip,<br>weight of each delivery |
| Technological and organizational variables | Typology of vehicles | dimensions and technical features of the vehicles |
| | Delivery period | period of the day in which the delivery of the goods is usually carried out |
| | Level of logistics optimization | capacity utilization of the vehicle (in weight and/or volume); |
| | Carriers typology | on own account, self provisioning, third party logistics, |
| | Nodes of the supply chain | departure points producers, suppliers, warehouses of wholesalers, etc. |

Source: our elaboration on City Ports reports, 2005

To describe this complex scenario related to urban food transport[19], we focus on selected components characterizing city logistics and perishable goods logistics processes, on the basis of the technical guidelines

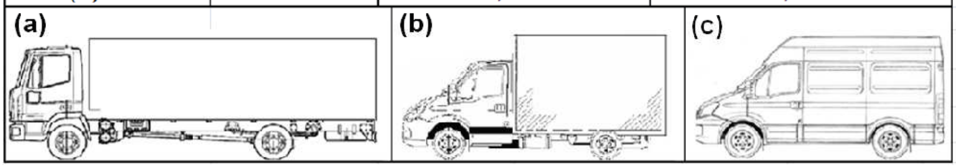
[19] More in general, the OECD definition of urban goods transport (2003) is: *"The delivery of consumer goods (not only by retail, but also by other sectors such as manufacturing) in city and suburban areas, including the reverse flow of used goods in terms of clean waste".*

issued by the Regione Emilia Romagna, Mobility and Transport Department (Rosini et al. 2005). According to the City Ports report (2005), there are logistics, technological, organizational variables characterizing the performance of city logistics, as described in table 4.3.

In the analysis we refer to commercial vehicles up to 3.5 tonnes gross weight as "LCVs" (light commercial vehicles). There are several different terms used by different organizations in different countries to describe these vehicles (including vans, light vans, light goods vehicles, light commercial vehicles, small trucks etc).

Table.4.4 Commercial vehicle categories

| Type | Weight [t] | Average length [mm] | Average width [mm] |
|---|---|---|---|
| Truck (a) | > 7.5 | 6,900 | 2,500 |
| Box Truck (b) | 3.5 < t < 7.5 | 5,900 | 2,200 |
| Van (c) | < 3.5 | 5,400 | 2,000 |




Source: Quack, 2008

### *4.3.3 Food logistics chains*

In general, food will spoil if exposed to improper temperatures or humidity levels or long periods of time prior to consumption. The loss of perishable goods in transit means lost revenue, for instance produce (fruits & vegetables) face a decline of their value in relation to the level of spoilage that took place during transportation, since it will limit their shelf life and as such their commercial potential. Thus, a relevant share of food distribution system involves cold chain logistics to maintain the thermal integrity of the shipments, it must be performed constant during transport at local, regional and interregional level.

The food supply chains :

- dry grocery;
- produce and fresh food products;
- refrigerated grocery;
- frozen foods.

The term "fresh food products" is intended for fresh foodstuffs with close expiry date and bound by special preservation conditions, while “dry retail” are foodstuffs at middle or long expiry dates, not bound to specific preservation conditions (paste, oil, canned food, etc.).

### *4.3.4 Evaluating city logistics measures performance*

According to different studies (BESTUFS, 2005; City Ports, 2005; Dablanc, 2007) and to our original data collection, the distribution of urban goods is not organized efficiently and there are options to reduce urban goods traffic (vehicle-km) through co-ordination and consolidation of transports. To rationalize urban freight traffic, the concept of urban distribution centers was developed (see REFORM, 1999) in order to consolidate goods flows and thus to increase the efficiency of the collection or distribution process, thereby reducing the environmental impact of urban delivery activities. By bundling various trips of one or several carriers to single trips with better capacity usage or smaller and cleaner vehicles, congestion and noise in the city can be reduced, time gained and delivery made more reliable.

- The urban distribution center

In this section, we selected the most important aspects that are included in the evaluation of the urban distribution center and its delivery service. Our analysis of the city logistics measures performance centres the urban distribution center (UDC) management and the logistics services it provides. According to the definition of Browne et al. (2005), UDC is:

*"a logistics facility that is situated in relatively close proximity to the geographical area that it serves be that a city centre, an entire town or a specific site (e.g. shopping centre), from which consolidated deliveries are carried out within that area'.*

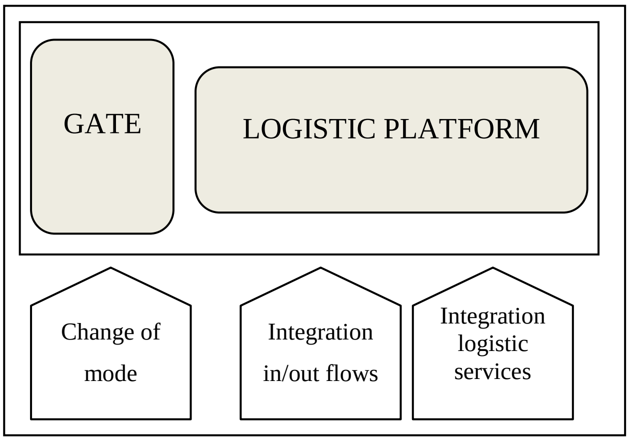
The key aim of a UDC is to reduce the number of separate deliveries to one area by providing facilities where deliveries can be collected together and then the commercial vehicle can make one large delivery into the target area. To evaluate its performance from an environmental point of view, four different measures are identified to be investigated:

i. changes in the number of vehicle trips;
ii. changes in the number of vehicles;
iii. vehicle load factor;
iv. changes in vehicle emissions.

- The logistic center for perishable products

According to the Emilia Romagna's logistics guidelines, the logistic centre for perishable goods cover three main functions: change of mode, integration of in/out flows integration of logistic services. These functions respectively allow to use the centre as a "transit point", as a consolidation platform, and to facilitate specific logistics actions i.e. cross docking, multipack, multidrop as well as change of packaging. The figure 4.3 shows the characteristics of logistic center for perishable products.

Figure 4.4 Types of structure of a logistics centre and its functions




Source: RER, 2005

To provide a deeper understanding of the workings and the functions of a food hub, a set of factors are analyzed grouped in three main macro-categories: organizational aspects, political measures and technical measures, as reported in table 4.5 to evaluate the performance of the logistics service provided by Parma wholesale market.

Table 4.5. Factors to describe food hub performance

| Organizational aspects | Political measures | Technical measures |
|---|---|---|
| Organization of the hub | Regulation in the access | ICT |
| Type and numbers of users | Subsidies | Type of commercial vehicles |

Source: own elaboration

### 4.4 Estimating pollutant emissions

In this section, we describe the methodology to examine how the food transport sector contributes in terms of pollutant emissions to the urban environments air quality. Environmental effects are measured for assessing the effectiveness of logistics initiatives which aim at reducing air pollution from good vehicles, reducing noise from good vehicles, reducing fossil fuel consumed by goods vehicles.

The selected case studies are investigated in order to assess:

- *baseline scenario*: all emissions generated by light commercial vehicles which transport food products to Ho.Re.Ca. and independent retail operators in urban area (in order to consider overall impact of change);
- *increased efficiency scenario*: emissions in urban area compared with previous emissions to make same deliveries.

Our model estimates the emissions of air pollutants from road transport generated by light commercial vehicles in urban areas. It includes all major pollutants (CO, NOx, VOC, PM) in physical measures (in kt of emissions) uses, which are calculated on the basis of COPERT 4 parameters and coefficients. COPERT 4 is a software which has been developed by the European Topic Centre on Air and Climate Change (by Aristotle University of Thessaloniki) with the support of the European Environment Agency (EEA). The European Commission's Joint Research Centre (JRC) coordinates the scientific development of the model.

Calculating the exhaust emissions dependent on three factors:

1. Activity
   - Number of vehicles [veh.]
   - Distance travelled [km/period of inventory]
2. Hot Emissions
   - Technology / Emission Standard
   - Mean travelling speed [km/h]
3. Cold Emissions
   - Technology / Emission Standard
   - Mean travelling speed [km/h]
   - Ambient temperature [Celsius]
   - Mean trip distance [km]

An emissions module quantifies the external effects of freight traffic by vehicle type (in our case studies: light commercial vehicle), according to the following formula:

emission [g] = number of vehicles [veh] x mileage per vehicle [km/veh] x emission factor [g/km]

The emissions are estimated in weigh and result by:

$$E_{total} = E_{hot} + E_{cold} :$$

$E_{total}$ = total emissions (g) of any pollutant for the spatial and temporal resolution of the application during stabilised (hot) engine operation,

$E_{hot}$ = emissions (g) during stabilised (hot) engine operation,

$E_{cold}$ = emissions (g) during transient thermal engine operation (cold start).

Table. 4.6 Data used in COPERT 4 for the calculation of the emissions for urban food deliveries

| Type of data | |
|---|---|
| Average vehicle speed in urban area | 40 km/h |
| Average mileage | 30.000 Km/year |
| Average temperature | 14° |

Source: own elaboration

The scenarios have been developed on the basis of average data which typical for the type of traffic analysed and on the average temperature for the cities of Parma and Bologna (see table 4.6).

## 4.5 Case studies selection

The case studies investigated in this research are both located in Emilia Romagna (ER) region, in the Po valley, which is one of the most urbanized, industrialized and agriculturally developed areas of Italy. ER is densely inhabited and the population is concentrated in medium size cities along the Via Emilia (SS 9 Emilia), the axis build by the Romans, where Parma and Bologna are located.
The choice of Parma and Bologna as our fields of study is motivated by the fact that in a number of ways the urban morphology and the urban food distribution system represent a paradigmatic model of Italian modern cities, combining significant flows of city users from peri-urban area and the highly fragmented presence of food outlets and services in the core areas of cities with old and established centres.

In particular Parma has been selected as one of few cases of city logistics project on food products in Europe. In fact, after a literature review, it became apparent that only few cities are implementing co-ordination and consolidation of transports which include the food supply chain. This is due to the additional/specific constraints related to the perishable products logistics, which tend to increase the operational costs of delivery service and, thus, to limit the economic sustainability of the project.

The case of Bologna has been selected for a preliminary study to assess the urban food transport performance and the potential environmental benefits associated with a city logistics scheme similar to the Parma's one. The Municipality of Bologna is strongly committed in urban sustainable mobility and launched a variety of city logistics initiatives, however the food distribution has not yet been addressed by the urban transport planning strategies.

## 4.6 Data collection procedures

The desired estimates of food flows for this study have the following characteristics:

- they represent an inflow or outflow to the community;
- they represent total flows managed by urban food supply system;
- their units are in mass (tons);
- they include all food flows and related mode of transport within the urban environment;

Primary data were collected through interviews and site visits with principals of supermarket, grocery stores, retail distribution centers, transport companies. These interviews provided descriptions and explorative analysis of each phase of the urban supply chain. Interviews were held with a range of relevant parties, selected from: freight transport and logistics operators, receivers of goods (shop owners, supermarket managers) in urban areas, local government/policy makers with transport responsibilities. Issues addressed during the interviews with the sample of respondents included their views about supply chain organization, type of receiver/ type of provider, geography/location of delivery point, suitable types of vehicle, appropriate traffic regulations / restrictions.

Additional data are collected from regional and municipal government reports, previous feasibility studies, interviews with local government officials, local permits, prior material flow research, and other sources. In particular, we gathered data from: Osservatorio regionale del Commercio (RER), Regional directorate of Mobility and Transport (RER), Institute for Transport and Logistics (RER), Municipality of Parma and Municipality of Bologna (Department of Business and Economic development, Department of Traffic).

- *Data on individual food requirement*

The figures quoted are for an "average" consumer in Italy, i.e. by taking the average amount of consumed and wasted food. The table 4.7 shows this average of consumption, purchase, and amount of waste which provides the likely food demand by city dweller.

Table 4.7. Daily total food (solid and liquid) purchase, consumption, avoidable waste. *Pro-capite*

| | Total food (kg/day) | Percentage |
|---|---|---|
| Amount consumed | 2,120 | 80% |
| Amount discarded | 0,530 | 20% |
| Amount purchased | 2,650 | 100% |

Source: own elaboration on Leclerc (2009), ADOC (2008), ISMEA (2007) data.

- *Data on urban population flows*

Official population figures issued by the Municipality register provide data about residents and sleeping tourists. The estimation of city users (employees, business-persons, students, tourists, etc.) is obtained through interviews with the Municipality officers[20].

- *Data on consumption and expenditure patterns*

On the basis of Confesercenti ER study which describes the consumption style of people living in the Emilia-Romagna Region, we obtain a representation of food volumes finalized to at home and out of home consumption bought by the urban population, as main result people (age > 3 years) eating one meal out of home per day are 36% . Moreover, due to limited available data about average meal weight, we assume at home and out of home meals have the same weight.

[20] There are no available official data about city users in the most of Italian cities. Some research has been conducted for big cities as Milan and Turin. The last population census, dated 2001, does not provide relevant aggregated data on city users.

- *Data on urban transport*

Our research relies on original empirical data and focuses on urban food transport variables. In 2005 a regional survey on urban freight transport was realized in the main cities of Emilia Romagna region ("City ports). It was particularly geared to deal with city logistics and goods transport features. The collected data are used in this research to analyze the existing urban freight distribution system for food products. From these data sets, we elaborated relevant variable such characteristics of the , delivery characteristics, strategic

- *Data on Parma city logistic project*

The data collection has been made by two complementary methods. First, several reports and internal documents have been consulted during and after the visits to the urban distribution center of Parma. The bibliographic research included: internal report, RER reports, City ports reports, articles in newspapers.

Second, five interviews to internal operators of Ecocity and of the wholesale market authority, in charge of implementing the service. The first was a investigative interview, based on a detailed information form, to describe the general context and the different phases of the city logistics system's conception and experimentation, with the person who manages Ecocity. Other face-to-face open interviews have been made to: a representing member of Infomobility, the transport agency that supports Ecocity; the wholesale market authority manager; the person in charge of Ecocity logistic platform operations; the person in charge of quality control.

- *Data on Bologna city logistics for food products*

Primary and secondary sources have been used to collect data for the Bologna case study: interviews with supply chain participants; direct observation in the wholesale market, stores and business premises and the collection of secondary economic and demographic data by official registers, news articles; websites. In particular, in the investigation phase I focused on the relationships with food suppliers, wholesalers, carriers, managers, shop owners, public representatives, and other stakeholders have been investigated. Several interviews have been carried out to the marketing and logistics services manager of the wholesale produce market.

## 4.7 General assumptions

Several general assumptions are made to estimate the value and mass of food inflows and outflows for Parma and Bologna case-studies. Also, certain types of flows are excluded from the estimates for all categories as part of the general methodology. Additional assumptions and omissions associated with specific data conversion techniques are included in the case studies discussion.

- *Static population:* This study uses the Parma and Bologna Municipalities' 2009 population estimate and assumes that this population remained static throughout the year. In particular, *no seasonal* *change of population* are included. The full population of Parma and Bologna, including students and commuters, is assumed to be present year round. This is a significant assumption, given that a relevant share of these populations is students (especially Bologna), many of whom leave the community in the late spring and return in the fall.

- *Consumption implies inflow*: In many cases, it is assumed that all consumption of food is satisfied by an inflow of food from outside the community and not from reducing existing stocks of food within the community. For example, it is assumed that the amount of food purchased by city users and city dwellers from retail stores implies an equal amount of food replaced in the store's inventory from outside the community.
- *No internal production:* This study does not include the urban production of food and assumes that all goods came from outside the community. This omission is made in order to focus the study on the most flows of food that all communities have in common. Urban agriculture varies widely among communities, but Italian cities, with old and established centres, usually have limited cultivable land within the administrative limits and, therefore the potential contribution to the food provisioning is marginal in quantitative terms.

# PART II. Analyzing the urban food transport systems

# 5. The Region Emilia Romagna context and the city of Parma - Case study 1

With regard to the focus of my study, here I investigate the specific measures reducing the urban traffic externalities, and, especially, those generated by urban freight distribution. Regione Emilia-Romagna (RER) and local administrations started a significant set of initiatives to support concrete interventions in the city logistics sector, financing structural and technological interventions to improve the efficiency and to reduce the negative impacts of the urban freight distribution. The case of the city of Parma is investigated and the Ecocity project is outlined. Then a preliminary analysis of the urban food transport in the city of Bologna is presented and two optimization scenarios are identified, on the basis of the Parma logistics solution.

## 5.1 The context: Emilia Romagna region

The region has an excellent infrastructural supply and an advanced economy based on the biggest agricultural sector in Italy, and on automobile, motor and mechanic productions. In recent years in ER, economy has stabilized, while the volume of goods moved by road (tone kilometers) and the volume of road freight traffic (vehicle kilometers) continue a steady growth.

### *5.1.1 The food distribution system*

The food retailing system in ER is advanced and widespread in the whole region. Grocery stores, including hypermarkets, supermarkets, discounts, superettes and specialized food stores, account for the largest share of retailing business area (63,4%). Independent retailers, including neighborhood and "mom and pop" grocery stores, account for the remaining 36,6% and for 90,8% of total food outlets, reaching 15.566 points of sale. A detail picture on relevance of different type of food outlets at regional level is reported in table 5.1.

Table 5.1 Food retailing system in Emilia Romagna - 2008

| Regione | Numero punti vendita | | Superficie di vendita | | |
|---|---|---|---|---|---|
| Forma distributiva | valore assoluto | % sul totale | valore assoluto | % sul totale | Media |
| IPERMERCATI | 32 | 0,2% | 225.392 | 13,0% | 7.044 |
| *Ipermercati < 6.001 mq* | *14* | *0,1%* | *61.564* | *3,6%* | *4.397* |
| *Ipermercati > 6.000 mq* | *18* | *0,1%* | *163.828* | *9,5%* | *9.102* |
| SUPERMERCATI | 587 | 3,4% | 549.976 | 31,8% | 937 |
| *Supermercati <1.500 MQ* | *506* | *3,0%* | *372.446* | *21,5%* | *736* |
| *Supermercati 1.500-2.500 MQ* | *68* | *0,4%* | *133.892* | *7,7%* | *1.969* |
| *Supermercati > 2.500 MQ* | *13* | *0,1%* | *43.638* | *2,5%* | *3.357* |
| DISCOUNT | 252 | 1,5% | 144.200 | 8,3% | 572 |
| MINIMERCATI-SUPERETTE | 561 | 3,3% | 143.686 | 8,3% | 256 |
| SPECIALIZZATO | 138 | 0,8% | 33.685 | 1,9% | 244 |
| *Totale medie e grandi superfici* | *1.570* | *9,2%* | *1.096.939* | *63,4%* | *699* |
| TRADIZIONALE | 15.566 | 90,8% | 632.423 | 36,6% | 41 |
| Totale | 17.136 | 100,0% | 1.729.362 | 100,0% | 101 |

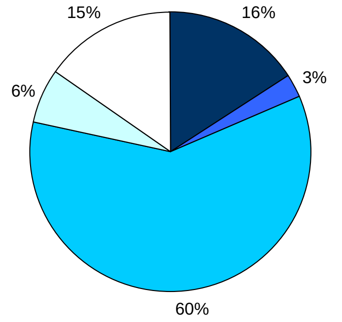
Source: Osservatorio del Commercio, 2010

### *4.1.1 Freight road transport*

Road transport is the dominant mode of transport in the region, about 93,9% of total weight of goods is transported by heavy and light commercial vehicles, while local and regional railroads are used for only 6,1%. Among the types of commodities transported by road, the most relevant are metallurgical products, raw and mineral products, and building materials. Agricultural products and live animals, foodstuffs and fodder are the second highest part, accounting for 16% of the total regional freight transported by road, as shown in figure 5.1.

More than 70% of today's road freight trips in ER conurbations are on distances below 50 km and can be defined as urban transport. This phenomenon is connected to the peculiar production and distribution systems in ER, which are highly fragmented and dispersed in the regional area, and it is reflected in the composition fleet, in fact 70% of commercial vehicles circulating in the Emilia-Romagna has a capacity less than 7.5 tonnes. These vehicles are mostly vans and small trucks running on either diesel or petrol. More precisely, according to the Italian Automobil Club (2010), over the last twenty years diesel engines have become far more common in LCVs than petrol engines. As result, the Emilia Romagna's LCVs fleet is characterized by an overwhelming majority of diesel vehicles, whose a relevant part is old and generates high emissions.

Figure 5.1 –Road transport by type of goods by in Emilia Romagna – 2007 (%  on weight)




| | |
|---|---|
| | **Macrocategory 1**: Agricultural products and live animals, foodstuffs and fodder |
| | **Macrocategory 2:** Oil, mineral fuels and petroleum products, crude and manufactured minerals |
| | **Macrocategory 3:** Metallurgical products, raw or mineral products, building materials |
| | **Macrocategory 4:** Fertilizers, chemicals, cellulose |
| | **Macrocategory 5:** Machinery and equipment, vehicles, leather, textile and clothing, miscellaneous articles |

Commodity aggregation of the 24 product groups of the international classification NST / R, adopted by Standard goods classification for transport statistics. Source: RER, 2011

### *4.1.2 Road transport and pollution in Emilia Romagna*

Despite the various air quality and cleaner air measures adopted in the past years by local authorities and regional government, ER maintains pollutant levels that threaten human health and ecosystems. Air pollution problems occurring in the Po Valley are generated by the combination of its geological and morphological make-up, the presence throughout the territory of historical cities characterized by high population densities, and mobility rates which are among the highest in Europe. Since late 90s, a substantial increase in the levels of pollution has been recorded, due especially to the presence of high concentrations of fine particulates (PM10). The health limit of 50µg/cm (set by directive 99/30/CE and included in Ministerial Decree n. 60/2002) was exceeded several times. The 2009 average PM10 concentration recorded in the region’s urban areas was 39 µg/mc; 8 provincial cities exceeded the yearly threshold set by legislation to protect public health at 40 µg/mc, in the period 2005-2009 (> 35 times).

In almost all the cities of the Emilia-Romagna region PM10 concentrations decreased between 2005 and 2009, as shown in figure 5.3, although the cities of Bologna, Reggio Emilia and Parma exceeded the 35 limits threshold value throughout the same period (see fig. 5.2).

Figure 5.2 Exceedance days the of $PM_{10}$ threshold in Emilia Romagna cities – Annual basis

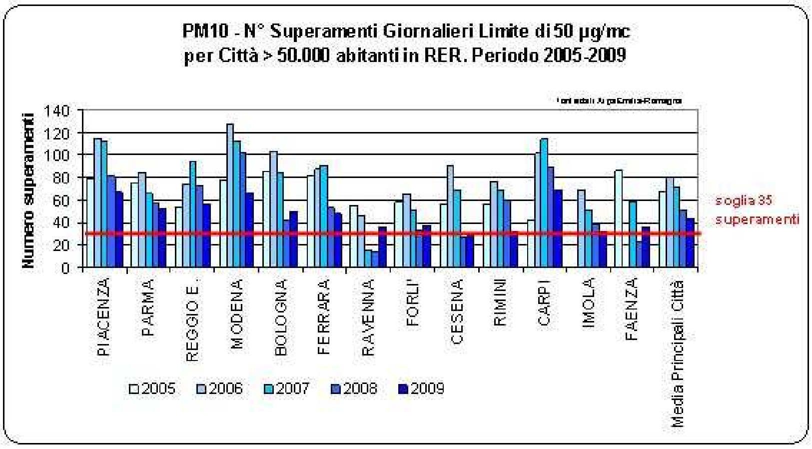
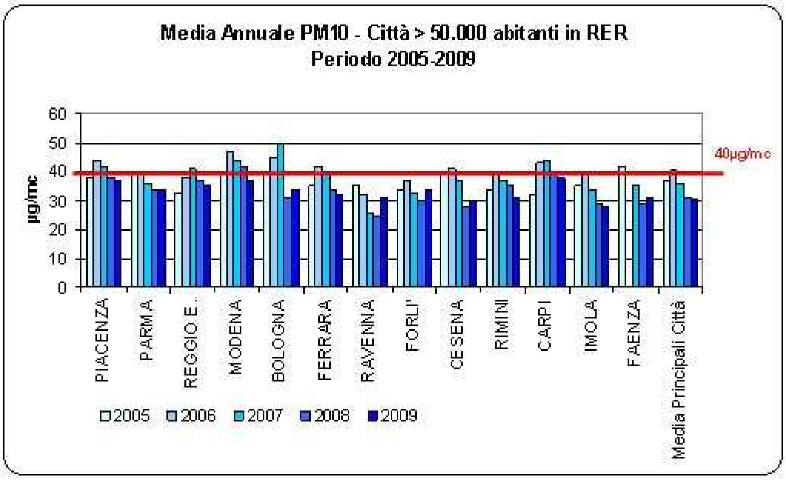


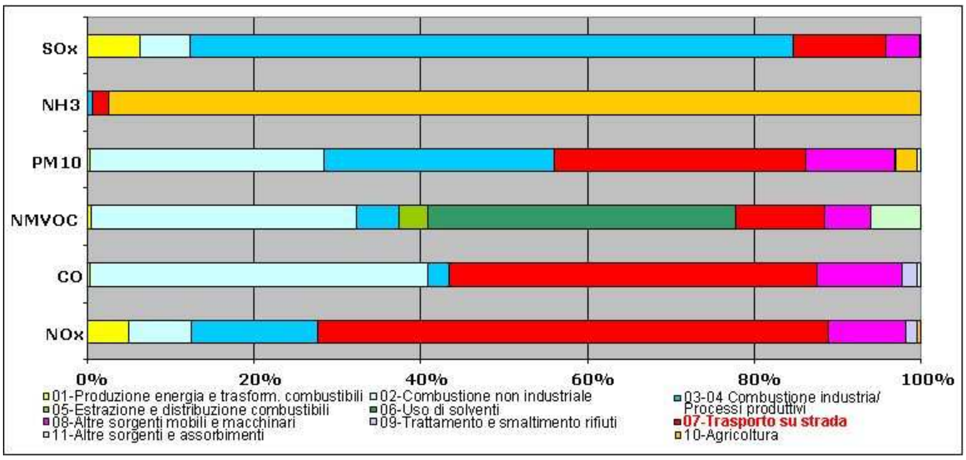

Figure 5.3 Average annual concentration $PM_{10}$ in Emilia Romagna cities




Source: ARPA, 2010

In ER, transport activities in total are one of the most significant contributor to ambient air pollution as indicated in figure 4.5 by the red segments. With regards to NOx, CO and PM 10 emissions, road vehicles are the dominant source of transport pollutants, because of their numbers and their use throughout the main population centres.

Figure 4.5. Air pollutants source by type of human activities in Emilia Romagna




Source INEMAR 2007, PRIT 2010-2020

The road traffic pollution is generated by 3 main sources (Citeair, 2005):

- *local traffic* causes an average 20% of total PM10 emissions in urban areas;
- *sources within the area* as non-local traffic, heating, etc. generate 24% of total PM10 emissions;
- *causes outside the area*, i.e. industrial plants, thermoelectric stations, traffic, etc.. are responsible 56% of total PM10 emissions.

Local traffic is generated private cars, public transport and commercial vehicles. Here we focus on the commercial vehicles transporting goods within the city.

### *3.1.3 Urban traffic in Parma and Bologna*

The two selected cities have a set of similarities dealing with the urban morphology and the urban freight traffic issues: both cities have an urban plan dating back to the Middle Ages, and the road structure is not geared to today's traffic volume. Congestion, street hazards, air and noise pollution are the negative effects of this traffic volume which pose a threat to the living environment of the city centre. The urban areas are characterized by high incidence of small traders and outlets who are not part of a regional/national business with a dedicated and sophisticated supply chain and who often use informal logistics activities.

Parma and Bologna’s city centres are undergoing a “retailing renaissance” and current transport infrastructure are unable to cope with the resultant increase in freight. In fact both urban areas are suffering from delivery problems (e.g. poor vehicle access, significant traffic congestion, constrained loading/unloading facilities).

The two urban transport systems have a common shape, with regard to specific features:

- Nearly 90 per cent of the commercial vehicles belong to the 3.5 tons maximum weight category, the others are above; only a small percentage consists of heavy- vehicle traffic (28 tons, 44 tons total), which occurs not only in sub-urban and industrial areas, but is also related to the food-store delivery into residential areas.
- The average daily delivery volume is very differentiated: while small retailers are going to be served only twice to five times a day (e.g. grocery stores), big food outlets tend to be delivered 15 to 25 times a day, dependent on the size and the diversity of the goods supply. Supermarkets are the most frequented retail locations with about 30-40 commercial vehicles trips a day.
- The transport function for the food supply system is served by: (i) transport operators and logistic providers (nearly 30%),(ii) suppliers and wholesalers delivering in own account (more than 50%), retailers themselves (20%).

## 5.2 Parma's food system

The second city in Emilia-Romagna, Parma is a historical city with 190'000 inhabitants, located in northern Italy between the Po River and the Apennine Mountains. Its economy is mainly based on the agri-food sector and it is well-known as the capital of Italy's "food valley", where traditional, high quality food products as *Parmigiano Reggiano* and *Prosciutto di Parma* are produced. It is an important rail and road junction on the main routes from Milan to Bologna, being a line of traffic which carries one –third of goods passing through Italy.

### *5.2.1 The urban food demand*

To estimate the demand of food expressed by the city in a working day, the number of consumers is considered. The flows of permanent and temporary residents, city users and tourists is calculated through the official Municipality population figures and officers interviews. As a result, the total estimated number of people flows within Parma's city area is about 240.000 people (see Table 5.2), purchasing in the city at least one meal.

Table 5.2 Parma's people flows, 2009

| **Population group** | Total food (kg/day) | Percentage |
|---|---|---|
| Residents | 184.460 | 76,9 |
| Temporary residents | 21.000 | 8,8 |
| City users* | 33.000 | 13,8 |
| Turists | 1.200 | 0.5 |
| Total | 239.660 | 100% |

* Net of commuters, hiving off residents commuting to the peri-urban area

Source: our elaboration on Municipality of Parma data, official statistics and secondary sources, 2009

According to my estimation, figures of people eating at home are the daily amount of food are 157.377, while people eating out of home a meal per day in Parma are about 82.280, including all city users and a share of city dwellers. I estimate their total amount of purchased food is 109 tons.

Table 5.3 Out of home /At home consumption food demand by Parma city groups- 2009

| People flow | | Purchased food per capita (Kg) | Purchased food per group (ton) | Total amount per type of consumption (ton) |
|---|---|---|---|---|
| City dwellers eating at home (all day) | 157.382 | 2,650 | 417 | 482,3 |
| City dwellers eating at home (one meal) | 49.280 | 1,325 | 65,3 | |
| City dwellers eating out of home (one meal) | 49.280 | 1,325 | 65,3 | 109 |
| City users eating out of home (one meal) | 33.000 | 1,325 | 43,7 | |
| | | | Total | 591,3 |

Source: own elaboration

### *4.1.3 The food supply*

In Parma, there is a significant presence of registered food commercial activities within the city limits.

In particular, the independent food retailers and food services are widespread and greatly vary for management structure, size, and food products selection high, having different features according to the geographical location. Thus, in the inner-city there is high concentration of small grocery stores, while in the suburban neighborhood there are higher presence of supermarkets. The presence of farmers markets and farmers shops is increasing, but still it remains a niche market for the Parmesan dwellers.

At district level, the food selling areas per 1000 inhabitants is 393,96 $m^2$. Concerning the retail chain sector, particularly relevant in 2009 have been the increases of discounts and superettes selling areas (respectively + 26,4 and +5,5 % ). Additional information are gathered by the RER studies on the food distribution system and resumed in table 5.4.

Table 5.4. Retail surfaces share within Parma city limits

| Type of point of sale | % |
|---|---|
| Hypermarket | 20% |
| Hyper < 6.001 $m^2$ | 20% |
| Hyper > 6.000 $m^2$ | 0% |
| Supermarket | 49% |
| Super <800 $m^2$ | 12% |
| Super 800 - 1.299 $m^2$ | 11% |
| Super 1300 - 2.499 $m^2$ | 12% |
| Super > 2.499 $m^2$ | 14% |
| Discount | 12% |
| Superette | 14% |
| Specialized | 6% |
| Total | 100% |

Source: Osservatorio del Commercio - RER, 2010

The independent retailers are recorded in the Municipality register of commercial activities as “free service business” (*libero servizio*) and include food outlets with a business area smaller than 250 $m^2$. In Parma, as in many other Italian cities, in the past decades they constituted the main food provisioning channel for city dwellers and, even if the corporate retailing is increasing market share, the local independent system market has a steady presence in the market in Parma supply reaching the 41% of whole food business area (Osservatorio del Commercio - RER, 2010). As result, there are still 850 independent food outlets within the city limits (see figure 5.5).

Table 5.5 Parma’s independent food retailers

| Size of store | N. |
|---|---|
| Store < 150 $m^2$ | 811 |
| Store 151 – 250 $m^2$ | 39 |
| Total | 850 |

Source: Municipality of Parma, 2009

Data on out of home food consumption expenditures account for slightly over one/fourth of total food expenditures. This results in growing presence of “eating and drinking places”, as hotels, restaurants and cafés, playing a relevant part of economic activities provided to Parma city dwellers and city users. As shown in table 5.6 the number of food services within the city limits is 806 (2009).

Table 5.6 Parma’s Ho.Re.Ca. - 2009

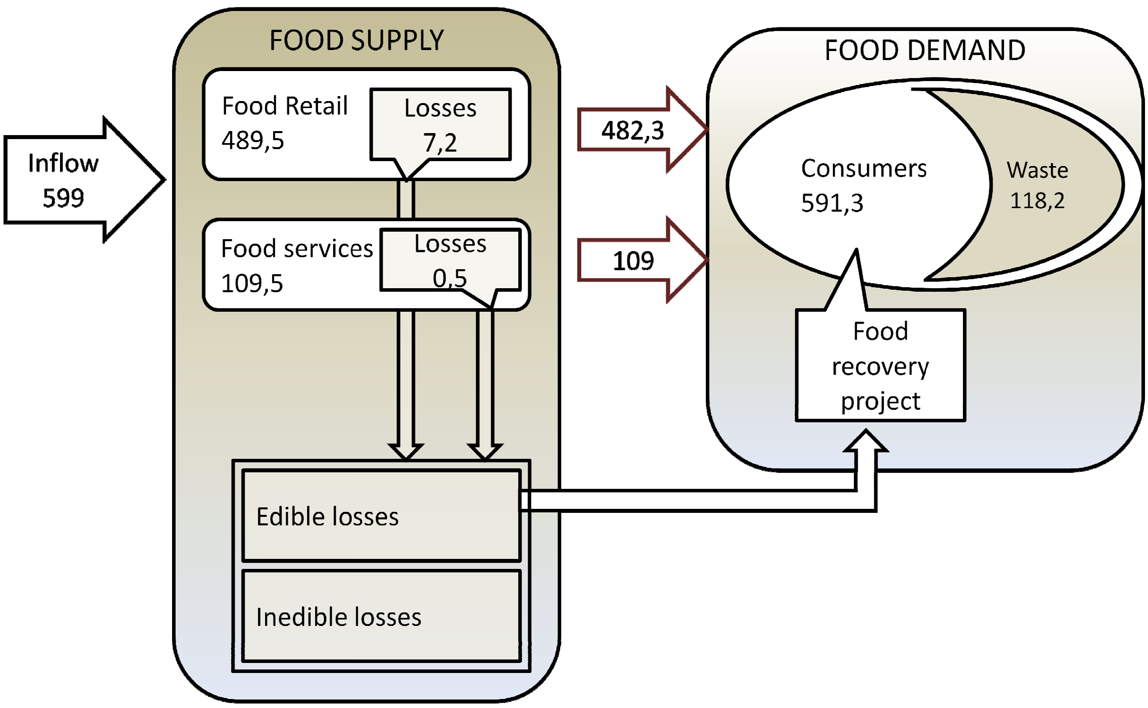
| **Ho. Re. Ca. category** | N. |
|---|---|
| Café (bar, pastry store, pub, etc.) | 487 |
| Restaurant (pizza, burger, etc.) | 213 |
| Hotel | 106 |
| Total | 806 |

Source: Municipality of Parma, 2009

### *5.2.2 Parma’s food metabolism*

Figure 5.5 shows the estimated mass of food associated with each flow described above. The Parma’s daily food demand is about 591,3 tons, whose about the 82% is food to be consumed at home. No significant agriculture takes place within Parma, in fact only four acres within the city are used for agriculture. Therefore self-production and food products from home gardening is not included in this representation of food flows. The urban food supply channels provides to the population this amount of food and even more, due to the physiologic and non-physiologic losses occurring in both the retailing and catering systems. The full amount of food circulating in the city is thus 599 tons reaching the points of sale or the processing sites with commercial vehicles.

Figure 5.5 Parma’s urban food metabolism - 2009



Source: own elaboration

The methods were used to estimate each flow are described in the previous chapter. Note that this flowchart includes the food recovery projects, that provide surplus of food in food outlets to certain groups of consumers. (i.e. low income population). No estimation of recovered food is reported, due to the fact there are no available data on this flows for the city of Parma.

## 5.3 Parma food transport performance

In this section we describe the performance of freight vehicles operating within the city limits, assessing the efficiency of freight movements, and estimating load factors and empty vehicle-km. The features of intra-city food transport of both the independent retailers and Ho.Re.Ca. supply chains are investigated, representing about the 37% of the full amount of circulating food products in the distribution system.

Tables 5.7 and 5.8 show the logistics and technical variables for the Parma's independent retailing and Ho.Re.Ca. supply system. Depending on size of business and type of food products transported (fresh, dry, etc.), frequency, weight and timing of the delivery vary. However these distribution systems present similarities, and, in some cases, they merge together, i.e. a local producer delivering by his own food products to restaurants and grocery stores.

Table 5.7 Parma's food transport details. Independent retailers food supply chain (dry, fresh food product)

| Macro- variables | Variables | Details |
|---|---|---|
| Logistics variables | Frequency requested by receivers | Average: 1,6 delivery per day |
| | Load unit | Food products are mostly loaded on vehicles in boxes, and also in pallets, rolls. Each parcel weights on average 13,5 kg. |
| | Delivery features | N. of deliveries /trip: 5<br>Weight of each delivery: 115 kg |
| Technological and organizational variables | Typology of vehicles | Diesel LVGs (up to 3.5 tonnes gross weight) distribute 97% of total food flows to independent retailers and Ho.Re.Ca. businesses.<br>75,2% of LVGs are engine emission standards Euro 2,3,4 |
| | Delivery period | Deliveries are carried out during in the morning:<br>Peak's hour: 7-8am |
| | Level of logistics optimization | Average (A/R): 25% of loading capacity |
| | Carriers typology | 92% own account and self-provisioning |
| | Nodes of the supply chain | Warehouses of wholesalers, Parma freight platform, cross-dock facilities and wholesale market.<br>Mostly of the nodes are located within 50 km from the city center. |

Source: primary data, City ports (2005)

By this analysis, I observe that:

- most of receivers asks for deliveries between 3 times per week and every day;

- about 55% of LVGs uses approximately 20% of their loading capacity on their way out, 15% only is over the 60% of loading capacity;

- high percentage of on own account (suppliers distributing their goods) and self provisioning (i. e. retailers picking up from the wholesaler). Third party logistics and transport operators not relevant for these supply chains;

- most of trips originate in the Parma's district, from terminals and facilities located within 50 km by the city center.

According to these data, two main differences occur among the two supply chains: (i) the quantity of food per delivery and (ii) the scheduling of deliveries. Concerning the amount of food transport, the average weight of each parcel and each delivery is smaller for Ho.Re.Ca. businesses than independent retailers. This can be explained by the fact that cafés, bars and restaurants usually have limited stocking space and request fresh products with high frequency, thus each deliver consists in a limited quantity of food products, comparing to the volumes requested by the grocery stores.

In both systems, deliveries are mostly concentrated in the morning, however a slight shift in peak hour time is observed: independent retailers prefer scheduling deliveries between 7 and 8 am, while Ho.Re.Ca. schedule a significant number of deliveries between 8 and 9 am. Most likely the receivers asking for this timing are restaurants, which start processing food products later on the morning. This difference of delivery pattern can be a relevant benefit in consolidating and multi-drop delivery operations.

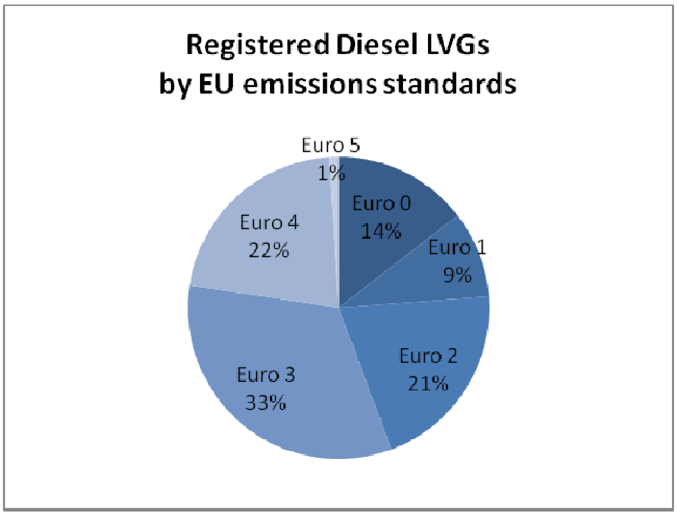
Table 5.8 Parma's food transport details – Parma Ho.Re.Ca. food supply chain (dry, fresh food product)

| **Macro- variables** | **Variables** | **Details** |
|---|---|---|
| Logistics variables | Frequency requested by receivers | Average: 1,8 delivery per day |
| | Load unit | Food products are mostly loaded on vehicles in boxes, and also in pallets, rolls. Each parcel weights on average 4,5 kg. |
| | Delivery features | N. of deliveries /trip: 4<br>Weight of each delivery: 45 kg |
| Technological and organizational variables | Typology of vehicles | Diesel LVGs (up to 3.5 tonnes gross weight) distribute 97% of total food flows to independent retailers and Ho.Re.Ca. businesses.<br>75,2% of LVGs are engine emission standards Euro 2,3,4 |
| | Delivery period | Deliveries are carried out during in the morning:<br>Peak's hour: 8-9am |
| | Level of logistics optimization | Average (A/R): 25% of loading capacity |
| | Carriers typology | 92% own account and self-provisioning |
| | Nodes of the supply chain | Warehouses of wholesalers, Parma freight platform, cross-dock facilities and wholesale market.<br>Mostly of the nodes are located within 50 km from the city center. |

Source: primary data, City ports (2005)

Most of the food transport operations are carried out with vehicles of relatively small capacity that can travel along any street in the city-center area to perform the required distribution activities. These LCVs may be of several types in terms of functionality (e.g., refrigerated or not), box design, loading/unloading technology, capacity, and so on. The most relevant aspect to this investigation is the type of engine and related emissions standards. The Parma LCVs fleet has an overwhelming share of diesel engine vehicles, whose 76% have been registered having emissions standards are Euro 2,3,4 (see figure 5.6).

Figure 5.6 Parma's light commercial vehicles fleet, 2009




Source: ACI, 2009

## 5.4 The urban freight distribution governance

The Municipality of Parma set up a communication and support process with local key players interested in the urban freight distribution system, and especially in food transport. By creating a strong stakeholders partnership among trade associations, logistics companies, transport operators, suppliers, producers and local retailers, the local government aimed at defining an effective scheme suitable to everybody's needs. As results, all the interested parties concerted new regulations and signed the "Protocol agreement for air quality – Rationalization of urban goods distribution", in December 2005.

On the basis of this agreement, the Municipality of Parma has taken several initiatives to force back the number of commercial vehicles in the city centre (*cerchia dei bastioni*) with the aim of protecting the quality of the living environment. The urban planners pursued specific objectives :

- to reduce the air pollution, greenhouse gas emissions, waste and noise to levels without negative impacts on the health of the citizens or nature;

- to improve the resource and energy efficiency and cost effectiveness of the transportation of goods, taking into account the external costs; and
- to contribute to the enhancement of the attractiveness and quality of the urban environment, by avoiding accidents, minimizing the use of land, without compromising the mobility of citizens.

The policy of improvement the urban accessibility and sustainability centres in two main issues: (i) reorganizing the overall regulation concerning both transit and parking of freight transport within the inner center, and (ii) promoting the rationalization of the urban distribution of goods based triple bottom sustainability, with special focus on urban food products transport.

### 5.4.1 *Defining the project*

The discussion and planning actions have been managed by a *Monitoring Committee* including the private and public sectors, i.e. Trade Associations. Based on the wish to facilitate a constant and high quality food supply to the city centre, the thought arose that a city distribution centre would be an attractive alternative for transport companies that were unable to deliver complying with the traffic limitations or that did not want to drive into the crowded city centre anymore. Shop keepers and other entrepreneurs in the city centre would also be able to profit from a city distribution centre by moving their storage elsewhere and having their goods delivered on call. As a result, the designing of urban distribution center and the urban delivery services took place during the period 2005-2006, under the name *Ecocity*.

The Municipality of Parma identified the “Centro Agro-Alimentare e Logistica”(CAL), the wholesale produce market authority[21], as body able to manage “last mile” goods distribution in respect to the sustainability criteria adopted by the committee. CAL has been selected as Ecocity leading actor considering its strategic location in the urban area, its perishable goods logistics competences and the opportunity to use the existing facilities of the wholesale market, which were not fully in operation. This aspect is strongly relevant due to the limited public financial resources and to the absence of available land within the city area.

### *5.4.2 The role of wholesale produce market in the logistics project*

CAL operates as wholesale market manager and, since Ecocity project started, as logistics provider. This company was created to deal with the management of produce supply for the city of Parma and, therefore, to handle the additional services, i.e. food logistics and transport operations at urban level, which are complementary to the mere marketing functions. The mission of CAL has thus been revised: beside the

[21] The wholesale produce market of Parma is geared by the center for food and logistics “Centro Agroalimentare e Logistica (CAL), which is a semi-public company born in 2007, whose major shareholders are: Municipality of Parma, the District of Parma, the Region of Emilia-Romagna, the Chamber of Commerce of Parma, the bank “Cassa di Risparmio di Parma e Piacenza” and “Banca del Monte”.

former objective of ensuring food security, transparency, access and availability, there is a stronger commitment in supporting urban retail trade and promoting environmentally-friendly logistics.

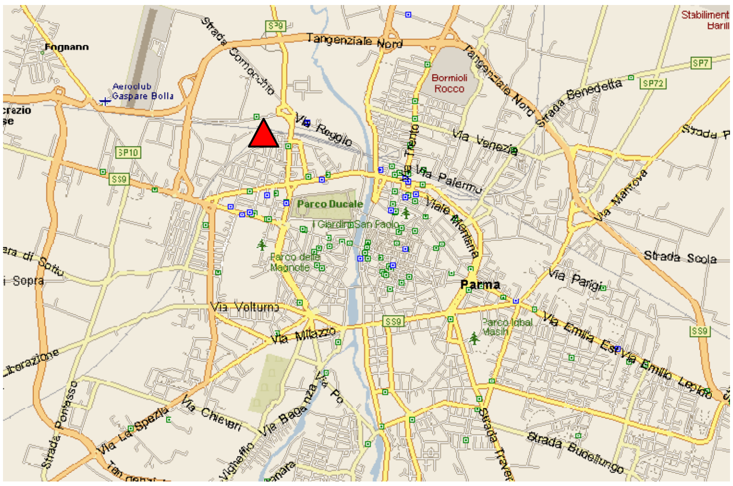
Moreover, thanks to its renewed services, CAL plays a crucial role in enhancing the networking activities among the various actors of food supply chain and food transport system, enhancing the information and communication activities at different stage of the provisioning system. Moreover corporate retailers have progressively been integrated within the CAL customers, enhancing interconnections among traditional operators and modern retailing companies.

## 5.5 The Ecocity project

Ecocity started in 2006 as a voluntary scheme with the purpose of providing consolidated delivery to retailers and businesses in the urban area. Rather than a new consolidation center being set-up, the existing distribution facilities of the wholesale produce market of Parma are used. Ecocity provides a delivery service to the businesses located both in the historical center and in the whole urban area. It captures a significant part of the freight flows of fresh food, dried food, Ho.Re.Ca goods, and also clothes, and packaged goods. There are about 250 shops, restaurants, hotels and bars which receive 40 tons/day of food products within the city.

CAL is located very close to the area which it serves, near the strategic road network, beside the northern bypass and 5 km to the Parma city center, as shown on the map below. It is well located with respect to the local traffic situation as it enables to easily reach the highway Milano-Bologna.

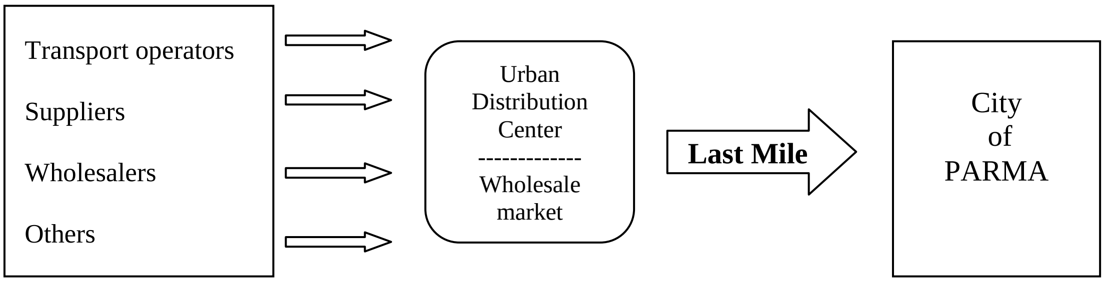
Figure 5.7 – Parma wholesale produce market's location




### *5.5.1 Organizational measures*

CAL is responsible for managing the logistic platform and the consolidation operations, providing the delivery services and coordinating the marketing activities related to the project. The CAL area has two platforms: one is dedicated to the wholesale produce market and it hosts 12 fruit and vegetables wholesalers. The second platform is the logistic centre, which has been realized on the premises of a former CAL facility, and include warehouses and cross-docks.

Figure 5.8 Ecocity urban distribution process




Source: own elaboration on Ecocity data

- *Hub and service organization*

All deliveries within the area served by Ecocity are made on vans (< 3.5 tonne gvw) with methane engine system so-called "BRC Gas Equipment" FASTNESS with MPI injection, compliant with the European Regulations R110Currently, suppliers and transport operators deliver to the CAL platform and then fourteen 3.5t vehicles are used to distribute goods from the CAL to urban area receivers. The management of the flows of the "last mile" is operated in a centralized manner by a the CAL team, while a cooperative is in charge of uploading and delivering operations. Whereas requested, the cold chain is guaranteed thanks to the refrigerated warehouses and the refrigerated vehicles.

Table 5.9 Ecocity service

| Operational and technical features | |
|---|---|
| Size of the hub | Indoor area of 1.500 m², ca. 100 m² of which refrigerated |
| Area served | - Main area: Central Parma<br>- Secondary area: Parma District |
| Businesses served (type and number) | - Ho.Re.Ca.<br>- Independent retail<br>- Corporate retail |
| Distance from CAL to main delivery target | 5 km average |

Source: own elaboration

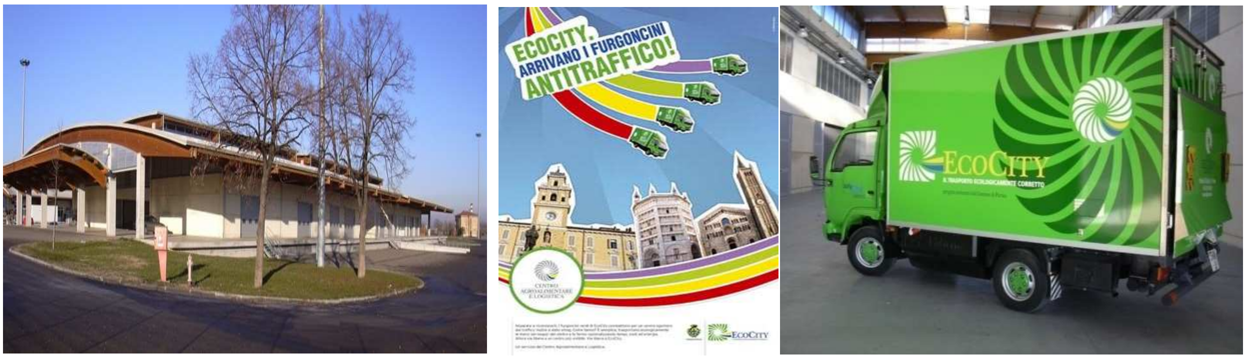
The major working area of Ecocity was to be the city centre of Parma. Since the customers asked for additional deliveries outside the historical center, the working area was soon expanded to the whole of Parma and the city's surroundings.

From an operational point of view, CAL renews the role of traditional wholesale market and plays as food hub in the urban food supply system. It provides 3 main complementary services to the Ecocity users:

1. synergies in logistic processes such as storage (incl. cooling), packaging, commissioning
2. provision of internal services such as customs, waste disposal services, information services, training and consulting
3. facilitate the presence in the market fresh and local produce, through the implementation of a specific certification managed by the CAL itself, the “Colto Fresco” label.

Whereas the primary focus of CAL platform is to consolidate loads on the inbound journey, if the transport operation is to be optimized it is equally important that vehicles returning to the UDC are as highly utilized as possible. To achieve this, waste recycling and reverse logistics operations are planned to be implemented.

Figure 5.9 The CAL platform. The Ecocity promotion flyer. The Ecocity vehicle




Source: CAL, 2009

- *Type and number of users*

The major food supply actors beneficiaries from the establishment of Ecocity are:

- transport operators making small, multi-drop deliveries
- independent and smaller retail companies
- businesses located in an environment where there are particular constraints on delivery operations (e.g. limited access conditions – physical or time related)
- corporate retailers with businesses in central areas.

After 3 years, Ecocity projects involves: 16 transport operators and carriers, 17 food manufacturers and suppliers (fresh and dry products), 7 corporate chain retailers, 10 produce wholesalers. The receivers are about 250 food businesses and food services, i.e. hotels, restaurants, cafés, grocery stores, corner shops, specialized stores, corporate retail points of sale (mostly superettes) which every day request fresh and dry food products.

### *5.5.2 Political measures*

Based on a literature review, it occurs that any form of urban distribution center that is not related to a major new development is unlikely to proceed let alone succeed, the political support is, thus, fundamental, especially in the first phases of the city logistics project.

- *Regulation in the historic center access*

In 2008, the Ecocity project was launched by the Municipality of Parma. Beside the creation of the urban distribution center, special traffic regulations have been identified to reduce the environmental pollution. The regulations include:

- restrictions on the road network usable in terms of routes for goods haulage, areas for loading/unloading vehicles etc.;
- restrictions on the times of the day when the road network is usable;
- restrictions on the vehicles usable to access those parts of road network as a function of vehicle dimension, loading capacity and emission factors;
- restrictions on the efficiency of transport whereby the access to those parts of road network is based on loading factors of the goods vehicles;

As result, the historical city is to be protected from the negative impact of vehicular traffic and cannot be entered by commercial vehicles that do not comply with specific criteria, as reported in table 5.9. All the commercial vehicles complying with the requirements are able to obtain the accreditation allowing to enter the restricted area. This certificate grants them the special right to deliver outside the given time-windows was made for one city distribution centre that was open to more shareholders.

Table 5.10 Municipality of Parma access criteria

| | Requirements to obtain Ecocity permit |
|---|---|
| 1 | Deliver fresh food, Ho.Re.Ca. (Hotel, Restaurant, Catering) parcels, clothes |
| 2 | Use eco-friendly commercial vehicles (e.g. methane, electric, bifuel) or at least vehicles Euro 4 |
| 3 | Use light vehicles (3.5 tons) |
| 4 | Guarantee high load factor of vehicles (at least 70% of vehicles' whole loading capacity) |
| 5 | Set up localization systems in order to allow vehicles' tracking and monitoring |

Source: own elaboration

The Ecocity scheme is based on a voluntary basis. Transport operators and suppliers have the opportunity to choose between the asking for their own permit or to entrust their goods to the Ecocity transport service.

- *Subsidies*

Investment costs are about 2 Mill EUR, covered by Region Emilia Romagna, District of Parma, Municipality of Parma, Infomobility spa. The initial funding from central, regional and local government have paid for the research work and pilot studies, the vehicles and equipments purchase. The project is now commercial viable. The breakeven point has been reached in 2010.

### *4.1.4 Technical measures*

The project includes data transmission systems, supported by satellite networks for the localization of the vehicles. The scope is to centralize the orders and, thus, to optimize the routes, the deliveries, the fleets and the loads, and so as to improve simultaneously the efficiency and the operational capabilities of the distributive system and to recover the cost of the load breakdown.

- *Information and communication technology*

The technological platform implemented by CAL is open and shared between the different key-actors involved in the urban logistic process to allow sharing, management and transferring in real time a lot of data and information among the different actors. The integrate a web-based technological platform provides the management of real time information with most diffuse technologies for getting data from mobile devices (e.g. GSM, GPRS, GPS, WIFI).

- *Type of commercial vehicles*

The fleet of commercial vehicles is equipped with GPS, GSM and Bluetooth technologies in line with the regulations laid down by the Municipality for city distribution.

## 4.2 The environmental impact of urban food transport

The final objective of the work is to formulate with a high level of detail the calculation of the pollutant emissions related to urban food transport for independent food retailers and Ho.Re.Ca businesses in the city of Parma. This calculation stems from the previous modeling characterization of freight transport flows, as seen in tables 5.7 and 5.8.

Concerning the food transport system for the selected supply chains, the pollutant emissions are calculated for two scenarios: *before* and *after* two years by the implementation of Ecocity project. Type of vehicles used, the distances travelled by them, their average speeds and the number of stops they make are determinants included in the model to estimated the emissions by road transport, according to the methodology Copert 4 (as described in the previous chapter).

The baseline scenario is developed in order to realistically represent urban food transportation. According to my model, everyday in Parma 616 Diesel LCVs circulate within the city limits delivering the food products to Ho.Re.Ca. outlets and independent retailers.

Table 5.11 Food transport emissions (independent retailer & Ho.Re.Ca.) before Ecocity –per year

| | CO | NOx | VOC | PM |
|---|---|---|---|---|
| ehot conv | 1,1241 | 1,673 | 0,1306 | 0,28492 |
| ehot eur1 | 0,3928 | 1,1379 | 0,1306 | 0,0698 |
| ehot eur2 | 0,3928 | 1,1379 | 0,1306 | 0,0698 |
| ehot eur3 | 0,322096 | 0,955836 | 0,080972 | 0,046766 |
| ehot eur4 | 0,25532 | 0,773772 | 0,030038 | 0,02443 |
| ehot eur5 | 0,25532 | 0,557571 | 0,030038 | 0,001396 |
| ecold/ehot | 1,48 | 1,118 | 1,84 | 1,7 |
| ehot per year | 8.211.865,13 | 19.787.855,07 | 1.689.924,30 | 1.531.699,76 |
| ecold per year | 1.773.762,87 | 1.050.735,10 | 638.791,38 | 482.485,42 |
| **TOT (gr)** | **9.985.627,99** | **20.838.590,17** | **2.328.715,68** | **2.014.185,18** |

Source: own elaboration

The Ecocity scenario is developed on the basis of the reduction of vans reached through the load factor optimization and the administrative limitations, taking into account the use of eco-friendly vehicles by Ecocity service. These deliveries would normally have been done by a commercial courier company, a supplier or the shop owner, involving the use of petrol or diesel engine vehicles and without consolidation operation. The resulting emissions estimates are reported in table 5.12.

Table 5.12 Food transport emissions (independent retailer & Ho.Re.Ca.) Ecocity 2nd year (2010)

| | CO | NOx | VOC | PM |
|---|---|---|---|---|
| ehot conv | 1,1241 | 1,673 | 0,1306 | 0,28492 |
| ehot eur1 | 0,3928 | 1,1379 | 0,1306 | 0,0698 |
| ehot eur2 | 0,3928 | 1,1379 | 0,1306 | 0,0698 |
| ehot eur3 | 0,322096 | 0,955836 | 0,080972 | 0,046766 |
| ehot eur4 | 0,25532 | 0,773772 | 0,030038 | 0,02443 |
| ehot eur5 | 0,25532 | 0,557571 | 0,030038 | 0,001396 |
| ecold/ehot | 1,48 | 1,118 | 1,84 | 1,7 |
| ehot per year | 6.157.266,34 | 15.494.812,23 | 1.283.517,05 | 1.080.575,75 |
| ecold per year | 1.329.969,53 | 822.774,53 | 485.169,45 | 340.381,36 |
| **TOT (gr)** | **7.487.235,87** | **16.317.586,76** | **1.768.686,50** | **1.420.957,11** |

Source: own elaboration

The comparison between pollutant emissions levels *before* and *after* the Ecocity implementation are presented in the following figures, showing the contribution of each supply chain to the air pollution.

Figure 5.10 Compared CO emissions

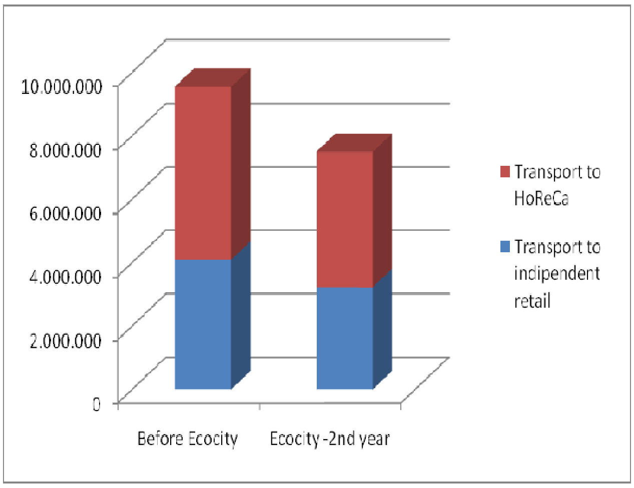



Figure 5.11 Compared NOx emissions

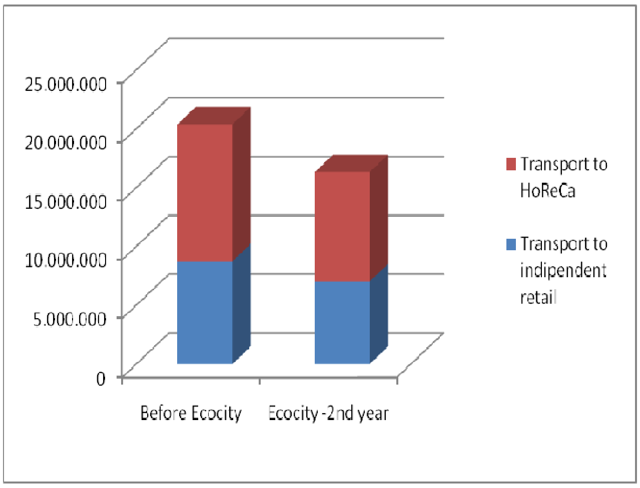
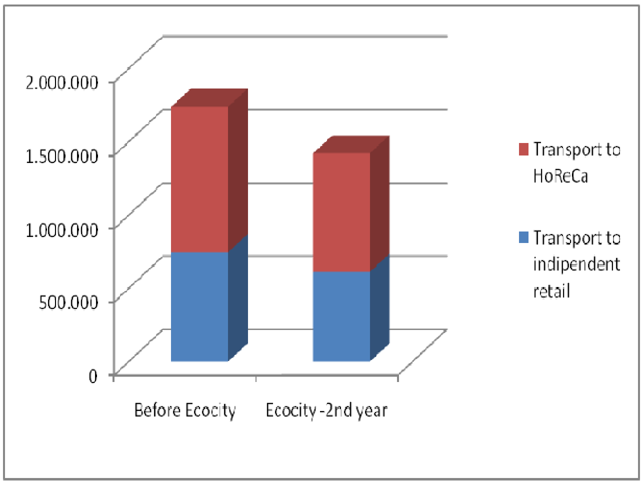



Figure 5.12 Compared VOC emissions


Figure 5.13 Compared PM emissions




Source: own elaboration

According to my scenarios, air pollution has decreased by a significant share compared to the food flow captured by the Ecocity service: the amount of food managed CAL is about 8% of the full amount of food circulating in Parma, while the decrease of pollutant emissions achieved through rationalization and eco-friendly delivery is estimated in a range of 22-29% , according to the different emissions. The most harmful emissions, PM and NOx respectively decrease of 29 % and 22% per annum.

Table 5.12. Emissions reductions - 2nd year Ecocity

| Pollutants emissions | |
|---|---|
| CO | - 25% |
| NOx | - 22% |
| VOC | - 24% |
| PM | - 29% |

## 5.6 Remarks on Ecocity project

Two years after implementation, it appears the Ecocity project reached some significant results in terms of pollution reduction and delivery scheme efficiency. These results have been obtained through to three main type of innovations:

- consolidation of good flows within the urban area, achieved through the set up of an urban distribution center within the wholesale market area;
- use of non (low) polluting vehicles;
- Municipality regulation focused on restricting certain activities on the basis of size, technological equipment, type of engine and load factor of the light commercial vehicles.

According to my findings, the Ecocity service offers greatest scope for those retailers, predominantly smaller stores, independent retailers and Ho.Re.Ca operators, who are not part of supply chains in which deliveries are already highly consolidated at distribution centres into full vehicle loads, since vehicles already carrying full-loads for a single retail outlet will not benefit.

However there are critical factors in the introduction of a logistics service as Ecocity, in fact there added costs due to the load breakdown, and issues concerning contractual continuity with the recipient of the goods. These aspects have been taken into account in the designing phase and have been overcome thanks to the strong commitments of all the involved stakeholders.

Finally, the most relevant advantages of this project are:

- a reduction of air pollution;
- the goods are transported to and from the city in environmentally friendly (electric) vehicles, geared to the size of the city centre streets;
- transport companies can deliver their goods at the edge of town, which makes them gain time.

# 6. Case study 2 – The city of Bologna

In this section we present the study case for the city of Bologna and its background context, then we describe the urban freight traffic performance for selected food supply chains. A baseline scenario is developed to estimate current pollutant emissions generated by the LCVs carrying food products to independent retailers and Ho.Re.Ca. operators in the urban area of Bologna. Finally, two optimization models are proposed, based on the implementation of a urban distribution center, which can potentially be located within the wholesale produce market area. These scenarios are developed to help explore potential effects of food products consolidation and low carbon transport solutions.

## 6.1 The city of Bologna

Bologna is the capital town of the northern-central region of Emilia-Romagna. The population consists of 377.000 inhabitants, and it is at the heart of a metropolitan area of about 1,000,000 inhabitants, located at the center of the Padana Plain. Considering the city and the satellite towns it is the seventh largest community in terms of population in Italy, with high density level. Economically, the district has an old industrialized vocation dominated by agro-food industries, machine tools, engineering, electronics, footwear, and textile. Bologna is also an important logistics center crossed by five major railway lines and four highways of Northern Italy, serving as a national and European hub for merchandise transit. There is also a long tradition in servicing small firms by professional forwarders and transporters, connected with the import-export activities.

Bologna is home to the one of the oldest universities in the world, University of Bologna, founded in 1088, hosting a large student body which takes part to the local social, economic and cultural life. The city has important retail and wholesale trade activities and one of the first Italian vegetable and fruit markets. The urban area is characterized by high concentration of specific topographic bottlenecks for transportation, typical of Medieval settlements layout with concentric rings areas and narrow streets.

## 6.2 Bologna's food system

### *6.1.1 The urban food demand*

The demand of food in a working day in the city of Bologna is estimated on the whole people flow, such as permanent and temporary residents, city users and tourists. Thus the total estimated consumers within Bologna's city area is approximately 494.300 people, purchasing in the city one meal or the entire daily food request depending on the type of population group, as shown in table 6.1.

Table 6.1. Bologna's people flows

| **Population group** | Total food (kg/day) | Percentage |
|---|---|---|
| Residents | 377000 | 76,3 |
| Temporary residents | 45000 | 9,1 |
| City users* | 70000 | 18,5 |
| Turists | 2300 | 0,4 |
| Total | 494300 | 100,0 |

* Net of commuters, hiving off residents commuting to the peri-urban area

Source: our elaboration on Municipality of Bologna data, official statistics and secondary sources, 2009

On the basis of the RER studies, most of the people purchase food to consume it at home. Approximately there are 424.300 people who purchase 981,3 tons of food products per day. I assume all city users and a share of city dwellers eat out of home a meal per day, as a result they are about 107.948 people, asking for 235,7 tons of food products, as shown in table 6.2. Although not all this food will be consumed, 18% is usually wasted by the households and goes to the landfill.

Table 6.2 Out of home /At home consumption food demand by Bologna city groups - 2009

| People flow | | Purchased food per capita (Kg) | Purchased food per group (ton) | Total amount per type of consumption (ton) |
|---|---|---|---|---|
| City dwellers* eating at home (all day) | 316.352 | 2,650 | 838,3 | 981,3 |
| City dwellers eating at home (one meal) | 107.948 | 1,325 | 143 | |
| City dwellers eating out of home (one meal) | 107.948 | 1,325 | 143 | 235,7 |
| City users eating out of home (one meal) | 70.000 | 1,325 | 92,7 | |
| | | | Total | 1.217 |

* "City dwellers" include people who overnight: permanent and temporary residents, and two or more nights sleeping tourists

Source: own elaboration

### *6.1.2 The food supply*

Within the city of Bologna there is wide supply of food through both retailing and catering channels, which respectively accounts 68% and 32% of sales area (Osservatorio del Commercio- RER, 2010). Concerning the corporate retailing system, most of food retailing sales area at municipal level is represented by hypermarkets and supermarkets (see table 6.3), located in sub-urban areas. Recently, big and small corporate retailers opened superettes in the inner center, with the aim of capturing the group of consumers that have not private vehicles or time to go shopping in the neighborhoods.

Table 6.3 Retail surfaces share within Bologna's city limits

| **Type of point of sale** | % |
|---|---|
| Hypermarket | 22% |
| Hyper < 6.001 $m^2$ | 0% |
| Hyper > 6.000 $m^2$ | 22% |
| Supermarket | 56% |
| Super <800 $m^2$ | 6% |
| Super 800 - 1.299 $m^2$ | 13% |
| Super 1300 - 2.499 $m^2$ | 29% |
| Super > 2.499 $m^2$ | 8% |
| Discount | 11% |
| Superette | 8% |
| Specialized | 3% |
| Total | 100% |

Source: Osservatorio del Commercio - RER, 2010

Within Bologna's city limits, there are 1.046. Independent retailers located, having a sales area under 250 $m^2$ and providing fresh, canned, dry, frozen food and fruit and vegetables A recent trend appeared in the independent retailing system, it is the high share of ethnic food outlets both the inner center and in neigh boroughs, replacing "mom and pop" grocery store and providing a wider choice in ethnic food products.

Table 6.4 Bologna's independent food retailers

| **Size < 250 $m^2$ stores** | N. |
|---|---|
| Corners shops, Small grocery stores, etc. | 1046 |

Source: Municipality of Bologna, 2009

Bologna represents a center of attraction for the peri-urban and regional population, due to the presence of the University, of a large number of companies and business services and a variety of entertainment attractions and shopping points. As a result, the city is characterized by a wide supply of "eating and drinking places": there are 300 hotels and 1815 sale points registered as cafés, pubs, bar and restaurants (see table 6.5).

Table 6.5 Bologna's Ho.Re.Ca.

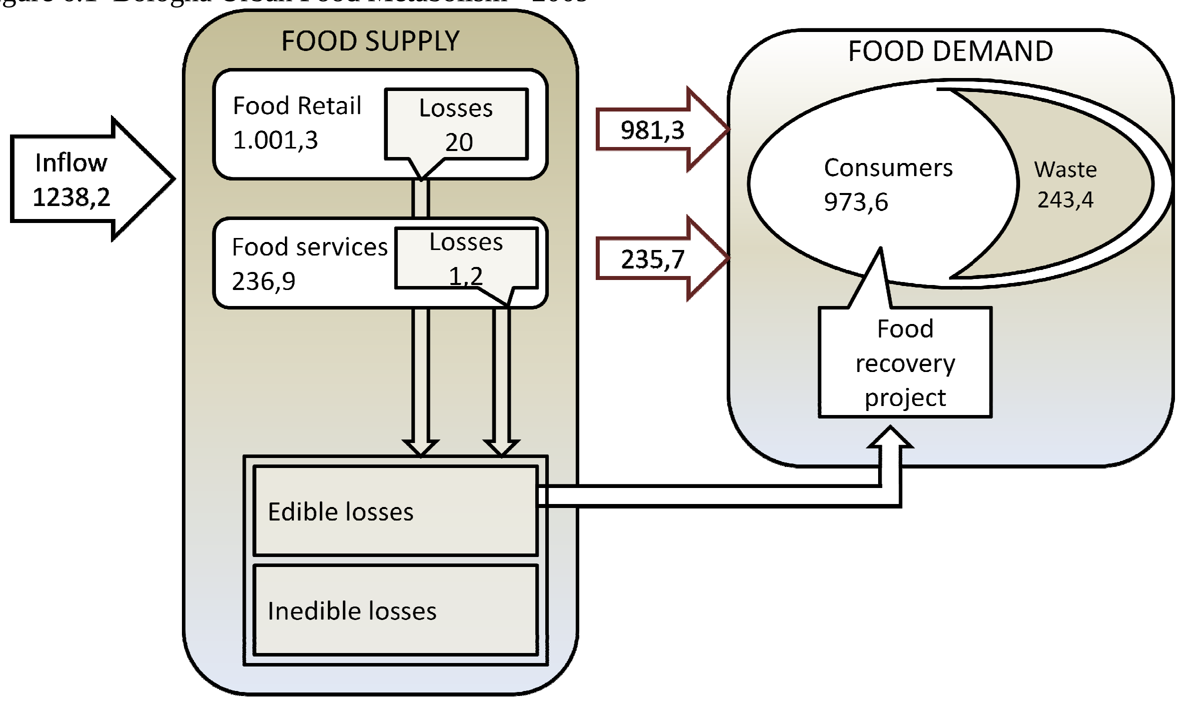
| Ho. Re. Ca. category | N. |
|---|---|
| - Cafés (bar, pastry store, pub, etc.),<br>- Restaurants (pizza, burger, etc.) | 1.815 |
| - Hotels | 300 |
| Total | 2.115 |

Source: Municipality of Bologna, 2009

### *6.1.3 Bologna's food metabolism*

Inbound food flows in a working day, identified as Bologna's food supply, is about 1240 tons. Figure 6.1 shows the estimated mass of food associated with each flow described above. The Bologna's daily food demand is about 590 tons, whose about 82% is food intended to home consumption. In Bologna, there is no significant agriculture, in fact only six hectares within the city are used for agriculture. Therefore self-production and food products from home gardening is not included in this representation of food flows. The urban food supply channels provides to the population this amount of food and even more, due to the physiologic and non-physiologic losses occurring in both the retailing and catering systems. The full amount of food circulating in the city is thus 599 tons reaching the points of sale or the processing sites with commercial vehicles.

Figure 6.1 Bologna Urban Food Metabolism - 2009




Source: own elaboration

The urban food metabolism of Bologna is presented in figure 6.6. The flows of recovered food is included in the representation even if there are not comprehensive data on the total amount of edible food that is redistributed through recovery projects[22].

## 6.2 Bologna food transport performance

The features of food transport of both the independent retailers and Ho.Re.Ca. supply chains are described in this paragraph. The food flows captured by these supply chains is about the 33% of the full amount of food products circulating in the urban distribution system. According to my findings, the food transport systems in Parma and Bologna present high similarities in terms of frequency, load unit, type of vehicles and delivery period. Three facts are although peculiar to the food delivery scheme to Ho.Re.Ca and independent in Bologna:

- 67% of the trips leave the point of origin with saturation < 25%
- only 12% of the trips have a loading optimization over 50%
- third party operators have higher load factor rate compared to own account operators.

Table 6.6. Bologna's food transport details. Independent retailers food supply chain

| Macro- variables | Variables | Details |
|---|---|---|
| Logistics variables | Frequency requested by receivers | Average: 5,4 delivery per day |
| | Load unit | Food products are mostly loaded on vehicles in boxes, and also in pallets, rolls. Each parcel weights on average 4,3 kg. |
| | Delivery features | N. of deliveries /trip: 10<br>Weight of each delivery: 43 kg |
| Technological and organizational variables | Typology of vehicles | Diesel LVGs (up to 3.5 tonnes gross weight) distribute 97% of total food flows to independent retailers and Ho.Re.Ca. businesses.<br>75,2% of LVGs are engine emission standards Euro 2,3,4 |
| | Delivery period | Deliveries are carried out during in the morning:<br>Peak's hour: 7-8am |
| | Level of logistics optimization | Average (A/R): 25% of loading capacity |
| | Carriers typology | 92% own account and self-provisioning |
| | Nodes of the supply chain | Warehouses of wholesalers, Bologna freight platform, cross-dock facilities and wholesale market.<br>Mostly of the nodes are located within 50 km from the city center. |

Source: own data, City ports (2005)

[22] Most of the recovery projects implemented in Bologna are managed by the academic spin-off Last Minute Market. Specific data on recovered food amount are available only for the projects using this model, other initiatives have not yet been monitored.

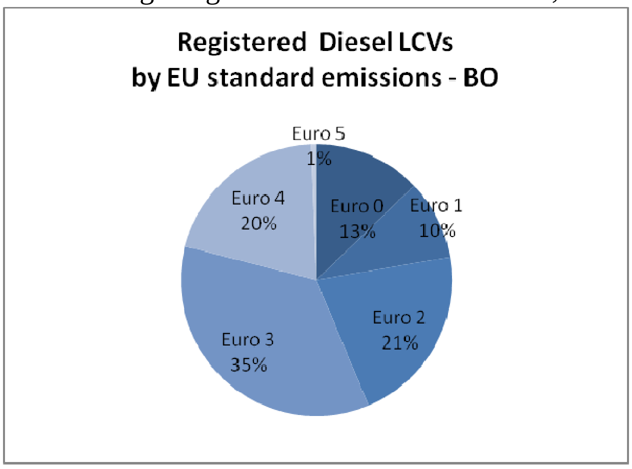
Table 6.7 Bologna's Food transport details –Ho.Re.Ca. food supply chain

| Macro- variables | Variables | Details |
|---|---|---|
| Logistics variables | Frequency requested by receivers | Average: 2,3 delivery per day |
| | Load unit | Food products are mostly loaded on vehicles in boxes, and also in pallets, rolls. Each parcel weights on average 2,3 kg. |
| | Delivery features | N. of deliveries /trip: 4<br>Weight of each delivery: 13,8 kg |
| Technological and organizational variables | Typology of vehicles | Diesel LVGs (up to 3.5 tonnes gross weight) distribute 97% of total food flows to independent retailers and Ho.Re.Ca. businesses.<br>75,2% of LVGs are engine emission standards Euro 2,3,4 |
| | Delivery period | Deliveries are carried out during in the morning:<br>Peak's hour: 8-9am |
| | Level of logistics optimization | Average (A/R): 25% of loading capacity |
| | Carriers typology | 92% own account and self-provisioning |
| | Nodes of the supply chain | Warehouses of wholesalers, Parma freight platform, cross-dock facilities and wholesale market.<br>Mostly of the nodes are located within 50 km from the city center. |

Source: own data, City ports (2005)

Delivering operations in Bologna presents similar patterns to the ones carried out in Parma, using a large number of vans which have a carrying capacity under 3,5 tons. Furthermore, the Diesel engine LCVs fleet circulating in Bologna has a composition similar to the Parma's one: emissions standards Euro 2,3,4 account for 76% of registerd vehicles (see figure 6.2).

Figure 6.2 Bologna light commercial vehicles fleet, 2009




Source: ACI, 2009

### *6.2.1 The urban freight distribution governance*

Comparing with some European cities, Bologna has the highest percentage incidence of the commercial vehicles on the whole moving fleet, as shown in table 6.8, and it accounts for 25% of local vehicles flows (using PCUs – Passenger Car Units). Moreover the road transport of goods traffic is responsible for 60% of NOx emissions (ARPA RER, 2010) at local level.

Table.6.8 Traffic generated by freight distribution, various cities

| City | Commercial vehicles per city over whole moving fleet |
|---|---:|
| Rome | 22% |
| Milan | 15-20% |
| Bologna | 25% |
| Basle | 18-24% |
| Hanover | 12% |
| Nuremberg | 15% |
| London | 11% |

Source: Curi, 2002

The Municipality has been involved over the last few years in policies intended to reduce traffic congestion, air pollution and noise, which affect citizens' lives, reflecting negatively on health and safety[23]. Selected actions have been adopted with the aim of improving citizens' quality of life, through specific objectives:

- to reduce air and noise pollution,
- to save energy in the transport sector,
- to achieve widely-available but sustainable access,
- to increase public transport and reduce private vehicles,
- to improve road safety,
- to encourage a more eco-compatible stock of vehicles.

In order to fostering Bologna's accessibility and rationalizing freight deliveries, the Municipality adopted the "City Freight delivery Plan" (2005), which mostly focuses on the inner city traffic area, where it has been created a Limited Traffic Zone (LTZ). The key developments are four:

1. enhancing management of city access permission release setting different rules for third party operators (carriers, logistic providers, etc.) and for operators delivering in their own (producers, shop owners, etc.) ;
2. fostering freight vehicle fleet conversion and/or introduction of new low emissions vehicles to reduce the environmental impact;
3. decreasing vehicles accesses through a rationalization of commercial vehicles loads and freight delivery routes;

[23] The integrated policy constitutes of a variety of strategies: "Air quality agreements with Municipalities, Districts and Region" (2003- 2009), "Urban Traffic General Plan" (2006), "Air quality special emergency measures" (2005), "Urban freight distribution" (2006), Van sharing project (2007).

4. rationalizing road occupancy, with specific load/unload areas.

Furthermore, the Municipality is working with the transport operators and trade associations, local logistics providers, Regione Emilia Romagna and a wide range of partners to implement the travel aims and policies of this plan. Partnership with the supply chain operators is especially important in implementing policy and enhancing the economic vitality of the city.

### 6.2.2 *New transport and logistics measures in Bologna*

To achieve the Municipality's vision of a sustainable city, the quality of Bologna's transport and infrastructures must be transformed and improvements in logistics services are needed. In particular, it is urgent to improve city users mobility within the city and efficiency on freight transport, to meet the growing demand of goods expressed by businesses in the metropolitan area of Bologna. Policy makers are thus adopting an integrated approach including transport and land planning issues, making major improvements in public transportation and tackling traffic congestion. To this end, the "Bologna Municipal Structural Plan" (Piano Strutturale Comunale - PSC) defines strategic principles driving urban development in the next fifteen years on the basis of: economic, social and cultural development; quality of life improvement; aware use of non-renewable resources. PSC identifies Seven Cities, namely seven main projects focused on different strategic measures, strongly interconnected and interdependent among others.

These measures aim at improve the accessibility to different urban spaces that are centre for local, national, international relations (railway station, airport, expo centre, business centres, wholesale produce market), in particular they focus on redesigning the urban flows among historic city, areas of new urban development, sub-urban districts, residential areas, logistics platforms, manufacturing and services areas. The objective is to put in place strategies to make best use of network capacity, encouraging transport operators to coordinate and optimize the delivery system.

Here I include three representations of Bologna strategic transport networks (see figures 6.3, 6.4, 6.) as defined by the PSC, where new developments of local railways and freight flows main routes are foreseen. In these plans we observe the Municipality's aim to ensure that suitable sites and facilities are made available to enable the consolidation and rationalization of flows through existing sites which have been renewed or, as second option, through new sites. Particularly relevant for this study is the progressive inclusion of the wholesale produce market business area within the urban transport networks.

Figure 6.3 The City of Railway – Bologna PSC

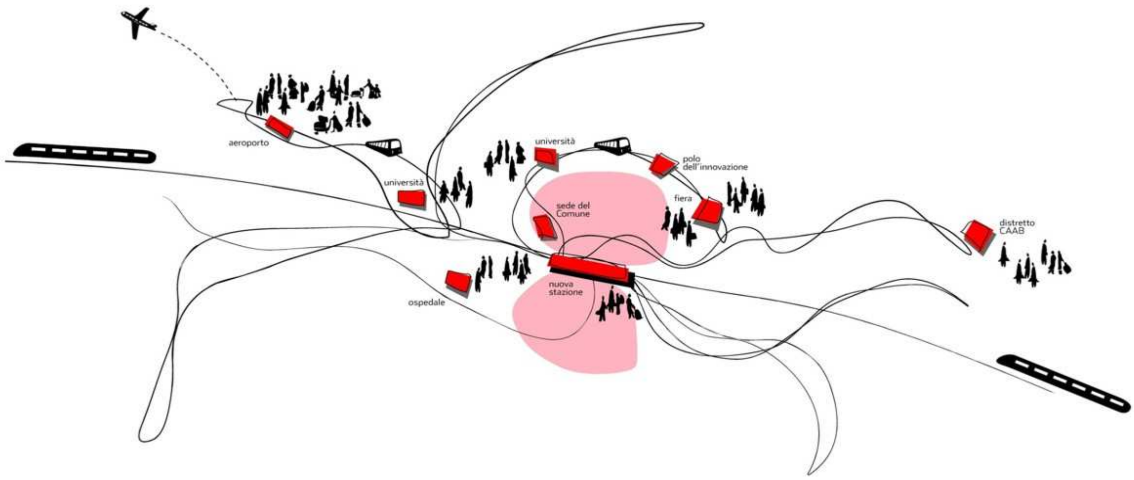



Figure 6.4 The City of Savena – Bologna PSC

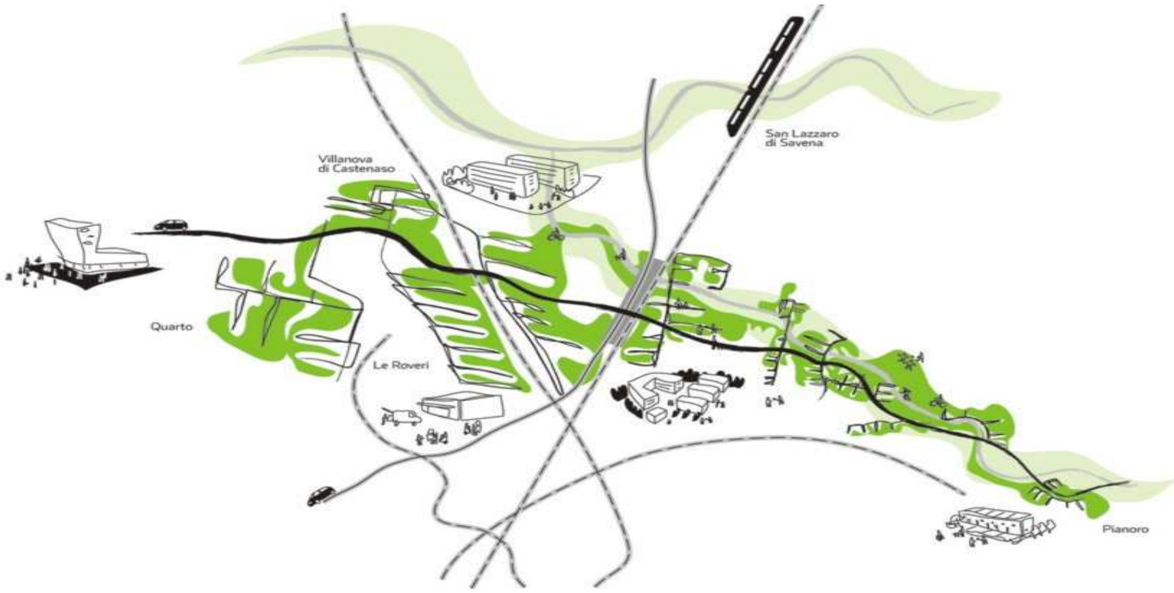
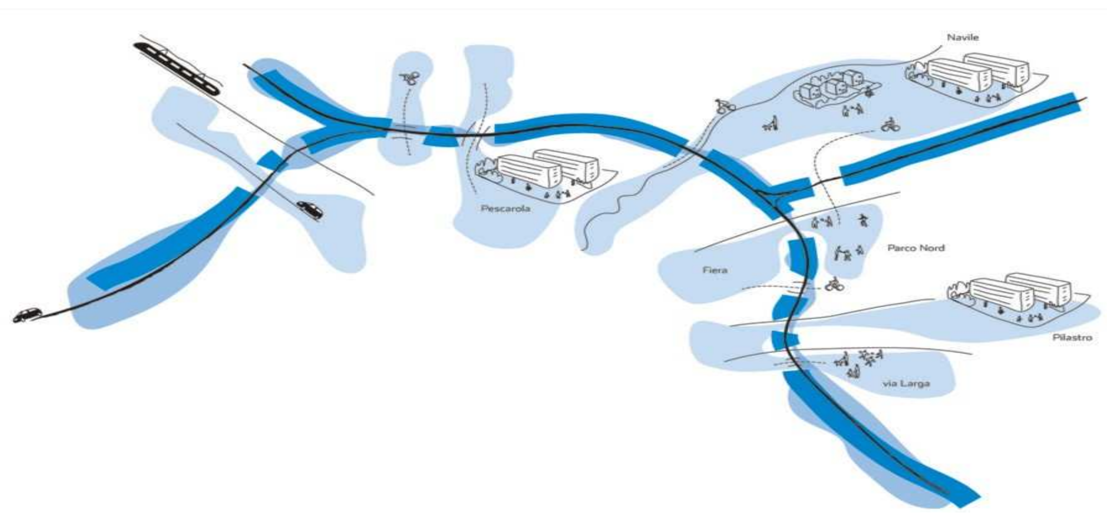



Figure 6.5 The City of By-PassRoad – Bologna PSC



*6.2.3 The potential role of the wholesale produce market*

The Agri-Food Centre of Bologna (CAAB) is the structure created to promote the wholesale trade of food and produce, as well as the related logistics services within the city of Bologna. It is a logistic platform and a centre of advanced services for the agri-food sector (picking, packaging, etc.). The wholesale facilities include refrigerated warehouses (4.300 m2), covered logistic platforms, backup structures, offices and support structures. 34 wholesalers, 6 cooperatives that group 200 companies, 80 agricultural businesses direct marketing, 2000 wholesale and retail customers. Besides wholesale and producers business area, CAAB also includes platforms for picking and supplying to corporate retailers.

CAAB plays a relevant role in the Bologna urban food supply system, and it covers functions intermediary at regional and national level by attracting and concentrating supply and demand, thus enhancing business and trade. With the aim of enhancing CAAB logistics role within the urban food chain services, wholesale market representatives drafted potential actions enhancing food distribution and transport efficiency for the city of Bologna (Caccioni, 2008).

Figure 6.6 CAAB entrance and market area


Source: CAAB, 2008

## 6.3 The environmental impact of urban food transport

The main objective of this preliminary study is to assess the current environmental quality in the city of Bologna (baseline scenario) and potential improvements resulting from two optimization scenarios. The first scenario foresees a limited optimization of loading factors for the Ho.Re.Ca and independent retailing supply chain, through deliveries consolidation, the operators partially improve (+8%) the loading factor of commercial vehicles. The second scenario adds to the first one the enforcement of traffic restrictions and the provision of technological incentives to enhance the food distribution with eco-friendly vehicles.

Type of vehicles used, the distances travelled by them, their average speeds and the number of stops they make are determinants included in the model to estimated the emissions by road transport, according to the methodology Copert 4 (as described in chapter 4).

The baseline scenario is developed on the available data in order to realistically represent urban food transportation. As results, it foresees 1719 diesel LCVs circulating within the city limits delivering the food products to Ho.Re.Ca. outlets and independent retailers.

Table 6.9 Food transport emissions (independent retailer & Ho.Re.Ca.) baseline scenario –per year

| | **CO** | **NOx** | **VOC** | **PM** |
|---|---|---|---|---|
| ehot conv | 1,1241 | 1,673 | 0,1306 | 0,28492 |
| ehot eur1 | 0,3928 | 1,1379 | 0,1306 | 0,0698 |
| ehot eur2 | 0,3928 | 1,1379 | 0,1306 | 0,0698 |
| ehot eur3 | 0,322096 | 0,955836 | 0,080972 | 0,046766 |
| ehot eur4 | 0,25532 | 0,773772 | 0,030038 | 0,02443 |
| ehot eur5 | 0,25532 | 0,557571 | 0,030038 | 0,001396 |
| ecold/ehot | 1,492 | 1,1232 | 1,876 | 1,74 |
| E hot annui | 23.229.389,63 | 57.156.138,55 | 4.938.429,00 | 4.271.214,98 |
| E cold annui | 5.142.986,86 | 3.168.736,32 | 1.946.728,71 | 1.422.314,59 |
| **TOT (gr)** | **28.372.376,49** | **60.324.874,87** | **6.885.157,71** | **5.693.529,57** |

Source: own elaboration

Table 6.11 Food transport emissions (independent retailer & Ho.Re.Ca.) Load factor optimization & technological subsidies

| | **CO** | **NOx** | **VOC** | **PM** |
|---|---|---|---|---|
| ehot conv | 1,1241 | 1,673 | 0,1306 | 0,28492 |
| ehot eur1 | 0,3928 | 1,1379 | 0,1306 | 0,0698 |
| ehot eur2 | 0,3928 | 1,1379 | 0,1306 | 0,0698 |
| ehot eur3 | 0,322096 | 0,955836 | 0,080972 | 0,046766 |
| ehot eur4 | 0,25532 | 0,773772 | 0,030038 | 0,02443 |
| ehot eur5 | 0,25532 | 0,557571 | 0,030038 | 0,001396 |
| ecold/ehot | 1,48 | 1,118 | 1,84 | 1,7 |
| ehot per year | 6.157.266,34 | 15.494.812,23 | 1.283.517,05 | 1.080.575,75 |
| ecold per year | 1.329.969,53 | 822.774,53 | 485.169,45 | 340.381,36 |
| **TOT (gr)** | **7.487.235,87** | **16.317.586,76** | **1.768.686,50** | **1.420.957,11** |

Source: own elaboration

According to my elaboration, the deliveries rationalization mechanism foreseen by the optimized scenario 1 can potentially generated a reduction of 16% of air pollution in Bologna's environment.

Table 6.10 Food transport emissions (independent retailer & Ho.Re.Ca.) Load factor optimization scenario & Technologic subsidies

| | CO | NOx | VOC | PM |
|---|---|---|---|---|
| ehot conv | 1,1241 | 1,673 | 0,1306 | 0,28492 |
| ehot eur1 | 0,3928 | 1,1379 | 0,1306 | 0,0698 |
| ehot eur2 | 0,3928 | 1,1379 | 0,1306 | 0,0698 |
| ehot eur3 | 0,322096 | 0,955836 | 0,080972 | 0,046766 |
| ehot eur4 | 0,25532 | 0,773772 | 0,030038 | 0,02443 |
| ehot eur5 | 0,25532 | 0,557571 | 0,030038 | 0,001396 |
| ecold/ehot | 1,492 | 1,1232 | 1,876 | 1,74 |
| E hot annui | 9.973.089,09 | 29.309.785,83 | 2.412.695,00 | 1.393.683,69 |
| E cold annui | 2.208.041,92 | 1.624.934,53 | 951.084,37 | 464.096,67 |
| **TOT (gr)** | **12.181.131,01** | **30.934.720,35** | **3.363.779,36** | **1.857.780,35** |

Source: own elaboration

The impacts reached through city logistics measures on urban food transport are presented in the following diagrams (see figures 6.7, 6.8, 6.9, 6.10).

Figure 6.7 Compared CO emissions

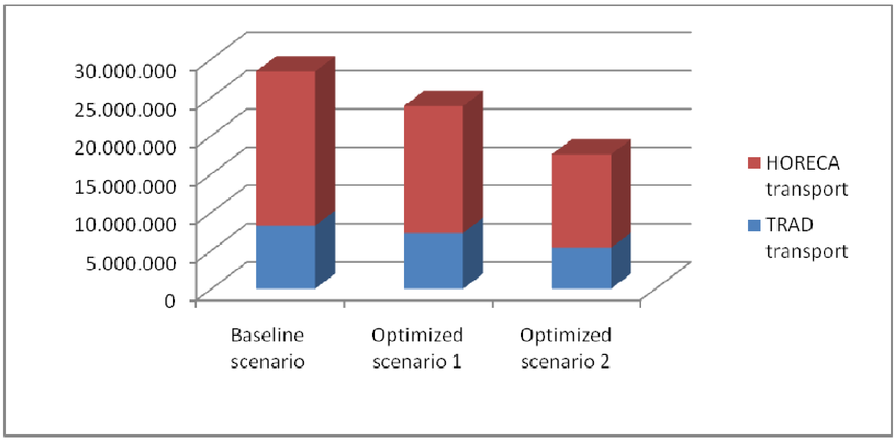



Figure 6.8 Compared N0x emissions

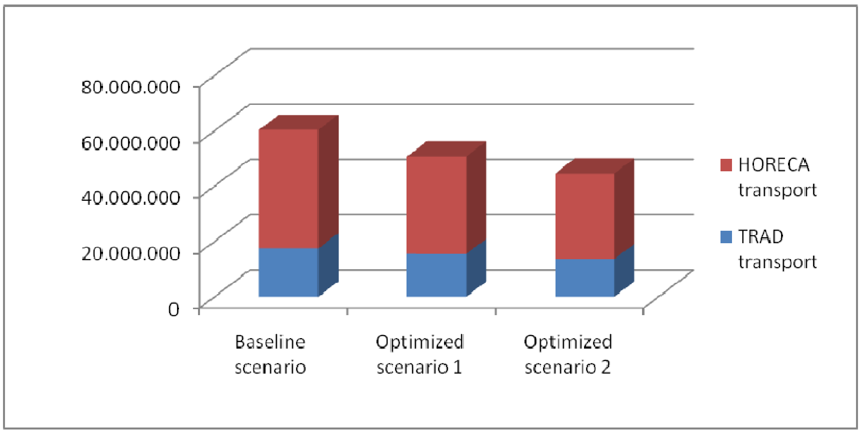


Figure 6.9  Compared VOC emissions

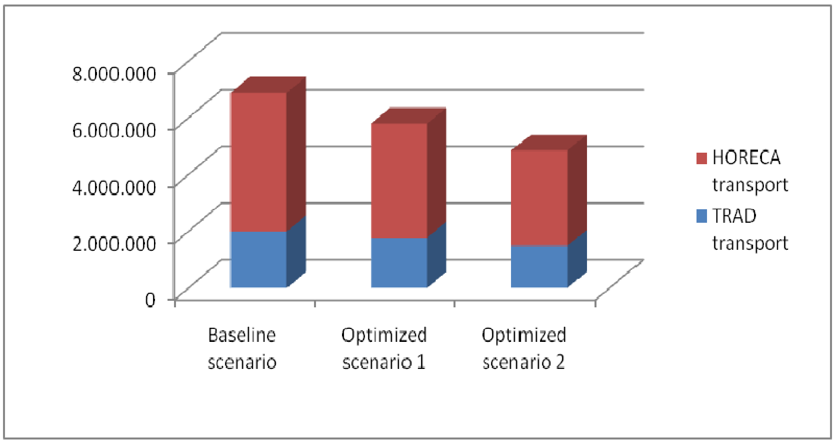
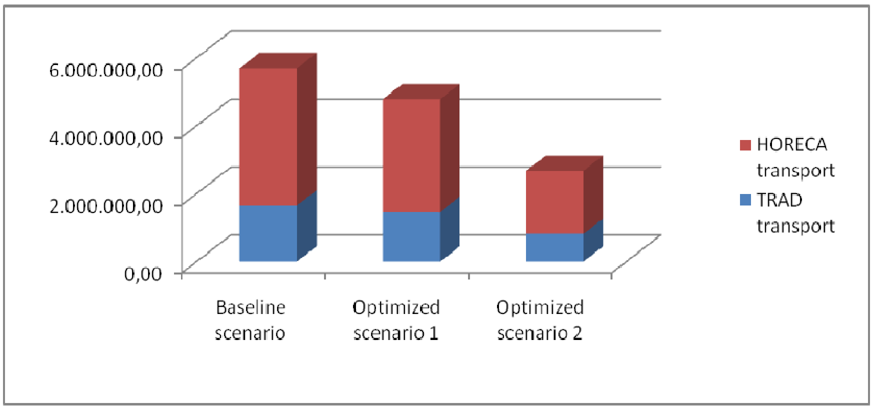



Figure 6.10 Compared PM emissions




According to my findings, combining the deliveries rationalization with the gradual phasing out of older diesel vehicles allows to achieve significant results in terms of pollutants emissions reduction, as shown in table 6.11.

Table 6.11 Emissions reductions – 1, 2 Optimization scenarios

| Pollutants emissions | Optimiz.1 | Optimiz.2 |
|---|---|---|
| CO | - 16% | - 38% |
| NOx | - 16% | - 27% |
| VOC | - 16% | - 30% |
| PM | - 16% | - 47% |

## 6.4 Remarks on defining food logistics projects in Bologna

The urban food distribution system in Bologna presents inefficiencies and lack of coordination, and consequently generates a relevant impact of the air pollution at local level. In particular, the independent retail and Ho.Re.Ca. supply chains are characterized by informal logistics activities, most of them directly operated by food suppliers, producers and shop owners, with limited deliveries consolidation measures. The resulting scheme foresees many “small deliveries” trips, with high transport costs. Moreover the most of urban delivery vehicles are old and highly pollutants: these are diesel light commercial vehicles, which strongly contribute to the air pollution, particularly, they remain a major source of particulate matter and NOx.

Concerning the two cases study, I observe that, even if Bologna and Parma are cities of different sizes, they present a variety of common patterns related to the urban consumers behavior and urban food distribution systems. According to my findings, Ho.Re.Ca. and independent retail chains in Parma and Bologna ask for similar logistics services, in terms of frequency, timing and delivery volumes and weight. In addition, in both cities the wholesale produce markets play a relevant role in the urban food provisioning system, they both have a strategic location in urban morphology and logistics facilities in run.

As a result, I identify the opportunity to implement in Bologna a city logistics project for food distribution following the Parma Ecocity model, which includes the implementation of a urban distribution center within the wholesale produce market and the renewal of the food transport fleet. In practice, urban planners would be in charge of activate a process of transformation of the Bologna's wholesale produce market toward a *Food Hub* solution. The environments benefits generated by this solution, as presented in this thesis, would be significant in terms of pollutant emissions reduction for the city of Bologna.

# 7. Final remarks

Urban food provisioning and distribution are crucial issues in our modern civilization. The unprecedented pace of urbanization and its effects on cities sustainability make it urgent for local administration to develop urban policies oriented to redesign the food chain on the base of new types of social, economic and environmental relationships amongst food producers, retailers and consumers.

## 7.1 Keys findings

According to the research questions proposed, the outcomes of the study provide the following answers to the research questions posed at the begining:

- *What are the food flows circulating in the city? How to estimate the demand of food requested by city dwellers and city users? How to estimate the supply of food offered by the different food retail systems existing in the city?*

The question is answered in chapters 5 and 6, by the analysis of the urban food systems of Parma and Bologna. Chapter 4 provides a framework that can be used to structure the urban food flows by identifying the food chain sub-systems with basic classifications and by explaining the relationship between these sub-systems in the urban food system (see figure 4.1). The main data to develop this framework contains the available literature, the acquired knowledge during this Ph.D. trajectory, the on-field research on Parma and Bologna's study cases, and discussions with experts.

In the model, the investigated sub-systems are the urban food demand and supply, *who requests* and *who provides* food are the two main dimensions. City dwellers and *city users* constitute the whole demand side, while the food supply is represented by the retailing system (corporate retailers, independent retailers, alternative channels) and the catering system (Ho.Re.Ca., institutional cafeterias, business food services). Moreover the model identifies a hidden flow, which is the food wasted at distribution and consumption phases, and proposes a method to estimate the amount of wasted food. The urban food distribution can be captured by the dimension of *what,* which describes the type of consumption, i.e. at home and out of home streams. I used this model to assess the urban food metabolism of the cities of Parma and Bologna, reaching an estimation of the full amount of food which circulates within the city in a working week.

The proposed model provides a comprehensive and organic representation of the fragmented and dispersed food flows which daily occur at urban level. My frame results innovative by including two specific components which in the most of the analysis are only marginally considered: (i) the *city users* and (ii) the wasted food. In modern cities, city users represent a relevant flow of people coming from the peri-urban and regional areas, which travel to the city for various reasons, including work, study, shopping, business and socializing. Even if city users constitute a transitory flow, they take part to the city life, by utilizing goods and services, participating to the socio-economic city networks and, not least, purchasing and consuming significant amount of food. Concerning the food waste, this food flow is defined as “hidden flow” because it has not been systematically investigated until now, although recent researches (Segrè et al., 2011) emphasize the high incidence of wasted food along the supply chain, generated in particular at the distribution and consumption phases.

- “*What are the basic features of the urban food supply transport system*s*?*”

The answer is explicated in chapters 3 and 4 based on the research framework in Figure 4.3. It has been applied the data set provided by City Ports (2005), which describes the Parma and Bologna’s urban freight transport systems through logistics, technological and organizational variables. Additional data on independent and Ho.Re.Ca. supply systems have been gathered through the food businesses and food services register issues by the Parma and Bologna Municipalities (2009), and through interviews with transport operators, suppliers, and retailers in both cities. By introducing the concept of “last food mile” I have set the boundaries of the research analysis and set a research protocol to collect detailed case data on the retailers store deliveries, distribution strategy, stores management (i.e. storage space), and the vehicle fleet in urban areas.

The collected data and information provide a detailed description of the “last food mile” distribution scheme for the selected supply chains. The food transport system in urban environments is characterized by small scale distribution of goods, according with the receivers requests, which ask for high frequency deliveries of limited number of parcels, in a narrowed time-window. Additional crucial issues are: (i) the fragmentation of the receivers, in fact food outlets and Ho.Re.Ca. are dispersed in the whole urban area, and (ii) the perishable goods transport must be performed with *ad hoc* vehicles, which maintain the cold chain logistics and guarantee the hygienic requirements.

The most problematic issues resulting by this atomized food distribution scheme are that commercial vehicles operate below their maximum carrying capacity (Quack, 2009) and empty runs accounts for a significant part of total kilometers-vehicles. In fact, the urban small scale deliveries are usually operated with light commercial vehicles (> 3,5 tons) which leave the warehouse, the wholesale market or the supplier terminal with an average 25% of loading capacity. It goes without saying that the economic costs of these type of delivery highly increase and strongly entails the marketing performance of independent retailers and Ho.Re.Ca. operators.

- “*What is the environmental impact of the urban food transport*?”

The environmental impact is examined in the fifth chapter. COPERT 4 software has been used to calculate realistic vehicle pollutant emissions for the selected food supply chains in different policy scenarios. Two scenarios have been developed for the case of Parma: before the implementation of city logistics project Ecocity and after two years since the project started. The Bologna case has been explored through three scenarios: the baseline one, the loading factor optimization (increasing by 25 to 33%) one, and the third one which foresees the loading factor optimization and the technical improvements (decreasing the older Diesel vehicles).

My analysis points out the substantial contribution of light commercial vehicles, the dominant mode of urban food deliveries, to air pollution. LCVs are responsible of a disproportionate amount of pollution, by emitting high share of NOx and PM. More precisely older diesel vans generate air pollutants containing particularly harmful fine particles, provoking breathing and cardiovascular illnesses.

According to my findings, the project Ecocity, which captures and rationalizes urban deliveries for about 8% of the total food flows circulating within the city of Parma, generates a significant reduction of pollutant emissions, such as - 29 % of PM and - 22% of NOx. The improved food logistics scenarios defined for the city of Bologna foresee the rationalization of the same share (8%) of the total amount of food distributed at urban level. The potential benefits generated by a logistics service similar to the Parmesan one result on reductions comprised between 22-28% of PM and 18-24% of NOx emissions.

- “*What are the potential actions on improving the food transport efficiency? Which logistics solutions can be implemented by the wholesale produce market as actors of the food supply system?”*

The question is answered through the case study of Parma and Bologna (chapter 5 and 6). I have examined the case of Parma and its logistics service Ecocity provided by the wholesale produce markets, on the basis of data collected from the market authority.

The case of Parma presents innovative aspects in the process of redesigning the urban food distribution system, combining transport sustainability issues with renewed services provided by a former actor in the urban food chain: the wholesale market. In practice, the existing distribution facilities of the wholesale produce market have been identified suitable to the implementation of the distribution center serving retailers and businesses in the urban area. The WPM authority is in charge of managing the logistic platform and the consolidation operations, providing the delivery services with eco-friendly vehicles and coordinating the marketing activities related to the project. Three are the main results reached by the Ecocity project: (i) reducing the air pollution and greenhouse gas emissions; (ii) improving the resources efficiency and cost effectiveness of the transportation of goods, taking into account the external costs; and (iii) contributing to the enhancement of local businesses performance, assuring high level efficiency in delivery service.

In this context, the wholesale produce market plays a relevant role due to its strategic location in the city environment and to its specific skills in managing perishable goods flows, improving efficiency of the urban food provisioning system. Moreover, the integration of innovative logistics services to the traditional functions of the WPM are key factors to renew the role of this historic operating organization, which is suffering the effects of the global agri-food system crisis and which is threaten by the increased market position of the corporate retail system. Looking at other International examples, it is possible to relate and enlarge the role of the wholesale market to the *Food Hubs* (Morgan & Morley, 2010), intended as (existing) supply chain intermediaries playing a new or renewed role in the urban food provisioning system. Food hub organizational model focuses on including environmental and social criteria, associated to the sustainable food systems, to the market management procedures. Three core components, such us *(i)* aggregation, distribution and wholesale; (ii) active coordination; (iii) permanent facilities characterized the Food Hub, and it includes the provisioning of additional logistics, marketing and communication services.

Finally, due to the limited public financial availability and to the absence of available land within modern cities, the opportunity to implement a city logistics project for food products centered on wholesale market role appears a cost-effective solution that policy makers can evaluate while defining urban food planning strategies. Although barriers to the success of similar projects are identified in the need of strong partnerships and effective commitment of the main urban food system stakeholders, i.e.: city-government, businesses association, transport operators, suppliers and producers.

This study provides a set of information to improve the knowledge about the urban food metabolism and the complex urban food supply systems, with special focus on urban food transport issues. This study also provides analytical tools for: (i) identifying important food flows, (ii) describing urban food transport performance and (iii) assessing its impact in terms of pollutant emissions. Applying this approach of analysis to their specific areas of intervention, other researchers and community leaders may enhance their knowledge on urban food transports system, to target future research and to develop specific solutions that meet their community's needs.

## 7.2 Scientific contribution

As Sonnino (2009) points out, there is a significant lack of comprehensive and comparative studies on the functioning of the urban food system, its potential, its limitations and its interrelations with other urban policies, such as transport, land planning, and waste management.

Whit the aim of reducing the gap of knowledge about food systems and freight transport linkages at urban level, this thesis has developed a methodological framework, which include three sub-systems: (i) food purchase, intended as food demand, (ii) the urban food provisioning, as food supply, and (iii) the food transport among supply chain actors. In a few words, this system has been oriented toward the analysis of the size and characteristics of the urban food flows, the way these flows circulate in the city and the environmental impact they generate.

In particular, the proposed methodology has intended to provide means to:

- Estimate the daily food supply by the food businesses and food services;
- Estimate the daily food demand by the city residents and city users;
- Describe the urban food transport performance, for selected supply chains;
- Evaluate the environmental impact of the urban food transport, related to different city logistics measures.

In order to *capture* and evaluate these processes, the concept of "last food mile" and a system of indicators have been devised. These indicators provide specific information on the pollution emissions generated by the food transport and are could be a basic tool that helps policymakers in assessing the environmental sustainability of different logistics measures related to urban food transport.

Nonetheless, approach asks for new qualitative information and statistical data that should allow planners to evaluate the *urban food metabolism* (how much food is requested by/offered to the city) and its distribution scheme (how food is delivered to the supply chain operators). Currently, data on city users flows, size and type of food businesses, type and performance of freight transport are missing or highly dispersed among a variety of Municipal and Regional databases, hampering the definition of a comprehensive scenario of the urban food system.

Even if in many countries such data are not systematically collected, some effort, especially at city level (i.e.: San Francisco and London, Sonnino, 2009), have been carried out in order to depict the urban food system and its transport scheme. In Italy, only few attempts have been made to support public policies in the urban food planning issues. The most relevant cases are: the city of Parma, which implemented the urban food distribution project Ecocity, investigated in this thesis, and the city of Pisa, which is defining the District food plan (*Piano del Cibo*).

## 7.3 Policies addressing urban food distribution inefficiencies

The crisis has played a major role in highlighting the negative effects of globalization on consumers and the vulnerability of the global food chain. As a result, urban decision-makers everywhere have come closer in understanding and acknowledging the important role that cities can play in enhancing sustainability through initiatives which support and nourishing local communities and economies, on a environmental protection basis.

The next step is thus to identify the most effective measures which can be replicated with major chance of success. Looking at Italy, common aspects characterizing urban areas can be easily listed, such as the average medium size, the high density of population and road transport. To this extent the strong need of facilitating lighter, faster, safer and sustainable flows of products urgently needs to match with the need of strengthening the food market competitiveness (Bologna, 1998).

According to the findings of this thesis, the opportunity to enhance the urban food distribution system sustainability by renewing the role of the local wholesale produce market through innovative logistic service seems to be an effective solution to be applied both in terms of sustainability, through reduced environmental impact and road traffic, as well as in terms of improved suppliers' competitiveness, by reducing costs and improve efficiency to reach the final users.

This solution is supported by the World Union of Wholesale Markets, that in the its Paris Declaration (2009) states the commitment to pursue essential values as quoted below:

*ensure a quality–price ratio that is of service to consumers; […] support of urban retail trade; the promotion of environmentally-friendly logistics.*

## 7.4 Recommendations for further research

In this thesis, I explored new methods for valuing the environmental impact of food transport considering that the air pollution effects are one of the externalities that must be assesses when defining a new logistic policy for food distribution. The implementation of an integrated approach on food planning requires data and information on many other aspects of a city's design and functioning, such as land planning, urban infrastructures, business and economic development. Furthermore future investigations could contribute to deepen the relationships between the urban food transport and the associated economic and social burdens by integrating the set of indicators applied with an increased number of variables.

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