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Can waste become a resource?

Development and analysis of eco-innovative solutions in the cities of Hamburg and Turin

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List of Abbreviations

ANPA – Agenzia Nazionale per la Protezione dell'Ambiente

ATO – Ambiti Territoriali Omogenei

CE – Circular Economy

EC – European Commission

EEA – European Environmental Agency

EFA – Energy Flows Analysis

EIS – Eco Innovative Solution

EU – European Union

GDSE – Geodesign Decision Support Environment

HMR – Hamburg Metropolitan Region

IE – Industrial Ecology

ISWA – International Solid Waste Association

LCA – Life Cycle Assessment

MFA – Material Flows Analysis

Mtoe – Million Tonnes of Oil Equivalent

PULL – Peri Urban Living Labs

SDG – Sustainable Development Goal

SRH – Stadtreinigung Hamburg

UM – Urban Metabolism

UN – United Nations

WCED – World Commission of Environment and Development

WEEE – Waste Electrical & Electronic Equipment

WMS – Waste Management System

WP – Work Package

Abstract

Since the Industrial Revolution, our economy has followed a linear path, based on the principle “take, make, use, dispose”. However, the climate change, the depletion of natural resources, and biodiversity loss caused by this system have highlighted its unsustainability and the need for new systems of growth. The term circular economy has emerged from the debate as a new model of sustainable growth in which the life cycle of resources and products is extended, minimizing the waste production. The transition to a circular economy shifts the focus to avoidance, reuse, repair, renewed and recycling practices. From this perspective what used to be considered as waste can be transformed into a resource.

To reach a circular economy, the eco-innovation is one of the key aspects. The eco-innovation regards all forms of innovation and progress towards the goal of sustainable development. This responds to the need of new model and technologies to manage and create a sustainable environment.

Accordingly, the purpose of the thesis is to demonstrate how a waste can be consider a resource through the application of an eco-innovative solution developed within the European project REPAiR to two cities. Starting with a review of circular economy and urban metabolism concepts and approaches, the attention shifts to two case studies in the city of Hamburg and Turin. The two case studies allow to apply the concepts so far described to a concrete example. The purpose of the development of an eco-innovative solution is to implement the circular economy locally, demonstrating how a waste can be consider a resource. Moreover, its analysis allows to understand the effects that this solution could have on the waste management system.

Abstract in Italian

Dall’avvento della rivoluzione industriale il nostro sistema economico ha perseguito un percorso lineare, basato sul principio “produrre, consumare, smaltire”. Tuttavia, il cambiamento climatico, la disponibilità limitata delle risorse naturali e la perdita di biodiversità causati da questo sistema ne hanno messo in luce l’insostenibilità e la necessità di trovare nuovi sistemi di crescita. Il termine economia circolare è emerso dal dibattito come un nuovo modello di crescita sostenibile nel quale il ciclo di vita delle risorse e dei prodotti è esteso per il maggior periodo possibile, minimizzando la produzione di rifiuti. La transizione verso un’economia circolare ha spostato l’attenzione sui temi del riutilizzo, del riparare, del rinnovare e del riciclare. Da questa prospettiva cosa viene normalmente considerato un rifiuto può essere trasformato in una risorsa.

Per raggiungere un'economia circolare, l'eco-innovazione è uno degli aspetti chiave. L'eco-innovazione riguarda tutte le forme di innovazione e di progresso nel raggiungimento dell'obiettivo di uno sviluppo sostenibile e risponde alla necessità di nuovi modelli e tecnologie per gestire e creare un ambiente sostenibile.

Sviluppata in questo contesto, la tesi si pone come obiettivo quello di dimostrare come un rifiuto possa essere considerato una risorsa attraverso l’applicazione di una soluzione eco-innovativa sviluppata nell'ambito del progetto europeo REPAiR. Partendo da una revisione dei concetti e degli approcci dell'economia circolare e del metabolismo urbano, l'attenzione si sposta su due casi studio nelle città di Amburgo e Torino. L’ambizione della soluzione eco-innovativa sviluppata è quello di implementare l'economia circolare a livello locale, dimostrando come un rifiuto possa essere considerato una risorsa e permettendo di applicare i concetti teorici, precedentemente descritti, a una situazione concreta. Inoltre, un’analisi della soluzione permette di comprendere gli effetti che essa potrebbe avere sul sistema urbano di gestione dei rifiuti.

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01 INTRODUCTION

1. Introduction

“Poorly managed waste is contaminating the world’s oceans, clogging drains and causing flooding, transmitting diseases via breeding of vectors, increasing respiratory problems through airborne particles from burning of waste, harming animals that consume waste unknowingly, and affecting economic development such as through diminished tourism. Unmanaged and improperly managed waste from decades of economic growth requires urgent action at all levels of society” (Kaza et al., 2018). In 2016, about five percent of global greenhouse gas emissions were generated from solid waste management, and the municipal waste production per capita is constantly increasing. Urban waste management is considered as a crucial aspect to achieve sustainable, heathy, and inclusive cities and communities for all.

A European citizen generated on average 489 kg of urban waste in 2018 (Eurostat, 2020). In the last years, the increasing interest in circular economy (CE) has led States and Countries to embark actions which entail improvements in waste management. In 2015, the European Commission adopted the Circular Economy package, a set of measures to reach a more sustainable growth. In the ‘European action plan for the circular economy’, the CE is defined as an economy in which products, resources, and materials are maintained in the cycle as long as possible, minimizing the waste production (European Commission, 2019).

Often recycling targets are set to reach long-term recycling objectives established by States and Countries. However, these measures not always bring the desirable effects: the cost of the separated collection of recyclables implies additional costs that not constantly are compensate. Moreover, recycling should be considered the last step before disposal, and not a solution to the poorly waste management. To reach imposed targets, great attention has been paid to the theme of recycling, but few initiatives have focused on the waste avoidance and reuse of products.

1.1 Research context

In the last years, the term circular economy has emerged in contradiction to the term linear economy. Since the Industrial Revolution, our economy has followed the linear principle “take, make, use, dispose”. However, the massive resource consumption and the negative impacts on the environment have led to the need for a new model. The first documents to highlight the unsustainability of the linear model were ‘The Limits to Growth’ (1972) and ‘Our common future’ (1987) that pointed out the limited resources on our planet and the need to change our development model. Even if there is not a univocal definition of the ‘new model’, the term circular economy has emerged from the debate as a model of “economy with closed material loops”.

Alongside the economic debate, there has been a growing focus on cities, characterized by high concentration of economic activities, population, buildings, energy and material flows that represent potential ecosystems impacts. From this perspective, the term ‘urban metabolism’ has emerged, according to which a city can be assimilate to a living organism, that requires resources to serve all its function, and, the use of these resources, creates products and generates waste (Rogemma, 2019). As for a living organism, if the waste generated cannot be reintroduces in the system, they create adverse effects on the organism, and, translate to the city, adverse effects on the city ecosystem.

The two terms have their roots in diverse disciplines, though today we can state that the two term are related. Indeed, to achieve the goal of a circular economy, cities should have a circular metabolism, in which the inputs from external system and outputs generated are minimized, limiting negative externalities and waste (Longato et al., 2019).

With reference to these concepts, the European project analysed in the present thesis has been developed: REPAiR (REsource Management in Peri-urban Areas: Going Beyond Urban Metabolism). With a view to move from the perception of waste as a problem to waste as a resource, REPAiR project aims

to improve the waste management system in six metropolitan areas to achieve the goal of a circular economy. In this context, the starter point of this thesis has been an internship hold at HafenCity University in Hamburg. During the internship, the research has focused on REPAiR project, and, specifically on one of the Eco-Innovative Solution (EIS) developed for the Hamburg case study. Later, the research was extended to the city of Turin to understand which implications the EIS may have on another city.

1.2 General aim and specific objectives

Led in the framework of REPAiR project, the thesis wants to prove how waste can become resources, both by using theoretical sources and two case studies in the cities of Hamburg and Turin.

To achieve the general aim, the following specific objectives are identified:

- Provide a review of the concept of circular economy from the scientific literature available and relate the concept of CE to the European policies and the urban and regional planning framework;
- Introduce REPAiR project and its related approach of urban metabolism;
- Develop one of the Eco-Innovative Solutions established within REPAiR in both case studies to demonstrate locally how waste can become a resources and which implications the solution could have on the waste management system;
- Provide a comparison between the two case studies to highlight similarity and differences in the application and achievement of a circular economy in two cities belonging to diverse Sates, with structural differences in the planning and waste management systems.

The review of the concept of circular economy allows to define the state-of-art of the CE, and, moreover it supports to understand how waste can be consider a resource. Alongside the definition of the concept, it is related to the European and planning framework, in order to define if there are already policies and practices in place linked to the CE at the European level with regard to the

urban and regional planning. The introduction to REPAiR project and the definition of the urban metabolism approach allow to define the context and the methodology consequently adopted for the development of the Eco-Innovative Solution in the two case studies. The application of the EIS to the two case studies aims to demonstrate how the concepts of CE can be applied to a concrete situation. To achieve the goal, firstly the planning and waste management systems, and some socio-economic analysis are defined to understand the current situation. Afterwards the solution is applied to the two case studies and its expected impacts are analysed. Finally, the last specific objective aims to compare the two case studies with the goal of understand the feasibility and the implications of the EIS on the two planning and waste management systems.

1.3 Research questions ad preliminary hypothesis

With a view to move from a perception of ‘waste as a problem’ to ‘waste as a resource’ this thesis aims to answer the following questions:

- What is the circular economy and how waste can be consider a resource?
- What are the goals of REPAiR project?
- Which is the role of the urban metabolism approach?
- How can the Eco-Innovative Solution “Quarter Service Center” designed for Hamburg case study implement the waste management system of the city?
- Is the EIS developed for Hamburg transferable to the city of Turin?
- How the waste management system of Turin could be affected by the EIS?
- Which are the analogies and differences between the planning and waste management systems in the two cities in analysis?
- What are the implications of the planning and waste management systems in implementing the solution in the neighbourhoods?

Based on these research questions some preliminary hypothesis can be advanced:

- A waste can be considered a resource if it could be maintained in the cycle, instead to be dispose;
- To implement the waste management system at least one Quarter Service Center should be open in the study area with the function of being both a waste collection and an information point;
- The EIS will bring a reduction of waste that will be repaired, reused and recycled in the local center, closing the loop at the local level;
- In the city of Turin, the solution could be applied to San Salvario neighbourhood due to its socio-economic characteristics and its low rate of separated collection;
- An interaction between the planning and the waste management systems is necessary to implement the solution.

1.4 Methodological hints

The thesis is divided mainly in two parts. Firstly, a more theoretical part aims to define and contextualize the concepts of circular economy, waste as a resource, and urban metabolism. Afterwards, focusing on two case studies in the city of Hamburg and Turin, a second part aims to apply the concepts so far described to the two cities, providing an analysis of the waste management system and its potential improvements due to the implementation of an Eco-Innovative Solution.

The approach for the first phase demanded a research, scientific literature has been analysed in order to define and present the concept of circular economy and related it to the European and planning framework. After, the introduction of the REPAiR project has deal with the definition of the urban metabolism. The urban metabolism approach has been the basis of the analysis and definition of the solution presented in the two case studies.

The second part has been the most applicative one, however, to develop the EIS, both scientific data and literature, and on-going initiatives have been analysed. Firstly, the definition of the waste management and planning system

allowed to understand the context in which the solution has been applied. Then, a socio-economic analysis has been carried in order to define the specific characteristics of the case study and its implication on the waste generation. Finally, the analysis of the on-going initiatives and the spatial identification of them has allowed to identify strengths and weaknesses of the areas and, consequently, better define the solution.

Once the EIS has been developed, an analysis of the potential impacts of the solution on the waste management system has been done. The analysis of the system and its upgrades has been done with reference to the 'sustainable assessment framework' defined in REPAiR project.

1.5 Thesis organisation

To achieve the propose, the thesis has been divided in nine chapters.
The present chapter introduce the general topics and objectives of the thesis, presenting the concepts of circular economy, waste as resource, and urban metabolism further developed in the following chapter. The second chapter focuses on the several definitions of the CE in order to give a general overview of the term. Moreover, the relations and application of the terms in the European policies and programmes and in the urban planning framework are analysed to understand the state-of-art of CE in these fields. In the third chapter, REPAiR project is presented. To contextualize the project, the programme in which it was developed is presented: Horizon 2020. In addition, the urban metabolism approach is introduced to explain the approach adopted in the development and analysis of the eco-innovative solutions.

The fourth chapter introduces the Hamburg case study, with a contextualization of the German planning and waste management systems. The description of the two systems allows to build the frame in which the solution is developed. The fifth chapter describes the EIS adopted for Hamburg and its impacts on the waste management system. A series of analysis are carried out in this chapter, first to understand which services are already on place, and, in a second moment, to evaluate the potential impacts of the solution, comparing the status quo and the proposed process. In the sixth

chapter the same analysis carried out for Hamburg are repeated for the Turin case studies. While, in chapter seven, the EIS is transferred to a neighbourhood in Turin with an evaluation of its potential impacts on the waste management system. Even for Turin, a number of analyses have been carried out. Firstly, the waste generation in Turin's neighbourhoods has been highlighted to understand the criticalities and propose a neighbourhood in which implement the solution in response to them. Secondly, the services already on place and the projects on waste management developed for the city have been analysed to show the status quo of the study area. Then, the potential impacts of the solution have been evaluated, comparing the status quo and the proposed process.

Finally, the last two chapters aim to give an overview of the research, trying to understand the feasibility of the EIS. Chapter eight provide a comparison between the two case studies, starting from the analogies and differences among the planning and waste management system and their implication in the realisation of the solution. While, chapter nine provide a conclusion, highlighting the limits of the adopted approach and the future research prospective.

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02 CIRCULAR ECONOMY AND WASTE AS RESOURCE

2. Circular Economy and waste as resource

Since the Industrial Revolution, our economy has followed a linear path, based on the principle “take, make, use, dispose”.

If the initial resource availability has allowed the consolidation of the so-called linear economy, in the last decades, it became clear the unsustainability of this model. Natural resources are constantly decreasing, and their massive consumption is one of the main reasons of global climate change and biodiversity loss. Hence the importance of switching to a different model, capable of decrease the resources consumption, maximizing their re-use and minimizing their disposal. In this context, the term Circular Economy (CE) has emerged from the debate as a model of “economy with closed material loops”.

According to the World Bank’s last report, 2.01 billion tonnes of municipal solid waste was generated in 2016. This data is expected to reach 2.59 billion tonnes by 2030 and 3.40 billion tonnes by 2050.
Meanwhile, 1.6 billion tonnes of CO_2-eq greenhouse emission were generated from solid waste management in 2016. It accounts for around 5% of total global emissions (Kaza et al., 2018). These data and projections are an alarming evidence of how the economy is still strong oriented to the disposal of the goods. This consideration reinforces the need to start considering waste as a resource. Instead to be disposed, they should be reused in the cycle to close the loop and foster the transition from a linear economy to a circular one.

Aiming to introduce the concept of circular economy and waste as a resource, the chapter is structured as follows. Firstly, the terms are presented and defined, afterwards they are analysed in the European framework and, finally, the research focuses on the role of urban and regional planning in this field.

2.1 Defining circular economy and waste as resources

There is not a univocal definition of circular economy. It is often depicted as a combination of reduce, reuse and recycle activities, and linked to the concept of sustainable development.

This sub-chapter aims to analyse the development and the different meanings attributed to the term over the years, in order to build a reference framework. Furthermore, it aims to understand as waste could be consider a resource and how they can play a key role to reach the circular economy goal.

2.1.1 Origins of Circular Economy

The term circular economy has been introduced the first time by the environmental economists Pearce and Turner in 1989. However, the concept has been developed in different disciplines since the 1960s. In 1966, the ecological economist Boulding stated that “Earth could work as a cyclical ecological system, thereby recirculating the limited resources and making them unlimited” (Prieto-Sandoval et al., 2018).

Roots of CE are also detectable in the *industrial ecology* (IE). This line of ecology considers the industrial system as an ecosystem, in which occurs an exchange of flows material between the industries and natural ecosystems. In this context, in 1969, the economists Ayres and Kneese recognized the production of the “residual” as a part of the production and consumption process (Ayres and Kneese, 1969). Furthermore, in 1987, Ayres first introduced the term ‘industrial metabolism’ to express the similarity between an industry and a living organism. “The metabolism of industry is the whole integrated collection of physical processes that convert raw materials and energy, plus labour, into finished products and wastes in a, more or less, steady-state condition” (Ayres, 1997).

In the same years, two reports*, The Limits to Growth* (1972) and *Our common future* (1987), pointed out the limited resources on our planet and the need to change our development model.

The publication The Limits to Growth analyses the exponential economic and population growth, highlighting the finite supply of resource. The authors' aim is to show the limits of our world system, providing warnings on potential crisis if trends in the system do not change (Meadows et al., 1972). Our common future, also known as Brundtland report, first introduced the term "sustainable development" as a development that meets the needs of the present without compromising the ability of future generations to meet their own needs. Written by the World Commission of Environment and Development (WCED), the report highlighted three fundamental components to sustainable development: environmental protection, economic growth and social equity.

Within this framework, and based primarily on the previous studies conducted by the ecological economist Boulding, in their book *Economics of Natural Resources and the Environment* Pearce and Turner (1990) introduced the term circular economy to explain the importance of the environment in economic flows and the need to close industrial loop in order to preserve the environment.

2.1.2 From a linear to a circular economy

Despite the divergences, the various definitions of CE have the same starter point: our current economic system is no longer sustainable. We need a new model with the goal to use in a more efficient way the resource and to reduce as much as possible the negative effects on the environment.

To easily explain the transition from the linear economy to the circular one, the architect Stahel (2016) used a similarity. He described the linear economy as a river and the circular economy as a lake.

The first flows like a river, companies turn natural resources into products and sell them to an end consumer, that could decide whether the goods will be reused or disposed. In this economic model, companies sell large volumes of cheap goods, consequently, it is more convenient for the owner to buy a new product than to repair an old one. The CE is compared as a lake, here goods are reprocessed, saving resources and reducing waste production. A small

amount of resources enters “the lake”, where the products are reprocessed in a cyclical way, causing only a fraction of them to leave the lake to be disposed.

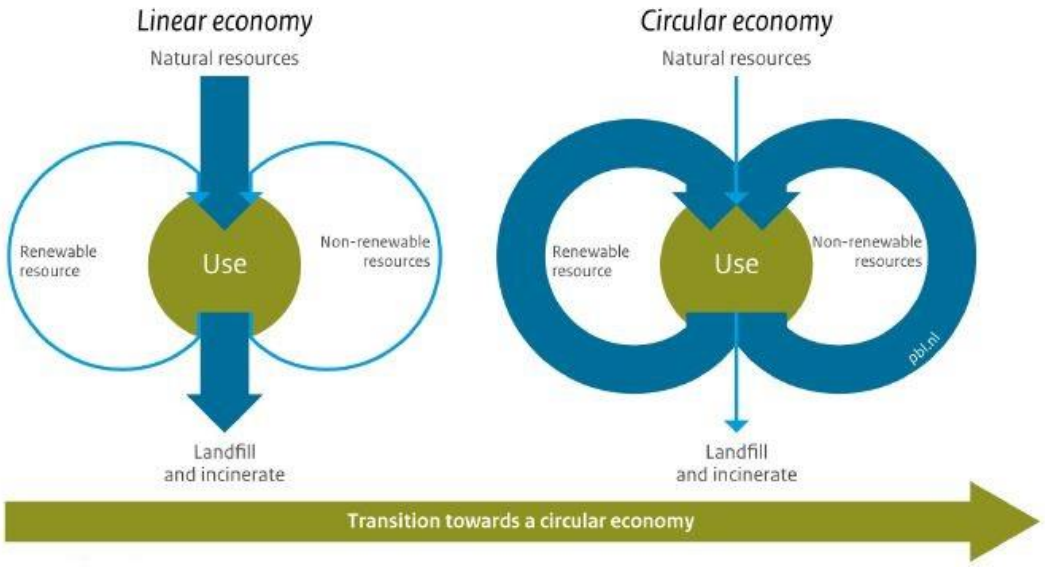

Figure 2.1 - From a linear to a circular economy. The figure shows a schematic representation of both linear and circular economy (Source: Pottine et al.,2016).

Figure 2.1 shows a simple scheme of the transition towards a circular economy. As mention before in the linear model there is a massive resources consumption, followed by an almost total disposal of the goods, after their use. While, in the circular model, the main objective is to close the reintroduction of products in the loop, before the disposal step.

In the past century, the growth of the liner economy had driven by the low level of resource prices, hence reusing materials has never been a priority. It can be stated that the limit of this model is the ‘end-of-life’. In Europe, 2.538 million tonnes of waste were generated in 2016, but less than 40% of them were reused, recycled, or composted and digested (Eurostat, 2020a). This data highlights an attempt to respond to the need of change, mainly due to the steady price increase of natural resources since 2000. However, the 40% symbolize only the starter point to the transition towards a circular economy.

Nowadays, the most accredited CE definition is the one of the Ellen MacArthur Foundation (2013). “The term ‘circular economy’ denotes an industrial economy that is restorative by intention and design. In a circular economy, products are designed for ease of reuse, disassembly and refurbishment, or

recycling, with the understanding that it is the reuse of vast amounts of material reclaimed from end-of-life products, rather than the extraction of resources, that is the foundation of economic growth. With the adoption of a circular economy, unlimited resources like labour take on a more central role in economic processes, and resources that are limited by natural supply play more of a supporting role."

In this 'new economy' we can recognize two type of materials flows (see *Figure 2.2*): biological and technical. The first flow focus on biological nutrients, that can be directly reintroduced in the biosphere and become a resource for the next cycles. The second flow consist of 'technical nutrients', where materials cannot be reabsorbed by the biosphere, we have to design the products in such a way that allows easily maintenance, reuse, redistribute, remanufacture, refurbish or recycle.

These two flows are meant to be restorative and regenerative. From this perspective the CE system results to be strongly planned to minimize the loss, aiming to extend the productive use of materials and products as much as possible, trying to contain loss of quality or value.

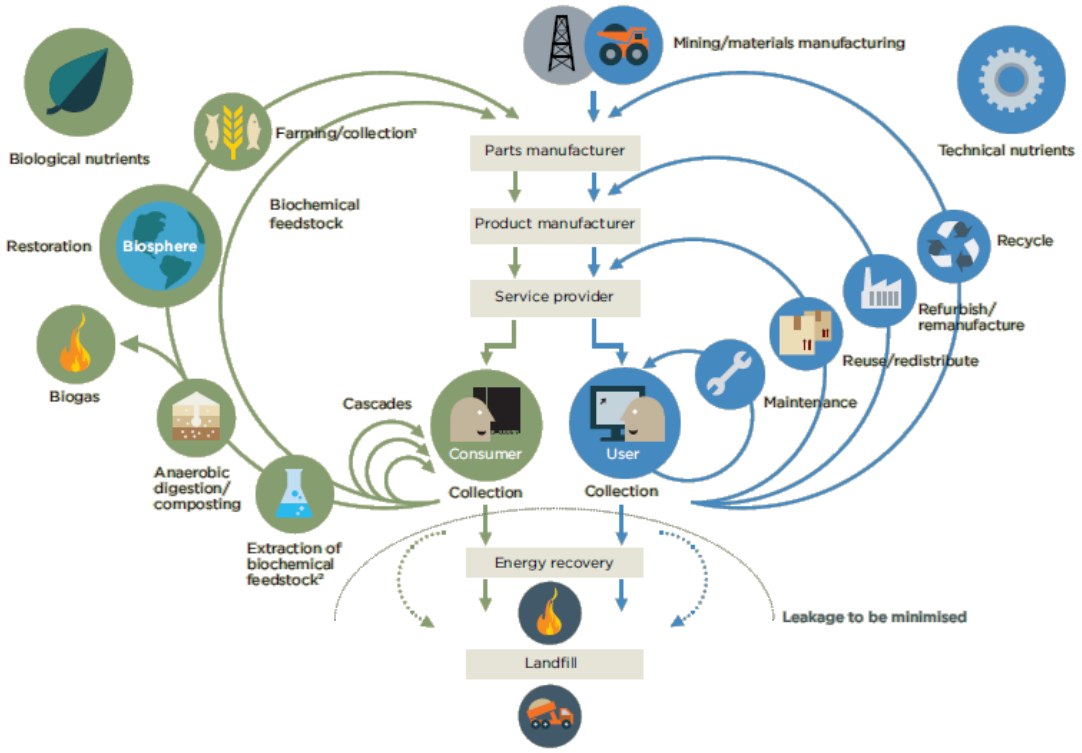

Figure 2.2 - Biological and technical flows. The scheme shows how the biological and technical "nutrients" should work in the Circular Economy (Source: Ellen MacArthur Foundation, 2013).

According to the Ellen MacArthur's definition, five are the principles of a CE model:

- design out waste (products have to be designed in a such a way that their disassembly and refurbishment is quick and easy);
- build resilience through diversity (systems should work on diverse scale and be versatile and adaptive);
- rely on energy from renewable sources (systems should prefer the use of renewable resources);
- think in 'systems' (each element has to be thought as a part of a whole, and in relation to the environmental and social spheres);
- waste is food (the product should be made in such a way that can be reintroduced it into the biosphere).

Recently, founded on an analysis of 114 CE definition, the Innovation Studies Group of Utrecht University proposed a comprehensive definition that aims to summarise and combine different aspects of the circular economy that have emerged over the years.

“A circular economy describes an economic system that is based on business models which replace the ‘end-of-life’ concept with reducing, alternatively reusing, recycling and recovering materials in production/distribution and consumption processes, thus operating at the micro level (products, companies, consumers), meso level (eco-industrial parks) and macro level (city, region, nation and beyond), with the aim to accomplish sustainable development, which implies creating environmental quality, economic prosperity and social equity, to the benefit of current and future generations” (Kirchherr et al., 2017).

There are two main aspects that emerge from this definition. The first concerns the replacement of the "end-of-life" concept with recycling, reducing, reusing and recovering practices. The second highlights the action levels of the circular economy. Indeed, if at first the CE concept emerged in the industrial framework, nowadays it is clear that it does not concern only the industrial process, but it implies different layers, from the product design to a whole territory.

2.1.3 The R framework

Across the several CE definitions, it is possible to find terms such as recover, recycle, repurpose, remanufacture, refurbish, repair, reuse, reduce, rethink, refuse. These terms constitute practices to achieve the circular economy goal. Each one acts on a fraction of the economic cycle; thus, their combination is necessary to reach system improvements.

Over the years, the importance of these ‘actions’ is emerged. One of the most accredited principles is the 3R one: Reduce, Reuse and Recycle.
This principle has been implied in several national policies. It was adopted by China in the Circular Economy Promotion Law, enacted in 2008. While, other countries such as EU, Japan, Korea, Vietnam have introduced this principle in their waste management policies (Sakai et al., 2011). The sequence of words in the principle is important because it expresses the application’s priority of the practices, therefore, first of all we have to reduce, then reuse, and finally, recycle.

The Reduction principle focuses on the improvement of production and consumption processes, by reducing the use of primary energy and natural resources. This principle has to be applied at the beginning of the chain, here the key is the choice of easily reusable resources and the introduction of new technologies. The Reuse principle aims to reintroduce in the cycle all the products or components that can be used again. Reuse a product lead to a reduction in terms of resources, energy, labour. The Recycle principle refers to the restoration of materials and it is seen as the last suitable solution, before the disposal. Recycling waste allow to extract usable resources and reduce the amount of waste to dispose.

Another principle develops from the 3R is the 4R one: Reduce, Reuse, Recycle, Recover. The 4R's principle adds the word recover to the previous one. The Recover is applied where no other action can be taken; the good is intended for incineration, but at least energy is produced by it.

A more complex, but exhaustive framework is the 9R one: Refuse, Rethink, Reduce, Reuse, Repair, Refurbish, Remanufacture, Repurpose, Recycle, Recover. The 9R framework consists of nine graduations of circularity, starting with the highest level "Refuse" and ending with the lowest, "Recover" (Pottine et al., 2017).

If the starter point of the 3R and 4R principles is the reduce, this more articulated frame adds the concepts of refuse and rethink as first steps to implement. *Figure 2.3* shows a schematization of the 9R framework.

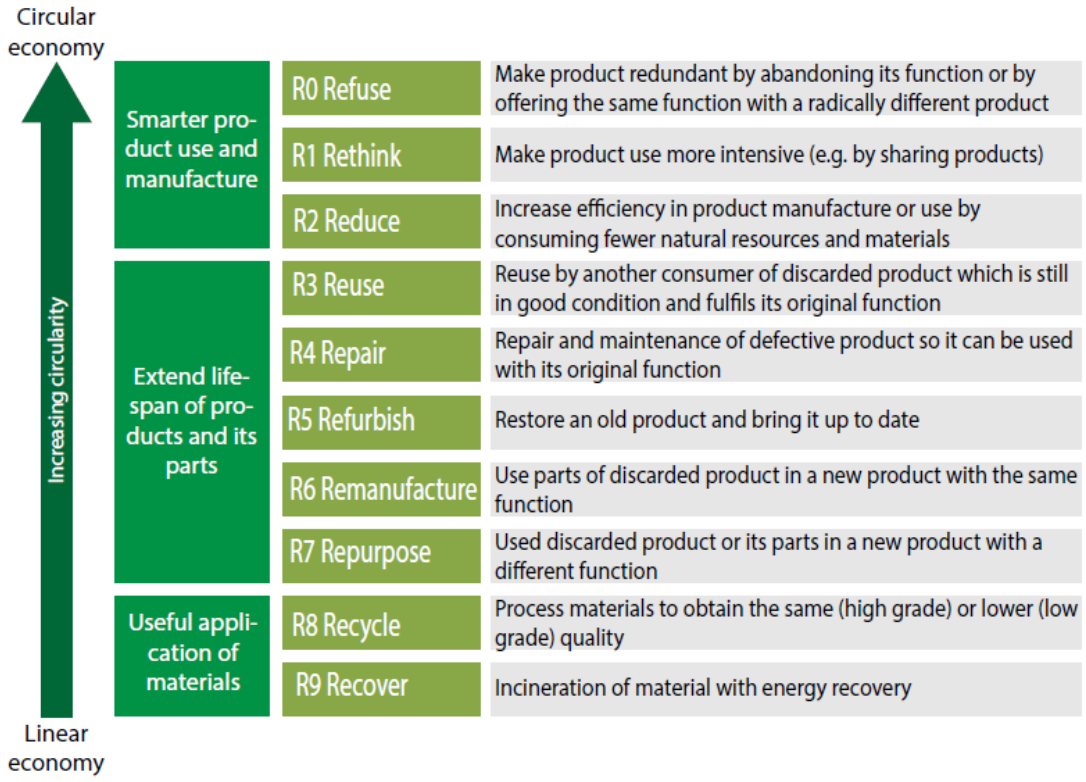

Figure 2.3 - The 9R framework. The scheme shows which are the "R" and their importance in the transition from a linear economy to a circular one (Source: adopted from Kirchherr et al., 2017).

Refuse, rethink and reduce are the actions needed to achieve a high level of circularity. The objective is to be able to maintain as long as possible materials in the system. As a result, fewer natural resources are needed to produce new goods and the amount of waste is limited. Along with the reuse process, this framework introduces other terms as recycle, refurbish, remanufacture and repurpose.

All these actions act on the product or part of it by extending its life and limiting the use of new raw material. As last there are the recycle and recover procedures. Recycle and recover actions constitute the two lowest levels of circularity, because they do not prevent waste's production, but they seek to limit their impacts.

2.1.4 Three levels of circular economy

Several authors outline that CE is characterized by three levels of research and implementation: micro, meso and macro (Ghisellini et al., 2016; Yuan et al., 2008).

At the micro or individua firm level, companies focus on their own improvement processes. ‘Eco-design’, ‘green design’ and ‘cleaner production’ are the key terms of this layer. The design is relevant because the sustainability of a product is strongly related to the decisions taken during the design stage. Moreover, the word eco-design introduces the concept of environmentally friendly products and processes; the environmental aspects are introduced in the design in order to minimized products’ negative impacts and facilitate their disassembly and disposability. The micro level, focusing on the individual company, is also accountable of the ‘consumer’s responsibility’. The costumer should be aware about what they are buying through information and labelling systems.

The meso level refers to the industrial level, involving the development of ‘eco-industrial parks’ and ‘industrial symbiosis districts’. Industrial symbolism arises when industries, that usually work as separate entities, start cooperating to facilitate a resources exchange (e.g. waste of an industry could be used as a primary resource for another one). Eco-industrial parks are planned industrial area in which a suitable mix of production units allow to minimize waste production and emissions.

The macro level refers to city, provinces, regions and, according to Ghisellini et al. (2016), at this level CE involves four systems: industrial system, infrastructure system, cultural network and social system. In this framework plays a key role the term ‘Eco-city’. The term born in 1970s, with the idea of restructure city in equilibrium with nature, however, in the last decades, the concept of Eco-city has been referred to the sustainability, including economic, environmental, social and cultural aspects (Hu, 2016).

In the macro level we can also speak about ‘collaborative consumption models’, that are based on a shared ownership (e.g. sharing and renting). In

this kind of model there is not an ownership, the costumer has only the right to use the product by paying a charge. As the ownership is one of the core problems of a linear economy, because when a product is sold the owner can choose what do, the development of such collaborative consumption is a valid alternative. Of course, also at the macro level, the waste management system plays an important role. Over the years, the CE transition has been translated by some cities into ‘zero waste programmes’.

Based on recognition of the potential application of the CE concept at different scales, we can state that CE is not and should not be applied to a single fraction of the economic system, but different level and different actions have to be taken in order to achieve the CE goal. Moreover, these levels are not to consider something apart from the R framework previously introduced. The ‘R actions’ are part of each level and they acts in them several ways.

2.1.5 The waste’s role

Alongside the CE concept, over the years, the terms ‘waste’ and ‘resource’ have been examined and have contributed to the development of different school of thought. Here some of them are briefly presented in order to show the increasing importance of waste in literature.

Blue Economy

The Blue Economy concept is recent and was introduced the first time only in 2012, during the United Nation Conference on Sustainable Development. This branch of economics is based on 21 principles and aspires to implement new models, which respond to the needs of a society with “what is locally available” (Pauli, 2010). The Blue Economy suggests that we should find solutions based upon simpler and cleaner technologies, instead use rare and non-renewable resources. One the principles stated: “Natural systems cascade nutrients, matter and energy – waste does not exist. Any by-product is the source for a new product” (The Blue Economy). Through the cascade metaphor, this principle claims that waste does not exist, because the waste of one product becomes the input to a new one. Local environment and physical resources are the key for this kind of economy.

Cradle-to-cradle

Cradle-to-cradle is a sustainable business strategy that focuses on the regenerative cycle of nature in which waste is reused. In contrast to the model cradle to grave, that is typical of a linear economy, this model aims to eliminate waste, reintroducing resources in the cycle. In this perspective, “waste equals food”: in nature waste does not exist, so all products and industrial processes should be designed in such a way that they could be easily reintroduced in the cycle.

Performance Economy

The architect Stahel firstly introduced the term performance economy. For him this model of economy goes a step further the CE model. In this perspective goods are sold in form of services. The manufacturer is the owner of the products and thus has the responsibility for the impacts, and waste. services and new solutions are the real products of the performance model, in which most part of waste are avoided from the beginning (Stahel, 2016).

The Waste Hierarchy

Adopted by several waste management policies, the waste hierarchy is a principle that sets out the most and least favourable ways in which waste should be managed.

It responds to 3 principles: avoidance, resource recovery, disposal. The first step aim to avoid waste generation, the second refers to the most efficient way of products’ recover, it implies practices as reuse, recycle, reprocess; finally, the disposal is to be applied in the most environmentally responsible manner, when no other actions of avoidance and recovery are possible (EPA, 2017).

Zero Waste Strategy

Since solid waste has become one of the global environmental issue, zero waste practices and zero waste strategy are emerged to challenges and opportunities to transform the waste management system toward a zero - waste vision.

There is no single strategy to achieve zero waste, but several cities and continents have adopted strategies that aim to eliminate waste generation. For

example, Zero Waste Europe is the strategy for the European Union that pursues the conservation of all resources. “Zero Waste is the conservation of all resources by means of responsible production, consumption, reuse and recovery of products, packaging and materials without burning, and with no discharges to land, water, or air that threaten the environment or human health” (Zero Waste Europe).

All these theories have an own vision about products and waste, however what should be pointed out is the association of waste with the environment. The blue economy and the cradle-to-cradle strategy state that waste in nature does not exist, or rather a waste is always a resource in natural cycles. Our economy should be integrated to the environment and resources should be reused in the cycles without causing negative impacts on the environment. The zero waste strategies recognise the climate impacts of waste and emphasise the need of eliminate waste production. Although it doesn't directly refer to the environment, also the waste hierarchy introduce as first preferable step the non-production of waste through the avoidance. Finally, the performance economy focuses more on the dematerialization of waste by giving the products in form of service. From the point of view of waste generation, this kind of economy is more detached from the environmental context, however, the introduction of “products in form of service” purposes to reduce the negative impacts of products and waste on the environment.

2.2 Contextualizing the circular economy in the European Union

The idea of a Circular Economy has gained importance, and several regions and countries have adopted it in their policies. The European Union (EU) has adopted several documents in pursuit of a more sustainable system of growth.

In 2008, the European Parliament enacted the Waste Framework Directive, or Directive 2008/98/EC. With this directive, the EU provides a general framework of waste management requirements and sets the basic waste management definitions for the EU.

On December 2015, the EU put forward the Circular Economy Package to support the transition to a CE. A product of this package is the “closing the loop – an EU action plan for the circular economy”. The plan is divided in 54 actions, each of which refers to a precise fraction of the economic cycle and aims to promote the transition to a circular economy.

Finally, in 2019 EU presented the European Green Deal, a “new growth strategy that aims to transform the EU into a fair and prosperous society, with a modern, resource-efficient and competitive economy” (European Commission, 2019b).

The analysis of these documents allows to show the state of development of the concepts ‘circular economy’ and ‘waste as a resource’ in the European framework.

2.2.1 Waste Framework Directive

Enacted in 2008, the Waste Framework Directive “requires that waste be managed without endangering human health and harming the environment”. Even if the directive does not refer explicitly to the CE, it claims the need of waste reduction and a better use of resource to cut negative impacts on the environmental and social spheres. The directive starts with several definitions, including the one of waste, defines as “any substance or object which the holder discards or intends or is required to discard”.

As already pointed out, the waste generation lies in the hands of the holder, who can decide whenever a product becomes a waste. Moreover, this

definition may have different interpretations. It is highly subjective the perception of waste, what is to be discarded for one owner, could be not to be discarded for another.

Article 4 introduces the principle of “waste hierarchy” to adopt in waste management policies. The hierarchy provides for the implementation the follows priority: prevention, preparing for re-use, recycling, other forms of recovery, disposal. The prevention refers to the products, so the preferred step is to avoid waste production, by acting on the products and their manufacture. All the other solutions act on waste, by defining only the priority of application for each process. It stated that Member States have to apply this hierarchy and encourage the options that deliver the best overall environmental outcome.

Since the definition of waste associates the waste generation exclusively to the holder, in Article 8, the directive introduces the concept of ‘Producer responsibility’. “Member States may take legislative or non-legislative measures to ensure that any natural or legal person who professionally develops, manufactures, processes, treats, sells or imports products (producer of the product) has extended producer responsibility”. This implies that some products, after their use, have to be returned to its producer, who has the management and the financial responsibility for that good. Moreover, States may suggest or introduce appropriate design in order to reduce environmental impacts and waste generation. Products should be suitable for multiple use, durable and easily for dissemble.

In addition to the producer responsibility, the Directive introduces the responsibility for waste management (Art. 15). “Member States shall take the necessary measures to ensure that any original waste producer or other holder carries out the treatment of waste himself or has the treatment handled by a dealer or an establishment or undertaking which carries out waste treatment operations or arranged by a private or public waste collector”.

Article 11 encourages re-use and recycling practices, as repair network and economic instruments. By 2015, State Members have to set up separate collection at least for paper, metal, plastic and glass, and, by 2020, separate

collection of paper, metal plastic and glass from households have to reach at least 50% by weight.

Furthermore, the Directive foresees the adoption of waste management plans and waste prevention programmes (Art. 28-29). The plans should report an analysis of the current waste management system in each state and set out the measures to adopt to improve the Directive's objective.
Waste management plans have to contain the following data:

- type, quantity and source of waste generated;
- existing waste collection schemes and major disposal and recovery infrastructure;
- an estimation of the need for new collection schemas;
- waste management policies.

Waste prevention programmes have to be integrated in waste management plans and "the aim of such objectives and measures shall be to break the link between economic growth and the environmental impacts associated with the generation of waste".
The Directive introduces three type of measures that each state should adopted:

- measures that can affect the generation of waste (e.g. planning measures, economic instruments, promotion of research and development);
- measures that can affect design, production and distribution (e.g. eco-design, provision of information about waste prevention techniques, awareness campaigns);
- measures that affect the consumption and use (e.g. incentives for clean purchases, agreements with industry, promotion of the reuse and/or repair of appropriate discarded products or of their components).

2.2.2 Closing the loop: a European Action Plan for the Circular Economy

The Action Plan for Circular Economy purpose is to achieve a transition to a more circular economy “to develop a sustainable, low carbon, resource efficient and competitive economy” (European Commission, 2015).

The CE is seen as the solution to the scarcity of resources, it will help to create new business opportunities and new technologies for a more efficient production and consumption processes. At the same time, this new way of development will save energy and avoid the negative and irreversible impacts on the environment. Local, regional and national authorities are in charge of driving the transition, while the EU plays a support role. Although there is not a clear reference to three CE levels, it appears that each territorial level is involved in the transition and the cooperation between levels is necessary to create a regulatory frame for the transition.

The EU action plan for a circular economy is divided into 54 actions each one refers to a specific macro-area. The plan outlines main objectives for the seven macro-areas (*Table 2.1*) and, subsequently, declines the objectives into actions. The actions promoted a systemic approach across the entire value chains and a great amount of them relates to the implementation/creation of policies, regulations and guidelines.

Although the basic principle remains the prevention of waste generation, one of the areas is called “From waste to resources: boosting the market for secondary raw materials and water reuse”. This section focuses on secondary raw materials potential, that is little used in the UE. According to Commission information, this is due to barriers that restrict the growth of this important market. One of the barriers is linked to the uncertainty of materials quality; another issue is related to the chemical substances present in a product.

Table 2.1 - Main objectives description for each area of implementation. (Source: author own elaboration based on European Commission, 2015).

Area	Main objectives
1. Production	Improve design to increase the durability and make products easy to repair, upgrade or remanufacture (e.g. introduce eco-design). Resource efficiency to reduce environmental and social impacts during the production precess.
2. Consumption	Provide incentives and use economic instruments, such as taxation, to ensure that product prices better reflect environmental costs. Extend lifetime of products through reuse and repair, hence avoiding wastage. Promote awareness campaigns and economic incentives to reduce households waste.
3. Waste management	Apply the waste hyerarchy introduced by the Directive 2008/98/EC. Raise levels of high-quality recycling.
4. Boosting the market for secondary raw materials	Develop quality standards for second raw materials.
5. Priority areas	Five priority areas are identified: plastics; food waste; critical raw materials; construction/demolition waste; and biomass and bioproducts.
6. Innovation, investments and other horizontal measures	Develop new technologies, processes, services and business models. Funding programmes such as Cohesion Policy.
7. Monitoring	Develop a monitoring framework for the circular economy.

In 2019, the European Commission (2019a) published a report on the implementation status of this plan.

Even if the work on some actions will continue beyond 2019, it is already possible highlight some of the positive impacts generated. According to the production area has been implemented the “Ecodesign Working Plan 2016-2019”, that promoted the circular design of products, together with energy efficiency objectives (e.g. design for re-use and high-quality recycling of packaging). To promote the conversion of waste into resources the UE has revised the waste legislative framework. New recycling rates, reinforced rules and new obligations on separate collection and more strengthened waste prevention and waste management measures have been adopted.

Moreover, around €10 billion have been allocated to promote innovation and support during the transition. This includes programme and policy such as: Horizon 2020, Cohesion Policy, European Fund for Strategic Investments and Innovfin, LIFE. Finally, a “EU Monitoring Framework for the Circular Economy” has been created. The monitoring framework includes 10 indicators covering each phase of the lifecycle of products as well as competitiveness aspects. The indicators with the highest increase are the one related to the recycling/recovery rates for each stream (Eurostat, 2020b).

2.2.3 The European Green Deal

The European Green Deal is a “roadmap for making the EU's economy sustainable” with two main purposes:

- promote an efficient use of resources to achieve a clean and circular economy;
- restore biodiversity and reduce pollution.

Presented on December 2019, the Green Deal provides a roadmap with actions that cover all the economy sectors. Based on the principle of being the world's first climate neutral continent by 2050, all economy sector will have to reach target. The production and use of energy account for more than 75% EU’s greenhouse emissions, therefore the energy sector has to aspire to the complete decarbonisation. The energy demand decreases in Europe (from 1844 Mtoe in 2006 to 1647 Mtoe in 2017), even if the transition is slowly and still based on a massive consume of dirty fossil fuels as coal and gas (Pellerin-Carlin et al.,2019).

The 40% of EU energy consumption is by buildings, they have to be renovated in order to be more sustainable, cutting energy bills and use. The industry sector uses only 12% of recycle material, it is necessary for industries to be innovative and to become global leaders in the green economy. Transport is responsible for 25% of our emission and consumes 33% of EU energy. Cleaner, cheaper and healthier forms of public and private transport should be introduced (European Commission, 2019c).

Figure 2.4 - The Green Deal priority. The schema shows the 10 macro-areas of the roadmap. (Source: author own elaboration adopted from European Commission, 2019b).

The scheme summarizes the 8 macro-areas of intervention; each area is divided into key actions. Under "Mobilising industry for a clean and circular economy", the roadmap provides for the adoption of a new Circular Economy Action Plan, that focuses on sustainable products initiative, especially regarding textiles, construction, electronics and plastics sectors (European Commission, 2019b).

On March 2020 a proposal of the new Circular Economy Action Plan has been presented. A short document introduces the pillars of the plan and describes some examples of suggested measures and how to apply them. The new initiatives aim to cover the entire life cycle of a products in order to "modernise and transform our economy while protecting the environment".

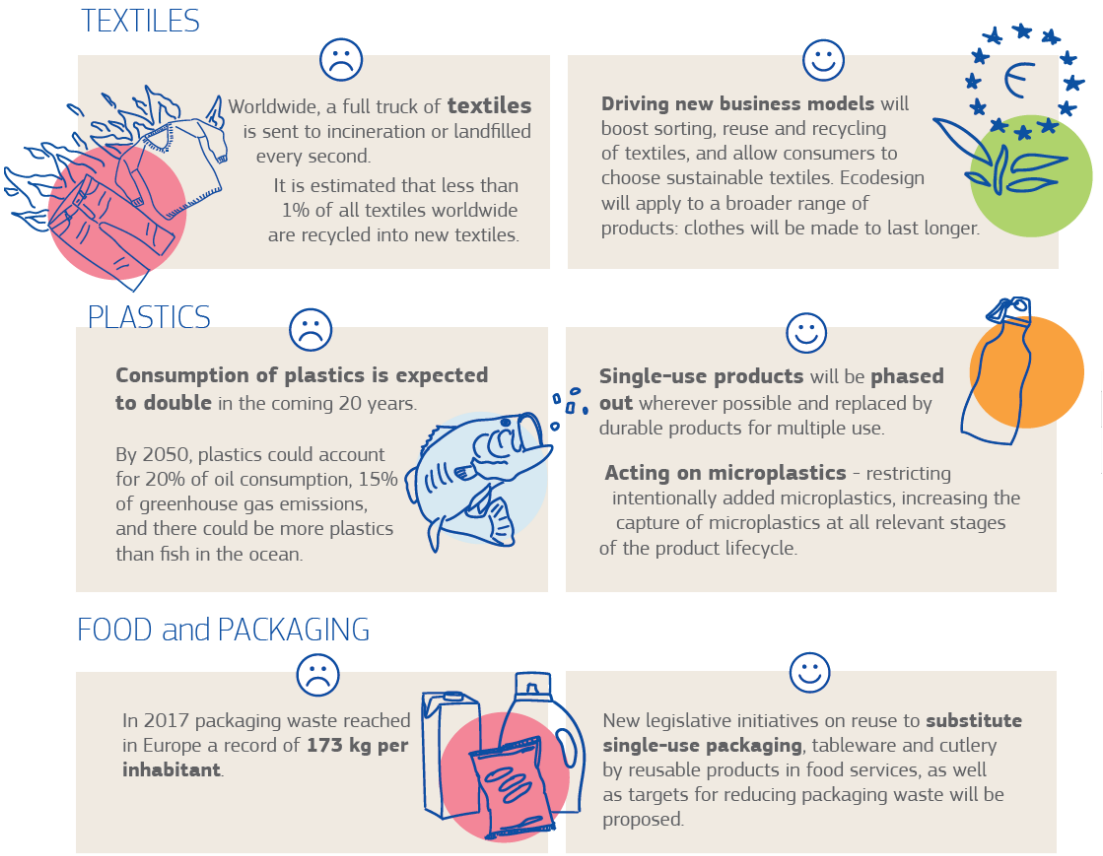

Figure 2.5 - Examples of suggested measures of the new Circular Economy Action Plan proposal (Source: European Commission, 2020a).

Figure 2.5 shows three of the suggested measures presented in the plan proposal. As we can see, the measures do not fix a standard or introduce a priority process, but, based on a negative *status quo*, they suggest the adoption of new initiatives to challenge each waste stream. What emerges from this first proposal is the intention to prevent the waste. If in the first Circular Economy action plan (2015) payed attention to measure and policies that include also the management and reuse of the waste, here the focus is more on the first steps of production and consumption. the emphasis is placed from the outset on the avoidance.

2.3 Circular economy in urban and regional planning framework

As analysed in the previous two sup-chapter, CE has gaining momentum over the years, and several documents have been adopted by EU to promote a more sustainable development. However, there are only few documents that introduce the CE in the planning framework.

Since 2007, more than half the world's population lives in cities, and it is projected that 6 out of 10 people will live in urban areas by 2030 (United Nations, 2019a). Likewise, cities are also the place of highest concentration of human activities, that generate between 40% and 70% of greenhouse world's emission according to UN-Habitat (2011). Hence the need to think about a more sustainable cities development, capable of integrating human activities with the environment.

On the 25 September 2015, the United Nations General Assembly adopted the 2030 Agenda for Sustainable Development. Divided in 17 goals (Sustainable Development Goals, SDGs), the 2030 Agenda set out a 15 years-old plan to promote prosperity while protecting the environment. About a year later, the United Nations Conference on Housing and Sustainable Urban Development (Habitat III) adopted the New Urban Agenda. With a close interconnection with the SDG 11 and an exclusively urban focus, the New Urban Agenda incorporates a new recognition of the correlation between good urbanization and development.

These documents do not contain plans or programmes; however, they focus on the importance and role of planning processes into cities and territories to pursue a more sustainable development. Moreover, cities are a focal point to the develop of the transition to a circular economy. They are seen as a hub in which rethink to our approach, creating new opportunities around housing, mobility, and economic development.

2.3.1 The 2030 Agenda

Composed by 17 SDGs, each one related to a thematic issue, the 2030 Agenda pointed out a strong connection between human well-being, the health of natural systems and the presence of common challenges that all countries are called to face. Several are the fundamental areas to ensure the well-being of humanity and the planet: from the fight against hunger to the elimination of inequalities, from the protection of natural resources to the affirmation of sustainable production and consumption patterns.

Some of the SDGs are considerable as a starter point for circular and green economy practices; here goals 11 and 12 are analysed in order to understand the implication of the CE concept in the Agenda purposes.

2.3.1.1 Make cities inclusive, safe, resilient and sustainable (SDG 11)

Goal 11 pointed out the importance of cities, seen as hubs for economies of several level. “With sound, risk-informed planning and management, cities can become incubators for innovation and growth and drivers of sustainable development” (United Nations, 2019b).

Urban areas are expanding faster than their populations, between 2000 and 2014, cities’ growth was 1,28 times faster than their populations. In such areas access to public transport remains low, on average 53% of urban residents in all regions had convenient access to public transport. The unplanned growth of cities increased pollution’s level. For every 10% increase in sprawl, there is a 5.7% increase in per capita of CO_2 emissions and a 9.6% increase in per capita hazardous pollution. Moreover, 2 billion people do not have access to waste collection services and 3 billion people do not have access to controlled waste disposal facilities; in densely populated cities, waste management is becoming a problem (United Nations, 2016).

To face these problems urgent actions are needed. In addition to addressing the problems listed above, these actions can provide an opportunity to develop cities that fit the circular model.

Among the targets of SDG 11 the following are of particular relevance:

- support positive economic, social and environmental links between urban, peri-urban and rural areas by strengthening national and regional development planning;
- support least developed countries, including through financial and technical assistance, in building sustainable and resilient buildings utilizing local materials;
- by 2020, substantially increase the number of cities and human settlements adopting and implementing integrated policies and plans towards inclusion, resource efficiency, mitigation and adaptation to climate change, resilience to disasters (United Nations, 2020a).

These targets open to new possibility from the planning point of view. First of all, the importance of national and regional planning is recognised. Then the focus is shifted to the single building, which has to be built in a way that is sustainable and resilient. The building plays a key role in the city, as well as being the cause of a large proportion of energy consumption, it is also a potential waste for the city when it is abandoned. Thus, the promotion of local materials, that are easily reusable. Finally, climate change has also had repercussions on the territory, hence the importance of adopting plans that on the one hand prevent it and on the other are able to adapt and respond to it.

The SDG's Report 2019 asserts that 150 countries have developed national urban plans, with almost half of them in the implementation phase.

2.3.1.2 Ensure sustainable consumption and production patterns (SDG 12)

Focusing more on consumption and production aspects, goal 12 aims to "improve resource efficiency, reduce waste and mainstream sustainability practices across all sectors of the economy". If world's population will reach 9.6 billion by 2050, to sustain our current model of development, we will need the equivalent of almost three planets to provide the natural resources needed (United Nations, 2019b).

Among the targets of SDG 12 the following are of particular relevance:

- By 2030, substantially reduce waste generation through prevention, reduction, recycling and reuse;
- By 2030, achieve the sustainable management and efficient use of natural resources;
- Encourage companies, especially large and transnational companies, to adopt sustainable practices and to integrate sustainability information into their reporting cycle;
- By 2030, ensure that people everywhere have the relevant information and awareness for sustainable development and lifestyles in harmony with nature (United Nations, 2020b).

In these targets can be found almost all the concepts present within the different EC definitions and expressed in the documents adopted by the EU. According to the Agenda national policy frameworks and instruments are necessary to enable the fundamental shift towards sustainable development.

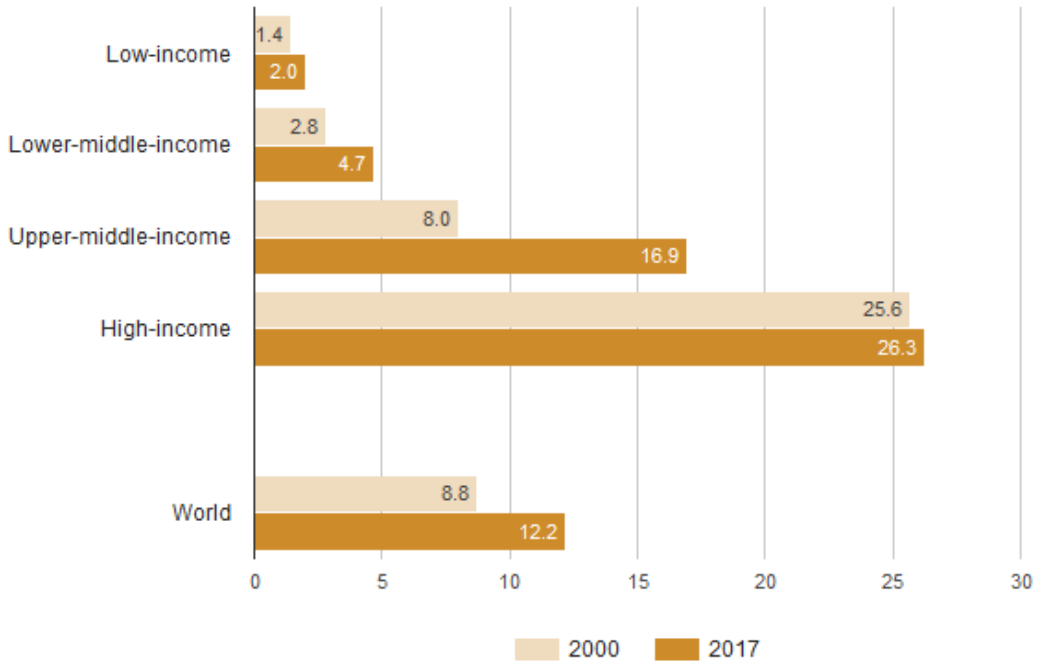

Figure 2.6 - Material footprint per capita (metric tons per person), between 2000 and 2017. "Material Footprint" refers to the quantity of raw material extracted and processed to satisfy the consumption demands (Source: United Nations, 2019a).

Figure 2.6 shows the increasing of material footprint per capita between 2000 and 2017. During the study period is evident an increase in raw material consumption. Though in 2018, 71 countries and the European Union reported on a total of 303 policies and instruments adopted, the indicator shows a still strong growth.

2.3.2 The New Urban Agenda

The New Urban Agenda was presented at the UN-HABITAT III Conference held in Quito, Ecuador, on 20 October 2016. The Agenda represents a shared vision for a better and more sustainable future, in which cities and urban system play a crucial role. It underlines the links between a good urbanisation and development, urbanisation is seen as a an “engine of sustained and inclusive economic growth”.

Five are the main pillars of implementation:

- national urban policies;
- urban legislation and regulations;
- urban planning and design;
- local economy and municipal finance;
- and local implementation.

Sustainable urban development is a critical step for realizing sustainable development. The scope is to reach every level of government, from the national to the local one, moreover the target should be the widest possible, from the citizens to the private sector. To achieve its goal the Agenda refers to three principles: no one has to be leave behind, the urban economies have to be sustainable and inclusive and environment sustainability has to be ensured.

“Ensure sustainable and inclusive urban economies by leveraging the agglomeration benefits of well-planned urbanization, including high productivity, competitiveness and innovation, by promoting full and productive employment and decent work for all, by ensuring the creation of decent jobs and equal access for all to economic and productive resources and opportunities and by preventing land speculation, promoting secure land

tenure and managing urban shrinking, where appropriate" (United Nations, 2017).

Even if the document never refers to the circular economy, several aspects of it emerges from the Agenda. The economic growth is not only based on the innovation and reduction of environmental impacts, but it should also ensure the inclusion and participation of all. From this point of view the role of the planning is crucial to ensure a fair growth that is inclusive and sustainable.

As outlined in the previous documents, cities are a focal point in the transition to a circular economy. However, today, in cities occurs the 75% of natural resource consumption. Cities produce 50% of global waste and 60-80% of greenhouse gas emissions. These data show how, especially in cities, the economy is still strongly based on the model "take, make, dispose" (Ellen MacArthur Foundation, 2019). While these data show a very problematic situation, they are also an opportunity. Indeed, cities make perfect hubs for innovations: their high concentration of resources, capital, data give to them the perfect position to drive the transition to a circular economy.

2.4 Chapter summary

Since the 1990s, the term circular economy has started to be used in a number of areas and its application has gained momentum, especially in the last years. Although the circular economy was born in the industrial context with reference to the so-called ‘industrial metabolism’ and industrial processes, nowadays the term has several meanings and application.

Despite the divergences, the various definitions of CE have the same starter point: our current economic system is no longer sustainable, the “make, use and dispose” model has reached its limits and a transition to a new economy is needed. This new model has to be restorative and regenerative, instead of promoting large-scale production and the subsequent products disposal, the new economy has to focus on the reintroduction of raw materials in the cycle, avoiding waste and environmental impacts. Moreover, the circular economy is not only about the industrial level, but acts at different scales, from local to macro level.

Based on this analysis, Nation and Countries have adopted CE in their policies. For instance, the European Union has already adopted two documents, the Circular Economy Action Plan and the Green Deal, in which CE is seen as the right economic model to achieve a more inclusive and sustainable growth.

The 2030 Agenda and the New Urban Agenda are two Agendas adopted by United Nations that highlight the importance of the planning in achieving a sustainable urban and economic growth. Especially cities are seen as perfect hubs for innovations: their high concentration of resources, capital, data give to them the perfect position to drive the transition to a circular economy.

Based on these definitions and analysis, the following chapter will introduce REPAiR project, a European project that aims to promote the circular economy in urban and peri-urban areas.

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03 REPAiR PROJECT

3. REPAiR project

‘Innovation’ is a recurrent term in definitions and policies concerning the circular economy. The European Union encourages innovation through “Framework Programmes for Research and Technological Development”, programmes that support and foster research in the European Research Area. In 2014 the eighth framework programme for research and technological development was launched: Horizon 2020.

Under Horizon 2020, the European project REPAiR began in 2016. The word REPAiR is the acronym for “REsource Management In Peri-urban AReas: Going Beyond Urban Metabolism”. The core objective of REPAiR is to promote the use of waste as a resource, following the initiatives of the European Commission and establishing a strong circular economy. To achieve the goal the project provides local and regional support, through the implementation of an “open source geodesign decision support environment (GDSE)”. Involving several stakeholders, this tool allows to create “eco-innovative spatial development strategies”, with the purpose of reach a quantitative reduction in the amount of waste flows (REPAiR Project, 2020).

An important aspect of the project is to investigate cities through ‘Urban Metabolism’ (UM) approach, in which urban subsystems with their environmental and spatial impacts are addressed more explicitly (REPAiR, 2017a). From this perspective the city is seen as living organism, that requires nutrients to function and the consumption of these nutrients generate negative internal and external impacts of the urban system.

This chapter aims to introduce the project and the core topics approached by the present master thesis. According to the European framework, a general overview of the project is first provided, then follows a focus on the concept of Urban Metabolism.

3.1 Contextualization of the project in the European framework

In 2014 the European Commission has given rise to Horizon 2020, “the biggest EU Research and Innovation programme to create sustainable growth and viable jobs in Europe” (European Commission, 2017).

Horizon 2020 is a ‘framework programme’; this kind of programme have been introduced by EU to provided financial support for research and innovation policies since the 1983. However, it was only with Horizon 2020 that the Commission proposed for the first time to create a “Common Strategic Framework” into which integrate all research and innovation founds in order to simplify the participation (Reillion, 2015). Moreover, Horizon 2020 is meant to be aligned with the strategy Europe 2020, “a strategy for smart, sustainable and inclusive growth” (European Commission, 2010).

With a total bouget around €80 billion of funding available over 7 years (2014 to 2020), Horizon 2020 is structured around three pillars and two specific objectives (see *Figure 3.1*).

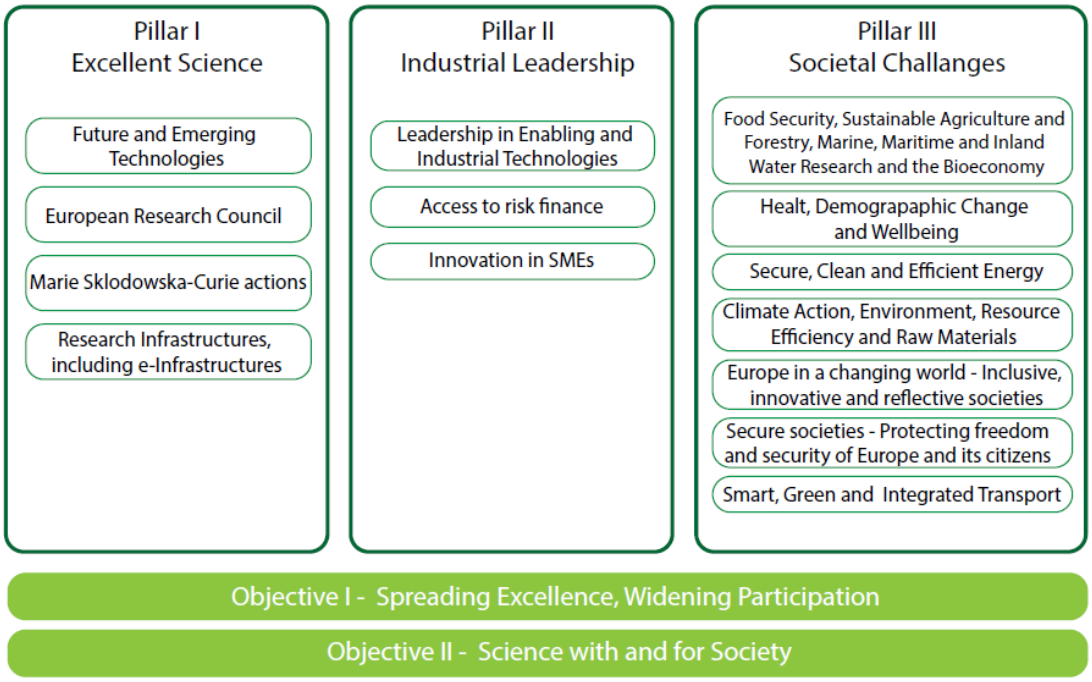

Figure 3.1 - Horizon 2020 structure. The scheme summarizes the three pillars of the programme with the related priorities and the two specific objectives (Source: author own elaboration based on European Commission, 2014).

The first pillar ‘Excellent Science’ aims to make the Union’s research and innovation more competitive on a global scale. The second pillar ‘Industrial Leadership’ promotes new technologies and innovation development in order to underpin tomorrow’s business and help innovative economy. The third pillar ‘Societal Challenges’ is organised around 7 societal challenges, here the goal is to bring together resource and knowledge to cover several fields.

In addition to these pillars there are two specific objectives:

- Spreading excellence, widening participation;
- Science with and for society.

In the frame of the priority ‘Climate action, environment, resource efficiency and raw materials’ (pillar societal challenges), the project deal in this thesis has been developed: REPAiR. This priority is based on the principle that the era of never-ending cheap resources is coming to end. Moreover, biodiversity and ecosystem are paying the price for an economy that is no longer sustainable. Hence, the solution is to invest in innovation and drive change towards a greener economy in sync with the environment. Waste and water are the two priority aspects of this transition. Indeed, the EU stated that waste was responsible for 2% of the EU’s greenhouse gas emissions in 2014, while investing in the water industry, increasing the sector by just the 1%, could create up to 20.000 new jobs. The budget for this priority is €3.081 billion, and 602 grants have been signed since 2014 (2,20% of Horizon 2020), for a total of €1.920 billion (European Union, 2020). REPAiR project has been started in September 2016, with a bouget of approximately of €5 million.

3.2 The project and its core topics

The European project REPAiR “REsource Management in Peri-urban AReas: Going Beyond Urban Metabolism” aims at a quantitative reduction of waste flows in peri-urban areas towards establishing a strong circular economy. Moving from a perception of ‘waste as a problem’ to ‘waste as a resource’ the project goals to define a set of Eco Innovative Solutions (EIS) and to create an open source software to provide decision support to local and regional authorities (Geodesign Decision Support Environment - GDSE).

As already mention, the project is part of Horizon 2020 priority ‘Climate action, environment, resource efficiency and raw material’, and, specifically, of the programme “Enabling the transition towards a green economy and society through eco-innovation”. Started in September 2016, and scheduled to end in August 2020, the project has a budget of €5 million, and analyses six metropolitan areas in six different countries: Amsterdam (Netherlands), Ghent (Belgium), Hamburg (Germany), Łódź (Poland), Naples (Italy) and Pécs (Hungary). Coordinated by the Technische Universiteit Delft (TUD), the project involves several public and private actors in each country.

3.2.1 REPAiR’s structure

Horizon 2020 projects are structured in work packages (WP), “building blocks” that breakdown the different tasks, deliverables, and milestones of the project. REPAiR is structured around 8 work packages and two levels.

WP1 (Project management), WP2 (Developing and implementing a Geo-design Decision Support Environment), WP7 (Knowledge transfer between cases) and WP8 (Dissemination and exploitation) operate across the cases and coordinate activities, while WP3 (Developing and implementing territorial metabolism models), WP4 (Developing and implementing evaluation and impact models), WP5 (Developing Eco-Innovative Solutions and changes strategies) and WP6 (Developing and implementing decision models) develop models for each study area.

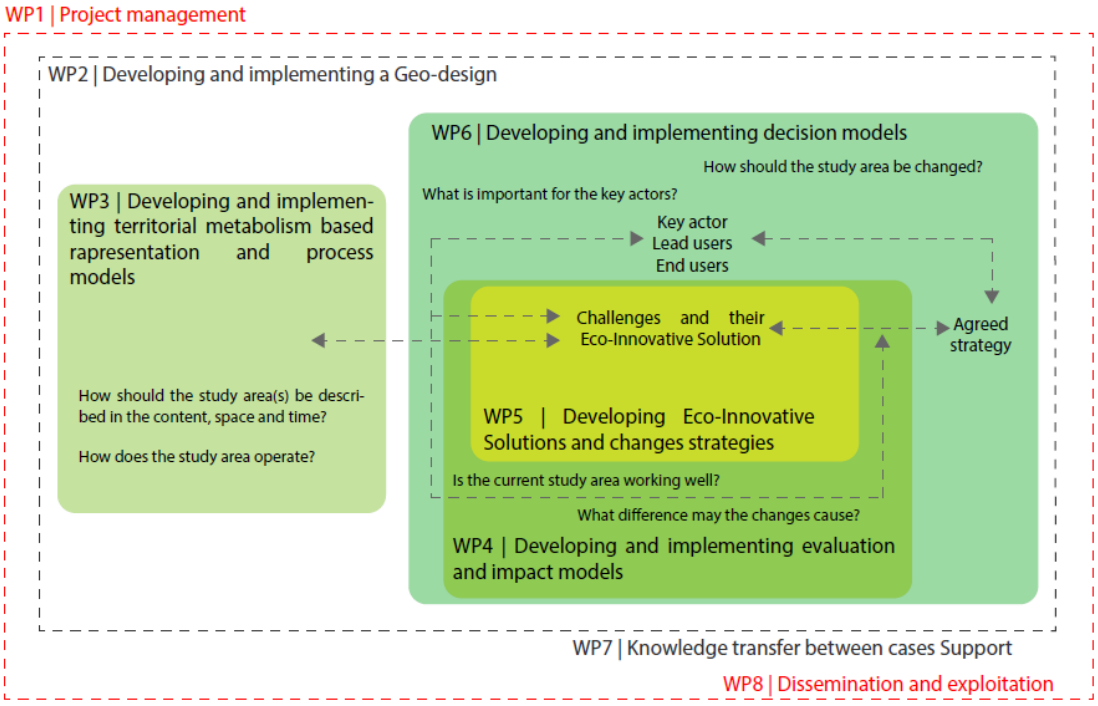

Figure 3.2 - WP structure. The schema shows the structure of REPAiR's Work Packages and their interrelations (Source: author own elaboration based on REPAiR, 2020).

To reach the project's goal, REPAiR teams need to:

- investigate and understand the need of the key actors in the study areas;
- define the concept of urban metabolism in order to describe the processes in the study areas;
- define potential change strategies, involving stakeholders, future users and thematic experts;
- develop a frame of indicators to evaluate the current situation and potential positive/negative impacts due to new strategies;
- develop a framework of knowledge transfer;
- develop the GDSE to allow policymaker to choose between alternatives in an easy and quickly way.

Four types of activities are present in the project, namely research activities, technological innovation, peri-urban living labs and promotion activities.

Research activities focus mainly on WP 3,4,6 and 7 where analyses are performed, and decision models are implemented on the study cases.

Technological innovation regards mainly the GDSE - open source geodesign decision support environment. The GDSE is an open source tool that allows policymakers to define and choose between alternatives the best options for the study area. This tool is designed to allow, in the decision-making phase, the collaboration of different actors including stakeholders, local and regional authorities, experts and end users.

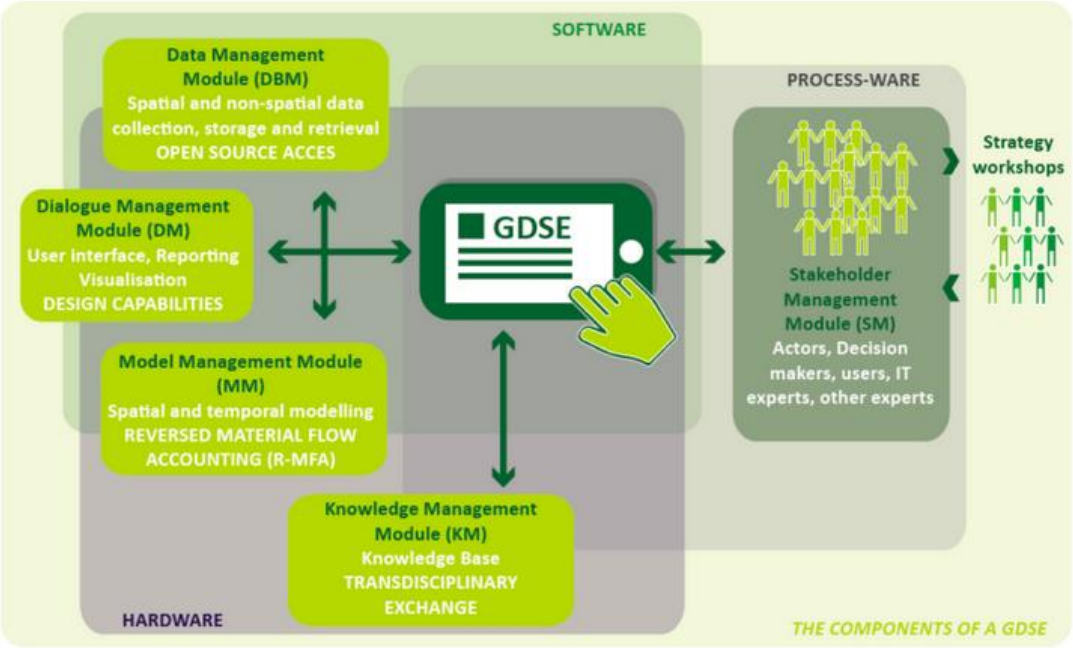

Figure 3.3 - GDSE structure. The schema shows actors and input data needed to the GDSE function (Source: REPAiR, 2020).

Living labs are physical or virtual spaces in which public and private people can develop together innovation, including the end users. Peri Urban Living Labs (PULLs) in REPAiR are meant to be a methodology that "leads to the change of mind-sets and current behaviour with reference to inadequate models of waste management and urban metabolism" (REPAiR, 2017b). Two are the key outputs of a PULL: empowerment and co-creation. Through the PULL, stakeholders, users, decision makers and experts can create a collaborative space in which co-create ideas and strategies. The co-creation implies also the co-evaluation of strategies that emerged.

3.3 Going Beyond Urban Metabolism

The concept of ‘urban metabolism’ (UM) is a crucial aspect of the project. Nowadays cities are characterized by high concentration of economic activities, population, buildings, energy and material flows that represent potential ecosystems impacts. The economic model ‘take, make, dispose’ has contributed to shape our cities, ignoring for long time critical output flows like waste and pollution.

3.3.1 Defining Urban Metabolism

Roots of the term ‘urban metabolism’ can be found at the end of the XIX century, when Carl Marx used that expression to describe how humans extracted material and alter the biophysical processes and landscape. However, the majority of authors argued that the term has been introduced firstly by Wolman in 1965 in response to deteriorating air and water quality in American cities. His vision assimilates a city to an ecosystem, in which material and energy flow and are consumed and, the use of these resources, creates products and generates waste. Understanding how resources are used and converted in product and waste is the key to understand the urban ecosystem (Zhang, 2013).

A city could be seen as an organism, it requires nutrients (resources) to function, and “the way these resources are used to serve all different functions of the city, and to which waste flows this lead, determines the metabolism of the body, and translated to urban flows, the urban metabolism” (Rogemma, 2019). Cities required to import nutrients to sustain the metabolism and the consumption of these nutrients generate metabolites. If these metabolites cannot be reintroduced in the cycle, they generated adverse effects on the organism. Therefore, an urban ecosystem works as well as a natural ecosystem only if the waste generated are reused somehow in order to prevent the negative internal and external impacts of the system.

The urban metabolism is frequently linked to the concept of ecological footprint. The ecological footprint is the amount of land needed to provide resource and adsorb waste and pollution generate by an urban system.

Figure 3.4 shows the increased of the footprint that, since the 1970s, has overcome the Earth capacity. Nowadays, in a theoretical way, the equivalent of 1,6 Earth per year are needed to satisfy the demand of natural resources and adsorb the output flows.

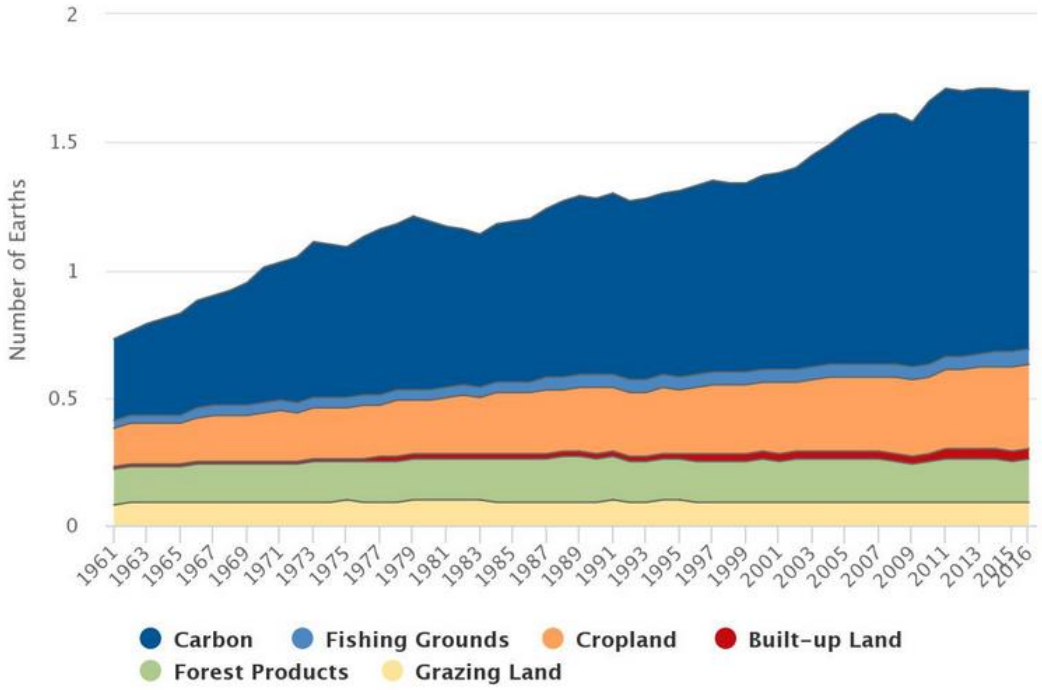

Figure 3.4 - Ecological footprint. The graph sows the growth of the ecological footprint in the last 60 years (Source: Global Footprint Network, 2019).

UM has introduced new thinking on how cities can be sustainable. Kennedy et al. (2007) stated that a "sustainable city implies an urban region for which the inflows of materials and energy and the disposal of wastes do not exceed the capacity of its hinterlands". With a biological system prospective, Cui et al. (2019) argued that the goal of a sustainable city is the reduction of natural resource consumption and waste production while improving the liveability.

Today urban metabolism studies are addressing a number of challenges; Broto et al. (2012) identified six urban metabolism themes, that are shown in *table 3.1*. Some studies aim to transpose the functionality of natural ecosystem to the design of cities, others account flows in order to reduce them and improve policies. Finally, some studies analyse the distribution of flows in cities, seen as driver of social inequalities.

Table 3.1 - Six urban metabolism themes (Source: Broto et al., 2012).

Theme	*Key question*	*Emphasis on*
The city as an ecosystem	What lessons from the functioning of ecosystems can be applied to design and plan better cities?	Nature-inspired models of development in urban planning and design
Material and energy flows in the city	What methods can account for material and energy flows through the city and can these provide suggestions for their optimization?	Comparative analyses of cities and models of urban planning in relation to their efficiency in allocating materials and energy
The material basis of the economy	What policy measures can break the link between urbanization, economic growth and resource consumption?	The material limits of the economy and macroeconomic models to achieve economic and resource stability
Economic drivers of rural–urban relationships	How do economic relations shape the distribution of flows between urban regions and their surroundings?	Forms of territorial organization in relation to different modes of economic circulation
The reproduction of urban inequality	How do existing urban flows distribute resources across the city and who controls these processes?	Patterns of unequal access to resources and the control of these patterns by urban elites
Resignifying socioecological relationships	What socioecological practices have the potential to reimagine and reconfigure existing socioecological flows?	Alternative visions and models of socioecological flows in cultural production, everyday practices, and policy innovations

What emerged is the interdisciplinarity of the concept: urban metabolism does not only focus on the sustainability of the city, but it highlights the need of dialogue between several disciplines as urban planning, design, economy, sociology.

3.3.2 Urban Metabolism methodologies

There are two main methodological approaches to study urban metabolism:

- MFA – Material-flow-analysis
- EFA – Energy-flow-analysis

The first focus on material and energy flows; the second describes urban metabolism in terms of energy equivalents.

The MFA goal is to provide how a city, region or nation functions, analysing the input, storage, transformation and output process in a well definite system. Through recording all the physical flows from and to an urban area, MFA model describes the relationship between the urban system and the environment (Broto et al., 2012).

The EFA, also called ‘energy balance’ aims to provide a more detailed understanding of urban metabolism than the first one. This methodology tracks the energy flows of an urban system to understand the imbalance between a city’s metabolism and the planet’s capacity (Urban Waste, 2016). In this

context, the ‘ecological footprint’ represents an approach that aims to quantify the amount of land needed to provide resource and adsorb waste generate by an urban system.

In REPAiR, the MFA is used to study the material flows and stocks of the subsystems of the six case studies. This methodology has been used to track specific activities, such as material flows and stocks from waste production. Therefore, the methodology adopted as been called ‘Activity-based Spatial Material Flow Analysis’ (REPAiR, 2017a).

Other methodologies are the data analysis, the input-output analysis and the life cycle assessment (LCA) analysis. The first is not a really defined methodologies, it consists of a juxtaposition of data coming from different sources. The second is a macroeconomic tool that provides an overview of flows based on interaction between economic sector. Finally, the LCA define the assessment of all the processes, from the extraction to the end-of-life phase. Moreover, it takes in account all the input and output flows entering and exiting the system during the process (Metabolism of cities, 2020).

3.3.3 Circularity in cities

The term circular economy described in Chapter 2 is directly connected to the urban metabolism described so far. Indeed, the CE aims to reduce natural resource consumption and avoid waste generation reusing the material and closing the loop, in the same way, focusing on cities and studying the material flows, the UM aims to reduce the negative impacts of the city on the environment. Cities are therefore characterized by linear metabolism when their inputs come from external systems and their outputs are dumped in other systems. On the other hand, cities have a circular metabolism when they minimize the inputs from external system and outputs, limiting negative externalities and waste (Longato et al., 2019).

The concept of circular economy is often associated with the concept of circular city. The role of building environment has gained momentum, due to its high environmental impacts, and the circularity is seen as an opportunity to

reduce energy consumption, greenhouse emissions and waste production (Pomponi and Moncaster, 2017). However, according to Marin and De Meulder (2018), to date frameworks for designing circular cities are missing.

The Ellen MacArthur foundation (2017) argued that implementing the circular economy in a city could bring opportunities for several aspects such as mobility, buildings and products. In their vision the implementation of circular economy principles in cities should be driven by:

- Planning: the layout and design of cities change the way flows move around them. Planning mobility, land use, and waste management system may allow the redistribution of materials, and the reduction of greenhouse emission and pollution;
- Designing: products are designed to be durable, adaptable, modular, and easy to maintain and repurpose;
- Making: products are designed out of waste, enabling their repair and reuse;
- Accessing: people gain access to things they need in different ways, as through sharing rather than owning;
- Operating and maintaining: people repair and refurbish their products; these activities may occur at several levels (individual, community, and commercial level).

Despite this attempt to define a vision of how implement city from a circular prospective, there is a relative lack of guidelines for introducing circular economy and urban metabolism concepts in a decision-making process able to support appropriate policies and strategies. According to Longato et al. (2019), CE activities have to be intended as specific measures to achieve a more sustainable and circular urban metabolism. Moreover, they consider necessary adopt participatory process in order to shape the cities' consumption patterns.

3.4 Methodology and case studies

After defining the circular economy and urban metabolism concepts, two case studies are presented and analysed in the following chapters. The methodology adopted for the case studies is strictly related to the concepts so far described. Indeed, based on the urban metabolism approaches, two study areas in the cities of Hamburg and Turin are analysed.

First the legislative and planning framework is defined, through the analysis of the planning and waste management systems at the country and city levels. This allows to highlight existing policies or potential implications for the elaboration of solutions to improve the waste management system with a view to a circular economy. Then the focus area is presented, and some socio-economic analysis are carried out. The socio-economic context contributes and is particularly relevant to understand the waste generation in the study areas.

After these preliminary analyses necessary to delineate the status quo of each study areas, an Eco-Innovative Solution defined within REPAiR project is developed in both case studies. The solution aims to close locally the circular economy loop, adopting an urban metabolism approach in which waste are consider flows of resources that enter in the area in form of resources and exit as waste, if not reintroduced in the cycle. The main goal is therefore avoiding the waste production and promote the reusing of waste in order to maintain the flow in the study area. Finally, the EIS impacts on the waste management system are evaluated through a ‘sustainable assessment framework’ defined in REPAiR with reference to the life cycle assessment methodology.

3.5 Chapter summary

Started in 2014, Horizon 2020 is a European framework programme to foster research and innovation across Europe. The programme is articulated around three pillars and, in the frame of the pillar “Societal challenges” the project REPAiR has been developed.

REPAiR aims to reduce the waste generation through enabling a circular economy in six metropolitan areas. The project is divided in work packages, each one focuses on a specific thematic; in particular, WP 5 goal is to develop Eco-Innovative Solutions to reduce waste production. One of the EIS adopted for Hamburg case study will be presented in the next chapters.

Moreover, the chapter has introduced the concept of urban metabolism, that lies at the base of the project. According to urban metabolism approaches, cities are seen as living organism into which energy and material flows enter and pollution and waste flows leave. Even if the terms circular economy and urban metabolism have different origins, to date the concepts are consider related. Indeed, to achieve a circular metabolism, CE practices have to be implemented into cities. However, it was found that a general framework for design circular cities and guidelines for introducing the concepts in decision-making processes are missing. In the next chapters, the planning and waste management systems of two cities will be provide in order to understand the existing and potential correlations with the circular economy and the urban metabolism approaches.

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04 A CASE STUDY IN GERMANY: HAMBURG

4. A case study in Germany: Hamburg

This chapter, together with chapters 5, 6, and 7, provides an analysis of two case studies: Hamburg and Turin. The objective is to apply concepts outlined so far to two concrete situations.

The first city to be analysed is Hamburg, one of the six metropolitan areas involved in REPAiR project. The city of Hamburg, together with Berlin and Bremen is a so called ‘federal city-states’. It is the second largest city in Germany with approximately 1,7 million inhabitants, and, at the same time, the second smallest federal state by area (755 km^2). As a city-state, Hamburg has a special status in the country's federal political system, enjoying considerable autonomies. The recognition of this special status has its roots in the century-old history of the city: Hamburg has been for long time a free Hanseatic city and the Germany’s largest harbour since the 16^{th} century.

The status of city-state gives to the city also a special position regarding the waste management system (WMS), that usually is coordinate by the state level. Indeed, each federal state elaborate its own law about waste, and, in the case of the city-states is the city that enhances is own law and defines the WMS. In Europe, Germany was at the third place in terms of amount of kilogram of municipal waste generated per capita in 2014, but, on the other hand, it was located first for what concerns recycling of municipal waste: the value of recycled municipal waste was circa 64% in 2014 (EEA, 2016).

The chapter attempts to define the planning and waste management systems framework, both at the national level than at the federal state of Hamburg level. After introducing the two systems, the chapter focuses on the study area of Altona district. The district is presented according to socio-economic analysis carried out within REPAiR project. Moreover, inside the district five ‘sample areas’ have been identified. Each of these areas has peculiar characteristics that have allowed to develop eco-innovative solutions.

4.1 Planning system in Germany

Germany is a federal state, composed of a central government (*Bund*) and a number of constitutive states (*Länder*).

The constitution of the Federal Republic of Germany, called Basic Law, states the separation of powers to ensure democratic representation and rational discharge of functions. This has led to a dense network of level in the participatory process (see *Figure 4.1*).

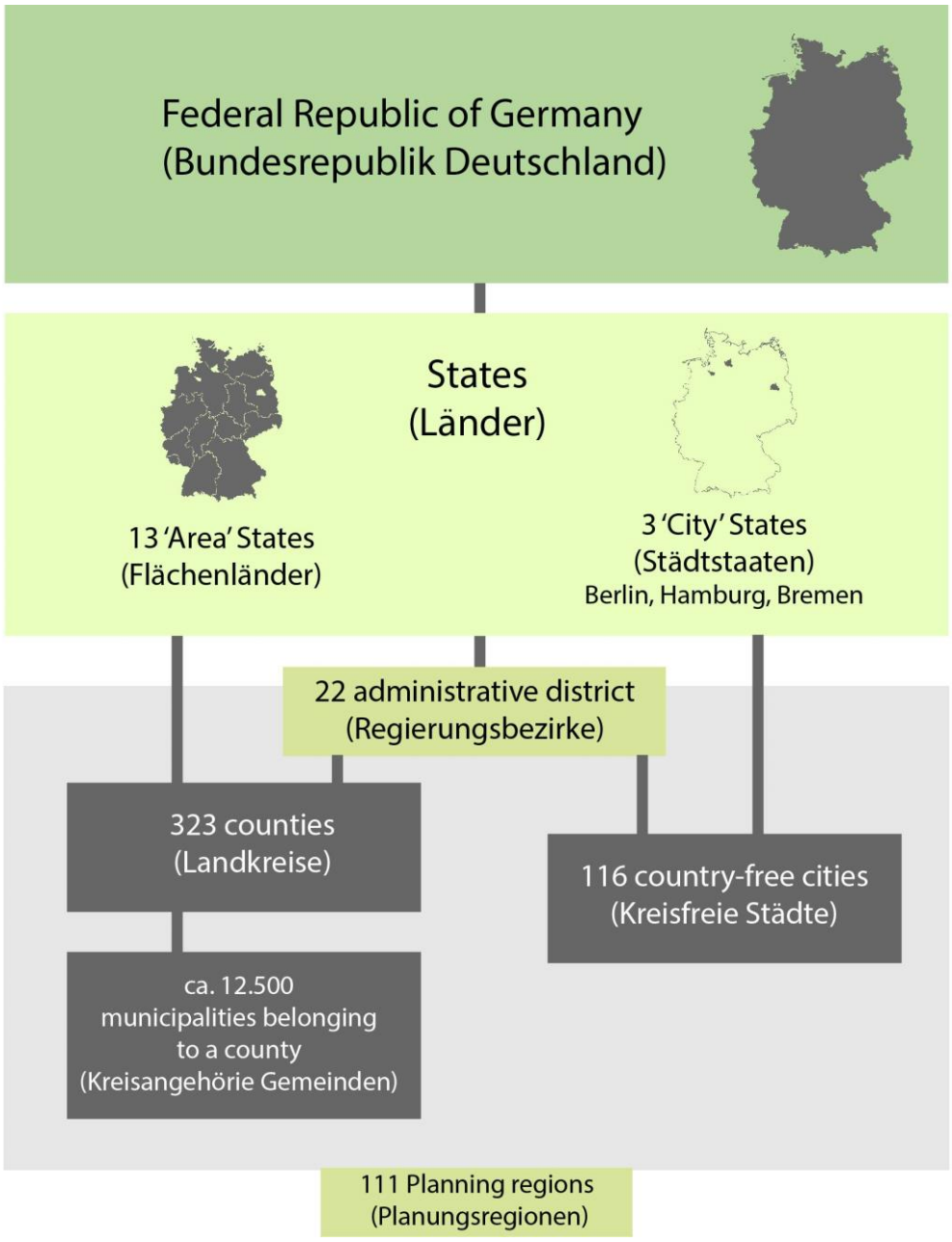

Figure 4.1 - Administrative structure in Germany (Source: author own elaboration based on Pahl-Weber and Henckel, 2008).

Since the 19th century several laws concerning building and urban expansion have been enacted. However, only in 1960, the Federal Building Act has aligned all the previous laws in a single act. This law enshrines the delimitation of functions between urban planning, spatial planning and building regulations, as well as the differentiation between local level and higher government levels. According to the Federal Building Act local authorities control and organize urban development through land-use plan, while federal and state authorities are in charge of spatial planning.

Despite this distribution of competence between the three federal levels (federal, state and local), they are interlinked by the "mutual feedback principle" by which each level is involved in the planning process of the other levels through a system of notification, participation and coordination (Pahl-Weber and Henckel, 2008).

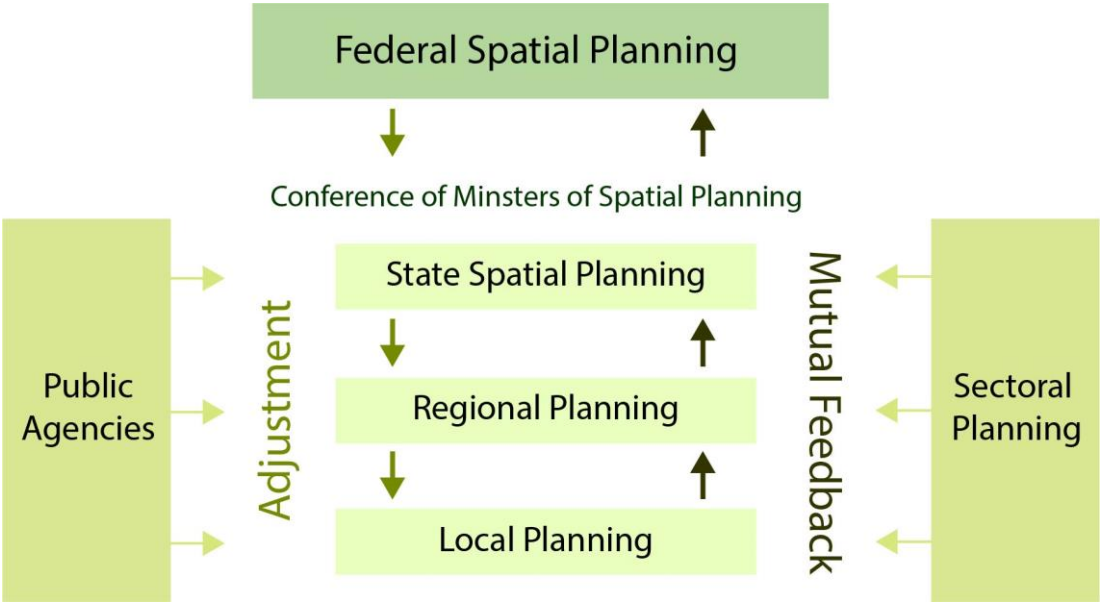

Figure 4.2 - Mutual feedback principle. The schema shows the interdependence between the planning levels (Source: author own elaboration based on Pahl-Weber and Henckel, 2008).

The federal level gives spatial planning's guidelines and schemas to be improved by each state level. At this level, a law, the *Raumordnungsgesetz* (ROG), defines the frame of spatial planning.

The state (*Länd*) is liable for the planning system at state and regional level, it coordinates the spatial planning and defines sectorial policies, moreover it regulates the local level. Each *Länd* can define its own planning system

through the *Landesplanungsgesetz* (State Planning Law), remaining within the confines of the Federal Law ROG. State plan and programmes are drawn up in each state.

The regional level aims to coordinate local development at a lower level than in the Länder. However, this is not a compulsory activity, and there is no administrative level specifically dedicated to this activity (Rivolin, 2016). In some states the regional planning takes the form of administrative districts, while in other regions there is the presence of relatively strong planning associations (Diller, 2016).

Local level is responsible mostly for two type of urban plan: the *Flächennutzungsplan* (F-Plan, preparatory land-use plan) and the *Bebauungsplan* (B-Plan, construction plan). The first include current and future land uses in the entire municipality, the second contains designations of urban development (REPAiR, 2017).

4.1.1 Planning system in Hamburg

The city of Hamburg is one of the three so called ‘federal city-states’, which means that the city has a certain autonomy and legislative powers, also as regards its planning system.

At the city-state level, the Ministry of Urban Planning and Housing (BSW, *Behörde für Stadtentwicklung und Wohnen*) is responsible for planning policies and processes. At this level only one document covers the topic of spatial planning for the whole area of the city: the preparatory land use plan (REPAiR, 2017). Additionally, the Ministry of Urban Planning and Housing can prepare informal strategic planning document such as ‘spatial development concepts’ and ‘strategic spatial vision’ (Othengrafen, 2016). These documents function as programmatic framework and give input to the legal planning.

Below the city level, seven city districts represent the municipal level. The districts are responsible for the local development plan that has to follow the guidance of the preparatory land-use plan. The districts have their own council and an administration responsible for different thematic on district level, among which environment, urban planning and public spaces management. Despite

representing an important level for the city, the districts have more limited competences compared to an independent municipality and, under special occasions, the City of Hamburg has the right to take over the preparatory land-use planning from the districts (REPAiR, 2017). Each district is divided in quarters (*Stadtteil*), statistical units without any political and planning power.

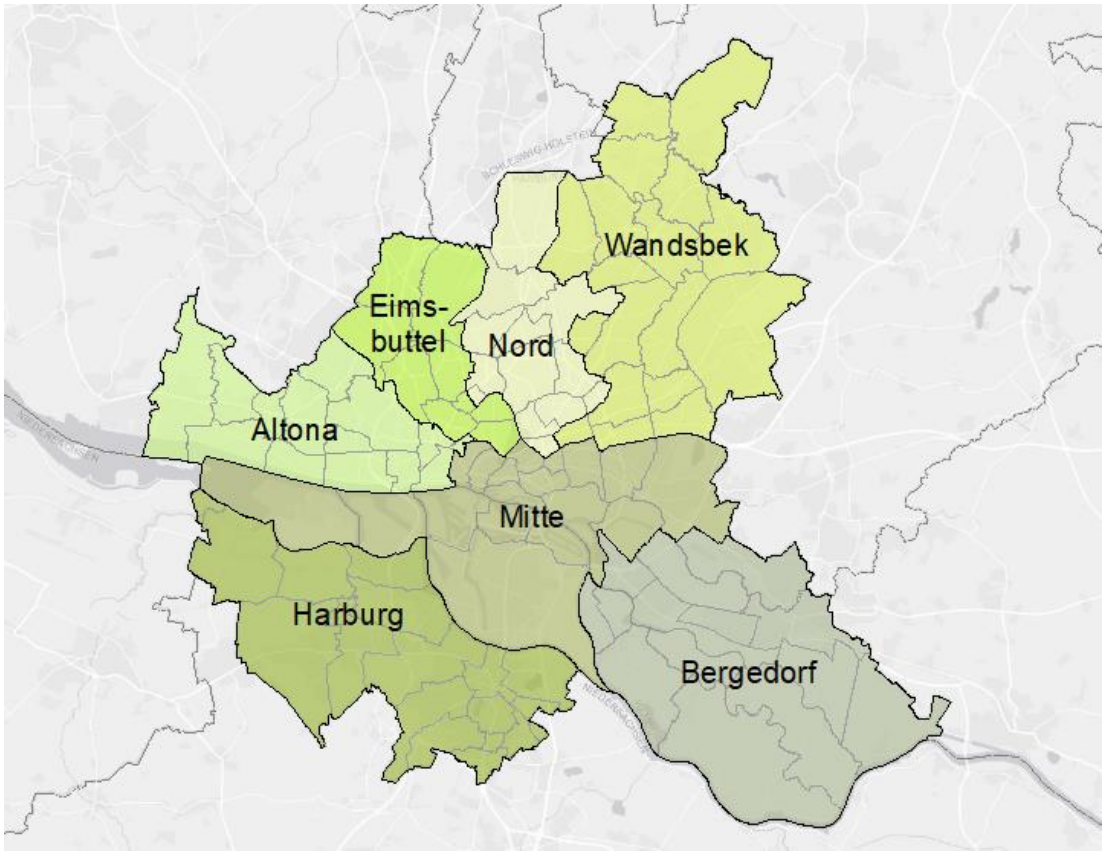

Figure 4.3 - Hamburg administrative division. The map shows with several colours the administrative limits of the seven districts of the city, and, with a grey line the limits of quarters (Source: author own elaboration).

Furthermore, Hamburg is part of the Hamburg Metropolitan Region (HMR), a volunteer cooperation based on a state contract between the federal states Hamburg, Mecklenburg-Vorpommern, Lower Saxony, and Schleswig-Holstein (REPAiR, 2017). The region has a strategic position; it is located at the crossroads of Europe's most important transport axes. This makes the metropolitan area the economic centre of Northern Germany.

With almost 5,4 million inhabitants, the HMR brings together 20 districts and more than 1.100 municipalities. The area has been characterized by a strong

regional cooperation since the 1920s, but only in 1991 an inter-state agreement has institutionalised the HMR (OECD, 2019).

The HMR aims to gear up its competitiveness, to improve quality of life, to formulate strategies against climate change and to manage its effects, and to develop settlement and spatial structures. The cooperation projects and programme are funded mainly by common funds, integrated by external finance from funds at state, federal government or EU level (Hamburg Metropolitan Region, 2020). Even if the HMR is based on an inter-state cooperation, it has not formal role in planning. Each state has its own spatial planning level and timelines. For instance, Hamburg and Schleswig-Holstein have one spatial planning body each at state level, Mecklenburg-Vorpommern has different regional planning association, while, Lower Saxony leaves regional planning to districts (OECD, 2019). The lack of a common framework sometimes makes cooperation difficult.

Figure 4.4 - Hamburg Metropolitan Region. The figure shows the boundaries of the HMR; besides Hamburg, only a part of the three surrounding state are part of the region (Source: hamburg.de, 2020a).

4.2 Waste Management System in Germany

The waste management and environment protection responsibility are shared between the federal, state, and local levels. At the federal level, the National Ministry of Environment, Nature conservation, Building and Nuclear Safety sets the priorities, participates in the enactment of laws, oversees strategic planning, information and public relations and defines requirement for waste facility (Fischer, 2013). Based on what is federally enshrined, each state adopts its own Waste Management Act (*Abfallwirtschaftsplan*). Indeed, there is not a national waste management planning, but each federal state can develop an own waste management plan for its area (EEA, 2009 and REPAiR, 2017).

Regarding waste generated by households, the Recycling Management and Waste Act (2012) stated that public local waste authorities have to deal with these wastes. While the responsibility for commercial waste is in competition between public and private waste management companies (Siechau, 2018). Additionally, Germany was the first country in EU to introduce the 'producer responsibility' in 1991. According to the principle the producer of a good is responsible for the product when it becomes a waste. This concept was subsequently adopted by the European Commission in the Waste Framework Directive in 2008 (see Chapter 2.2.1). However, still today, in Germany the principle is applied only to specific waste such as packaging and electronic components (Fischer, 2013).

In the same years, Germany was one of the first countries to introduce policies to limit landfilling and promote separately collection for certain waste. As a result, by 1995 Germany recycled the 40% of municipal waste and landfilled (EEA, 2009). Today the country has an established culture of recycling: 14% of the raw materials used in German industry are recovered waste products, and the recycling rates for households and commercial waste is approximately 60% (REPAiR, 2017). Moreover, German waste policy follows the EU's waste hierarchy (see Chapter 2.2.1), whereby the waste prevention is the first priority, followed by reuse, recycle, and material recovery and energy recovery,

depending on which is better for the environment (EEA, 2009). To include the EU Waste Hierarchy rules, the 2012 Circular Economy Act (KrWG) set a final deadline of 2015 for mandated separate collection of biowaste by waste producers and the assigned waste management authorities (REPAiR, 2018).

4.2.1 Waste Management System in Hamburg

The City of Hamburg, as a federal state, is responsible for waste management. In the city the Ministry of Environment and Energy (*Behörde für Umwelt und Energie*) is responsible for waste management, and, specifically, the Department for Waste Management (*Abteilung Abfallwirtschaft*) is the supreme agency for waste management in Hamburg. (REPAiR, 2017).

The law on waste management defines the organisation of WMS in Hamburg. By this law, since 1994, *Stadtreinigung Hamburg* (SRH) is the public company responsible for household's waste management in the city. According to SRH act and state law, the company is accountable for waste management, energy production and distribution, cleaning (streets, sidewalks, parks, etc.), and winter service and public toilettes (Siechau, 2018). Regarding waste collection and treatment, SRH is responsible for private household's residual waste and biowaste. Additionally, SRH has a contract to collect packaging waste (consisting of plastics, metals) and paper/cardboards through one of its subsidiary companies WERT GmBH (REPAiR, 2017).

Household's waste are collected with a four bin-system: residual (grey bin), biowaste (green bin), paper (blue bin), packaging and plastic (yellow bin). However, not all the city is cover by this system, especially in dense urban area, there is only a two bin-system with residual and biowaste. Moreover, around the city there are container parks in which is possible collect waste like glass, paper, textile, WEEE (Waste Electrical & Electronic Equipment).

In accordance with the producer responsibility principle, many bottles and cans carry the so-called '*Pfand*' (deposit) system of €0.08 up to €0.25 which the costumer receive back when he/she returns the empty items to a point of sale, e.g. supermarkets and kiosks (hamburg.de, 2020b). While hazardous waste

and large electronic appliances can be disposed at one of the 12 recycling centres in Hamburg.

4.3 Focus area

Within REPAiR, two focus area have been chosen in the Hamburg Metropolitan Area: Altona district and the County of Pinneberg. This thesis focuses only on Altona, because the solution analysed in the following chapters refers to this district. Consequently, the focus area here analysed is Altona district.

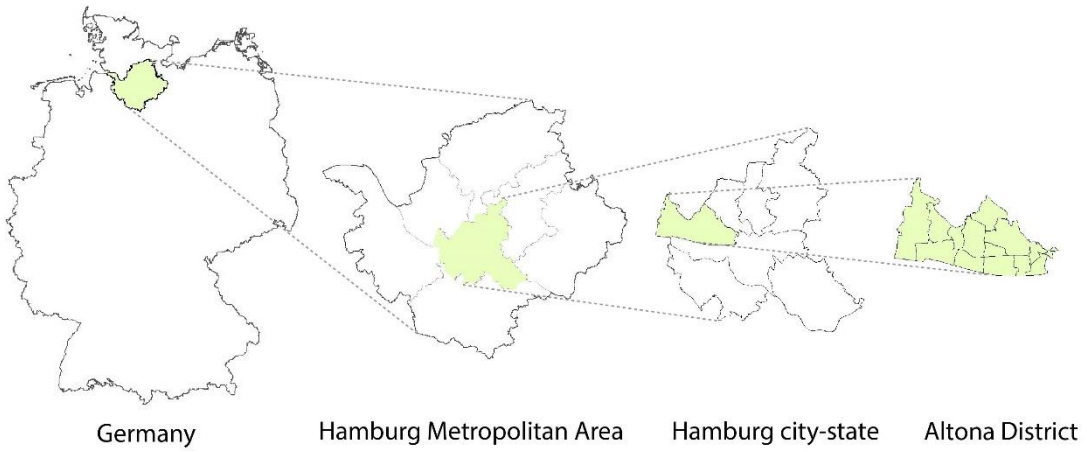

Figure 4.5 - Geographic framing of the District. The images show several scales of the study area (Source: author own elaboration based on REPAiR, 2018).

The district of Altona, one of the seven Hamburg's districts, is located in the North-West of Hamburg, at the northern margin of the Elbe river. With a population of 274.702 inhabitants (31/12/2018) and an area of 77,9 km^2, the district has around 15% of the Hamburg's population (Statistikamt nord, 2019).

As shown in *figure 4.5* the district is divided in 14 quarters, which have the function of statistical units. These quarters are characterized by several structure of built areas and open spaces. The East part, close to the city centre, presents densely built quarters, while the West area presents more suburban quarters and the North-West is characterized by the presence of large housing estates.

In five of the 14 quarters, the project has defined 'sample areas' in which promote "citizens' participation in the co-development of eco-innovative

solutions" (REPAiR, 2018). These areas represent significative aspects of five quarters: Altona-Nord, Ottensen, Osdorf, Blankenese, Rissen. Throughout the following sections each sample borrows the name of the quarter that encompasses it.

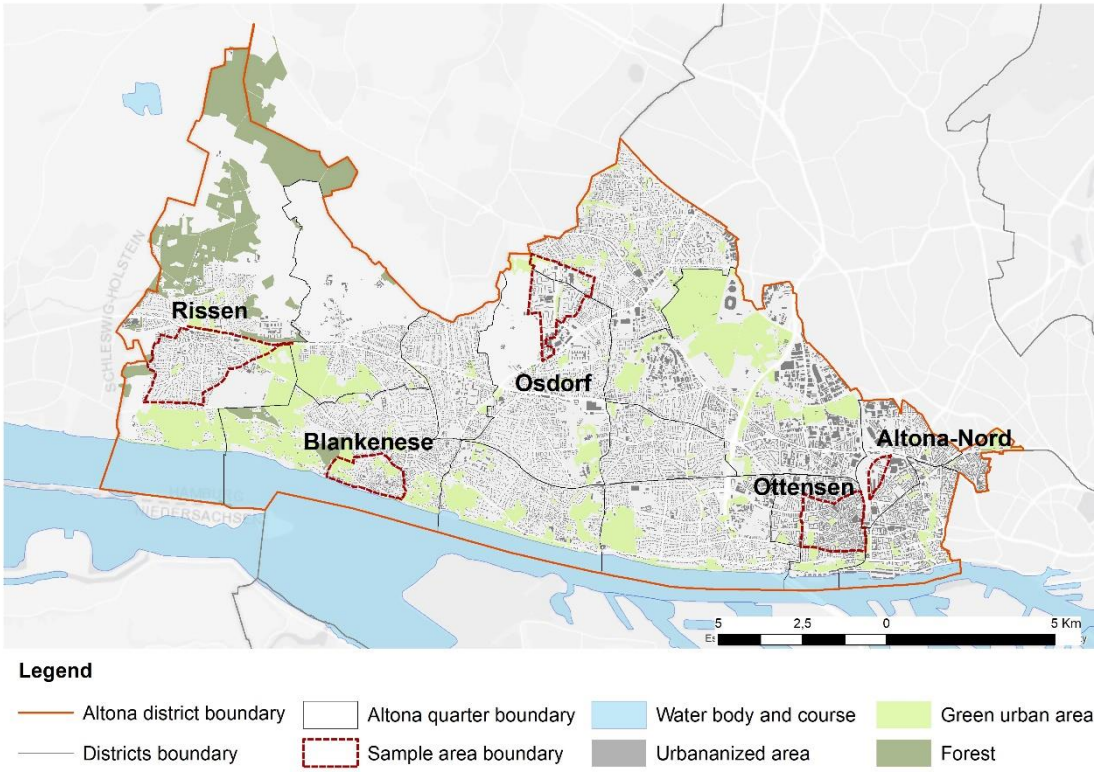

Figure 4.6 - Sample areas. The map refigures the subdivision of Altona district in quarters and the five sample areas defined by REPAiR. (Source: author own elaboration).

Although the East area is the more urbanized, most part of the district has urbanized area; the built environment in the district of Altona accounts for the 11.47% of the area (REPAiR, 2018). The green urban areas and the forests in Rissen quarter represent the green area of the district and they cover a large surface.

Altona has a bigger coverage of metro and train services that link the district with the city and the surrounding areas. Moreover, in Ottensen quarter there is the Altona railway station, an important hub of connection on the regional and national scales. Additionally, the water is considered as a transport mode; the Elbe river represents a way of connection in the city and in between the nearby areas. *Figure 4.7* shows the transport infrastructures.

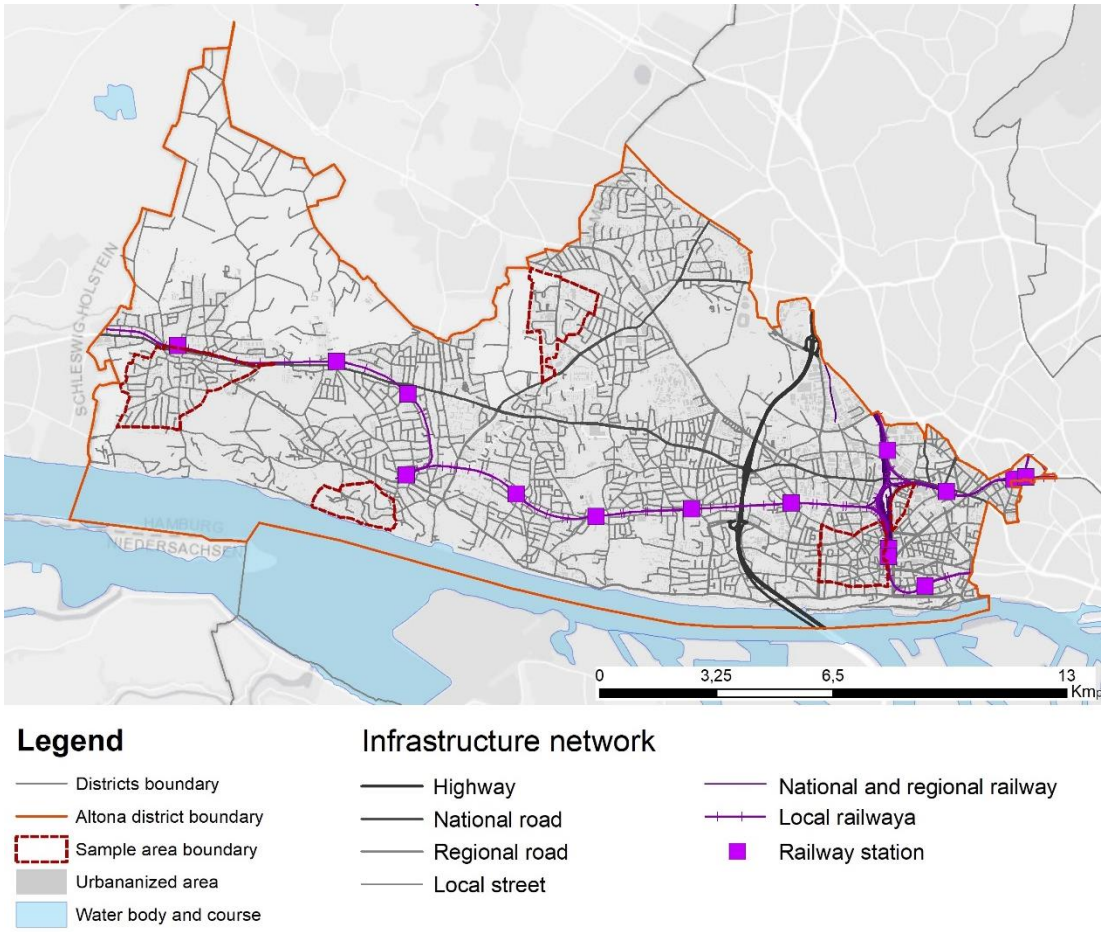

Figure 4.7 - Infrastructure network (Source: author own elaboration).

4.3.1 Socio-economic structure

Altona-Nord and Ottensen areas are the closer to the city centre and are densely populated. In Ottensen the inhabitants per km^2 are approximately five time higher than the average of Hamburg and four time the average of Altona district. On the other hand, located in the western part, Rissen has a population density three time lower than Hamburg and four time lower than Altona district. These data represent challenges from the waste management prospective. The high density reduces the public spaces, making difficult find places for waste facilities, while, the low density makes the waste collection less efficient. Indeed, Rissen area is six time larger than Ottensen area, although its population is really lower.

Table 4.1 - Population density. Inhabitants, area, and inhabitants per km^2 in the sample area, District of Altona and City of Hamburg, 31/12/2018 (Source: author own elaboration based on REPAiR, 2018 and Statistikamt nord, 2019).

Area	Inhabitants	Area in km^2	Inhabitants per km^2
Altona-Nord	24 153	2,2	10 890
Ottensen	35 585	2,8	12 731
Osdorf	26 635	7,3	3 673
Blankenese	13 686	7,7	1 769
Rissen	15 763	16,7	944
District of Altona	274 702	77,9	3 526
City of Hamburg	1 891 810	775,1	2 505

The following maps (*Figure 4.8*) show the proportion of children and adolescent under the age of 18 in the total population, the proportion of older residents over the age of 64 in the total population and the proportion of foreign population in total population.

Osdorf is the area with the highest concentration of young population (20,6%), followed by Rissen (19,2%). The other three quarters are consistent with the average of young population in the district of Altona and in the city of Hamburg is respectively 18% and 16,4%. The presence of young people is a strength of the area because they tend to be more cooperative and open to new procedure and, at the same time, they might influence their relatives (REPAiR, 2018).
On the other hand, the high portion of residents over the age of 65 may present a threat. Especially in the area of Rissen (29,4%), Blankenese (27,5%), and Osdorf (21,8%) the concentration of population older than 65 years is higher than the average of the city (18,1%) and the district (17,9%), while Altona – Nord (10%) and Ottensen (13,9%) present a lower percentage.

The foreign population may represent another challenge to the waste management. Indeed, people coming from abroad use to have other behaviour and methods of waste collection, moreover the language barrier may be a limit in adopting the procedures proposed by the city. Osdorf and Altona-Nord are the quarters with the highest concentration of foreign population 18,5% and 18,6%.

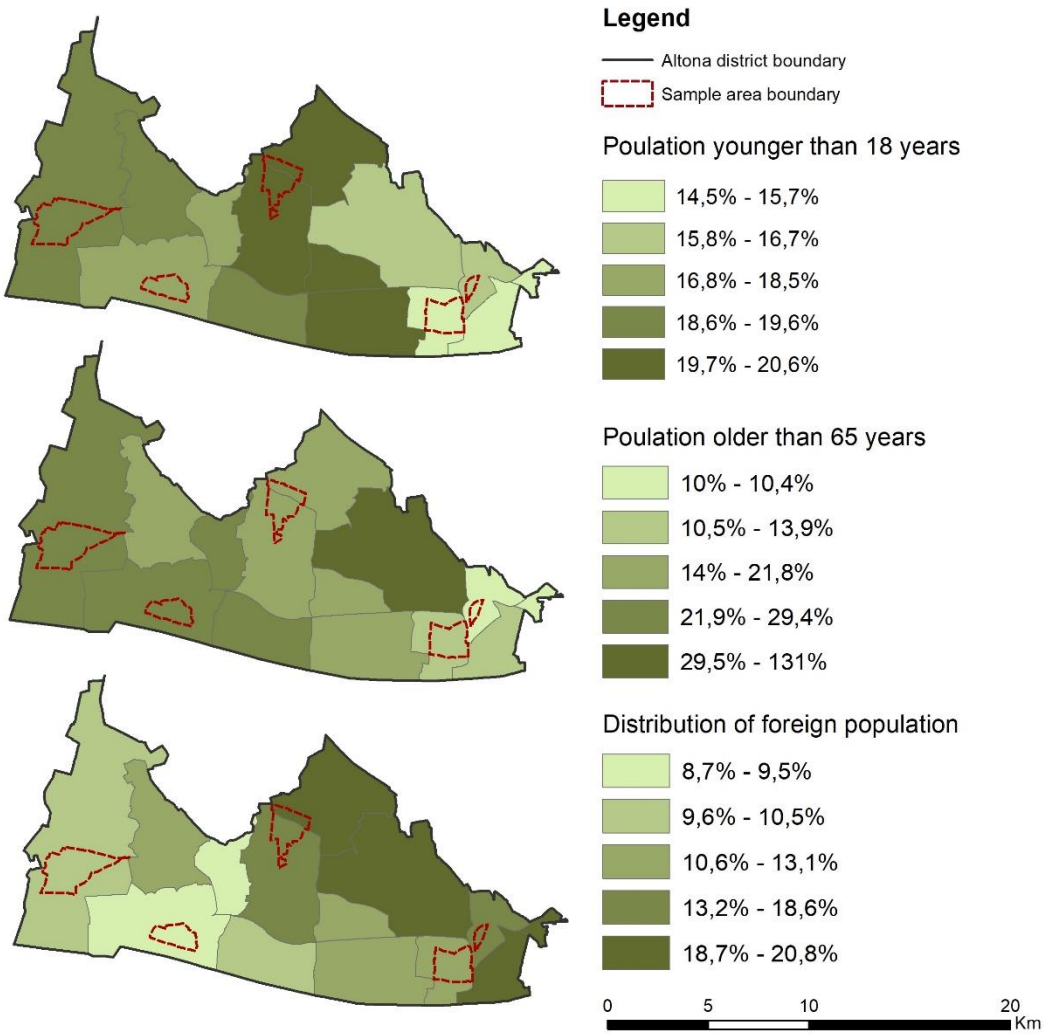

Figure 4.8 - Foreign inhabitants and inhabitants per proportion of age groups. The first map shows the percentage of population younger than 18 years, the second the percentage of population older than 65 years, and the last one the percentage of foreign population on the total population, 31/12/2018 (Source: author own elaboration based on data from Statistikamt nord, 2019).

Table 4.2 shows the households structure. The quarters of Rissen, Blankenese and Osdorf are characterized by a lower number of single person households (approximately 45%). This data reflects the difference in the predominant building typology in the quarters: Altona-Nord and Ottensen are characterised mainly by houses with several floors and apartments, while in Blankenese and Rissen prevail detached and semi-detached houses (REPAiR, 2018).

Table 4.2 - Households structure. The table contains data about number of households, average number of persons per households and percentage of single person households on the total, 31/12/2018 (Source: author own elaboration based on data from Statistikamt nord, 2019).

Area	Households	Average number of persons per household	Proportion of single person households on all households in %
Altona-Nord	14 394	1,7	61,0
Ottensen	21 743	1,7	61,4
Osdorf	13 179	2,0	46,5
Blankenese	7 082	2,0	45,5
Rissen	7 903	2,0	45,0
District of Altona	148 628	1,8	53,4
City of Hamburg	1 041 724	1,8	54,5

Table 4.3 shows the number of flats, their average size and living space per inhabitant in m^2 in each quarter. These data are important indicator to understand the built environment of the quarters. In Altona-Nord, Ottensen, and Osdorf there is a high number of flats compared to the number of residential building, while in Blankenese and Rissen the number of flats is approximately the double of the number of residential buildings. Moreover, the average apartment size and the average living space are larger in Rissen and Blankenese than in the other three quarters and, in general, in the district and in the city. The living space indicates the amount of space people have to live in. Small space means little space available for waste collection, especially if they need four bins in the apartment.

Table 4.3 - Residential buildings and flats, apartment size and living space in 2018 (Source: author own elaboration based on data from Statistikamt nord, 2019).

Area	Number of residential buildings	Number of flats	Average apartment size in m²	Average living space per inhabitant in m²
Altona-Nord	1 194	12 623	64,2	33,6
Ottensen	2 405	19 662	70,6	39,0
Osdorf	4 066	12 655	84,6	40,2
Blankenese	3 424	6 898	117,4	59,2
Rissen	3 800	7 714	99,8	48,8
District of Altona	38 040	137 274	81,0	40,5
City of Hamburg	252 751	956 476	76,1	38,5

With regards to the labour force, the following maps show the unemployed rate and the percentage of employees with a regular social insurance. Blankenese and Rissen show a lower portion of employees compared to the other; the data is also lower than the average of the district (56,3%) and the city (59,3%). This fact could be explained by a higher number of classic family models with one person (mainly women) not working (REPAiR, 2018). The unemployed rate is high in Altona-Nord and Osdorf, while is below the average of Altona (5%) and Hamburg (4,8%) in Balnkenese (3,3%) and Rissen (1,9%).

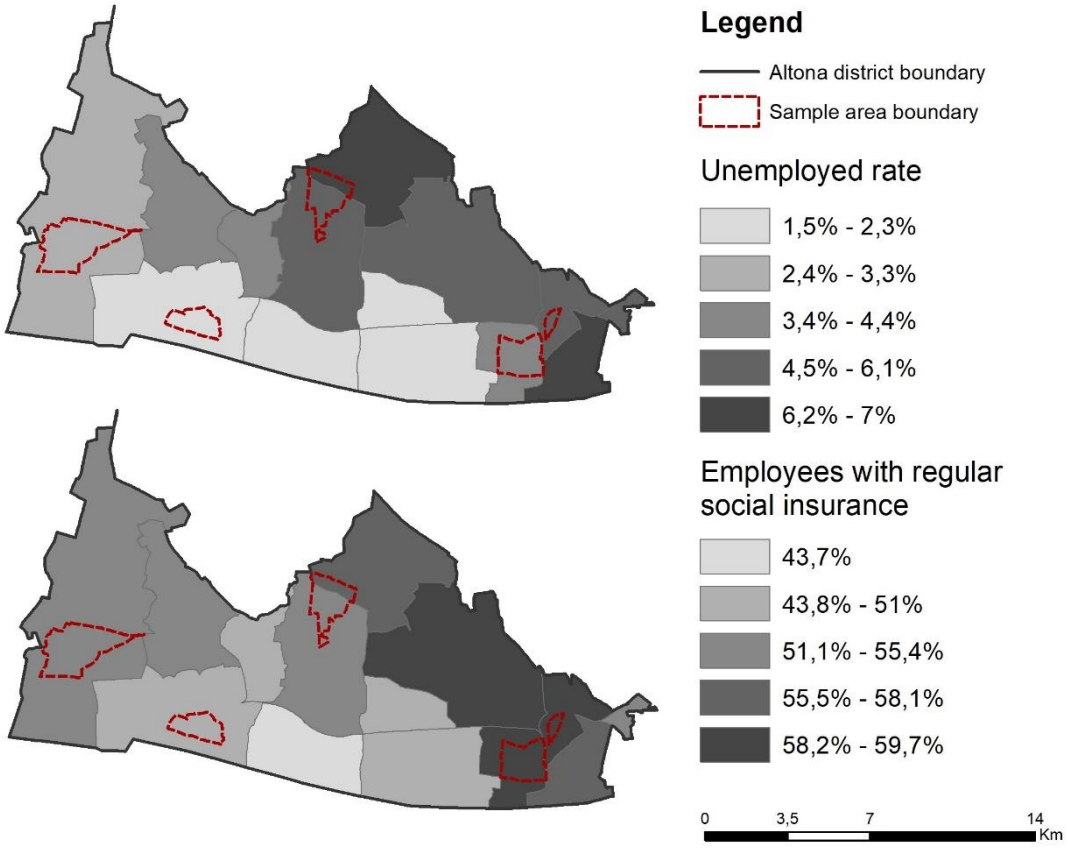

Figure 4.9 - Proportion of Employees with regular social insurance and Proportion of unemployed on all persons in working age, December 2018. The data shown on the maps are calculated on all persons in working age (above 15 and under 65) (Source: author own elaboration based on data from Statistikamt nord, 2019).

4.3.2 Waste generation

The waste generation is related to a series of urban and socio-economic characteristics of the area. Hence, the analysis of the land use has been used to define the prevalent activities. In the frame of the project the different land uses have been grouped in 15 land use categories, which allow to understand the characteristics of the district and the sample areas (*figure 4.10*).

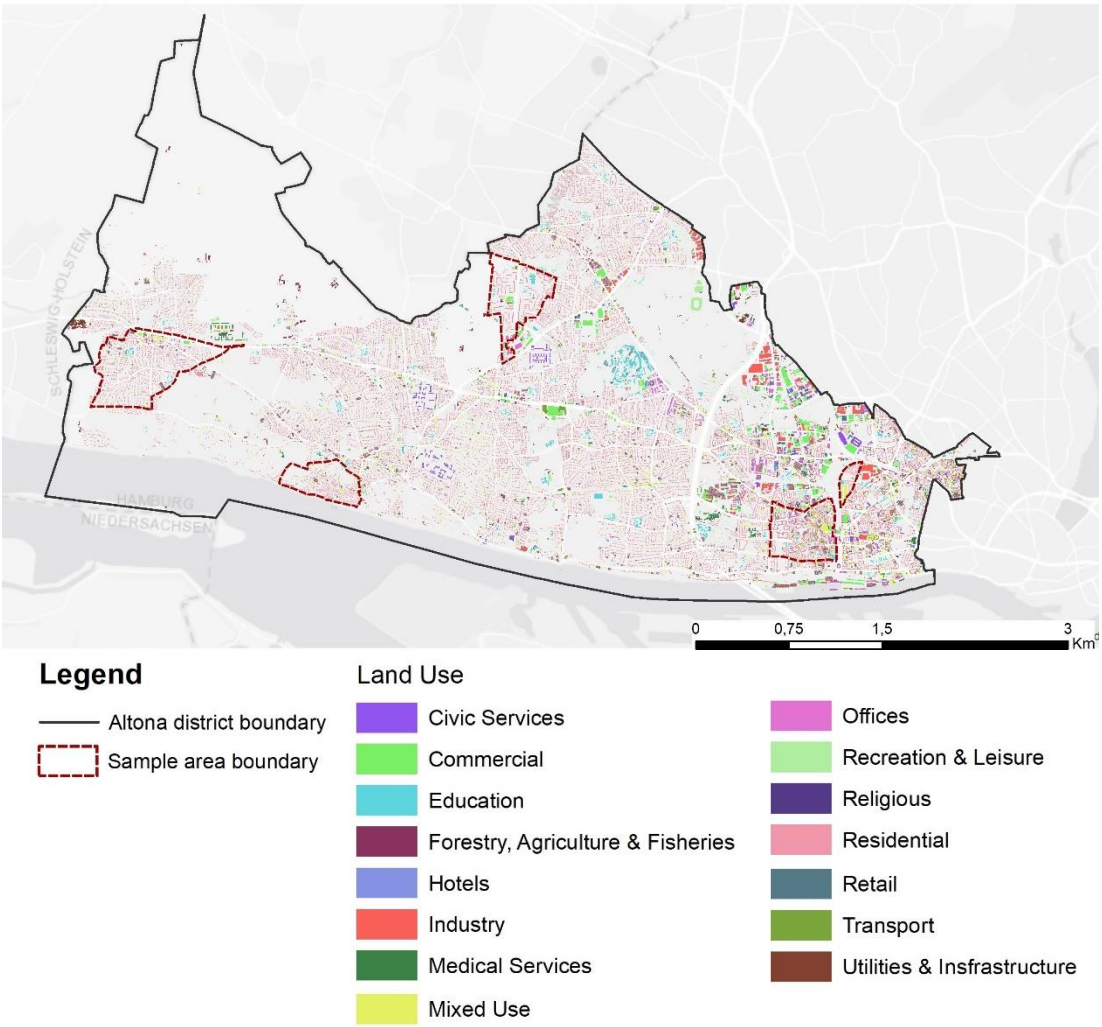

Figure 4.10 - Land use (Source: author elaboration adopted by REPAiR, 2018).

The residential use is the prevalent in the area, although to the East there is a concentration of offices, industry and commercial.

Table 4.4 shows the percentage of each land use in the sample areas, and, as in the district, the residential use is the predominant, however some differences may be highlighted. For instance, Rissen and Blankenese show the highest rate of residential use, respectively 72,5% and 79,2%, on the other

hand, in Ottensen and Altona-Nord only approximately the 50% of the land use is residential. This is due to the proximity of the two areas to the city centre: they present high percentage of mixed used and offices in Ottensen. Osdorf is characterized by the highest share of education and commercial uses.

Table 4.4 - Land use in the sample areas. The table shows the percentage of each land use per sample area (Source: REPAiR, 2018).

Land use	Rissen	Blankenese	Osdorf	Ottensen	Altona-Nord
Civic Services	0,34%	0,00%	0,14%	0,20%	0,00%
Commercial	1,96%	0,38%	5,88%	3,59%	0,00%
Education	3,42%	0,43%	14,57%	3,30%	6,96%
Forestry, Agriculture & Fisheries	0,14%	0,02%	0,00%	0,01%	0,00%
Hotels	0,13%	0,22%	0,00%	0,00%	0,00%
Industry	1,31%	0,00%	0,00%	0,56%	0,00%
Medical Services	0,00%	0,06%	0,00%	0,06%	0,00%
Mixed Use	10,89%	14,47%	4,09%	19,24%	34,64%
Offices	1,45%	0,68%	0,77%	11,28%	0,00%
Recreation & Leisure	0,82%	0,37%	3,06%	1,00%	0,00%
Religious	0,11%	0,00%	1,21%	0,61%	0,00%
Residential	72,50%	79,17%	60,98%	53,78%	54,59%
Retail	0,27%	1,11%	0,00%	3,49%	0,47%
Transport	6,36%	3,06%	9,26%	2,69%	1,99%
Utilities & Infrastructure	0,31%	0,05%	0,05%	0,18%	1,35%

Due to the prevalence of residential use, the study focuses on household's waste. As mention in chapter 4.2.1, in the city of Hamburg household's waste are collected with a four bin-system, however, in some densely built area of Altona the waste are collected in a pink bag because there is a lack of space for bins and containers. Furthermore, the data available for the district belongs to a study conducted by a consultancy company on behalf of SRH. The study analysed waste generated per house typologies, and, among others, gave the amount of several waste stream generated in a year per person (REPAiR, 2018).

In the deliverable D3.6 of REPAiR (2018), the methodology adopted to define the house typologies and the relative amount of waste generated are explained. Based on those analysis, a general frame on waste generation in the sample areas is presented below. *Figure 4.11* shows the house typologies in each sample area, while *table 4.5* shows the waste generated percentage by person in one year per house typology.

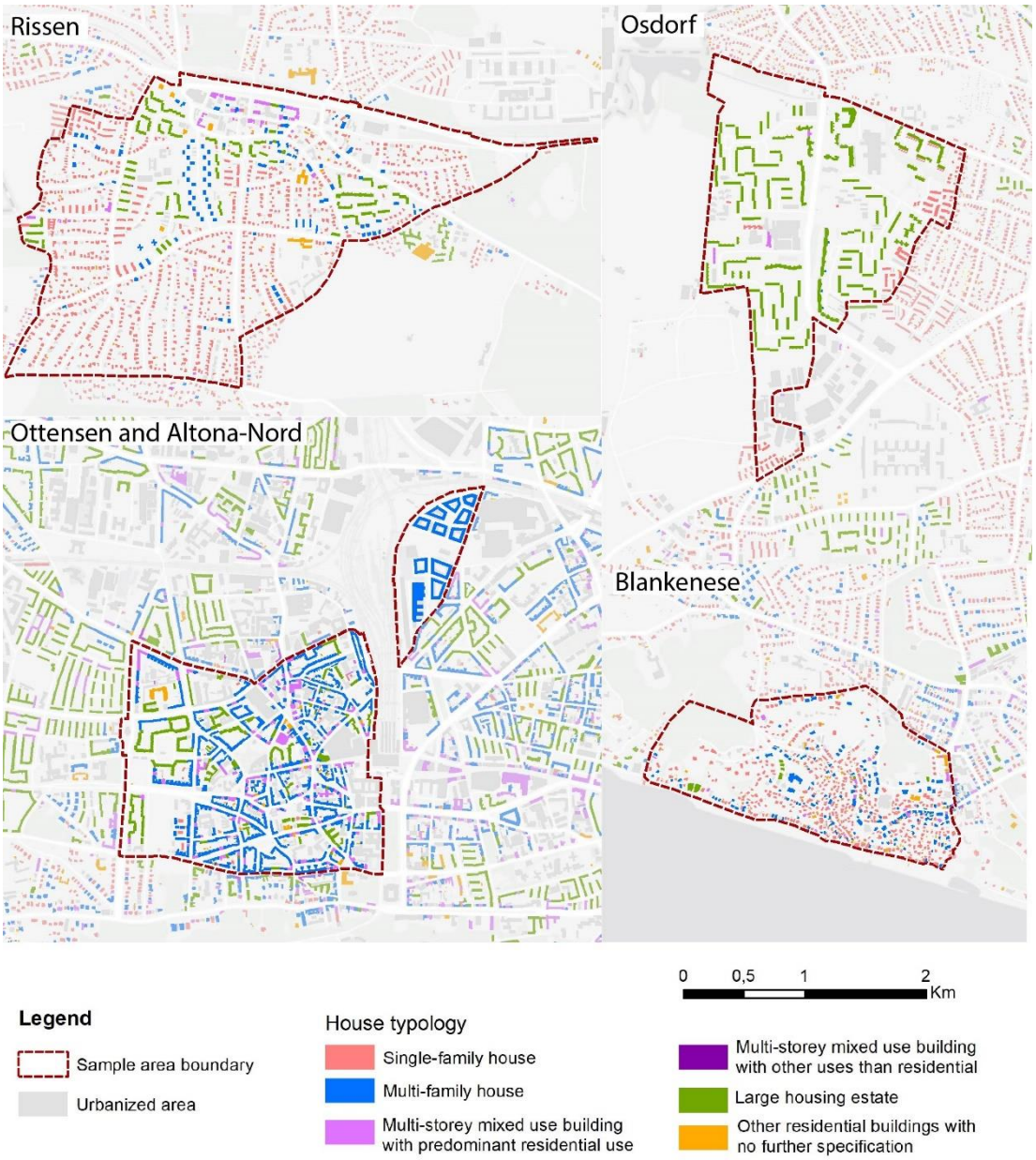

Figure 4.11 - House typologies in the sample areas (Source: author own elaboration based on REPAiR, 2018).

Rissen and Blankenese are characterized by a prevalence of single-family house, even if on the Northern area of Rissen there is a large amount of multi-family house and large housing estate. The large housing estate represents almost the entire building typology of the area. Instead, Ottensen and Altona-Nord are mainly composed of multi-family house and large housing estate.

Table 4.5 shows the waste composition of the four bins per house typology. The data refer to the waste generated by person per year, however, in the table the values are expressed in percentage due to the data confidentiality in kg/year in the reference year 2018. Concerning the single-family house, the main issues are the high presence of garden waste (92,6%) in the bio bin and of the kitchen waste (49,6%) and compostable (16%) in the residual bin. Also, in the plastic may be highlight critical points, such as the presence of other material like compostable (8,2%), paper (16,1%) and WEEE (7%).

A common problem is the high presence of recyclable waste in the residual bin, like kitchen waste, compostable, paper, and plastic. However, what should be alarming is the component of kitchen waste, which accounts for a higher percentage than the residual waste. For instance, in the multi-storey house, the residual bin is composed only for the 22,7% of residual waste, the other waste in the bin are kitchen waste (33,5%), compostable(14,8%), paper(9,2%), plastic(8,9%), glass (4%) and textile (4,2%).

The multi-family house has a high presence of garden waste (19,1%) in the bio bin, as for the single-family house, even if the data is more contained. Another weakness for this typology is the plastic bins. Even if the plastic is the 57,9%, there is a elevate concentration of metal (12,5%) and residual (11,2%).

In the multi-storey house and multi-storey mixed uses building there is a good share of waste kitchen in the bio bin, but these typologies have some problematics regarding plastic and paper. In the multi-storey mixed uses building, there are paper (10,7%) and metal (9,5%) in the plastic bin. Whereas, in the multi-storey house the plastic bin has high percentage of metal (7,5%) and WEEE (16%).

Metal, glass, textile and WEEE should be collected in apposite public containers located in public space throughout the city. The presence of these materials in the four bins may due to the remoteness of these public areas or their inaccessibility for certain categories of users.

Table 4.5 - Amount of the selectively collected waste. The table shows the percentage of each waste stream in the four bins per house typology. Green cells indicate a high presence of the correct material in its bin, on the other hand, the red cells indicate a high presence of a wrong material in one of the four bins (Source: author own elaboration based on data from REPAiR).

Typology	Waste Bins	Kitchen W	Kwnon composstable	Paper	Plastic	Metal	Glass	Residual	Garden W	Textile	WEEE
Single-family house	Plastic	3,4%	8,2%	16,1%	48,0%	7,2%	3,6%	6,2%	0,0%	0,5%	7,0%
	Paper	0,0%	0,0%	97,8%	1,0%	0,0%	0,0%	1,2%	0,0%	0,0%	0,0%
	Residual	49,6%	16,0%	2,6%	5,0%	0,3%	6,5%	17,5%	0,0%	1,2%	0,0%
	Bio	7,1%	0,0%	0,1%	0,0%	0,0%	0,0%	0,2%	92,6%	0,0%	0,0%
Multi-family house	Plastic	0,7%	3,3%	6,6%	57,9%	12,5%	3,9%	11,2%	0,0%	0,0%	3,9%
	Paper	0,0%	0,5%	98,8%	0,3%	0,0%	0,0%	0,3%	0,0%	0,0%	0,0%
	Residual	32,6%	9,4%	7,1%	14,7%	2,0%	7,0%	18,8%	1,3%	6,8%	0,3%
	Bio	75,9%	0,4%	4,3%	0,0%	0,0%	0,0%	0,4%	19,1%	0,0%	0,0%
Multi-storey mixed used building	Plastic	2,4%	1,2%	10,7%	71,4%	9,5%	1,2%	3,6%	0,0%	0,0%	0,0%
	Paper	0,0%	1,9%	93,3%	1,9%	0,0%	1,9%	1,0%	0,0%	0,0%	0,0%
	Residual	35,7%	7,0%	6,6%	8,8%	1,9%	7,8%	24,8%	1,2%	5,8%	0,5%
	Bio	88,9%	0,0%	1,2%	0,0%	0,0%	0,0%	0,5%	9,5%	0,0%	0,0%
Multi-storey house	Plastic	1,0%	1,0%	4,5%	63,0%	7,5%	2,5%	4,5%	0,0%	0,0%	16,0%
	Paper	0,0%	1,2%	82,0%	3,2%	1,7%	0,2%	7,4%	0,0%	0,0%	4,4%
	Residual	33,5%	14,8%	9,2%	8,9%	1,6%	4,2%	22,7%	0,9%	4,0%	0,2%
	Bio	92,0%	0,8%	0,8%	1,6%	0,0%	0,0%	0,8%	4,0%	0,0%	0,0%

This analysis outlined the main strengths and weaknesses of the sample areas. Indeed, each area is characterised by one or two prevailing building types, reflecting the behaviour of the population in generating waste. Even if the association between building typology and waste generation leads to a simplification of the areas, in the next chapter it will be used for the definition and development of an eco-innovative solution.

4.4 Chapter summary

In Germany the planning and waste management systems follow the same structure. The national level defines guidelines, and the federal states enact own laws on specific thematic, among which spatial planning and waste management. The city of Hamburg is one of the three city-states in Germany, and it has the same power of the other federal states, therefore, the city enacts own laws and it is responsible for waste management system in the city area.

In Hamburg, the SRH is the public agency responsible, among others, for the waste collection. The city has adopted a four-bins system for the door-to-door collection of residual, bio, plastic, and paper. Moreover, in the city, there are several public containers for the collection of textiles, glass, WEEE, etc. Even if this system covers the whole city, a lack of space and the high density make the function of the system problematic in some areas.

REPAiR project focuses on Altona district, as area in which implement eco-innovative solutions to improve the waste management system. In the chapter a socio-economic analysis has highlighted the main characteristics of the area, while the waste generation has made possible to identify the weaknesses. Since the waste generation data were provided for house typology, in Altona district have been identified five sample areas, with one or two prevailing building types. The following chapter presents the eco-innovative solutions adopted for these areas, and one of them is further developed.

According to REPAiR (2018) the solutions require more cooperation between spatial planning and waste management, indeed, “at the moment waste management does not play a major role in spatial planning in Hamburg”.

Chapter references and online resources

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05 ECO-INNOVATIVE SOLUTIONS

5. Eco-Innovative Solutions

Develop eco-innovative solutions and strategies is one of the main objectives of REPAiR project. The European eco-innovation observatory (2011) defined eco-innovation as “any innovation that reduces the use of natural resources and decreases the release of harmful substances across the whole lifecycle”. The eco-innovation can bring several aspects, it can be a new good, a new technology, a new process, an organisational change, but it can also have wider implication for economy and society (e.g. new production-consumption model).

According to REPAiR grant agreement “Eco-innovative solutions developed will improve the capacity of urban environments to deal with future resource management challenges, while triggering positive transformations in spatial qualities, sustainability and urban metabolism. These shifts will together enhance quality of life” (REPAiR, 2018c). Within REPAiR, Eco-Innovative Solutions (EIS) develop and implement new materials, technologies or processes in order to improve the current waste management system. Moreover, they may bring the modification of existing policies and the definition of new spatial and environmental design.

Each case study involved in the project has developed eco-innovative solutions. The EISs are the result of a co-creation process implemented in the PULLs (Peri Urban Living Labs) in which experts and stakeholders have propose solutions for case-specific problem related to waste management. In this chapter the EISs proposed for the Hamburg case study are presented and one of them is further developed. Then the effects on the system are evaluated through a life cycle assessment (LCA) perspective. The LCA methodology allows to evaluate all the life cycle of a products/flows in order to analyses the positive and negative effects of the solution on the waste management system.

5.1 Hamburg Eco-Innovative Solutions

Within Hamburg case study, ten eco-innovative solutions have been developed. The solutions have been outlined by experts, local authorities, and local stakeholders during several meetings that took place in form of Peri Urban Living Labs. This methodology is defined in the project as a 'co-creation' processes (REPAiR, 2018b).

Table 5.1 shows the Hamburg's solutions and their main goal. Through enhancing information and rewarding good waste avoidance, the first solutions aim to improve the quality of waste separation. On the other hand, more specific solutions goal to close the waste loop locally, especially regarding the organic waste that has resulted to be the more problematic (see chapter 4.3.2). Quarter service centers, composting plants in schools, and urban gardens are solutions to be applied in each neighbourhood in order to achieve the circular economy goal locally. Finally, three solutions focus on urban planning to integrate and promote waste management practices into urban planning.

Table 5.1 - Hamburg Eco-Innovative Solutions (Source: author own elaboration based on REPAiR, 2020).

Eco-Innovative Solutions		
Solution		Related Main Goal
WASTE AVOIDANCE & SEPARATION		Achieve high-quality separation of recyclables and bio-waste in Hamburg
EIS I	*Creating awareness about waste*	
EIS II	*Rewarding good waste avoidance and separation behaviours*	
ENABLING ENVIRONMENT FOR CIRCULAR ECONOMY		Close the waste loop locally
EIS III	*Quarter Service Center*	
EIS IV	*Decentralized composting plant in kindergartens and schools*	
EIS V	*Organic waste for urban gardening*	
EIS VI	*ZRE - Centre for Resources and Energy*	
CIRCULAR WASTE MANAGEMENT INTO URBAN PLANNING & GOVERNANCE		Integrate Waste Management and Circular Economy into the urban planners and governance agendas
EIS VIII	*Planning guide for planners to address the waste management topic*	
EIS IX	*Design manual for spaces dedicated to waste bins and containers in large housing estates and in public spaces*	
EIS X	*Guideline for new quarters*	

The solutions are not isolated singular actions, but to reach the circular economy goal, the solutions have to be developed and implemented together in synergy. Indeed, several solutions interact each other. For instance, the quarter service centre is strongly related with the awareness and change in behaviours, and, at the same time, with planning aspects. Composting plant in kindergartens and schools may have effects on behaviour both on children than on their relatives. Planning in synergy with the waste management and from a circular economy prospective may affects the local solutions.

5.2 EIS III – Quarter Service Center

The solution Quarter Service Center aims to improve waste separate collection by supporting the citizen through the opening of local centres that function both as collection/repair points for certain waste streams and as information centres.

In 2019, Altona district has adopted its climate change plan: the 'Altona Climate Concept Framework' (*Klimaschutzkonzept Altona*). One of the measures prosed by the plan aims to define climate-standards for Altona (*Altonaer StadtKlima-Standard*). In the frame of this measure the plan introduce the concept of 'neighbourhood service centers' or 'neighbourhood hubs' (*Quartiers-Service-Zentralen*), centers that can contribute to supporting a climate-friendly lifestyle. These spaces should be quickly accessible points for the residents of a neighbourhood, in which they can find various central functions, such as repair, recycling, sharing, advice, and support. Moreover, the centers should allow car-free or car-reduced households to easily integrate offers from different service providers into their daily chains of routes (ZEBAU, 2019).

Based on the Altona Climate plan and on the intentions of the EIS, to develop the solution in Altona's sample areas, an analysis of existing services has been done in order to define the need of each area. For instance, in Ottensen, and in the surrounding areas, several activities are already in place, therefore the priority is to implement these activities to create a network that meets the

needs of the neighbourhood. In other areas, such as Osderf, there is a lack of services or information, therefore new centers may be developed.

5.2.1 Existing activities and services

Ottensen and Altona-Nord are the two sample areas with a major number of services and activities. The map in *Figure 5.1* shows the location of the services in the two neighbourhoods and in the surrounding areas.

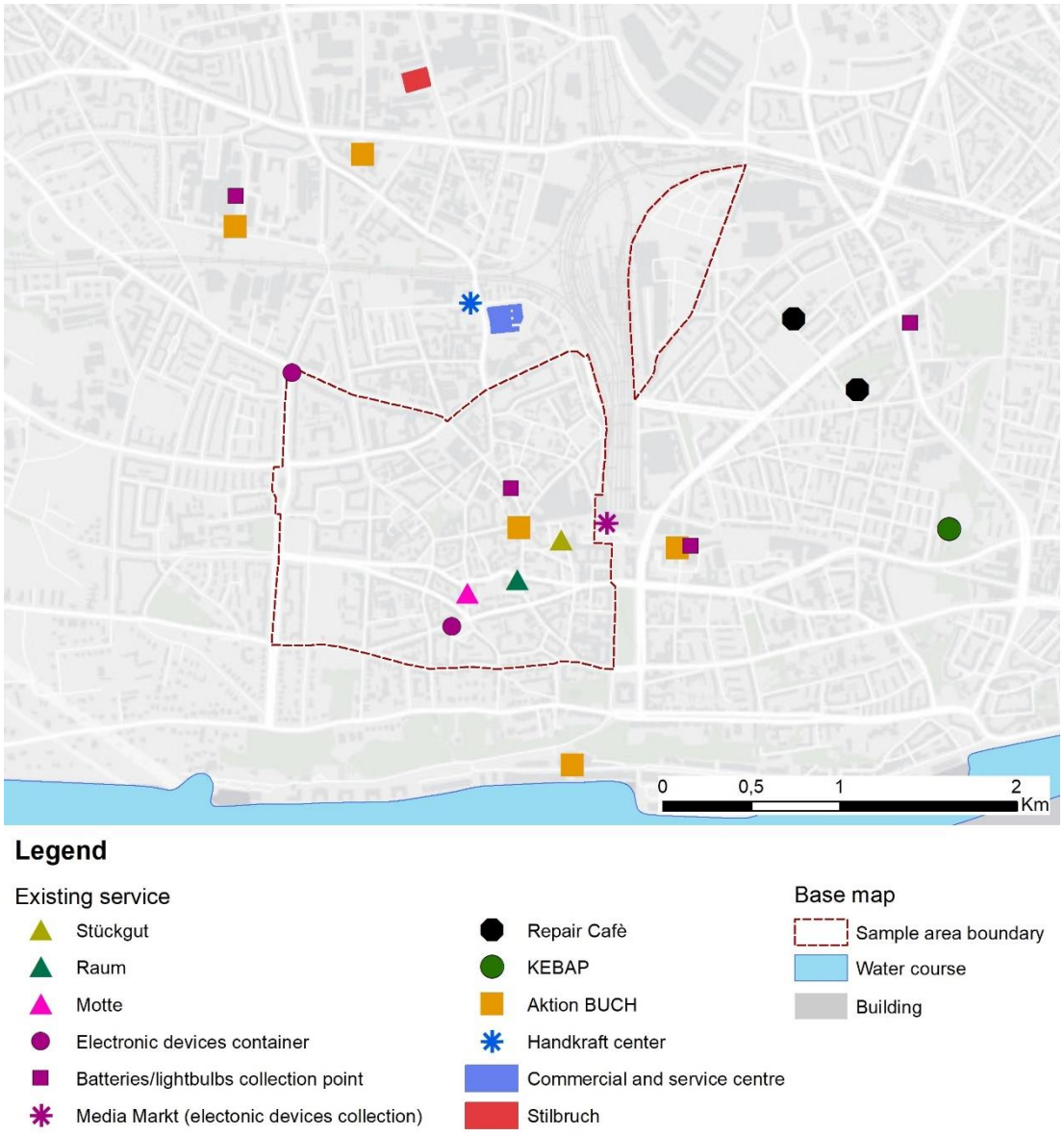

Figure 5.1 - Location and typology of existing service in Ottensen and Altona-Nord areas (Source: author own elaboration).

Two containers for electronic devices, four batteries/lightbulbs collection points, and Media Markt, a shopping centre in which is possible dispose

electronic devices (under a certain dimension), represent the offer for the collection of WEEE and batteries waste. While used books, CDs, and DVDs can be donate to one of the “Action BUCH” association point.

Stückgut is a zero-packaging shop, with the ambition of “create a place for discussion and exchange”. The shop is already linked with great projects such as ZeroWaste Hamburg, and it offers services such as repair cafés and workshops on waste avoidance (Stückgut Hamburg, 2020). Workshops developed by ZeroWaste Hamburg association take place also in Raum space. Motte and KEBAP (*KulturEnergieBunkerAltonaProjekt*) are two ‘community garden’ and meeting points for various neighbourhood activities. Here events, courses and workshops take place for children, young people and adults. Finally, there are two Repair café, AK LÖK and Repair Café Altona. A Repair café is a place in which people can meet to repair broken things alone or together with helpers. There are available tools and volunteer who help the visitors to repair as much as possible of the items they have brought with them themselves (HausDrei, 2020 and Repair café, 2020). AK LÖK aims to redistribute used things, repair defective equipment and self-organized education and culture, creating an experimental space for diverse experiences of sharing, contributing and making decisions together in communities (AK LÖK, 2017).

In the North of Ottensen, there is a commercial and service center at the intersection between Bahrenfelder Str. and Gaußstraße with empty space that can be used for a new Repair Café. Near this centre, there is the handcraft center (*Ottensen Hof*) that could work in synergy with the new Repair Café. In addition, there is *Stilbruch*, a second-hand shop, managed by SRH. The shop has a double function: it is a collection point for people who wants to get rid of superfluous items, and it is a selling point of second-hand items.

The other sample areas show fewer service and different socio-economic characteristics. For instance, in Osdorf area the average income is three times less than the Altona district average, and the amount of foreign population is significant: 62% of the population has a migration background and 25.9% of

inhabitants have a foreign nationality. This district has one of the lowest separating rates of organic waste and problems related to bulky waste, that are often left on the road or in the vicinity of public containers (REPAiR, 2018a).

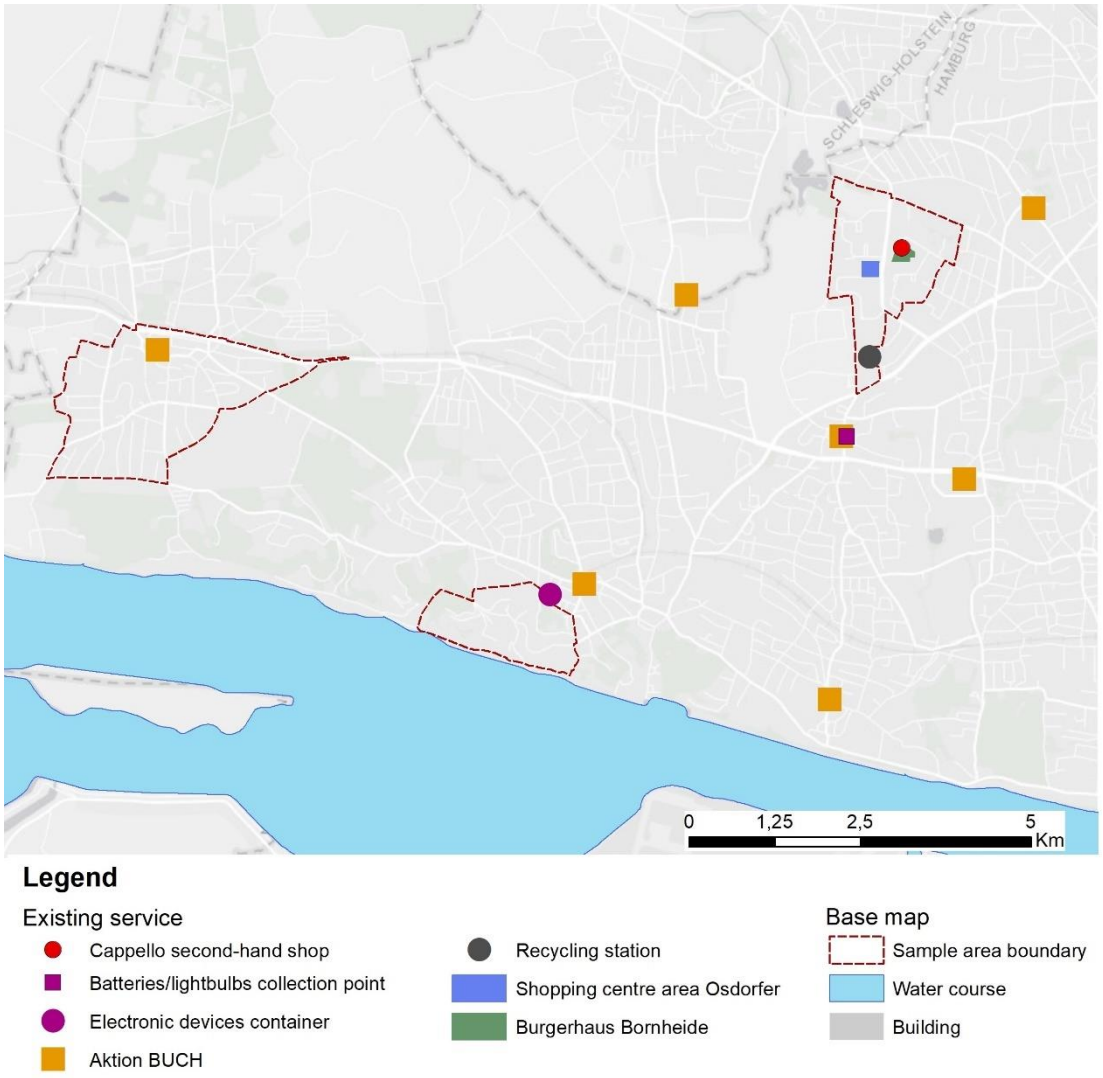

Figure 5.2 - Location and typology of existing service in Osdorf, Blankenese, and Rissen sample areas (Source: author own elaboration).

In Osdorf there is a second-hand shop, Cappello, inside the Bornheide community centre; a sorting/recycling-hub area on the south, and some collection points of Aktion BUCH. Since 2013, the Bornheide community centre offers spaces for civic engagement, cultural activities and numerous counselling and educational offers (Buergerhaus Bornheide, 2020). The second-hand shop, as the one in Ottensen area, is both a collection than a selling point. However, to date, the shop is open only a couple of hours in some

days and the building need some structural renovations. In addition, near the community center, there is the only shopping centre of the neighbourhood, in which empty spaces may be used for a repair center and/or collection point.

Riessen and Blankenese are the most residential area, as outlined by the land use analysis (see chapter 4.3.2). Here services linked to waste management are almost absent. Rissen's main problem is the considerable distance between housing units, that make difficult the collection: trucks have to travel a considerable distance in the neighbourhood to collect bins from every household. Moreover, the closest Stadtreinigung's center is 9 km away from the area. On the other hand, in Blankenese the collection is difficult due to hilly topography of the area. Indeed, a good part of the roads are made up of steps and, therefore, only accessible by foot.

5.2.2 Proposed actions

The characteristics and the existing services of each area have led to different actions for the sample areas. In Ottensen/Altona-Nord and Osdorf several actions have been developed to further implement or create services and activities. While, Rissen and Blankenese areas, being more residential and far from the city center, and therefore from services, are more suitable for other EISs. Especially in Blankesene more structural actions are needed to improve the waste collection.

In Ottensen the main goal is to implement the existing services/activities, in order to create a network that meets the needs of the neighbourhood. This network should be created through the following actions:

1. Open a new Repair Café in the empty space of the commercial and the service center;
2. Promote awareness and information, involving the population with workshops and neighbourhood activities;
3. Implement the second-hand shop Stilbruch in order to make it a collecting and repair hub.

The new Repair Café should become a space for waste prevention and reuse. Repair objects and explain people how to repair them should encourage the inhabitants not to throw away old and used things, but to give them a chance to be repaired. Moreover, the café can become a meeting point for the neighbourhood, in which discuss and improve waste behaviour.

The handcraft center (*Ottensen Hof*) near the commercial and service center represents a further strength. In the handcraft center there are already a lot of tools that could be used to repair items, if the center will work in synergy with the new Repair Café.

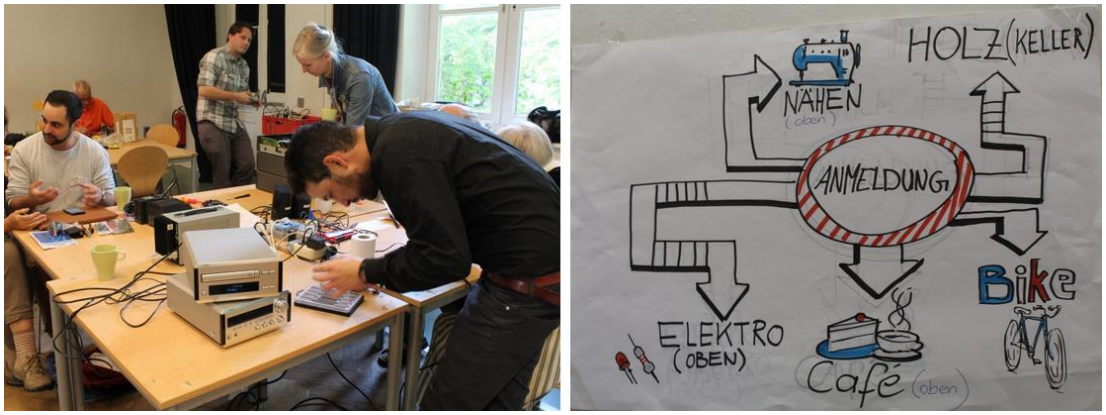

Figure 5.3 - Repair Café Altona. The images show an example of how a repair café can function; on the left a repair group is fixing electronic devices, while on the right the image shows the activities of the centre (Source: HausDrei, 2020).

In addition to be a point in which people can fix several objects, the Repair Café, can function also as food sharing point. The commercial and service center is a quite big structure, and it may have a space in which neighbourhood population or neighbourhood activities (such as bakeries, restaurants) can bring here expiring food instead throw away it. For instance, in Portugal there is an initiative named Re-food. Since 2011, this initiative aims to promote the collection of excess food. “Excess food from supply partners is collected and stored in containers and taken to the Re-food operation centers where it is divided into portions, which are distributed to people in the community” (UrbanWINS, 2020). Hence, on local basis, the Repair Café can work as hub for food collection. This activity can work in synergy with other activities already in place, especially the one linked to awareness and information.

The awareness and information are the starter points to achieve change in waste behaviour. In Ottensen there are already several initiatives, that may be implemented to widely involved all the community. Activities such as workshops may involve and teach waste avoidance to the population. For instance, workshops about how to cook with food waste or how to use broken/old items to make new gifts can become fun moments in which people learn by doing.

Figure 5.4 - Workshop about "waste cooking". These images show an example of a workshop that took place in St. Pauli neighbourhood at "Das Müll Projekt" in Hamburg (Source: ZerowasteXchange, 2017).

Stilbruch has a 'laboratory' to repair items, that should be implemented in order to become a collecting point for the neighbourhood. The citizens could bring here their broken or old items, especially the bulky waste and the electronic devices. These items could be fixed or reused in part in the laboratory, and then sold. Moreover, the device inside the two public containers of electronic devices may be brought to Stilbruch, instead to be disposed.

Figure 5.5 shows an example of a REUSE centre furnished in used furniture, and, in which visitors can find a small shop, storage room and a repair-room. The idea of these centres in to encourage people not to throw away old and used things, but to give them a chance to be repaired and resold at a small price. Based on this example, the second-hand shop may become a reuse shop, being more attractive for the neighbourhood.

Figure 5.5 - Example of a REUSE centre in Ljubljana. The aim of this shop is to reuse second-hand items, minimise the amount of waste and create green workplaces. In five years since its establishment the number of sold items increased from 50 to 190 per day (Source: Voka Snaga, 2019).

The main goal in the area is to create a network between existing services. Indeed, there are already several initiatives, however, is necessary a synergy between services, initiatives, activities in order to implement the circular economy locally. Four interaction flows have been identified:

- Information;
- Bulky waste, WEEE, and batteries;
- Book, CD, and DVD;
- Broken/repaired items.

Ideally the flows being from the neighbourhood and reach the activities and services in the area. The information flow represents the exchange and the cooperation of awareness information between the point in which workshops and other initiatives are already in place. The flow of bulky waste, WEEE, and batteries regards the collection points in the area and Stilbruch, in which these kinds of wastes can be repaired or in part recycled. The broken items should be brought to Stilbruch or to the new Repair Café, in which they can be repaired/fix and reintroduced in the cycle. Finally, the books, CDs and DVDs should be collected in apposite collecting points. *Figure 5.6* shows a conceptualisation of how the flows should interact in the area.

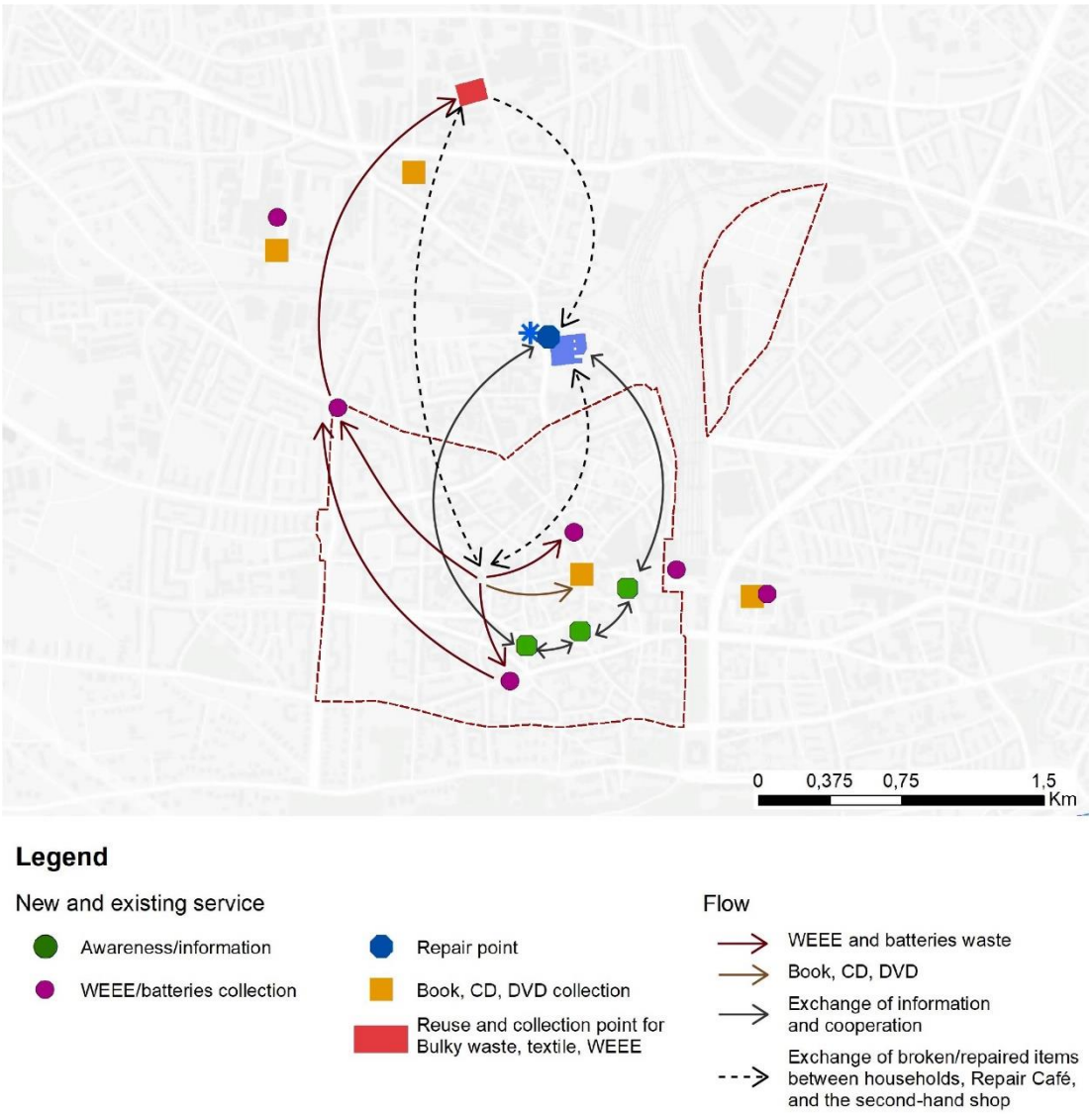

Figure 5.6 - New and existing services in Ottensen area. The map shows the desirable network between services and activities, how they could be linked and which kind of flow they supported (Source: author own elaboration).

In Osdorf the existing services have to be implemented and new services should be developed. Therefore, the following actions are proposed:

1. Implement and consolidate the activities of the Bornheide community centre;
2. Open two Repair Cafés: one in the second-hand shop, to improve its attractiveness, and a second in the shopping center parking;
3. Improve the recycling station already existing in the area.

The Bornheide community centre is an area in which there are already some functions, but they have to be consolidated. Moreover, structural changes are

necessary to make the area more attractive. The second-hand shop Cappello is opened only a half day from Monday to Friday and it does not collect all the items because the supply is greater than demand. Hence, the shop needs to be boosted. Additionally, near the shop new containers for bulky waste will be inserted. In this way people going to the shop can leave their waste, and the shop can repair or reuse them. What cannot be recovered could be transported to the recycling station to the South of the sample area.

Figure 5.7 - Bornheide community. On the left the map of the area, and, on the right, pictures of the buildings of the community (Source: Buergerhaus Bornheide, 2020 and Osdorfer-born, 2020).

In the Bornheide area there are already several services, however, open a Repair Café in the second-hand shop could improve its attractiveness. Moreover, the area could become also a collection point for bulky waste. Containers can be insert near the second-hand shop; this is a quite central location with a good accessibility, and the shop could function as a Reuse center. In addition, in the area there is a low rate of car owner (REPAiR, 2018a), hence, a pick-up service should be provided, especially for bulky waste.

The shopping center area is a strategic location for a new Repair Café, because going to shop, people can stop to leave or fix broken objects. The Repair Café could be open inside a container, in this way there will be no need of a new structure and furthermore it will be easy to move in case a new or

more desirable location will be found in future. *Figure 5.8* show images of container already existing in Hamburg, that can be used as example.

Figure 5.8 - Example of containers used in KEBAP cultural center (Source: KulturEnergieBunkerAltonaProjekt e.V., 2019).

Finally, to the South of the neighbourhood there is a recycling station. This station is one of the 12 recycling station in Hamburg. In the recycling station, households can drop off almost anything, accumulate in quantities typical for households. Recycling areas only accepts waste material, and they do not give them away. The waste materials accepted are recyclable materials, bulky waste, electrical and electronic devices, hazardous materials and garden refuse as well as corks, old clothing and shoes, toner cartridges, ink cartridges, CDs, Styrofoam packaging, etc. (Stadtreinigung, 2020). Moreover, there is a bulky waste pick-up services, that is free of charge, on reservation. Since the bulky waste are one of the mainly problems of the area, the service may be boosted. The recycling station should be promoted at the local level and more interaction with the neighbourhood is desirable. The recycling station may also work in synergy with the second-hand shop. Indeed, if in the second-hand shop will function also as a repair hub, damage waste could be fixed and sold there.

Figure 5.9 shows the desirable scenario for Osdorf neighbourhood. For this area three flows have been identified. The first regards bulky waste and WEEE; these kinds of waste should be deposited in the new container near the second-hand shop or bring to the recycling station. The waste inside the container could be fixed and sell in the second-hand shop or dispose in the

recycling area. The second flow represents the exchange of information and broken/repaired items between the neighbourhood, the Repair Café, and the second-hand shop, Cappello. Finally, the third flow regards the exchange between the recycling station and the second-hand shop. Indeed, some waste in the recycling station may still have a second life if sell in the shop, on the other hand, some of the waste bring to the Bornheide area have to be disposed to the recycling station.

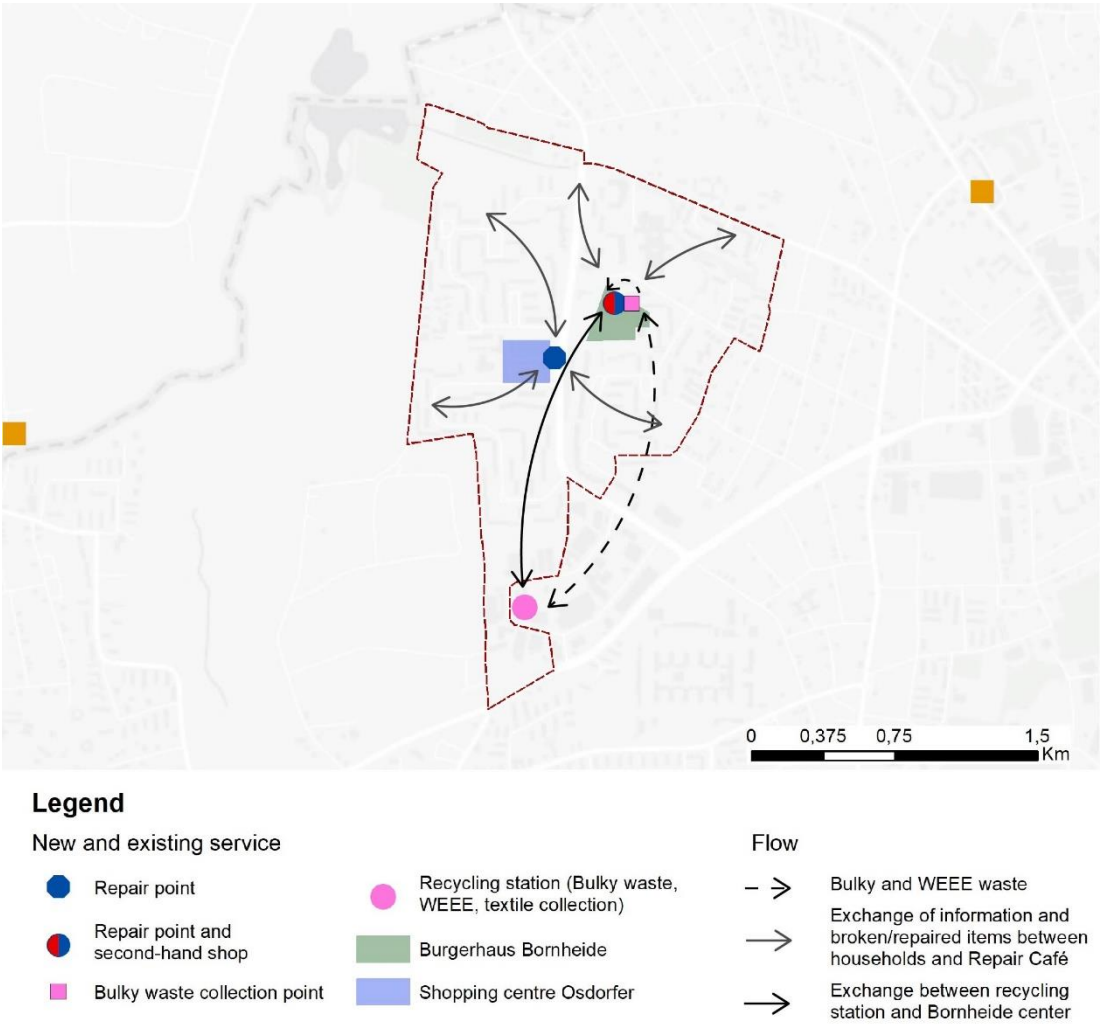

Figure 5.9 - New and existing services in Osdorf area. The map shows the desirable network between services and activities, how they could be linked and which kind of flow they supported (Source: author own elaboration).

5.3 Impacts of the solution “Quarter Service Center” on the Waste Management System

After defining the solution “Quarter Service Center”, this sub-chapter aims to evaluate the potential impacts of the solution on the waste management system. In the frame of REPAiR project, a “life cycle-based sustainable framework” has been defined to analyse the sustainability of the waste management system and to the eco-innovative solutions (REPAiR, 2018d). The methodology adopted in the project is based on the Life Cycle Assessment (LCA), a technique that aims to evaluate the entire life cycle of a product or a flow. Therefore, with reference to the sustainable framework defined in REPAiR, this thesis proposes to adopt some indicators to evaluate the status quo and the potential impacts of the proposed process “Quarter Service Center” on the waste management system.

5.3.1 The Life Cycle Assessment methodology

The LCA is a technique used to quantify the environmental impact of products, processes, systems or services over its entire life cycle (Taelman et al., 2018). This methodology was introduced for the first time in the frame of energy analysis in the 1960s and 70s. However, only in the 1990, the term Life Cycle Assessment has been introduced in scientific literature with a publication in which the methodology was setting out. Over the years, the LCA had several applications, it has become more commonly used by policy makers and other authorities for estimate the “effects beyond the project” (Mcmanus and Taylor, 2015). From the perspective of waste management system, the LCA is consider as an adequate instrument to provide support in analysing and evaluating different options for the same step or process (UrbanWINS, 2019).

The LCA has become a standardized methodology in 2006 with the ISO 14040:2006 “Environmental management — Life cycle assessment — Principles and framework”. The ISO states that LCA is composed by four phases:

- the goal and scope definition;

- the inventory analysis phase;
- the impact assessment phase;
- the interpretation phase.

The first stage consists in defining the functional unit (FU) upon which impacts will be assessed and in defining the system boundary for the model. For instance, in the two case studies analysed in this thesis, the functional unit is the amount of waste generated in one year and the system boundary is the focus area in which the EIS is applied. In the second phase, the inventory analysis, all the relevant data on the defined system are collected. The data have to include input and output flows to establish a life cycle inventory. The impact assessment is then carried out, during which the data relating to releases in the environment and to the resources' consumption are processed. Emissions and resources inputs to the system are processed in order to quantify the overall environmental impact for different impact categories. The interpretation is the final phase of the LCA procedure, in which the results are summarized and discussed. In this step is possible compare different scenarios and it represents the basis for conclusions, recommendations and decisions (COLLECTORS, 2019).

The REPAiR project aims to develop a 'life cycle-based sustainability framework', with which reaches a comprehensive sustainability assessment of WM systems considering environmental, social and economic impacts. Based on the goal of apply the framework to both the current WM situation and to the EISs developed by each case study to analyse the overall sustainability, different impact categories have been identified. The selected categories contain multidisciplinary, multi-scale and multi-size impacts. The multidisciplinary refers to the three pillars of the sustainability (environmental, social, and economic). The multi-scale reflects the geographical scale and location of the impacts, while the multi-size refers to the magnitude of the impacts, which can range from the micro to the macro scale (Taelman et al., 2019 and REPAiR, 2018d).

The categories have been selected through a participatory process, in which experts and stakeholders form each case studies have been involved. The impact categories were categorized into five areas of protection (AoP): human well-being, human health, ecosystem health, natural resources, prosperity. Once the impact categories were set, the most adequate quantitative indicator was identified per AoP and per midpoint impact category. *Table 5.2* shows the impact category, the AoP, and the related indicators.

Table 5.2 - Life cycle-based sustainability framework in REPAiR (Source: author own elaboration based on REPAiR, 2018d).

Impact category	AoP	Indicator	Impact size
ENVIRONMENTAL	ECOSYSTEM HEALTH	Eutrophication	Meso
		Ecotoxicity	Meso
		Land use	Macro
	NATURAL RESOURCES	Fossil depletion	Macro
SOCIO-ENVIRONMENTAL	HUMAN HEALTH - ECOSISTEM HEALTH	Global warming	Macro
	HUMAN HEALTH - ECOSISTEM HEALTH - NATURAL RESOURCES	Water use	Meso
SOCIAL	HUMAN HEALTH	Human toxicity	Macro
		Ozone depletion	Macro
		Tropospheric ozone formation	Meso
		Particulate matter	Meso
		Ionising radiation	Meso
		Occupational health	Micro
	HUMAN WELL-BEING	Effectiveness in achieving behaviour change	Micro
		Public acceptance/NIMBY syndrome	Micro
		Stakeholders' involvement	Micro
		Urban space consumption	Micro
		Odour	Micro
		Landscape disamenities	Micro
		Private space consumption	Micro
		Accessibility of WM system	Micro
ECONOMIC	PROSPERITY	Capital expenditure (CAPEX)	Micro
		Operational Expenditure (OPEX)	Micro
		End of life expenditure (OELEX)	Micro
		Revenues	Micro
		Total employment	Micro

In REPAiR the LCA methodology and the life cycle-based sustainability framework have been defined to become a decision-making support tool. Indeed, the ambition of the analysis is not to score the best solution, but to inform local stakeholders, waste authorities, and policies-makers on the

potential impacts and effects (both positive and negative) of one or more combined solutions on the waste system management. “The objective is to inform not only policy-makers at the EU or national level about potential global effects of waste-as-resource systems for decision-making, but also governments at the regional and local level about possible constraints/benefits of certain circular economy initiatives that are implemented locally” (REPAiR, 2018d).

5.3.2 Scenarios and indicators

The EIS “Quarter Service Center” aims to reduce the amount of waste generated by households, promoting waste avoidance, reuse, and repair practices. This solution is one of the four solutions designed to implement the circular economy at the local level of the neighbourhood. Therefore, the indicators presented here refer to the local impact and regard mostly the social impact category of the analysis.

For the analysis, the waste streams considered are: bulky waste, WEEE, bicycle, bio, and textile. More generally, to evaluate the EIS all the waste that can be repaired in the Service Center, and the waste fractions that could be reduced through awareness-raising workshops should be taken in consideration. In the current system the poorly management of these waste streams entails the disposal of most part of them. With the introduction of the EIS, part of the waste that now are dispose, should be reintroduced in the cycle through repair, recover, reuse and recycle practices. The amount of waste that will go to the Quarter Service Center should be defined during a PULL, in which stakeholders express their willingness to use this service.

Figure 5.10 shows the schemes of the status quo and the proposed process in the neighbourhoods in analysis. With the grey colour is represented the current situation, from the waste generation by households to their disposal. With the green colour is represented the desirable process to achieve with the introduction of a service center in the neighbourhood. Ideally, all these streams of waste generated by households will go to the service. However, since it is

expected that not all households will use the service, a percentage of waste will go to the service center, and a part will continue to be disposed.

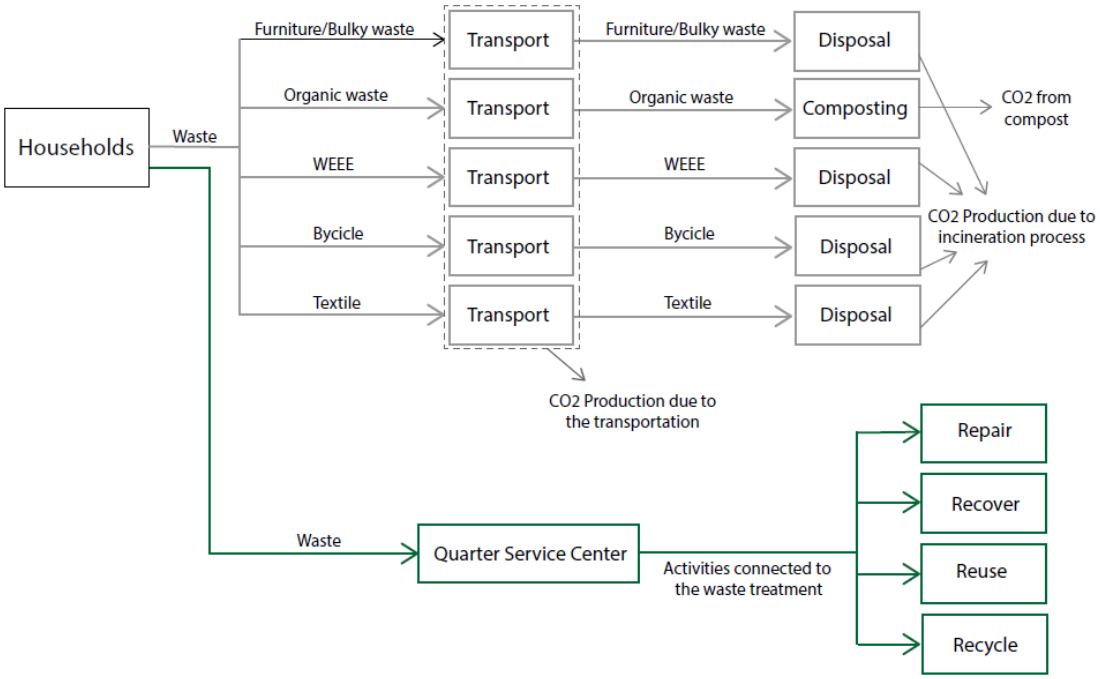

Figure 5.10 - Proposed process of the EIS "Quarter Service Center". The grey colour shows the status quo of the process, while the green colour shows the changes in the process with the introduction of the service center (Source: author own elaboration based on REPAiR).

After defining the proposed process, in this section a brief description of the indicators used in the analysis to evaluate this EIS is presented. The indicators belong to the deliverable D4.4 "Definitive framework for sustainability assessment" of REPAiR (2018d).

Effectiveness in achieving behaviour change

The indicator expresses the amount of the selectively collected waste compared to the whole amount of municipal solid waste. This indicator is based on the fact that the change in the percentage of selective collection can show the change of households' behaviour. Therefore, an increase in the number of users of the service center will lead to an increase in separate collection.

The following formula has been applied:

$$\frac{amount\ of\ waste\ flow\ x\ inside\ bin\ x}{tot\ amount\ of\ waste\ flow\ x}$$

Public acceptance

The aim of the indicator is to evaluate the public acceptance in relation to the costs imposed on citizens through taxes and the percentage of separate collection. This indicator measures the relation between the percentage of separate collection and the economic incentives (fee).

In order to calculate this indicator, the following data are needed:

- % of door to door collection (a)
- Waste fee (b)
- Waste fee if the waste is sorting (c)
- Waste fee if the waste is mixed (not sorted) (d)
- total weight of key waste flow sorted (yearly average) per actor [kg/year]; (e)
- total weight of mixed waste (yearly average) per actor [kg/year]. (f)
- weighted fraction of key flow (unsorted) in mixed waste [kg/kg]; (g)

The waste fee if the waste is sorting is calculated as followed:

$$c = [(a * 0) + (100\% - a)] * b$$

The waste fee if the waste is mixed is calculated as followed:

$$d = \frac{(b - c * g)}{(100\% - g)}$$

The indicator is calculated as followed:

$$\frac{c}{d} * \frac{e}{(f * g)}$$

Urban space consumption of the waste management system

The indicator expresses the amount of land occupied by waste management infrastructure on the total surface area in analysis.

The indicator is calculated as followed:

$$\frac{surface\ of\ public\ bins + surface\ of\ operational\ infrastructures}{surface\ of\ the\ study\ area}$$

Private space consumption

The indicator measures the area occupied by the bins inside private house. The typology of waste management system influences the number and dimension of bins inside private house, therefore a change in the system could be related to a change inside private house.

The indicator is calculated as followed:

$$\frac{surface\ occupied\ by\ bins\ inside\ the\ house}{total\ of\ house\ living\ space\ in\ the\ area}$$

Accessibility of waste management system

This indicator expresses the percentage of households that need to walk in a definite range to reach the nearest public waste collection point. The location of public bins is a crucial aspect to ensure the participation in the separate collection. For the calculation of this indicator, a GIS tool is necessary.

In order to calculate this indicator, the following GIS file are needed:

- location of the collection points;
- street network;
- location of residential buildings.

Through a service analysis, it is possible to define the accessibility ranges and, then, through a selection by location, select the number of households in each range. Finally, the indicator is calculated as followed:

$$\frac{number\ of\ households\ in\ range\ x}{total\ households\ in\ the\ area}$$

Total employment

The indicator shows the total amount of job available for the activities under assessment. The objective is to understand how the solution can influence the current employment situation.

Reveneus

This indicator measures the revenues of sales of products or incoming fees.

5.3.3 Results

In this section the indicators previously described have been applied to the status quo and to the proposed process in order to understand which effects the Service Center could have on the waste management system. The data collected refers to the house typology (as explained in chapter 4.3.2), therefore the data relating to the predominant typology has been used in each neighbourhood for the calculation of the indicators. In addition, it is assumed that 40% of the population will use the new service for analysis purposes. The percentage of citizens who will use the services should be defined together with the population in a PULL in which they can express they wiliness to use the center. However, in the work of this thesis, the percentage is assumed to be 40% in order to show how the indicator can change if the 40% of the population will use the service.

Effectiveness in achieving behaviour change

Only the 18,8% in Ottensen and the 24,8% in Osdorf of residual waste is properly separated. The remaining part consists of other waste streams incorrectly sorted, mainly kitchen waste, textile, WEEE, and plastic. Assuming that 40% of the population will use the service center, the indicator will increase to 23,4% in Ottensen and to 30,9% in Osdorf.

For the calculation of this indicator a linear reduction of 40% has been applied to the amount of waste streams incorrectly sorted by the neighbourhood's inhabitants in the residual bin during the reference year 2018. According to the scheme in *figure 5.10*, the reduction has been applied to portion of organic waste, textile and WEEE present in the residual bin. There are not data available about bulky waste and bicycle, therefore was not possible track these waste streams. Moreover, the available data have made possible to assume an improvement in separate collection even in plastic and paper bins. Even if the amount of separate collection of these waste is already quite high, therefore there is only a minimal variation. In Ottensen the plastic correctly separated will increase of 1,9% and the paper of 0,2%, while in Osdorf the plastic will increase of 1% and the paper of 0,8%. *Figure 5.11* shows the

comparison between the status quo and the proposed process in the two neighbourhood.

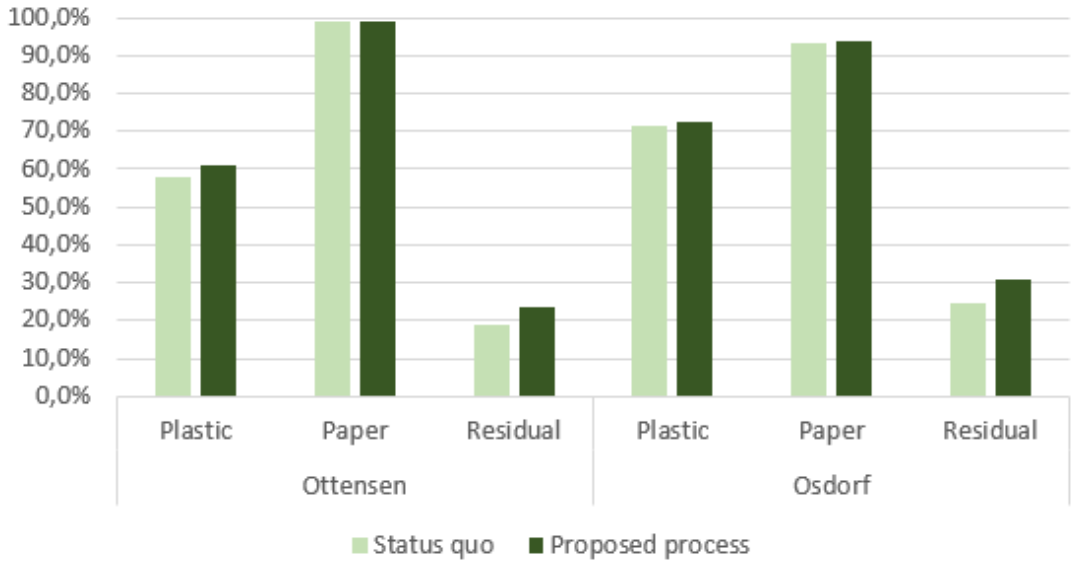

Figure 5.11 - Effectiveness in achieving behaviour change. The graph shows the status quo of the two neighbourhood and its potential variation if the 40% of the neighbourhood's population will use the service center (Source: author own elaboration).

Public acceptance

This indicator has not been calculated for Hamburg case study due to the existing taxation system. Indeed, in the city the waste fee is not a fixed cost, but it changes according to some characteristics of the service. There is a basic fee to which add a fee regarding the size of the bin and a fee for the service/transportation (Siechau, 2018). The bin size fee changes according to the dimension of the bin and the number of bins. In the city there is a four-bin system, however not every household has the four bins and not everywhere the size is the same. For instance, REPAiR team has established that the average fee for Ottensen neighbourhood is 210,72€ per household, while in Osdorf the fee is 302,64€ per household.

Urban space consumption of the waste management system

The Service Center will increase the urban space consumption due to the need of facilities in which promote both waste collection and activities linked to information, reuse, and recycle. It is important to highlight that most part of the new facilities will be insert inside existing building in order to use the available

spaces and limit new construction. The data need for the indicator are the area occupied by public bins and the area occupied by operational infrastructure. The dimension of the facilities and the number of public containers has been calculated through a GIS program, while the average dimension of the public container is assumed to be 2,5 m^2 (as in SRH, 2020b).

As shown in *table 5.3,* in Ottensen the surface occupied by the WMS infrastructure is expected to increase by three times, even if the weight on the total surface area of the area is really contained. On the other hand, even if more services will create in Osdorf, the increased is really low, due to the dimension of the interventions. Indeed, the new services in Osdorf are punctual intervention of small size that contribute to contain the space consumption.

Table 5.3 - Urban space consumption of the waste management system. The table shows the increase in surface occupation between the status quo and the proposed process (Source: author own elaboration).

	Ottensen status quo	Ottensen proposed process	Osdorf status quo	Osdorf proposed process
Area in m^2	2873244	2873244	3055026	3055026
Area occupied by public bins in m^2	130,0	130,0	67,5	80,0
Area occupied by other operational infrastructure in m^2	15746,7	41033,7	10050,4	11844,7
Tot area occupied by WMS in m^2	15876,7	41163,7	10117,9	11924,7
Indicator	0,55%	1,4%	0,33%	0,39%

Private space consumption

For the private space consumption indicator, the following data have been collected:

- total area of buildings per typology;
- coefficient of reduction for leaving space;
- area occupied by private bins;
- Number of households.

The buildings' area has been calculated through the use of a GIS program. The coefficient reduction for leaving space is 10% in Hamburg (REPAiR, 2018a), while the area occupied for private bins is established according to the bin and the house typology. An average of 3 bins per households is assumed.

Table 5.4 - Dimension of bin per house typology (Source: author own elaboration based on SRH, 2020b).

	Single-family house	Multi-family house	Multi-storey mixed used building and Multi-storey house
Bin in l	120	80	60
Dimension in m^2	0,262	0,160	0,123

The following table shows the status quo of the two neighbourhoods. The area occupied within private spaces is generally less than one percent. However, in the prevalent typology of Osdorf area, the surface occupied is circa 8%. These data highlight the small size of houses, which can result in the use of a single bin to save space.

Table 5.5 - Private space consumption indicator per house typology (Source: author own elaboration).

	Ottensen	Osdorf
Single-family house	0,15%	0,22%
Multi-family house	0,42%	0,00%
Multi-storey mixed used building	0,84%	8,09%
Multi-storey house	0,41%	0,03%

This indicator is not calculated for the proposed process, because the solution Quarter Service Center has not direct consequences on the private house bins. Even if the information activities are expected to lead to behavioural changes and as a result with a change in private house. What emerge from the indicator is the need of find solutions to the space consumption in the 'Multi-storey mixed used building', because the reduced liveable space of these houses makes very difficult to find space for the four separate waste bins.
Table 5.6 shows the indicator calculated assuming that all the households will use the four-system bins. From this table it is even more evident how it is necessary to find alternative solutions in the multi-storey mixed used building.

Table 5.6 - Private space consumption indicator per house typology in the case all the households will use the four-system bins for the separate collection (Source: author own elaboration).

	Ottensen	Variation	Osdorf	Variation
Single-family house	0,20%	0,05%	0,29%	0,07%
Multi-family house	0,56%	0,14%	-	-
Multi-storey mixed used building	1,12%	0,28%	10,78%,	2,70%
Multi-storey house	0,54%	0,14%	0,03%	0,01%

Accessibility of waste management system

The calculation of the indicator was carried out through a service analysis performed with ArcMap. Ten ranges of accessibility are set 0-50, 50-100, 100-200, 200-300, 300-400, 400-500, 500-600, 600-700, 700-800, >800. The analysis for the status quo has been performed with the location of the existing public bins, while, in the proposed process analysis, the location of the new collection points is added to the location of the existing public bins. It is important to note that in Ottensen only a new collection point is insert, corresponding to the new Repair Cafè, while in Osdorf three new collection points are insert. Consequently, more changes are expected in Osdorf.

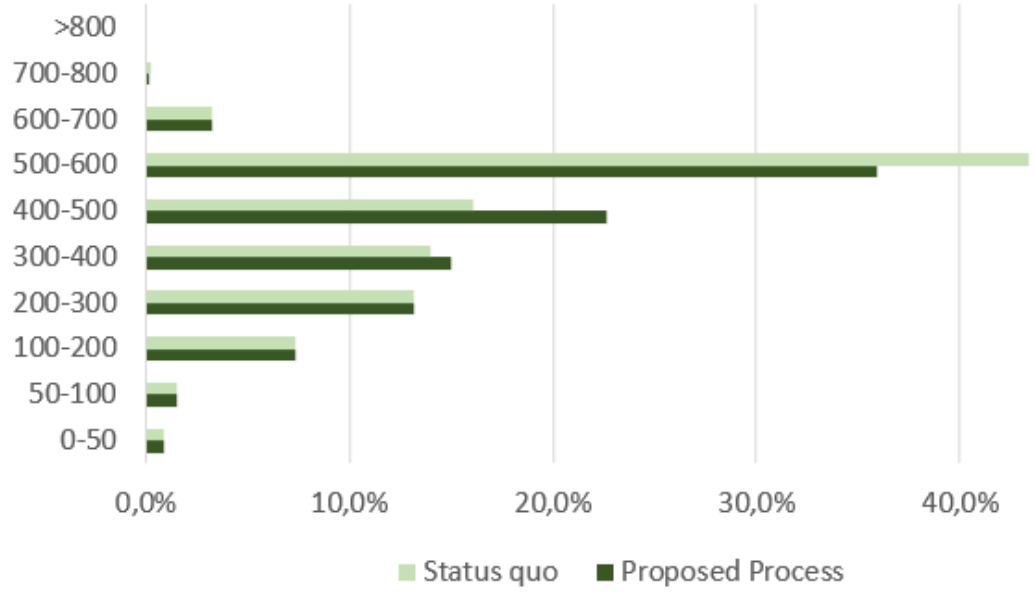

Figure 5.12 - Accessibility to the waste management system. The graph compares the status quo and proposed process in Ottensen area (Source: author own elaboration).

In the status quo almost half households live between 500 m and 600 m from the public bins' areas. The introduction of a Repair Café, consider as a

collection point, will reduce the distance for a part of the households who, instead of walking 500/600 m, will have to walk 100/200 m less. It is important to highlight that the Repair Café is not in a central location for the neighbourhood, therefore its influences on the accessibility is limited.

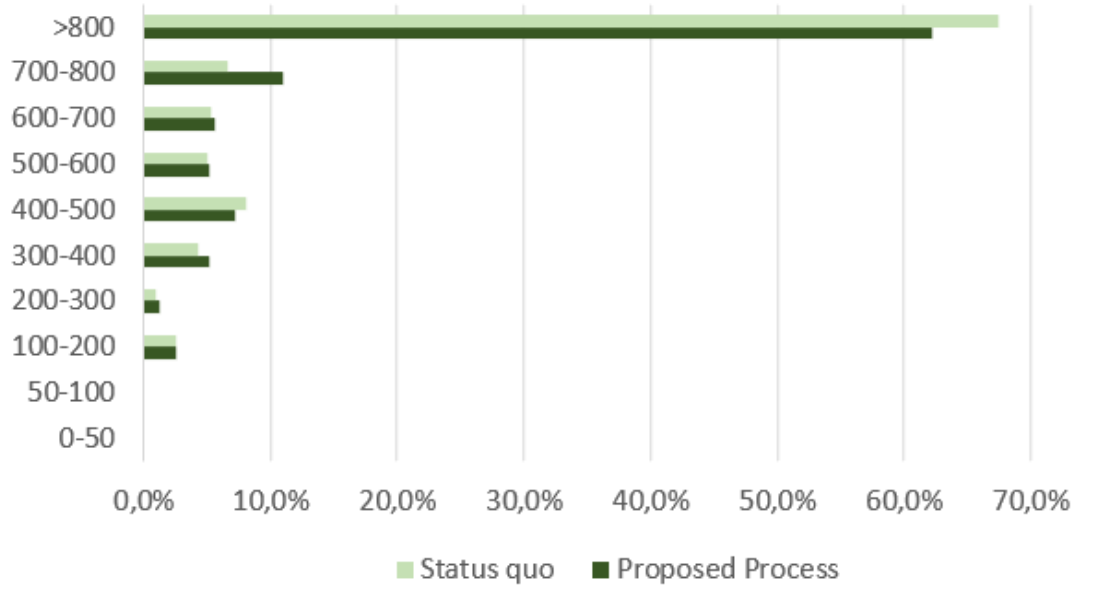

Figure 5.13 - Accessibility to the waste management system. The graph compares the status quo and proposed process in Osdorf area (Source: author own elaboration).

While, in Osdorf, the new collection points lead to an improvement in terms of accessibility. Almost all ranges show an increase of households and there is a 5,2% drop in households living more than 800 m away. The range 700-800 m shows the highest increase with +4,5%, followed by the range 300-400 m with +0,8%.

Economic indicators

The data available for the economic indicators refer to the public agency SRH in the year 2018 (SRH, 2018).

In 2018, the number of employees was 3259. The service centre and its related functions should work on a voluntary basis. However, especially for the Repair Café, the SRH may provide at least two new employees.

The revenues amount to 394 M€, whose 221,1 M€ are fees (81,2 M€ households fee, and 139,9 M€ containers fee). As in Hamburg the households fee is calculated according some variables that take in account the service

offered to the households, in the neighbourhood, the fee may increase in order to offset the cost of material and tools necessary in the center to repair and recover items.

The waste management expenses amounted at circa 354 M€ in 2018. Of these cost, 45,8 M€ are operating expenses, 150,3 M€ are material expenses, and 158,5M€ are wage and salaries. At the beginning the service center will increase the material and wage and salaries costs as new material and tools are need as well as new employees. Only in the medium to long term will there be a decrease in expenses due to better separate collection and a decrease in waste that instead of being incinerated will be repaired and reused. However, the two neighbourhoods are very small compared to the city of Hamburg, so if the solution is adopted only within them, the economic impacts will be rather small.

5.4 Chapter summary

The EIS “Quarter Service Center” aims to reduce the amount of waste locally generated. To achieve this purpose the solution has been implemented in two neighbourhood of the focus area previously presented. The ambition is to create facilities that will become both information and collection points for the waste management. Moreover, the center should function as a repair, reuse and recycle hub.

To achieve the goal, firstly, an analysis of the existing services has allowed to define solutions ad hoc, based on the presence or absence of services and facilities linked to the waste management. Then the solution has been implemented in the areas, with references to the existing services, trying to create networks of information and activities. Locations for the center have been proposed based on the availability of empty structure or spaces. In addition, some service already on place should be improve in order to become more attractive.

Once defined, the solutions have been analysed in each neighbourhood. The approach adopted for the analysis refers to the “sustainable framework” defined within REPAiR project. The framework is composed by several indicators that cover the three macro areas of the sustainability: economic, social and environmental. A selection of indicators has been calculated in order to define which impacts the solution could bring on the waste management system of Hamburg. The purpose of the analysis is to be a tool of information and support during the decision-making processes. Therefore, a comparison between the status quo and the proposed process is given to highlight the impact of the solution on the current situation.

The next two chapters propose the same analysis on the city of Turin, trying to understand if the solution is transferable to another city.

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06 A CASE STUDY IN ITALY: TURIN

6. A case study in Italy: Turin

This chapter focuses on the second case study, the city of Turin.
Turin is not one of the case studies of REPAiR project, however, this chapter and the following aim to understand if the solution “Service Quarter Center”, so far described, can be transfer on other cities.

Turin is the largest city in Piedmont region with approximately 880.000 inhabitants, and an area of 130 km^2. Together with other 311 municipalities, Turin constitutes the Metropolitan City of Turin, with 2.256.108 inhabitants and an area of 6.827 km^2. The planning system in Italy follows a four-systems structure, composed by national, regional, provincial/metropolitan and municipal levels, in which the national and regional levels can enact laws to define and regulate the system. Therefore, Turin planning system follows the rules of Piedmont region.

The waste management system is regulated by a regional law, as for the planning system, it is competence of the Region enact a law and a plan for waste management in the frame of national laws. In Europe, Italy is at the 12^{th} places in terms of amount of kilogram of municipal waste generated per capita in 2014, and at the 11^{th} places for what concerns recycling of municipal waste; the value of recycled municipal waste was circa 42% in 2014 (EEA, 2016).

The chapter attempts to define the planning and waste management systems framework, firstly at the national level, and secondly at the regional and local levels of Turin. Follows the introduction of the study area: San Salvario neighbourhood. The same analysis carried out for Hamburg’s focus area are repeated for the neighbourhood in order to be able to compare the two areas and evaluate the concrete transferability of the solution in Turin case study.

6.1 Planning system in Italy

Italy is a Republic, territorially and administratively divided in regions, provinces/metropolitan cities, and municipalities. The planning system follows a four-levels structure: national, regional, provincial and municipal. From a legislative point of view the urban planning (*governo del territorio*) competence is shared between the state and the regional levels. State and regions, with Trento and Bolzano autonomous provinces, are the only authorities that enact laws: the state defines framework laws, based on which each region enacts its own regional law and defines its own planning system.

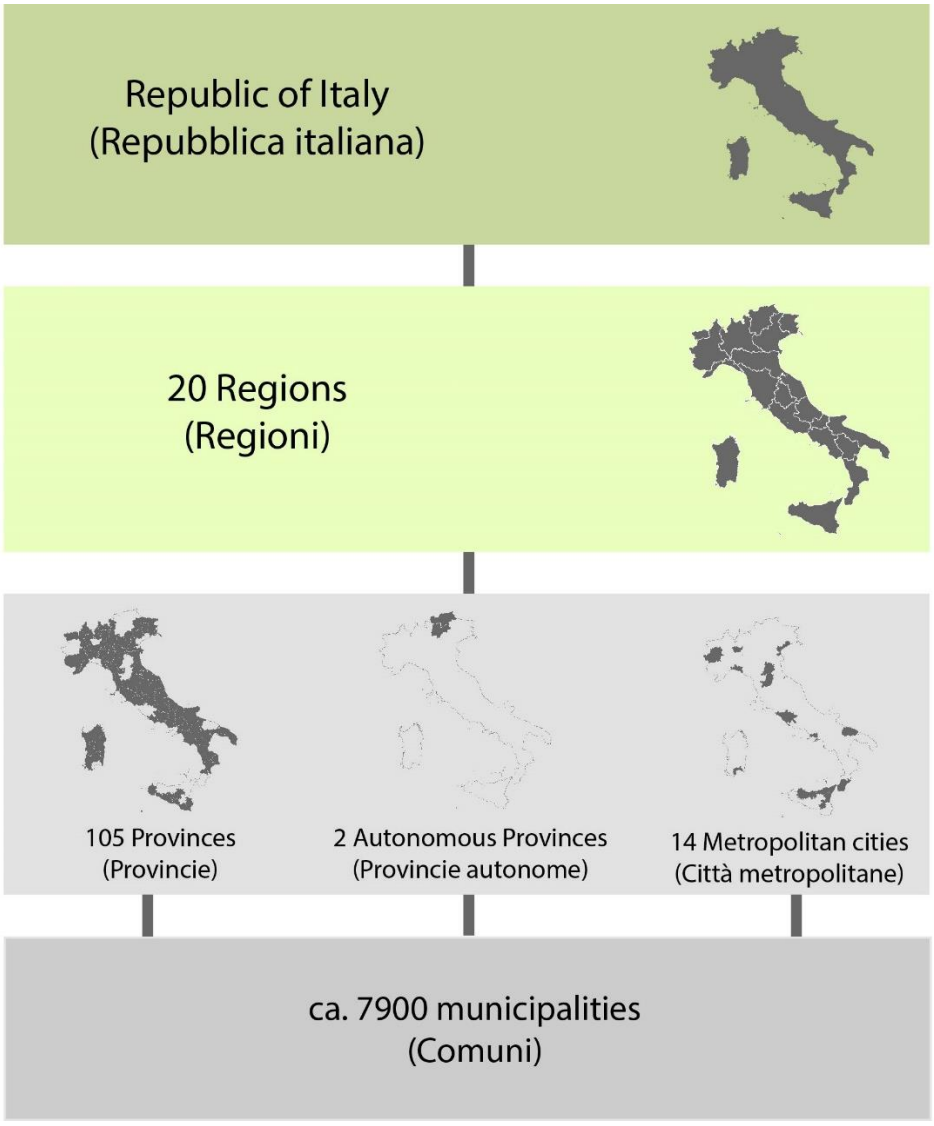

Figure 6.1 - Administrative structure in Italy. In the 105 Provinces are included also the six ex-provinces of Sicily, today free municipal unions "liberi consorzi comunali" and the four ex-provinces of Friuli-Venezia Giulia, today structured into intercommunal unions "unioni territoriali intercomunali" (Source: author own elaboration based on ISTAT, 2020).

The national level defines the frame of reference for programmes and sectorial policies. At this level, the Minister of Infrastructure defines guidelines for national planning (*linee fondamentali dell'assetto del territorio nazionale*).
The regional level is responsible for the regional planning, and each region defines its planning system through a regional law. At this level two plans, Territorial Regional Plan (*Piano Territorilale Regionale - PTR*) and Regional Landscape Plan (Piano *Paesaggistico Regionale - PPR*) define the regional priorities and strategies of intervention.
At the provincial level, the Territorial Coordination Plan (*Piano Territoriale di Coordinamento*) gives guidelines for the local planning. Since 2015, with the institutionalisation of the Metropolitan Cities, two new plans have been introduced for this new authority: the Territorial Plan (*Piano Territoriale Generale*) and the Strategic Plan (*Piano Strategico*).
The local level is responsible for the urban planning. At this level the Master Plan (*Piano Regolatore*) defines the land use.

Since 2001, with the Constitutional Reform, the European subsidiarity principle has been introduced in the Italian constitution. As regards planning system, the principle stated that the distribution of powers among different institutional actors takes place at the lowest possible and efficient level. Moreover, this principle promotes the transition from "traditional" spatial planning system to new spatial planning processes more open to territorial based initiatives promoted by emerging and auto-organized social groups (Brunetta, 2011).

6.1.1 Planning system in Turin

The city of Turin is the 'capital' of Piedmont region and, together with 311 other municipalities, is the Metropolitan city of Turin.

The Piedmont regional law 56/77 on land protection and land use (*Tutela ed uso del suolo*) defined the planning system and processes at regional, provincial and municipal levels. The law was reformed in 2013, with the introduction of new procedures to promote participatory and shared policies and actions (Regione Piemonte, 2020a). However, the main planning tools have remained unchanged.

Since 2015, the Province of Turin has been replaced by the Metropolitan City of Turin. The Metropolitan City supports the territory in the development and implementation of territorial and strategic planning tools, facilitating dialogue between all the administrations and actors involved (Città metropolitana di Torino, 2015c). This level coordinates the local development. *Figure 6.2* shows the Metropolitan City and its division into homogeneous zones (*zone omogenee*). These zones have been identified according to historical, territorial, social, and economic characteristics; the city of Turin constitutes one of the 11 zones.

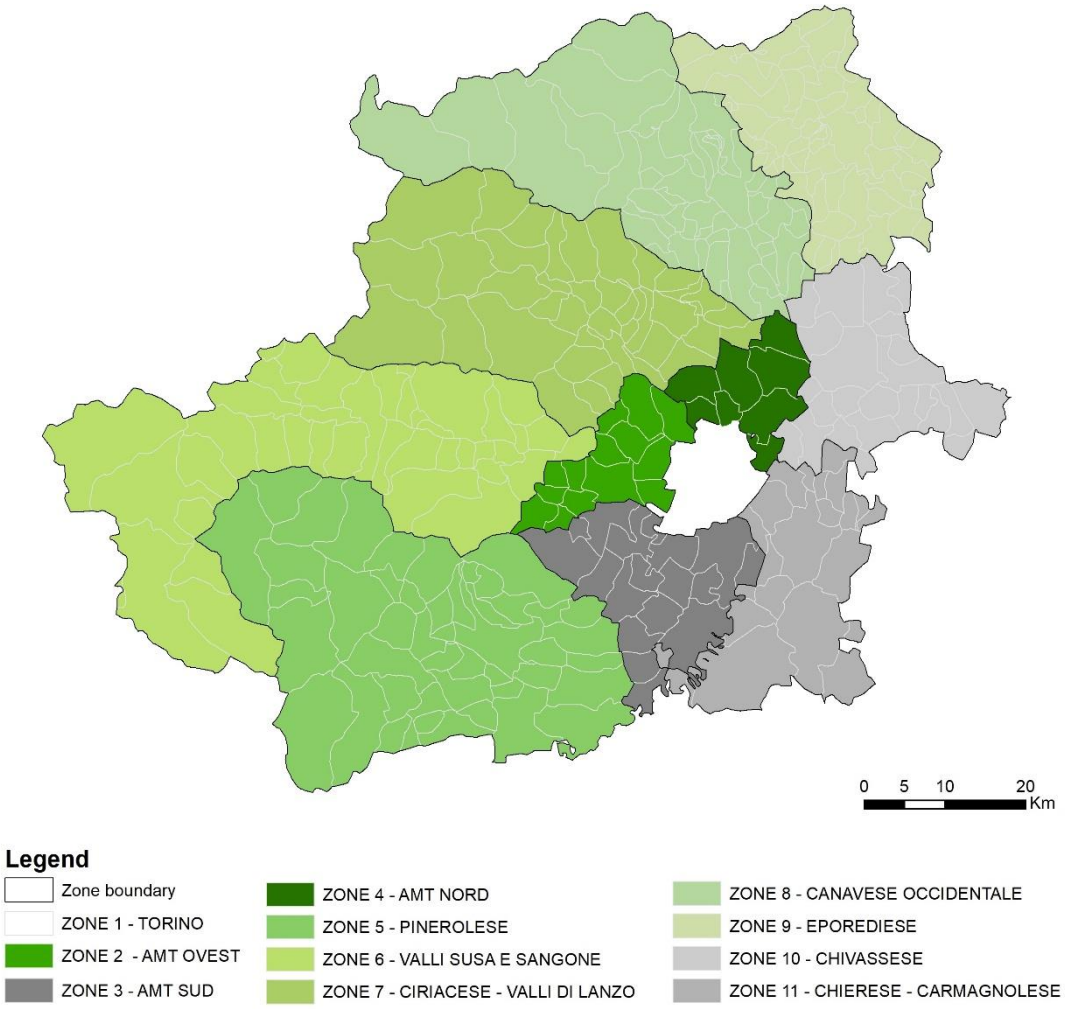

Figure 6.2 - Metropolitan city of Turin. The map shows the metropolitan city and its division in 11 zones (Source: author own elaboration).

The city level is in charge of urban planning. In 1995, the city of Turin has adopted its Master Plan (*Piano Regolatore Generale Comunale – PRGC*), that is still in force. The plan defines the land use and the main developments of

the city. Below the city level there are eight districts (*circoscrizioni*) and several neighbourhoods without any political and planning power.

Above the city level there is the metropolitan area, to be not confused with the Metropolitan City. The metropolitan area is not and institutional entity and does not have planning power. However, since the end of the 1990s, *Torino Internazionale*, an association composed by public and private actors, started a strategic planning process in the area. In 2015, the third strategic plan for the area has been adopted; the plan proposes a vision of the metropolitan area to 2025.

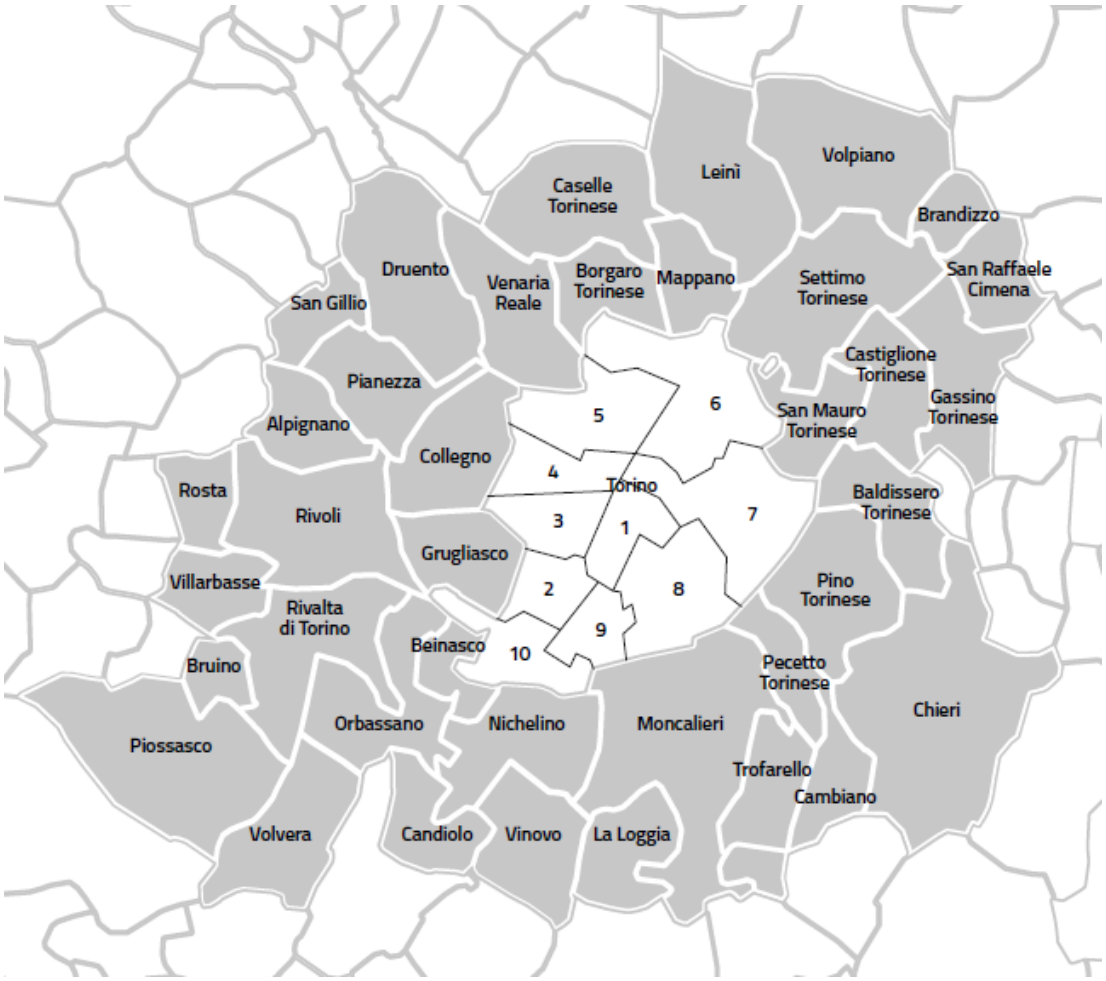

Figure 6.3 - Turin metropolitan area (Source: Associazione Torino Internazionale, 2015).

6.2 Waste Management System in Italy

In Italy, the waste management responsibility is shared between the national, regional, metropolitan/provincial, and municipal levels. At the national level the Ministry of Environment outlines the waste management strategy and the legislative frame, drawing up the National Waste Management Plan. Based on the national framework each region elaborates its own regional waste management plan to which the provincial/metropolitan plans are attached. The competence and the structure of the waste management system in Italy has been define by the law 22/97, replaced by the Legislative Decree 152/2006 that included most of its provisions (EEA, 2016).

In addition to the regional plan, the regions define the 'optimal areas for the management of waste' (*Ambiti Territoriali Omogenei - ATO*) that are responsible for meeting the targets on landfilling and separate collection of municipal waste. These ‘optimal areas’ are supposed to represent a geographical entity where waste management is economically feasible and usually coincide with provincial boundaries (EEA, 2009). The management of municipal waste in ATO is an objective of Regional Planning, while the Provinces organise the management of urban waste and ensure a unitary management through the Urban Waste Management Plan, which must also be drawn up on the basis of the indications provided by the Municipalities (ANPA, 2001).

6.2.1 Waste Management System in Turin

Since the 1995 Piedmont region started to deal with the issue of waste. In that year, the regional law “Rules for the reduction, reuse and disposal of waste” (*Norme per la riduzione, il riuso e lo smaltimento dei rifiuti*) proposed to regulate disposal and to encourage reuse and reduction of waste. However, only with the regional law 24/2002 on waste management (*norme per la gestione dei rifiuti*), the Region identified the responsibilities for each level, and defined the programming tools. According to this law, the Region is responsible for the administrative functions that require the unitary exercise at regional level, and it prepares and adopts the waste management regional

plan. The Provinces are responsible for the adoption of the provincial programme for waste disposal. In addition, they coordinate the forms of association between the parties responsible for implementing the integrated waste management system. Finally, the municipalities ensure the management of urban waste through consortiums.

The Department of the Environment, Urban Planning, Territorial and Landscape Planning, Mountain Development, Forests, Parks, Civil Protection (*Assessorato all'Ambiente, Urbanistica, Programmazione territoriale e paesaggistica, Sviluppo della montagna, Foreste, Parchi, Protezione civile*) is responsible for the elaboration of the regional plan, while, in the metropolitan city of Turin, the provincial programme is elaborated by the Department of Sustainable Development and Environmental Planning (*Assessorato Sviluppo sostenibile e Pianificazione ambientale*).

In 2016, the reginal council has adopted the Regional Plan for urban waste and sewage sludge management (*Piano regionale di gestione dei rifiuti urbani e dei fanghi di depurazione*). The main goals of the regional plan are:

- reduction of the waste generation pro capita up to 455 kg (in 2018 the production of waste in Turin was 514 kg/ab);
- increase in separate collection (> 75%) and recycling rate (> 65%);
- promotion of reuse practices.

Moreover, the plan defines medium- and long-term policy guidelines to achieve the circular economy goals defined by the European Union policies. The Region aims to informing, training and raising (culturally and economically) awareness among users and operators and activating more efficient collection and sorting systems (Regione Piemonte, 2016).

The law 7/2012 divided the regional territory into four ATO, each one with a own waste management system. ATO4 coincides with the boundary of the Metropolitan city of Turin. Moreover, each ATO is divided in consortiums (*consorzi*), that are responsible for waste collection in specific areas of the

ATO. In the ATO4 there are eight consortiums, one of which manages the city of Turin (Regione Piemonte, 2016). In each consortium the following services are performed:

- integrated management of separate contributions, separate collection, collection and transport;
- construction and management of facilities for separate waste collection;
- transfer to technological systems and landfills (Città metropolitana di Torino, 2015a).

Figure 6.4 shows the administrative division for waste management in Piedmont region and in the Metropolitan city of Turin.

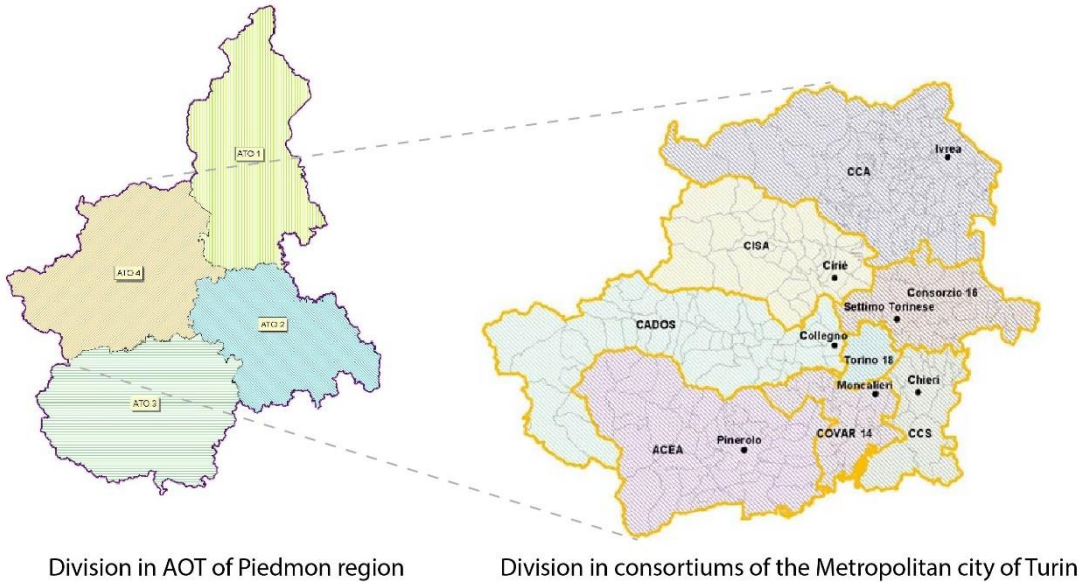

Figure 6.4 - Administrative division for waste management. On the left, the division of the Region in four AOT and, on the right, the division of the Metropolitan city of Turin in eight consortiums (Source: Regione Piemonte, 2016 and Città metropolitana di Torino, 2015a).

The Metropolitan City of Turin has a provincial programme of waste management (*Programma Provinciale di Gestione dei Rifiuti*). The program was enacted in 2006, when the metropolitan city was still a province, hence the name 'provincial programme'. The main objectives of the programme are:

- promote the reuse and the valorisation of each waste stream related to the urban waste;
- increase the recycling rate and reduce the waste generation.

The division in consortiums, is strictly linked to the division in zones of the metropolitan city. Indeed, even if all the areas do not coincide with the division in zones of the metropolitan city (see *figure 6.2*), there is a similarity. Indeed, the 11 zones have been designed to promote activities and decentralized services of the Metropolitan city.

In the city of Turin, the waste management system is entrusted to Amiat, a private agency. In 2005 the city enacted the regulation on urban waste management (*Regolamneto per la gestione dei rifiuti urbani*). The document outlines the importance of the waste prevention (art.4) and waste reuse (art.5). The waste avoidance should be reach through economic instruments, new clean technologies that allow greater savings of natural resources, and new products designed to prevent waste generation. Moreover, the regulation states that the city has to enact a municipal waste management programme (*Programma comunale per la gestione dei rifiuti*).

To date, in a great number of neighbourhoods is active the door-to-door collection. The waste collection follows a five-bins system: bio (brown bin), residual (green bin), paper (yellow bin), plastic (grey bin), glass and metal (blue bin). Other materials are collected in dedicated public areas or in the recycling stations. The door-to-door system was promoted since the 2013, and the recycling rate was between 56% and 65% in 2018. However, in the neighbourhood without the door-to-door collection, the recycling rate was much lower, around 35,5% (Amiat, 2019). This data outlined the good functionality of the door-to-door collection system.

6.3 Focus area

In this sub-chapter, the analysis carried out for Altona district have been repeated for San Salvario neighbourhood. To contextualize the analysis the data are compared to the other neighbourhoods of Turin. The socio-economic and the waste generation analysis aim to highlight analogies and differences between the two study areas in order to understand the applicability of the solution to San Salvario neighbourhood.

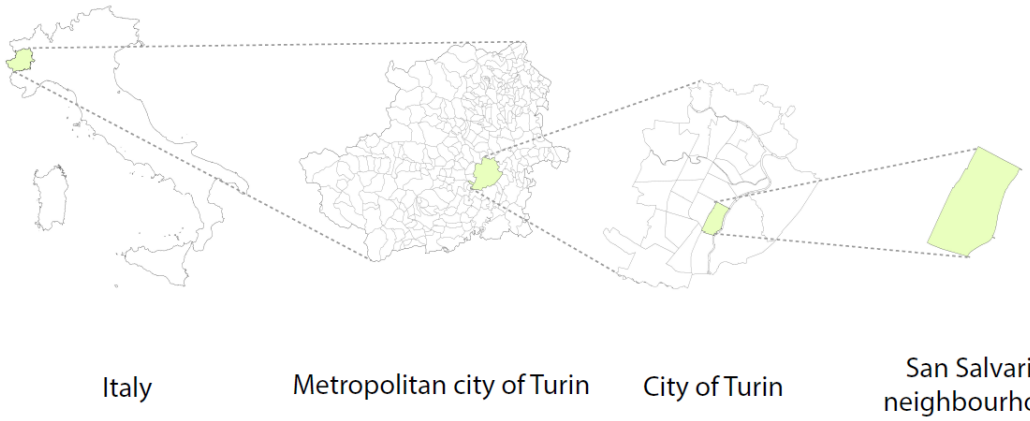

Figure 6.5 - Geographic framing of the study area (Source: author own elaboration).

The district of San Salvario is located in a quite central part of the city, at the left side of the Po river. With a population of 35.630 inhabitants and an area of 2,3 km^2, the neighbourhood has around 4% of the Turin's population (ISTAT, 2011). Compared to Hamburg case study, Turin focus area has approximately the dimension and the population of a sample area.

The West part is highly urbanized and is separated from the rest of the city by the regional railway line. On the other hand, in East part, bounded by the river, there is a large green area: the Valentino park. The neighbourhood has a great metro, buses, and tram services that link the area with the rest of the city. Moreover, on the North-West neighbourhood boundary, there is Porta Nuova railway station, one of the two main station of the city, hub for regional and national connection. The river to the east and the railway to the west are physical barriers delimiting the study area.

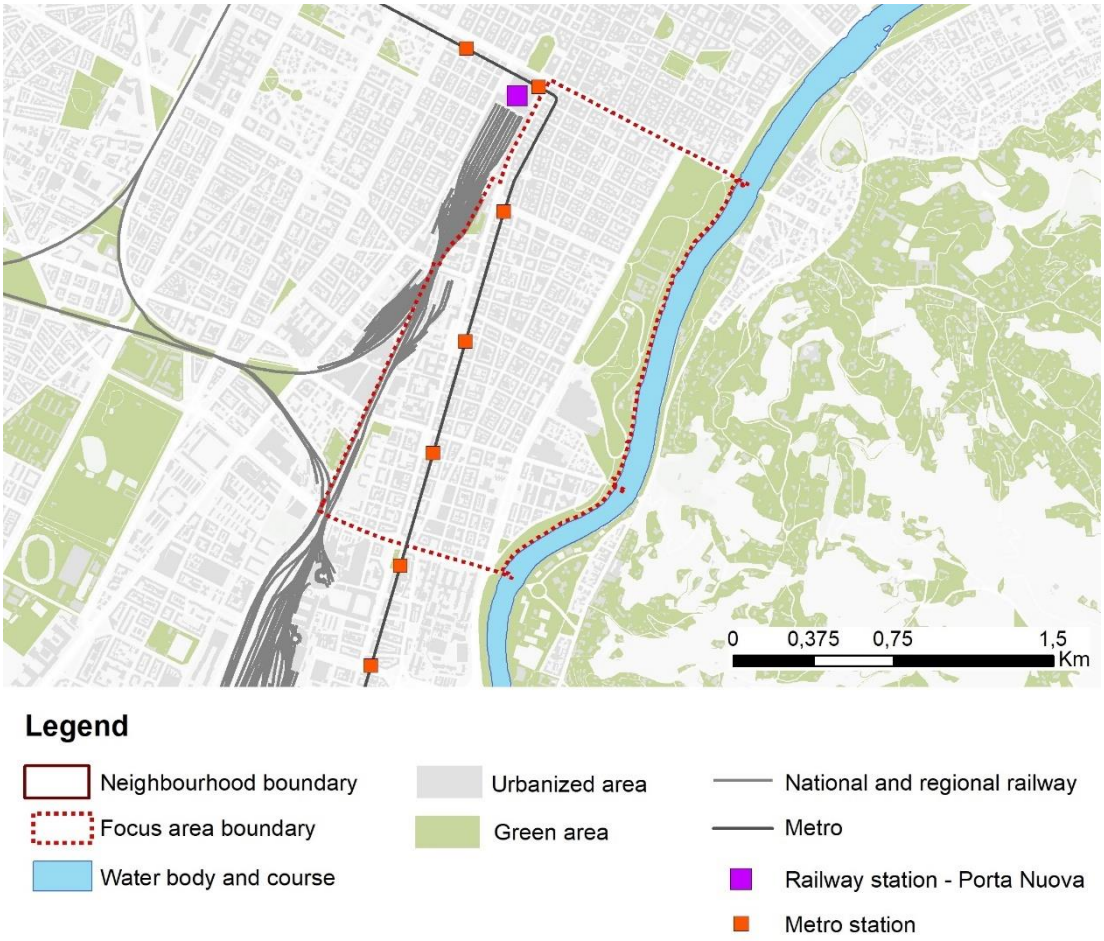

Figure 6.6 - Focus area main characteristics (Source: author own elaboration).

6.3.1 Socio-economic structure

This analysis compares San Salavrio neighbourhood with the other neighbourhoods in order to highlight specific characteristics of the area. The data were not available at the neighbourhood level; therefore, an aggregation of data was necessary. The National Statistcal Institute (*Istituto Nazionale di Statistica – ISTAT*) provides information about population composition at the level of statistical units. In the city of Turin there are approximately 3.800 units that have been merge according to the boundaries of the 23 neighbourhoods.

The inhabitants per km^2 in San Salvario are more than two times higher than the average of the city (6.695 inhanitants/km^2). The surrounding neighbourhoods, Centro at Nord, Nizza Millefonti at South, and Crocetta at West show lower population densities, even if the data are higher than the average of the city. These data confirm the high population density of the area,

that, such as for the Hamburg case study, may be challenged from the waste management prospective. Moreover, a good portion of the neighbourhood consist of the Valentino park, therefore the population density could be considered even higher than the one here calculated taking in account all the area of the neighbourhood.

Table 6.1 - Population density. Inhabitants, area, and inhabitants per km² in Turin's neighbourhoods and in the City of Turin, 31/12/2011 (Source: author own elaboration based on ISTAT, 2011a).

Area	Inhabitants	Area in km²	Inhabitants per km²
Aurora	38.996	2,7	14.443
Barriera di Milano	47.696	2,8	17.034
Borgata Vittoria	39.544	3,9	10.139
Borgo Po e Cavoretto	19.056	13,6	1.401
Cenisia	38.741	2,3	16.844
Centro	39.357	3,8	10.257
Crocetta	33.854	2,8	12.091
Falchera	26.134	12,6	2.074
Le Vallette	41.182	7,5	5.490
Madonna del Pilone	13.767	15,5	888
Madonna di Campagna	40.302	7,4	5.466
Mercati generali	48.363	3,5	13.818
Mirafiori Nord	43.230	3,8	11.376
Mirafiori Sud	35.001	11,4	3.070
Nizza millefonti	28.142	3,5	8.041
Parella	46.524	4,9	9.495
Pozzo Strada	56.691	4,2	13.498
Regio Parco	27.975	6,9	4.054
San Donato	49.211	3	16.404
San Paolo	34.766	2,2	15.803
San Salvario	35.630	2,3	15.491
Santa Rita	56.284	3,6	15.634
Vanchiglia	29.445	3,8	7.749
City of Turin	870.312	130	6.695

The following maps (*Figure 6.7*) show the proportion of children and adolescent under the age of 19 in the total population, the proportion of older residents over the age of 65 in the total population and the proportion of foreign population in total population.

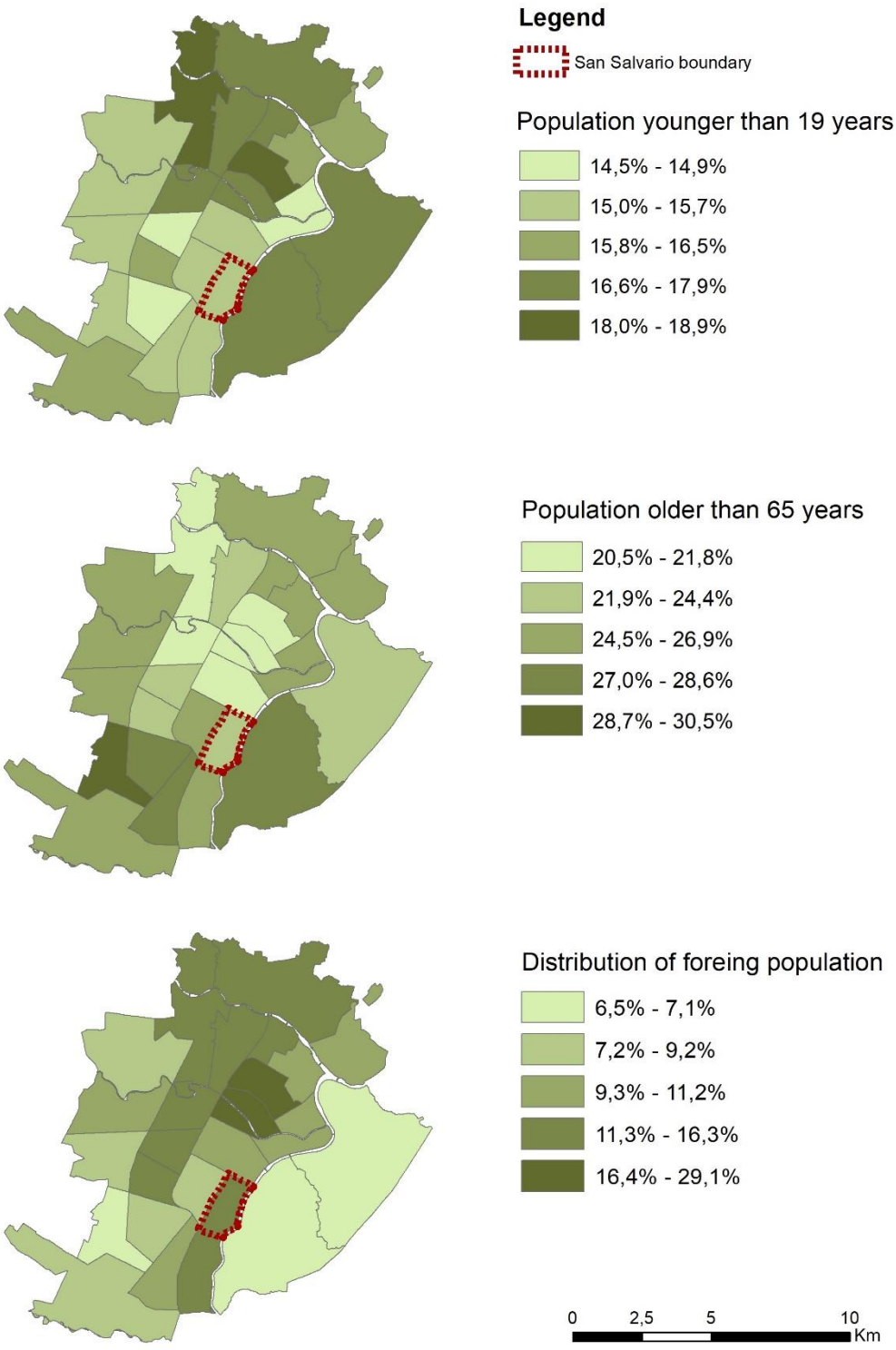

Figure 6.7 - Foreign inhabitants and inhabitants per proportion of age groups. The first map shows the percentage of population younger than 19 years, the second the percentage of population older than 65 years, and the last one the percentage of foreign population on the total population, 31/12/2011 (Source: author own elaboration based on data from ISTAT, 2011a).

The proportion of children and adolescent under the age of 19 in San Salvario (15,2 %) is lower than the other neighbourhoods and the average of the city (16,2 %). On the other hand, also the percentage of people older than 65 years shows a lower share than the city's average. The foreign population represents the 14,6% of the neighbourhood's population. This data is higher than the average value of the city (12,72%) but compared to the other neighbourhoods is in line with the trend. These data are important from the waste management perspective because, as outlined for the Hamburg case study, these people may be drivers for a behaviour change, and, in the other hand, they may be an obstacle for linguistic and habitual reasons. Moreover, the ISTAT data allow to understand the composition of the population between 19 and 65 years. The 10,1% has between 20 and 29 years, approximately the 16% has between 30-39 and another 16% has 40-49 years, and the 20,1% has between 50 and 64 years.

Table 6.2 shows the number of residential buildings and the households' structure. In San Salvario there are 1.322 residential buildings and 20.651 households. Even if the data about the number of apartments was not available at the neighbourhood scale, the high number of families compared to the number of residential buildings may suggest a high number of flats. The average apartment size is 42 m^2 per inhabitant (ISTAT, 2011b), however the data is available only at the city level, therefore it is not possible define the average size in San Salvario. What is known is the average of person per households that is approximately 2 (1,9 in San Salvario). Moreover, the share of single person households is available: it is 49% in the neighbourhood. The average number of persons per households is in line with the other neighbourhoods, while the percentage of single person households is higher than the average, the highest after Centro neighbourhood. Almost half of the households of the neighbourhood are composed only by a person.

The ISTAT data show only the population resident in the city. It is important to highlight that in the neighbourhood there are several university faculties and therefore a good number of students live here. However, not always the

students are registered as residents in the city, consequently the number of persons per households may not consider the student living in San Salvario.

Table 6.2 - Residential buildings and households' composition, 31/12/2011 (Source: author own elaboration based on ISTAT, 2011a).

Area	Number of residential buildings	Households	Average number of persons per households	Proportion of single person households on all households in %
Aurora	1457	21016	2,1	41,6%
Barriera di Milano	2175	24851	2,2	36,5%
Borgata Vittoria	1679	21171	2,1	36,4%
Borgo Po e Cavoretto	3394	9257	2,1	41,0%
Cenisia	2086	23884	2	44,8%
Centro	1700	23996	1,8	55,9%
Crocetta	1652	19656	2,3	47,4%
Falchera	999	12230	2,3	32,1%
Le Vallette	1315	19165	2,2	32,5%
Madonna del Pilone	2609	7534	2,1	39,8%
Madonna di Campagna	1984	21429	2,2	35,2%
Mercati generali	1138	24932	2,1	37,0%
Mirafiori Nord	1246	23364	2,1	35,4%
Mirafiori Sud	1471	20273	2,2	32,6%
Nizza millefonti	893	15242	2,1	40,8%
Parella	2383	22732	2,1	39,9%
Pozzo Strada	2287	30860	2,1	38,3%
Regio Parco	1845	15191	2,2	34,4%
San Donato	1992	26201	2	42,6%
San Paolo	1820	21945	2	42,4%
San Salvario	1322	20651	1,9	49,0%
Santa Rita	1838	31977	2	41,4%
Vanchiglia	1129	16258	1,9	44,7%

Finally, *Figure 6.8* shows the unemployed rate and the percentage of employees on all persons in working age (above 15 and under 65). The focus area has a quite good labour force. The unemployed rate is under the average, while the percentage of employees is one of the highest of the city (69,7%).

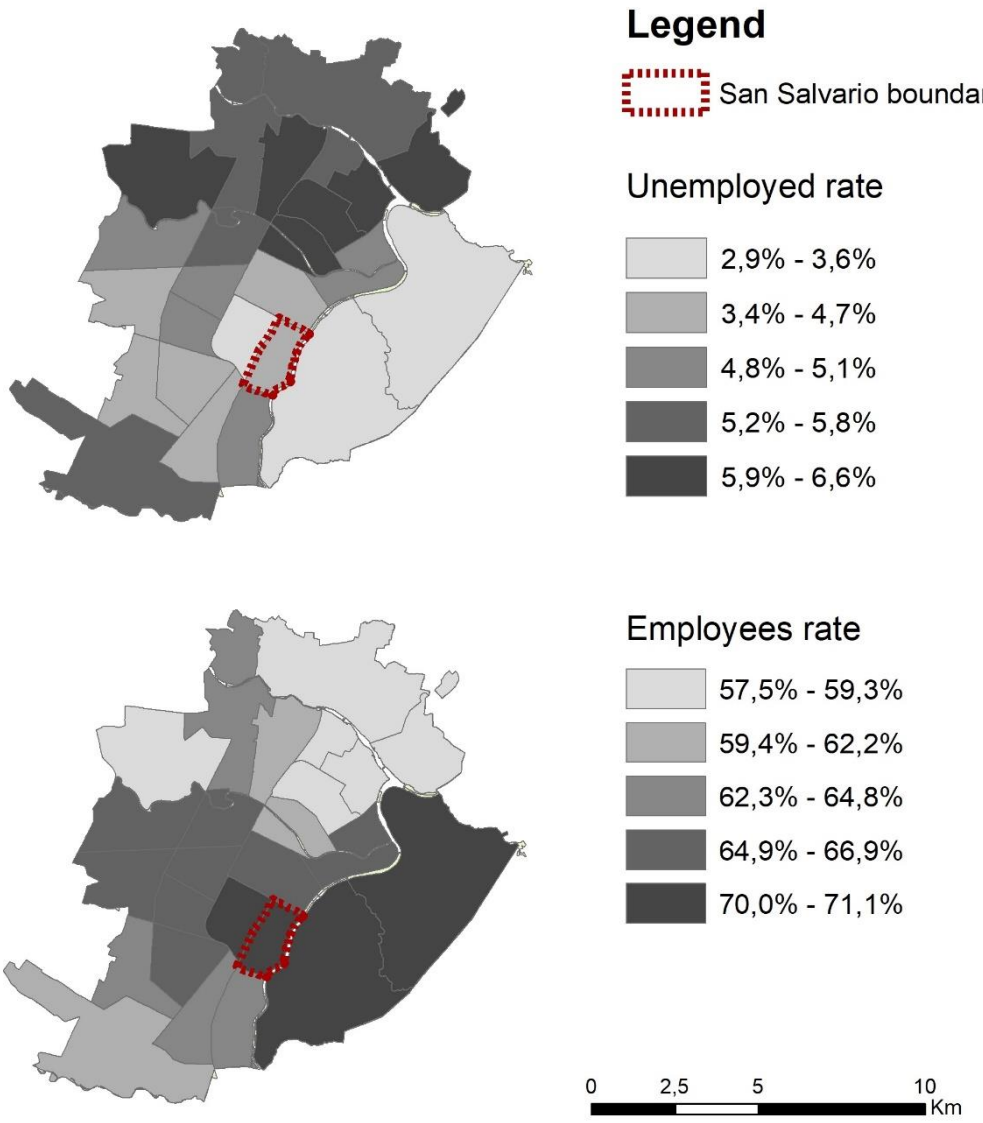

Figure 6.8 - Proportion of employees and proportion of unemployed on all persons in working age, 31/12/2011. The data shown on the maps are calculated on all persons in working age (above 15 and under 65) (Source: author own elaboration based on ISTAT, 2011a).

6.3.2 Waste generation

The waste generation is related to a series of urban and socio-economic characteristics of the area. Hence, the analysis of the land use has been used to define the prevalent activities. As for Hamburg case study, the land use categories have been clustered in order to easily understand the waste generation. *Figure 6.9* shows the prevalent uses: residential and services (mainly constituted by the Valentino park).

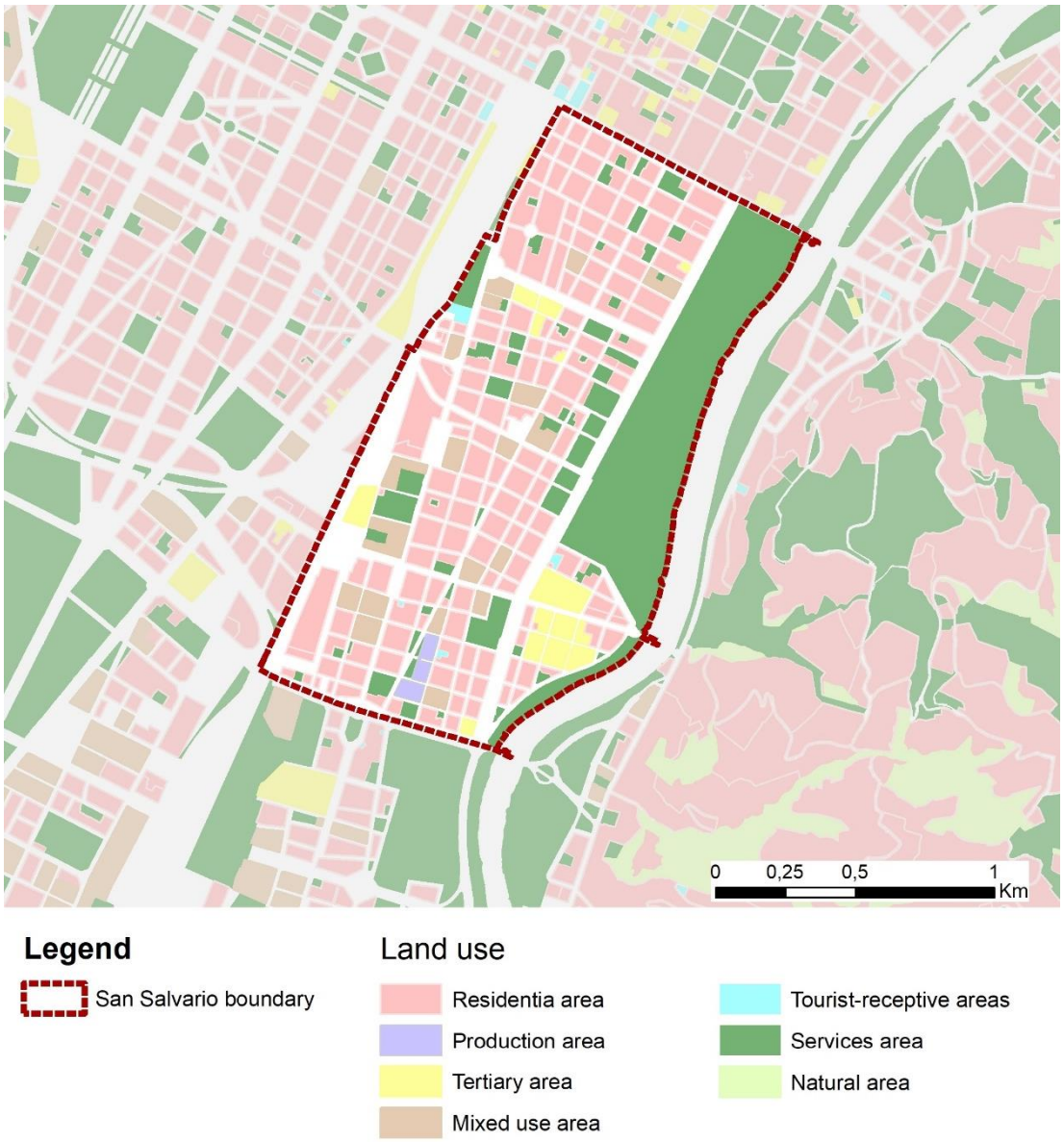

Figure 6.9 - Land use. The map shows the main land use of the neighbourhood (Source: author own elaboration).

The residential and service areas are the prevalent uses, with a percentage of 44,7% and 43,3%. The mixed-use is the third use by percentage (6,3%). To highlight in the area there is one of the biggest hospitals of the city and several schools and university faculties.

The city of Turin does not provide house typologies or classification, therefore, to better understand the waste generation into residential buildings a classification based on floors number has been done. *Figure 6.10* shows the number of floors in residential buildings. To simplify the analysis the floors have been grouped into five classes: one floor building, two or three floors building, four or five floors building, and more than six floor building. Based on this classification some assumptions may be done. For instance, the highest houses may have a highest number of flats and, consequently, a high amount of waste production, while lower buildings may have a lowest waste production.

The norther area of the neighbourhood is composed mostly by four or five floors building, while the southern area is characterized by a high rate of buildings with six or more floors. Although, on average, the houses are lower in the north, but the density is higher and almost all buildings are residential, this may pose a problem for the availability of public space for waste storage. On the other hand, in the south part the higher buildings may have more apartments, but not all the buildings are residential, therefore the space availability is less challenged.

Moreover, since 2018, in the southern area of the neighbourhood there is a system of door-to-door collection for residual, bio, paper, plastic, and glass/metal, while, in the other part of San Salvario waste can be thrown in bins or containers site on public spaces. This lead with a big difference in separate collection rate. In the neighbourhood the separate collection rate was 29,9% in 2014 and 33,2% in 2017, while, in 2018, with the door-to-door collection, the rate was 53,1% for the door-to-door area and 28,3% for the other area (Amiat, 2019).

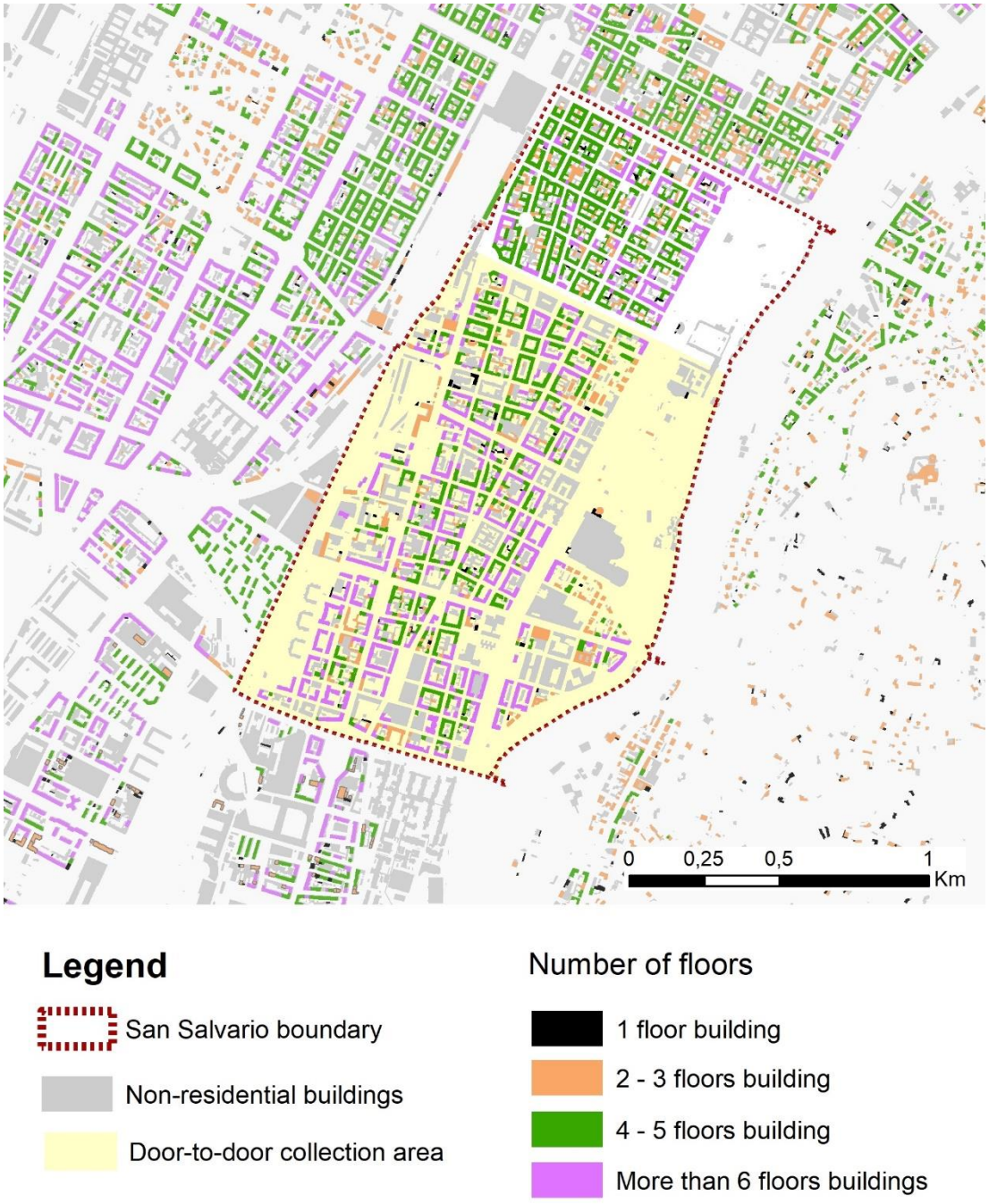

Figure 6.10 - Number of floors of the residential buildings. The map classifies buildings according to the number of floors, which have been divided into four classes: 1 floor, 2-3 floors, 4-5 floors and buildings with more than six floors (Source: author own elaboration).

The next tables show the percentage of collected waste streams. As mention in sub-chapter 6.2.1, the metropolitan city of Turin is divided into eight consortiums. The consortium '18 – Città di Torino' is the one responsible for the waste management of the city.

Since 2000, Piedmont region has elaborated a studio about residual waste composition, and for the metropolitan city area there are data available to 2009. *Table 6.3* shows the main components of residual waste. The bio and paper waste are the main materials in the residual with 22,12% and 20,44%. With more than 15%, also the plastic shows a high value. The other components show percentage lower and are less problematic than bio, plastic and paper.

Table 6.3 - Residual waste composition in 2009 (Source: Città metropolitana di Torino, 2016).

Composition of residual waste	Bio	Garden W	Plastic	Paper	Textile	Glass	Metal
Residual	22,12%	2,17%	16,41%	20,44%	3,26%	6,59%	3,92%

In 2015, 437.653 tons of urban waste (491 kg/inhabitant/year) have been produced in the city of Turin, and 42,4% of them were recycled (Città metropolitana di Torino, 2016). In 2018, the amount of urban waste was 450.468 tons (514 kg/inhabitant/year), and the separate collection rate was 45,96% (Regione Piemonte, 2020b). The trend shows an increase in the amount of waste production per capita (+23 kg), but also an increase in the separate collection rate that added another 3,5%. Despite the growth in separate collection percentage, Turin remains one of the cities with the lowest percentage in the region. Indeed, the average of Piedmont region was 61,2% in 2018.

Figure 6.11 shows the amount of recycled waste per stream waste in 2018. The percentage refers to the amount of each waste stream on the total waste separately collected. Paper and bio are the two waste streams most separated with a percentage of 24,5% and 19,7% constitute almost the half of the separate collection. On the other hand, plastic cover a low percentage, around 6,4%. Bulky waste, WEEE and CD&DVD also show a low share, 5,2%, however, it can be assumed that the production of this waste stream is lower that the production of bio, paper, and plastic. The multi material shows a good recycling percentage, 12,7%.

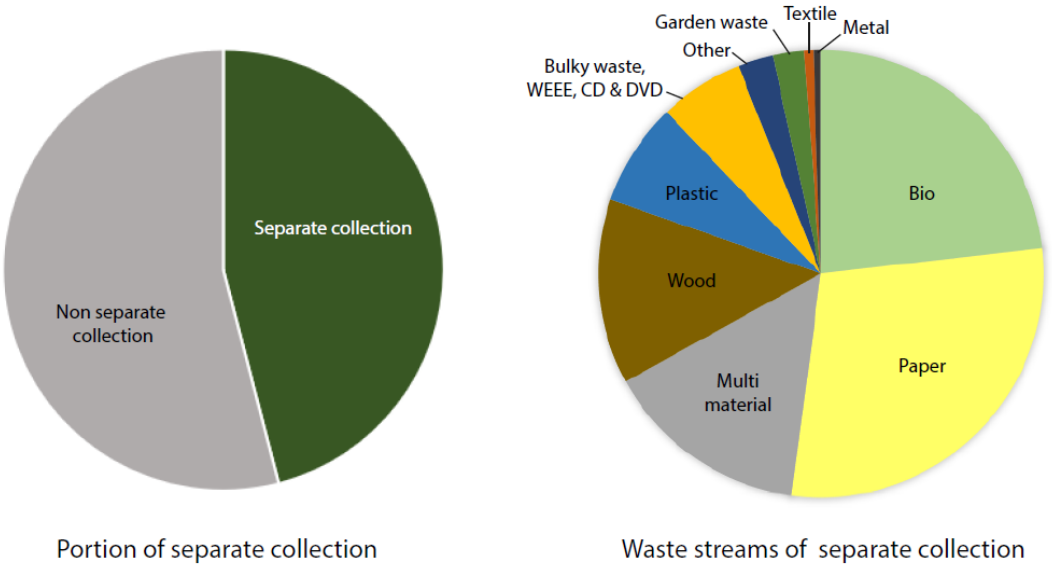

Figure 6.11 - Separate collection in 2018. The graphs show the amount of waste separately collected and the portion for waste stream (Source: author own elaboration based on Regione Piemonte, 2020b).

The recycling rate in the city of Turin is increasing, due to the door-to-door collection, that has been implemented since 2013. From 2015 to date, the separate collection rate is increased of almost 4,5%, indeed, it was 42,2% in 2015 and 46,95% in January 2020 (Città metropolitana di Torino 2015d). *Figure 6.12* shows the percentage of separate collection in Turin's neighbourhoods. The door-to-door collection is positively affecting the separate collection rate, while, the neighbourhoods in which the service is not active show lower shares.

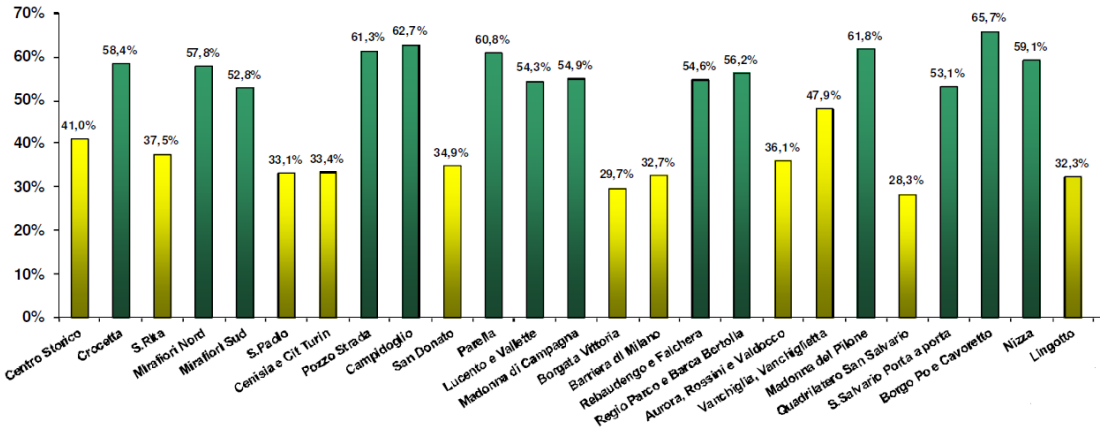

Figure 6.12 - Separate collection rate in Turin's neighbourhoods, 2018. The bar graph shows the in green the neighbourhood in which is active the door-to-door collection, while, in yellow the neighbourhood without the door-to-door service (Source: Amiat, 2019).

6.4 Chapter summary

In Italy the planning and waste management systems follow the same structure. The national level defines laws and guidelines, while at the regional level, each region enacts its own law to outline the systems. The city of Turin is the capital city of Piedmont region and its planning and waste management systems are strictly related to the hierarchical levels of Piedmont region and Metropolitan City of Turin. Moreover, it can be outlined a similarity and a certain correlation between the instruments adopted by the two system.

In Turin, Amiat is the agency responsible for the waste management. In the last years, the city has introduced the door-to-door collection system for five waste streams: bio, plastic, paper, and glass. Despite the introduction of the door-to-door collection system, not all the city is covered by this service. The percentage of separate collection is very different between the districts of the city: where door-to-door collection is carried out, the results obtained are decidedly higher.

The neighbourhood presented so far is San Salvario, a quite central area, in which there are different characteristics in waste generation. Indeed, in the norther area there is not the door-to-door collection service, and the percentage of separate collection is critical (circa 28% in 2018), while the southern area shows a better situation due mainly to the introduction of the door-to-door collection in the recent years. Based on the analysis carried out in this chapter, the following one aims to transfer and apply the eco-innovative solution developed for Hamburg case study to San Salvario neighbourhood to improve its waste management system.

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07 TRANSFERABILITY OF THE SOLUTION "QUARTER SERVICE CENTER" TO SAN SALVARIO NEIGHBOURHOOD

7. Transferability of the solution “Quarter Service Centers” to San Salvario neighbourhood

This chapter aims to apply the solution “Quarter Service Centres”, developed for Hamburg case study, to San Salvario neighbourhood. Within REPAiR, some of the solutions developed for each case study are consider transferable on other case studies, according to the needs and the ambitions of each area. From this perspective, the EIS is applied to the Turin’s case study. Turin is not part of REPAiR project, however, based on the analysis carried out, the neighbourhood appears to be an area in which a quarter service center may improve the separate collection and the behaviour of the population.

San Salvario is a really dense neighbourhood, with several challenges from the waste management perspective. The north area consists of mostly residential buildings with four or five floors and the rate of separate collection here is really low, it accounts for less than 30%. On the other hand, the southern part of the neighbourhood is characterized by higher building (six or more floors), however not all the buildings are residential, and the rate of separate collection is above the average of the city.

In addition, the European project of Horizon 2020, UrbanWINS, has developed actions linked to prevention and management of waste for the city of Turin. As REPAiR, the project follows the urban metabolism approach, therefore it is considered a good hint for this study case. Moreover, one of the pilot actions regards the creation of a ‘hub for circular economy’ to improve the awareness on waste management behaviour. With regards to this project and REPAiR project, the EIS III – Quarter Service Center is applied to San Salvario neighbourhood.

This chapter, with consideration to REPAiR and UrbanWINS projects, develops a solution for San Salvario neighbourhood. Firstly, an analysis of the existing activities and services is proposed, then some measures are proposed. Finally, some indicators are calculated to understand the potential changes of to the solution on the waste management system.

7.1 Existing activities and services

In the neighbourhood there are already some initiatives linked to waste prevention, reuse, and recycle. For instance, Network Zero Waste Italy (*Rete Zero Waste)* has defined a network of activities that promote a zero-waste style of life across Italy. According to this association, in San Salvario there are five second-hand shop, a tap water dispenser, in which pick up still water for free, and sparking water for a small amount of money (0,10 €/l), and two zero packaging shop. Moreover, there is the *Casa del Quartiere*, a “laboratory for the design and implementation of social and cultural activities”, in which several activities and workshops related to waste take place (Casa del quartiere di San Salvario, 2020). Other these activities, in the center there are spaces available for organize activities, a café, and several courses and services for the population.

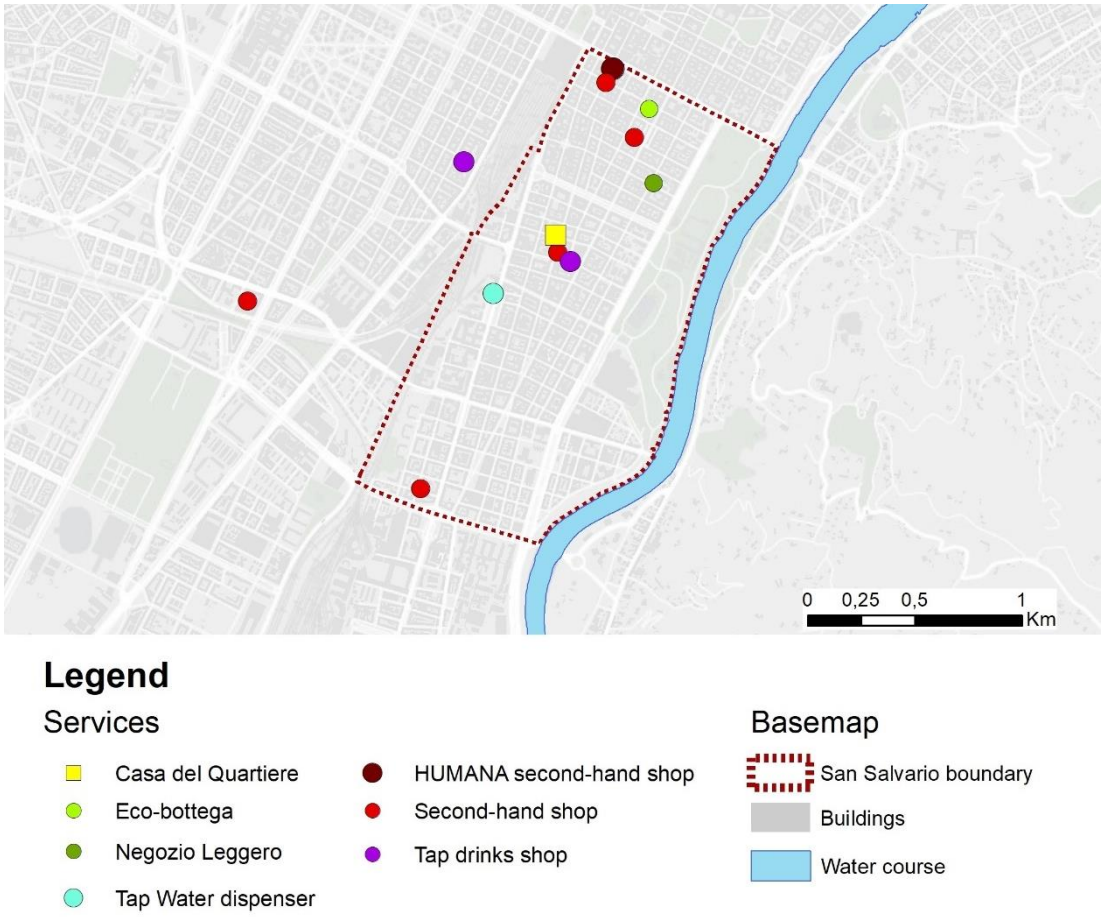

Figure 7.1 - Location and typology of existing service in San Salvario neighbourhood (Source: author own elaboration).

Figure 7.1 shows the activities highlighted from Network Zero Waste Italy and the Casa del Quartiere. There are also some shops that are reducing the use of plastic and glass bottles. They are mostly shops selling drinks on tap, especially wine.

The second-hand shop HUMANA organises several workshops linked to the reuse. For instance, it promoted workshop in the frame of the initiatives RIcuciTÓ, a project that aims to apply an innovative model of circular and collaborative economy that extends the life of post-consumer textile materials (Torinocitylab, 2020b).

Figure 7.2 - Images of the workshop RIcuciTÓ (Source: Torinocitylab, 2020b).

In addition to these activities, there are other initiatives. *Il tavolo del riuso* (lit. the table of reuse) is an initiative started in 2016 in the metropolitan area that aims to bring together different actors in order to discuss the issue of reuse in different sectors. The table includes cultural associations, cooperatives social media, newspapers (Tavolo del riuso, 2019). To date there are three projects active, with the intention of inform and awareness the population on the reuse theme. Some meetings of the 'table of reuse' take place at the Casa del Quartiere of San Salvario. For instance, the event 'Spritz for the future – Reuse your PC' has took place in November 2019. The goal of this kind of events is to give tips and hints on how to extend the life of a device.

Figure 7.3 - Tavolo del riuso. On the left an image of the ‘Spritz for the future’ workshop, and on the right the main project of the table of reuse (Source: Tavolo del riuso, 2019).

Triciclo is a social enterprise working towards the recovery and reuse of used products to contribute to the waste reduction. It works in synergy with the other territorial authorities to implement the separate collection of waste; for instance, it cooperates to the initiatives of the table of reuse (Triciclo, 2020). Moreover, triciclo has two Reuse centers in the city, but they are quite far from San Salvario neighbourhood.

Torino city lab, an initiative promoted by the city of Turin to test and realize innovative solutions, organizes workshops and projects linked to the circular economy. In February 2019, the project “Beautiful Precious Plastic, discover the project, bring your plastic” has been launched in the neighbourhood Barriera di Milano. This project aims to bring the separate collection of plastic at a local scale, through the use of Open Source machines capable of shredding and thermoforming the plastic (Torinocitylab, 2020a).

Quaderni, taccuini, agende in carta/cartoncino	contenitore giallo
Quadri	centro di raccolta
Rasoi usa e getta	contenitore verde
Reti metalliche e a doghe	centro di raccolta
Retine in plastica per frutta, ortaggi e verdura	contenitore grigio
Rubinetteria[2]	contenitore blu
Sacchetti del caffè	contenitore grigio
Sacchetti, buste e tabulati di carta	contenitore giallo
Sacchetti merendine, patatine, snack	contenitore grigio
Sacchetti usati dell’aspirapolvere	contenitore verde
Salviette umidificate	contenitore verde
Sanitari[2]	centro di raccolta
Sapone e saponette	contenitore verde
Scaffali	centro di raccolta
Scarpe	contenitore bianco
Scatole e lattine in metallo (alimenti, igiene...)	contenitore blu

Figure 7.4 - Extract of the Rifiutologo. The image shows an extract of the catalogue distributed by Amiat to promote the separate collection (Source: Amiat, 2018).

To promote the door-to-door collection and the separate collection Amiat has created a '*Rifiutologo*', a catalogue in which there is a list of several waste with indication about typology and kind of bin to use for their disposal. The catalogue is available only in Italian language, however near each waste there is a symbol with the colour of the corresponding bin that can facilitate the users.

Finally, to highlight there is a Green Office of the University named UniToGO. A Green Office is a hub to promote sustainability across students. UniToGO has five working groups about energy, green public procurement, sustainable mobility, waste, and food. The 'waste working group' aims to define strategies and actions to prevent waste production, increasing separate waste collection and managing the waste cycle within the facilities and buildings of the University of Turin (Green.unito, 2020). For instance, it is active a contest 'made at home' (*Made in Casa 2020*). This is an awareness-raising event on up-cycling: the process of reuse and improvement transformation of disused products and materials that aims to create new products whose functional, economic, aesthetic and emotional value is greater than the original. The office UniToGO, located in Via Verdi, is a bit far from San Salvario neighbourhood, however, it represents a best practice. In San Salvario there are several university faculties and student residences, therefore a center for student could be a great option.

7.2 Proposed actions

Started in 2016 and ended in 2019, the project UrbanWINS aimed to implement eco-innovative strategic plans in order to improve waste prevention and management. Turin was one of the pilot cities and a strategic plan has been developed for the city. The priorities set by the plan for the city were:

- prevention of waste production;
- reuse and recycle by improving the urban waste management;
- urban planning, improving the building waste management;
- education through the development of new shared strategies of communication (UrbanWINS, 2018a).

In the frame of the priority ‘education’, the action ‘hub for circular economy’ has been implemented. “The Hub aims to create a (social) network that gives and share information’s in order to reuse and recycle materials among citizens, private companies and professionals” (UrbanWINS, 2018b). The hub affects all the waste streams from which is possibly get material to reuse and recycle. Between November 2018 and February 2019, four workshops had been held to promote the initiatives. Each event explored an aspect of the circular economy, and each meeting was accompanied by participatory workshops on the theme of the meeting. Even if the event did not take place in the case study area, this initiative represented a first attempt to create a local service to promote the circular economy in the city.

The Casa del Quartiere in San Salvario may become a hub for circular economy in the neighbourhood. Indeed, several workshops and activities are already in place, and there is enough space to introduce new activities such as a repair hub. There is also a Cafè in which workshops about ‘sustainable practices’ take place, therefore the idea of a Repair Cafè introduced for Hamburg case study should be adapted to the center.

Figure 7.5 shows some of the spaces available for implementing the solution. The center has a fairly central location in the neighbourhood, which makes it easily accessible. Moreover, it could work in synergy with other activities of the area such as HUMANA second-hand shop. Negozio Leggero, a zero-packaging shop in the neighbourhood, is another space that can work in synergy with the circular economy hub. The shop promotes events to avoid waste from the source with the aim to create an active community in the area (Negozio leggero, 2019).

Figure 7.5 - Casa del Quartiere, San Salvario. The pictures show some of the center spaces that may be used to implemet the solution (Source: Casa del quartiere di San Salvario, 2020).

In addition, a neighbourhood service for students could be created. Indeed, in the area there is a great amount of university facilities and, therefore, students. Students could be more open to new behaviours, moreover they could be more incline to buy second-hand items for their temporary house. A space in one of the facilities can be adopted to become a green office or a repair hub. This center can become a meeting point for the students of the neighbourhood and workshops on repair, reuse, upcycle can be promoted here. This new office could work in synergy with the office UniToGO. For instance, the university KU Leuven has a green office and a Repair Hub in which there are available tools for students that can also be rent out for free. Moreover, events are organized in the hub to promote a sustainable style of life and to teach how to repair/reuse items for several functions (Green office for KU Leuven, 2020).

Combining the solutions of the two European projects REPAiR and UrbanWINS, the Casa del Quartiere appears to be the best location to promote a local hub for circular economy. The spaces can easily adapt to be temporary repair center or to host workshops and events. In addition, a cooperation with other local activities such as HUMANA and Negozio Leggero may improve the effectiveness of the hub. Other local activities and services could be involved

in the network. Moreover, the high presence of university facilities may allow the creation of a repair hub or a service center for the students. This will promote a community of collaboration and reuse across students.

Figure 7.6 shows the desirable network of activities and services that can bring locally circular economy. Three flows have been highlighted. An exchange of information and a cooperation between existing activities has to been promoted. Ideal flows from the neighbourhood to the Casa del Quartiere and vice versa will exist, if the Casa del Quartiere will become a hub for circular economy, promoting workshop, activities and repair labs. Finally, the third flow regard the universities and students. A cooperation between facilities and student will allow to create a repair and information center.

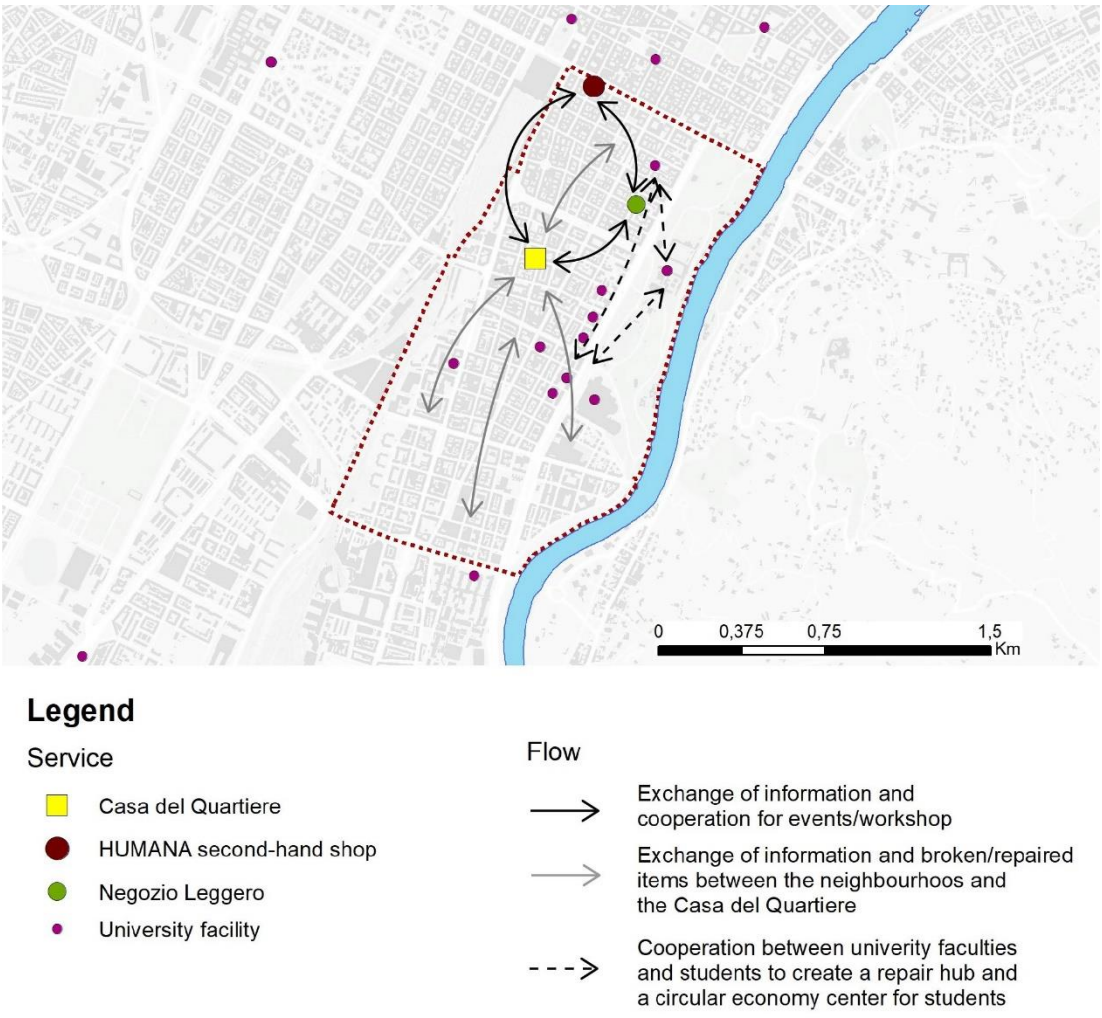

Figure 7.6 - New and existing services in San Salvario neighbourhood. The map shows the desirable network between services and activities, how they could be linked and which kind of flow they supported (Source: author own elaboration).

7.3 Impacts of the EIS on the Waste Management System

In this chapter the same analyses carried out for Hamburg case study are performed. The methodology and the indicators have already been described in the sub-chapter 5.3.1 and 5.3.2, therefore only the results for the Turin case study are reported here. As there are differences in the data availability between the two case studies, some clarifications on the calculation of the indicators are made. Moreover, as highlighted in chapter 6, in San Salvario there are mainly two areas with differences in the waste management: the door-to-door collection area and the non-door-to-door collection area.

7.3.1 Indicators and results

Effectiveness in achieving behaviour change

The data availability for the city of Turin show the amount of waste separately collected per stream waste and the amount of non-separately waste consider as residual waste. *Figure 7.7* shows the status quo and its variation, if it is assumed that 40% of the population will use the new service. The variation of the 40% is assumed as for the Hamburg case study to analysis purposes. Indeed, mainly for a lack of time, it was not possible defined the number of citizens who would use the center, therefore it was supposed. For Turin the residual data does not show the amount of waste incorrectly sorted, therefore the reduction is applied to the total amount of the residual waste.

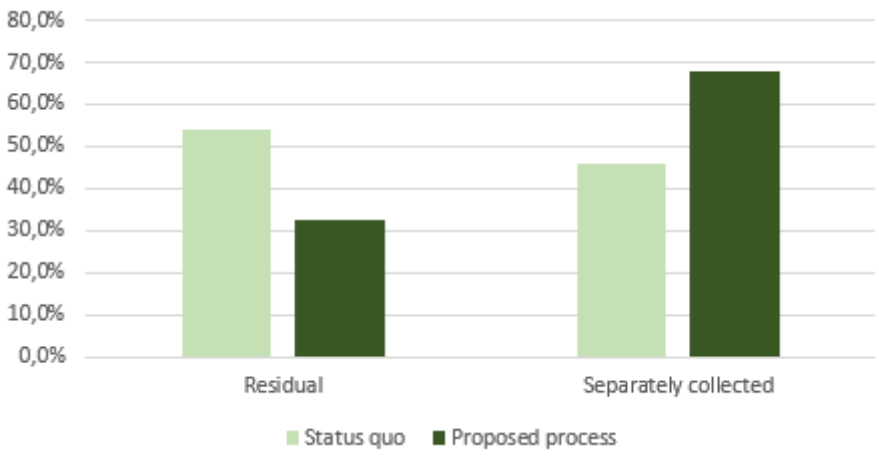

Figure 7.7 - Effectiveness in achieving behaviour change. The graph shows the status quo and its potential variation if the 40% of the neighbourhood's population will use the service center (Source: author own elaboration).

If the 40% of the population will use the service center, a reduction of 21,6% will occur, and consequently the amount of waste separately collected will increase.

Public Acceptance

In Turin the waste fee is not fixed, but it varies according to the dimension of the house and the number of inhabitants. To define the fee in San Salvario the data show in *table 7.1* have been assumed. The average of inhabitants per flat and the average dimension in m^2 per inhabitant has been define according to ISTAT (2011), while the fixed and variable cost are established annually by the municipality of Turin (Comune di Torino, 2019).

Table 7.1 - Data for the calculation of the waste fee in San Salvario (Source: author own elaboration).

Average number of persons per households	Average size of flat in m2 per inhabitant	Fixed cost	Variable cost for 2 inhabitants flat	Fee now
1,9	40,96	1,45422	134,17313	253,3

According to the assumption made for the previous indicator, and in relation to the fee calculated with data in *table 7.1*, the public acceptance will increase of 27,3%, from 20,9% to 48,21%.

Urban space consumption of the waste management system

The service center will increase the urban space consumption, however, the new facilities will be insert inside existing building in order to use the available spaces and limit new construction. Moreover, a distinction between the door-to-door collection are and the non-door-to-door collection area has to be done. In the first area there are not bins or other facilities in public areas, while in the second area there are a lot of public bins, therefore the indicator has been calculated for both the two areas. *Table 7.2* shows the increase in urban space consumption. In the non-door-to-door area the high number of public containers occupying approximately 0,20% of the area. On the other hand, in the door-to-door collection area there are no more containers on public spaces, except for three public bins for the textile. Also, in the proposed process the percentage of area occupied by operational infrastructure is really

low. Indeed, located in the Casa del Quartiere, the service center will occupied a small area.

Table 7.2 - Urban space consumption of the waste management system. The table shows the increase in surface occupation between the status quo and the proposed process (Source: author own elaboration).

	Non-door-to-door collection area		Door-to-door collection area	
	Status quo	Proposed Process	Status quo	Proposed Process
Area in m^2	587576,133	587576,133	1742881,6	1742881,596
Area occupied by public bins in m^2	1252,5	1252,5	5,5	5,5
Area occupied by other operational infrastructure in m^2	0	0	0	922
Area occupied by WMS in m^2	1252,5	1252,5	5,5	927,5
Indicator	0,21%	0,21%	0,00%	0,00%

Private space consumption

For the private space consumption indicator, the following data have been collected:

- total area of residential buildings;
- coefficient of reduction for leaving space;
- area occupied by private bins;
- Number of households.

The buildings' area has been calculated through the use of a GIS program. The coefficient reduction for leaving space is assumed as 10% in Turin, while the area occupied for private bins is established according to *table 7.3*.

Table 7.3 - Dimension of bin per house typology (Source: author own elaboration based on Provincia di Troino, 2007).

	Bio bin	Plastic bin	Paper bin	Residual bin	Glass bin
Bin in l	25	70-110	50	50	40
Dimension in m^2	0,049	0,160	0,071	0,071	0,063

It is supposed that households have on average all the five bins for the separate collection. Therefore, the space occupied inside each house for the bins is circa 0,4 m^2. With these data the indicator private space consumption

has been calculated. According to the indicator, in San Salvario the 0,21% of house is occupied by bins for separated collection.

This indicator is not calculated for the proposed process, because the solution Quarter Service Center has not direct consequences on the private house bins. Even if the information activities are expected to lead to behavioural changes and as a result with a change in private house. Moreover, the indicator does not show a high data and is not consider as a critical issue.

Accessibility of waste management system

The calculation of the indicator was carried out through a service analysis performed with ArcMap. Ten ranges of accessibility are set 0-50, 50-100, 100-200, 200-300, 300-400, 400-500, 500-600, 600-700, 700-800, >800. The analysis for the status quo has been performed with the location of the existing public bins, while, in the proposed process analysis, the location of the new collection points is added to the location of the existing public bins.

The analysis for the bio, paper, residual, glass, and plastic has been performed only for the non-door-to-door collection area because in the door-to-door collection area all the households are in the range 0-50 m. Only the accessibility to the textile bins has been carried out for the whole area of the neighbourhood. Indeed, the textile is not part of the door-to-door collection service and only three public containers are located in the neighbourhood.

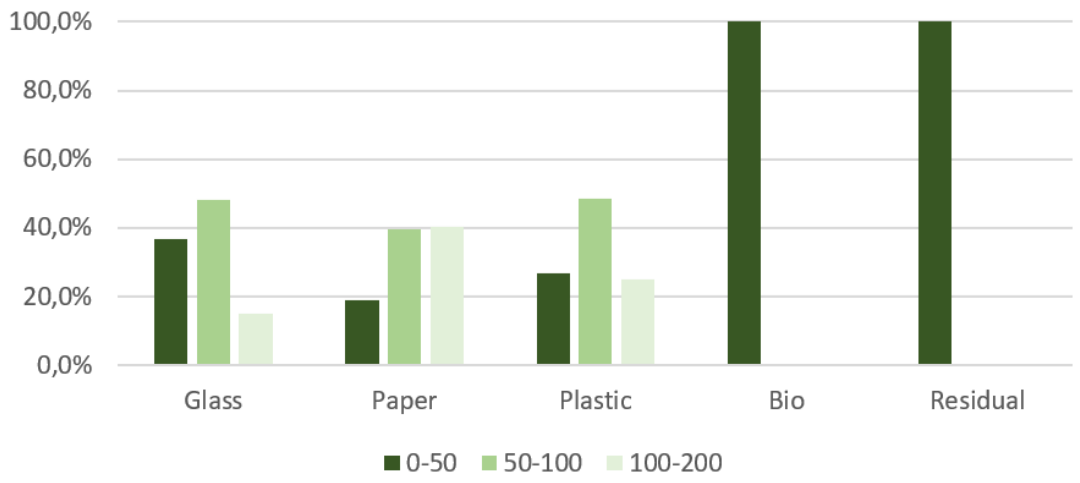

Figure 7.8 - Accessibility to the waste management system. The graph shows the status quo of the non-door-to-door area (Source: author own elaboration).

Figure 7.8 shows the accessibility to the five public bins located in the non-door-to-door collection area. Due to the high number of bins in the area, the accessibility is very high, there are not households far more than 200 m from a public bin. The paper is the typology with the lower accessibility; however, it is not considered a critical issue.

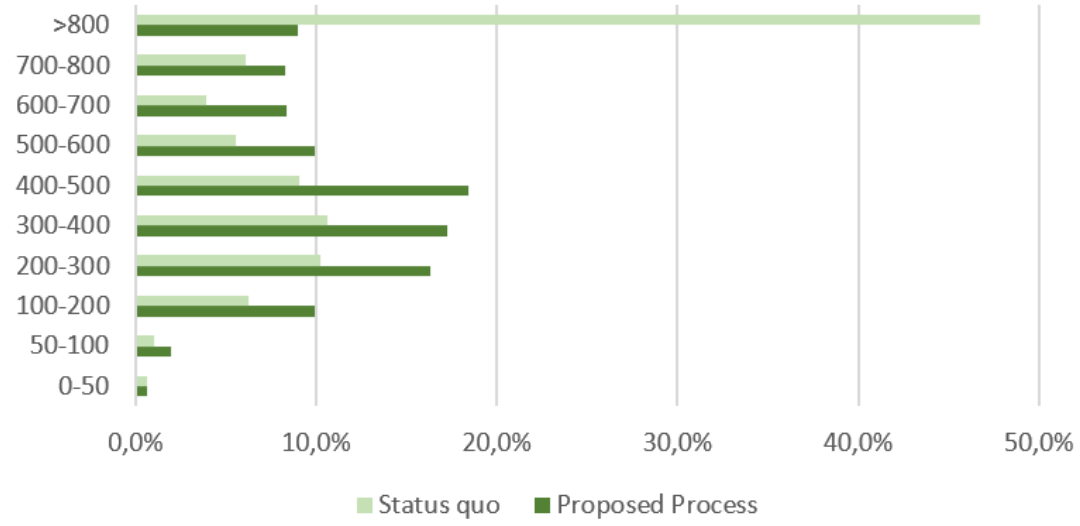

Figure 7.9 - Accessibility to the waste management system. The graph compares the status quo and proposed process for the textile bins in San Salvario (Source: author own elaboration).

Figure 7.9 shows the changes in accessibility to the textile bin if the Case del Quartiere will become a collection point in the neighbourhood. Indeed, the three existing collection point are all located at the south of the neighbourhood,

being too far for almost half of the households. The central location of the new collection point will improve the accessibility also for the waste stream for whom there are no other collection points in the area such as WEEE and bicycle. *Figure 7.10* shows as the accessibility may increase with the introduction of the Casa del Quartiere as a collection and repair point. Even if the maps show the accessibility to textile, the range of accessibility around the Casa del Quartiere point could be consider also range of accessibility for the other waste streams that are not collected in the five typology of public bins and are supposed to be collected there.

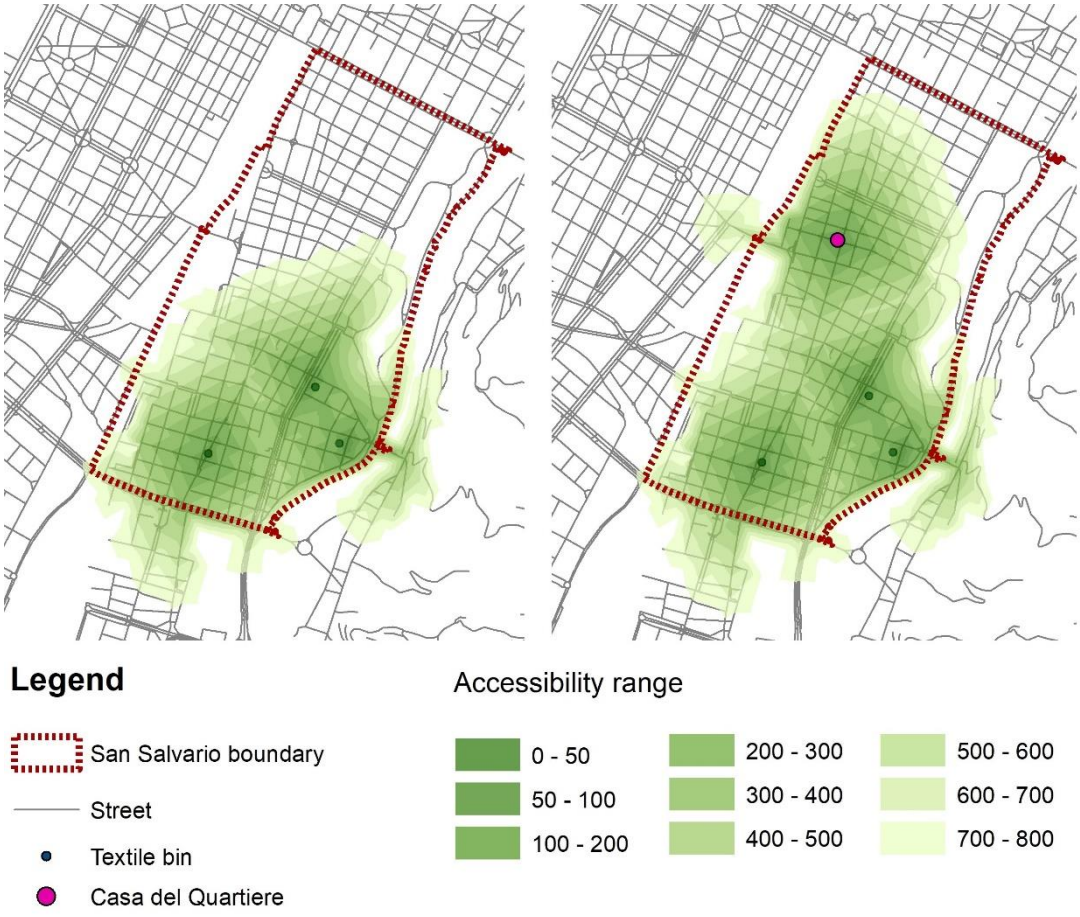

Figure 7.10 - Accessibility to the waste management system. The maps show the status quo and the proposed process for textile collection point. The map on the left shows the accessibility with only the three existing containers, while the map on the right shows the accessibility with the introduction of a new collection point (Source: author own elaboration).

Economic indicators

The data available for the economic indicators refer to the balance sheet of Amiat (2018b), the agency in charge of waste collection and treatment in the city of Turin.

In 2018, the number of employees was 1544. The service centre and its related functions should work on a voluntary basis. However, especially for the collection point in casa del quartiere, it may suppose the need of at least two new employees, as for Hamburg case study.

The operational cost of the waste management system amount to 175,7 M€ in 2018. It is expected that the new services will have positive impacts on the waste management cost, since part of the waste that now are incinerated will be repaired and reused. However, as already mention for the Hamburg case study, at the beginning the service center will increase the costs, and only in the medium to long term will there be a decrease in expenses due to better separate collection and a decrease in waste that instead of being incinerated will be repaired and reused.

7.4 Chapter summary

In this chapter the EIS “Quarter Service Center” described and analysed in chapter 5 has been transferred to San Salvario neighbourhood in Turin. As for the Hamburg case study, a series of analyses have been carried out in order to better define the solution.

In addition to the existing services, also another European project “UrbanWINS” has been analysed. Indeed, this project has been carried out from 2016 to 2019 in several cities among which Turin. The project proposed a ‘hub for circular economy’ in which information activities should take place to promote awareness and behavioural changes. Based on this project and on the existing services, the solution has been developed. A repair and reuse center could be created into *Casa del Quartiere*, a central building for the neighbourhood, in which there are a lot of spaces available and already some initiatives in place linked to the waste avoidance. Moreover, the central location, makes it easily accessible for a great amount of the neighbourhood’s population. Finally, initiatives linked to the university facilities, widespread in San Salvario, are proposed to reach a change in behaviour between students.

Once defined, the solution has been analysed. The approach adopted for the analysis refers to the “sustainable framework” defined within REPAiR project. The framework is composed by several indicators that cover the three macro areas of the sustainability: economic, social and environmental. A selection of indicators has been calculated in order to define which impacts the solution could bring on the waste management system of Turin. The purpose of the analysis is to be a tool of information and support during the decision-making processes. Therefore, a comparison between the status quo and the proposed process is given to highlight the impact of the solution on the current situation.

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08 ANALOGIES AND DIFFERENCES BETWEEN THE TWO CASE STUDIES

8. Analogies and differences between the two case studies

After defining the EIS “Quarter Service Center”, this chapter aims to compare the two case studies, highlighting the differences and analogies between the planning and waste management systems and their implications for the implementation of the solution proposed.

The solution “Quarter Service Center” is one of the EISs chose for Hamburg case study after a participatory process in which local stakeholders have been included. Therefore, the EIS respond to specific needs and requirements highlighted by local stakeholders in the district of Altona. Only at a later stage it was decided to apply the same solution to the city of Turin in order to understand what implications this solution would have on another city. For this reason, the aim of the comparison is to relate the implications that the implementation of such solution could have on the waste management systems of the two case studies.

Hamburg is a city-state with a population of circa 1,7 million inhabitants and a certain independency from an institutional and legislative point of view. Turin is the capital of Piedmont region with a population of circa 880.000 inhabitants and it is strictly connected to the region and metropolitan city systems. Therefore, their planning and waste management systems show different characteristics. In addition, with regards to the municipal solid waste production and separate collection the two cities belong to two States with significant differences. On one hand Germany is one of the European countries with the highest production of waste per capita (618 kg per capita in 2014), but also with the highest percentage of separate collection (64% in 2014). On the other hand, Italy is at the 13th place in Europe per waste production per capita (488 kg per capita in 2014), but, at the same time, with a percentage of 42% in 2014, the value of the separate collection is not really high (EEA, 2016 and Eurostat, 2016). On the total amount of waste generated in 2016, the waste generated by households counted for the 18% in Italy, while for the 9% in Germany (Eurostat, 2019).

8.1 Comparison of the planning and waste management systems

In the previous chapter the EIS “Quarter Service Center” has been applied to the two case studies, focusing mostly on the existing services and on the desirable functions of the new service center. However, the planning and waste management systems should not to be overlooked. Indeed, the implementation of the EIS have to deal with both the systems.

Between the two cities, the most significant difference is their institutional organisation. Hamburg is one of the three so called city-state of Germany, and for this reason it has a certain independency. This particular status confers to Hamburg the right to enact laws on par with the other federal states in Germany. Hence, the waste management system and the planning system are defined at the city level, without any interaction between the surrounding areas, that are part of other federal states. Moreover, below the city level there are seven city districts that represent the municipal level.

On the other hand, the city of Turin is strictly related to the waste management and planning systems of the Piedmont region. Indeed, below the State level, Regions are the only authority that can enact laws and, therefore, Piedmont region defines its systems. At the city level, only the land use plan and a regulation on urban waste management are defined. Consequently, as mentioned, it is important consider also the regional and the metropolitan city level, because the plans adopted at these levels have implications on the local level. Especially from the waste management perspective, the system is strictly defined at the regional and provincial/metropolitan levels in which the regional area is respectively divided into optimal areas for the management of waste (ATO) and consortium to ensure homogeneous and optimal management.

Table 8.1 shows the main tools and authorities involved in the planning and waste management systems of the two cities. The objective of the table is to propose a comparison between instruments and authorities of the two case studies.

Table 8.1 - Instruments and authorities involved in the planning and waste management systems of the two cities (Source: author own elaboration).

	HAMBURG		TURIN	
	Instruments	Authority	Instruments	Authority
Planning system	Preparatory land use plan	Hamburg City-state (Ministry of Urban Planning and Housing)	Territorial plan and Landscape plan	Piedmont Region
			Territorial coordination plan	Metropolitan city of Turin
	Local development plan	Districts	Land use plan	City of Turin
Waste Management System	Law on waste management (1994)	Hamburg City-state (Ministry of Environment and Energy)	Regional law on waste management (2002)	Piedmont Region
			Regional Plan for urban waste and sewage sludge management	
			Provincial programme of waste management	Metropolitan city of Turin
			Regulation on urban waste management	City of Turin

In Hamburg the waste management system and the planning system are a competence of two diverse authorities: the Ministry of the Environment and Energy and the Ministry of Urban Planning and Housing. This led with differences in the system structure. Indeed, the planning system is regulated by two instruments, one at the level of the city and the other at the districts level, while the waste management is regulated by a law that enshrine the function of the system and institute the public agency responsible for the waste management on all the city area.

In Turin the regulation on urban waste define the waste management at the city level, however the targets and goals of the waste management are set both at the regional and metropolitan levels. Moreover, there is a certain correlation between the planning and the waste management tools. Indeed, besides there is an analogy between instruments, also the department (*assessorato*) responsible for the plan elaboration is the same. The Department of the Environment, Urban Planning, Territorial and Landscape Planning, Mountain Development, Forests, Parks, Civil Protection

(*Assessorato all'Ambiente, Urbanistica, Programmazione territoriale e paesaggistica, Sviluppo della montagna, Foreste, Parchi, Protezione civile*) is both responsible for the elaboration of the urban waste and for the territorial and landscape regional plans. At the provincial level, the provincial programme of waste management is elaborated by the Department of Sustainable Development and Environmental Planning (*Assessorato Sviluppo sostenibile e Pianificazione ambientale*), that is related to the planning aspects and competences.

The systems structure of Turin and, more in general, of the Piedmont region results more articulated and interrelated. This could lead with a major interaction between the two system, but at the same time, these three levels system may be too complex and dispersive. On the other hand, Hamburg systems have a certain independence, because they are established only by the city. Moreover, the law on Waste Management (1994) instituted the public agency SRH as responsible for the waste management in the city; this provides to the agency a certain independency and flexibility.

Finally, there is one aspect that is not evident from the comparison between instruments, but very relevant: the attention paid by the State to the issue of waste. In Germany, the issue of waste and its related problematics have been a crucial aspect since the 1990s, when laws on landfill reduction and producer responsibility have bring the percentage of separate collection to 40% in 1995. Today the country has an established culture of recycling: 14% of the raw materials used in German industry are recovered waste products, and the recycling rates for households and commercial waste is approximately 60% (REPAiR, 2017). In Italy the rate of 40% of separate collection was reached only in 2014 (42%), and the first laws regarding the structure of waste management have been enacted only at the end of 1990s (EEA, 2016). These data highlight a minor established culture of recycling, which has only gained in importance in recent decades.

8.2 Comparison of the study areas

After defining the differences between the two systems, it is important to highlight also the differences and analogies between the two study areas. The two neighbourhood in the district of Altona are in a semi-peripherical position, while the neighbourhood in Turin is located in a quite central area. In addition, there are some characteristics in the socio-economic structure that led with a number of services and characteristics of each area.

Table 8.2 - Main characteristics of the study areas (Source: author own elaboration).

	HAMBURG		TURIN
District	Altona		-
Neighbourhood	Ottensen	Osdorf	San Salvario
Area in km^2	2,9	3,1	2,3
Inhabitants	40.792	24.618	35.630
Population Density (inhabitants per km^2)	14.066	7.941	15.491
Average of inhabitants per households	1,7	2,0	1,9
Prevalent house typology	Multy-family house	Large housing estate	Mixed-used house with prevalent residential use
Waste generation characteristics	Low rate in separate collection due to the high density of the area that makes difficult the separate collection service	Low separating rates of organic waste and problems related to bulky waste, that are often left on the road or in the vicinity of public containers	Low rate in separate collection where the service of door-to-door collection is not active
Existing services	The area has already a good network of services concerning several aspects of the waste management	The area has already some waste facilities, but an implementation is necessary	In the area there are some services, but they are punctual initiatives, without interrelation

Table 8.2 shows a comparison between the main characteristics identified in each area. The differences and the existing services already in place have allowed to develop specific solutions per each neighbourhood, starting from their strengths and weaknesses. Ottensen and San Salvario show a high population density, while Osdorf has almost half the density of the others two neighbourhood. Moreover, Ottensen and San Salvario are characterised by

multy-family house and mixed-use buildings, while Osdorf is characterized by a high concentration of large housing estate. This has led with a major number of activities and services in Ottensen and San Salvario and a prevalent residential use in Osdorf with a lack of services and activities. Based on these analogies and differences specific solutions have been proposed to implement the waste management in the three neighbourhoods. In Ottensen the main objective is to create and enhance a network between existing and new services and activities by opening a new Repair Café and promoting cooperation. In Osdorf, the lack of existing services has led to the creation of collecting and information hubs in strategic points. Finally, in San Salvario the existing services should be boosted, and, at the same time, services for students should be created.

Table 8.3 - Main characteristics of the solution "Quarter Service Center" in two neighbourhood in analysis (Source: author own elaboration).

	HAMBURG		TURIN
Neighbourhood	Ottensen	Osdorf	San Salvario
Main objectives of the EIS	Create a network between activities and services; Open a new Repair Café; Promote awareness and information; Implement the second-hand shop Stilbruch.	Implement the Bornheide community centre, including the restoration of the second-hand shop Cappello; Open a new Repair Café in the shopping area; Improve the exiting recycling station.	Create services for students; Promote the creation of a Repair and Reuse center in the Casa del Quartiere; Promote cooperation between existing activities.

The realisation of the proposed solution has to deal with the systems characteristics explained in the previous sub-chapter. In Hamburg, the waste management public agency SRH plays a key role in the city, being involved in several public initiatives. In the city and in the neighbourhood in analysis, there are already services managed by SRH, such as Stilbruch, therefore the implementation of the solutions may be easier. On the other hand, the waste management agency Amiat is mainly a private agency, with the task of dealing with the waste collection, but it is not involved in other initiatives in the neighbourhood, thus, the collaboration between Amiat and other institutions may be more challenged.

8.3 Chapter summary

The waste management and planning system show structural differences in the cities of Hamburg and Turin. Indeed, the city of Hamburg has a certain independence in the German federal context, while the city of Turin is highly dependent on the regional hierarchical system. This leads with differences in instruments and authorities responsible for the planning and waste management system, and, therefore differences in the application of the proposed solution.

On one hand, the waste management from the city itself gives a certain flexibility to the public agency responsible for the waste management. However, there is no dialogue between authorities and instruments of the two systems. On the other hand, the city of Turin is in a multi-levels well organized context, in which it is possible highlight a dialogue between waste management and planning authorities. This structure has a lot of potential, but its complexity can make it as well dispersive. Moreover, the waste management agency Amiat is mainly a private agency, with a poorly participation in neighbourhood initiatives, which could make the application of the solution more challenges.

In addition to the two systems, also the differences and analogies between the study areas have been analysed. Indeed, even if the same solution has been applied to the neighbourhood, specific interventions have been proposed for each area in order to face specific needs. For instance, where services and activities were already present, they have been enhanced, while where a lack of services was identified, they have been included. The waste management and the planning system and the characteristics of each area are considered the starter point for the implementation of the proposed solutions.

Chapter references and online resources

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09 CONCLUSION

9. Conclusion

The work described into this thesis has its basis in REPAiR project, which promotes the transition to a circular economy through the development of eco-innovative solutions. The transition from the current economic linear model to a circular one could help to overcome contemporary issues such as the consumption of natural resources, that is one of the main reasons of global climate change and biodiversity loss. According to the several definitions of circular economy, resources and products should be maintained into the cycle as long as possible, in order to limiting the consumption of natural resources and the waste production. Focusing mainly on the last part of the chain, the research carried out intended to demonstrate how the circular economy could be brought locally, considering waste as resource.

Cities play a key role in the transition to a circular economy. Indeed, cities are the places with the greatest criticality: today, the 75% of natural resource consumption occurs into cities. However, on the other hand, cities are also an opportunity, being perfect hubs for innovations: their high concentration of resources, capital, data give to them the perfect position to drive the transition. The eco-innovative solution developed and analysed in the cities of Hamburg and Turin aims to reduce the waste production, affecting population behaviour through activities and services linked to avoidance, reuse, and repair practices.

9.1 Concluding remarks and policy recommendations

In the last decades, the European Union has taken interest in the issue of the circular economy. For instance, the Waste Framework Directive (2008) has imposed targets and behaviour to reach by the States, while the Green Deal (2019) has pointed out the need for a clean and circular economy, suggesting measures to be implemented by the States. Likewise, in the two European states under analysis, Germany and Italy, some targets and procedures have been introduced. Since 1991, the ‘producer responsibility’ has been introduced in Germany, while in Italy each Region has to enact a waste management plan and to define the 'optimal areas for the management of waste'.

In this context Hamburg and Turin show a really different planning and waste management systems. Despite these attempts to introduce targets and procedures at the State level, the cities show a lack of interaction between the waste management and the planning structures. Indeed, as outlined by the urban metabolism approach, cities function as living organism in which input and output flows enter and exit the system. However, the design of cities has for long time ignored these flows that shaped the cities. Waste management has always been considered as a sectorial subject; though, it emerges the need of an integration between the two system. As highlighted in the New Urban Agenda, the economic growth is not only based on the innovation and reduction of environmental impacts, but it should also ensure the inclusion and participation of all. From this point of view the role of the planning is crucial to ensure a fair growth that is inclusive and sustainable.

9.2 Limits of the adopted approach

According to the concepts of circular economy and urban metabolism, the consumption of natural resources should be reduced to face the negative impacts that our growth model is having on the Earth. To achieve a circular economy several procedures and levels (macro, meso, and micro) should be taken in consideration. Indeed, only actions at different scales and in each step of the production and consumption chains can allow the transition to a circular economy. In this context, the eco-innovative solution developed and analysed in the thesis aims to bring locally the circular economy. To reach the objective, the solution focuses only on the neighbourhood level and on the last step of the chain: the waste. For reasons of time and data availability, the research focused only on the neighbourhood level and on waste, overlooking the previous steps in the production and consumption chains.

To promote the circular economy all the steps of the chain should be considered. Indeed, to avoided waste production the information is a key aspect but cannot be considered the only way. Structural changes should take place in the production chain, especially into the design and material choice phases. In addition, also the economic aspects may be considered. Indeed,

rewards or payments could affect the behaviour of the citizens. Finally, other levels have to be considered. The neighbourhood is a suitable level to the implementation of solution at the local scale; however, also the micro and the macro level should be taken in consideration. To best achieve the aims of the solution, changes should already take place at the micro level, during the design and production of items and goods. Indeed, change upstream of the chain could improve the implementation of the solution locally.

9.3 Future research perspectives

Future research should consider the entire production and consumption chain. Indeed, to achieve a circular economy the role of the industries is consider as a key aspect. Industries are responsible for a great amount of resources consumption and the way they produce goods influences their consumption. The service center proposed could promote the circular economy locally, however it should be laid into a wider context. Moreover, the research should be extended to other scales. For instance, the city level should be taken in consideration, understanding if there is the need of center in each neighbourhood or if it is enough had some center in strategic location for the city.